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RESEARCH ARTICLE

REVIEW

Evaluation of Dental Pulp Volume Changes in Patients with Hypertension and Type 2 Diabetes Mellitus: Observational Study

Hipertansiyon ve Tip 2 Diyabet Hastalarında Diş Pulpası Hacim Değişikliklerinin Değerlendirilmesi: Gözlemsel Çalışma

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ABSTRACT

INTRODUCTION: The aim of the study is to evaluate of the dental pulp volume change in patients with hypertension (HT) and Type 2 Diabetes Mellitus (DM) on cone-beam computed tomography (CBCT) images with three-dimensional analysis.

MATERIAL and METHODS: The observational cross-sectional study was conducted using CBCT images of patients with at least one healthy maxillary canine tooth. The patients were classified into three groups according to self-reported systemic diseases: HT group, Type 2 DM group, and control group. Volumetric (pulp/tooth volume) and linear (pulp/tooth length and pulp/tooth diameter) measurements were made. ITK-SNAP software (Cognitica, Philadelphia, USA) was used. The measurement values were statistically compared between the groups.

RESULTS: A total of 90 individuals, 30 individuals in each group, were included in the study. The mean pulp volume of the HT group (28.13±5.89) and Type 2 DM group (25.99±3.13) were lower than the control group (29.06±5.60). However, the mean pulp volume was not difference between the groups (p>0.05). The mean tooth volume was difference between the groups (p<0.05).

CONCLUSION: : It was found that there was no statistically significant change in the dental pulp volume of HT and Type 2 DM patients compared to healthy individuals with three-dimensional analysis.

Keywords: *Cone-beam computed tomography, diabetes mellitus, hypertension*

ÖZ

GİRİŞ: Bu çalışmanın amacı hipertansiyon (HT) ve Tip 2 Diyabet (T2D) hastalarında diş pulpası hacmindeki değişimin konik-ışınlı bilgisayarlı tomografi (KIBT) görüntüleri üzerinde üç boyutlu analiz ile değerlendirilmesidir.

GEREÇ ve YÖNTEM: Gözlemsel kesitsel bu çalışma, en az bir sağlıklı maksiller kanin dişi olan hastaların KIBT görüntüleri kullanılarak gerçekleştirildi. Hastalar kendi bildirdikleri sistemik hastalıklara göre üç gruba ayrıldı: HT grubu, T2D grubu ve kontrol grubu. KIBT görüntüleri üzerinde hacimsel (pulpa/diş hacmi) ve düzlemsel (pulpa/diş uzunluğu ve pulpa/diş çapı) ölçümler yapıldı. Ölçümler için ITK-SNAP yazılımı (Cognitica, Philadelphia, ABD) kullanıldı. Ölçüm değerleri gruplar arasında istatistiksel olarak karşılaştırıldı.

BULGULAR: Her grupta 30 birey olmak üzere toplam 90 birey çalışmaya dahil edildi. HT grubunun (28.13±5.89) ve Tip 2 DM grubunun (25.99±3.13) ortalama pulpa hacmi kontrol grubundan (29.06±5.60) daha düşüktü. Ancak, ortalama pulpa hacmi gruplar arasında istatistiksel olarak anlamlı bir farklılık göstermedi (p>0,05). Ortalama diş hacmi gruplar arasında istatistiksel olarak anlamlı bir farklılık gösterdi (p<0,05).

SONUÇ: Üç boyutlu analiz ile HT ve Tip 2 DM hastalarının diş pulpa hacminde sağlıklı bireylere kıyasla istatistiksel olarak anlamlı bir değişiklik olmadığı bulunmuştur.

Anahtar Kelimeler: *Diyabet, hipertansiyon, konik-ışınlı bilgisayarlı tomografi*

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INTRODUCTION

Hypertension (HT) is a chronic cardiovascular disease characterized by increased peripheral vascular resistance, with a worldwide prevalence of approximately 31.1%.[1] HT generally has no sign or symptoms, and it is diagnosed with blood pressure measurements.[2] HT is classified into as essential and seconder. Essential HT is observed in approximately 90% of patients. Seconder HT is seen in about 10% of patients and secondarily develops in other systemic diseases.[3] HT causes premature and sudden death due to its association with severe complications such as stroke, myocardial infarction, heart failure, and kidney disease.[2,4]

Diabetes mellitus (DM) is a chronic metabolic disease characterized by hyperglycemia.[5] DM is caused by insufficient insulin production in the pancreas glands or insulin resistance developing in target tissues. Decreased insulin levels and/or increased insulin resistance can cause hyperglycemia.[6] DM is classified into Type 1 and Type 2. Type 1 DM is a congenital autoimmune disease, while Type 2 DM is an acquired process associated to insufficient insulin production and is the most frequent form.[7] DM affects various systems and tissues such as the cardiovascular system, eyes, pulmonary, renal, and oral tissues. Many serious complications can occur in patients with DM, including fibrosis, retinopathy, neuropathy, and cardiovascular diseases.[8]

The dental pulp is a connective tissue with a micro–vascularization system without lateral blood vessel branches.[2] Many in–vivo, in–vitro, and animal experiments studies have reported that local and systemic factors cause changes in the pulp tissue.[2,7,9] Systemic diseases such as HT and DM cause changes at the microcirculation level in the pulp.[8,10] In patients with DM, an inflammatory process is more intense due to micro– and macrovascular change.[11] Furthermore, it has been showed that DM increases inflammation, fibrosis, calcification and induced vascularization in the dental pulp.[13-15] In addition to, a recent study has reported that the pulp volume increased in patients with HT (high blood pressure) compared to healthy individuals.[2]

Although the effect of HT on pulp volume has been investigated,[2] the possible effect of other frequently observed systemic diseases on pulp volume has not been sufficiently investigated. The aim of the present study is to evaluate of the dental pulp volume change in patients with HT and Type 2 DM on cone-beam computed tomography (CBCT) images with three–dimensional analysis. The null hypothesis was that the HT and Type 2 DM does not influence the pulp volume.

MATERIALS and METHODS

This study was approved by the x University Ethics Committee (Research code number: 2022-1471, Date:22.10.2022). All procedures were in accordance with the Helsinki Declaration. Written consent was obtained from all participants.

Sample selection and group classification

The observational cross-sectional study was performed using CBCT images of patients who were admitted to Department of Radiology Clinic, Faculty of Dentistry, x University for various dental reasons, between January and June 2023. No additional CBCT scan was taken for the study.

Patients who were 40–65 years old, had been diagnosed with HT or Type 2 DM according to the self-reported, had the disease controlled, and free from other systemic disease were included in the study. In addition, patients without systemic disease were included as a control group. Patients had at least one health maxillary canine tooth. The tooth was free from caries, restoration, prosthetic or endodontic treatment, fracture or pathology, pulpal calcifications, periodontal bone loss, and trauma. If the right canine tooth did not meet the criteria, the left canine tooth was evaluated in the same patient.[16] Patients who took other drugs, smoked, or alcohol consumed, and CBCT images with insufficient quality were excluded. The age, sex, and self-reported systemic disease information of the patients who met the inclusion criteria were recorded. The patients were divided into three groups according to self–reported systemic diseases as follows:

1. HT group: Patients who have been diagnosed with HT for at least 1 year and whose disease is currently under control (HT diagnosed by a physician based on medical records, lifestyle factor, and a systolic blood pressure ≥ 130 mmHg or a diastolic blood pressure ≥ 80 mmHg). Patients were taking antihypertensive medications (diuretics, beta blockers, calcium channel blockers, etc.) for HT. Duration of medication use ranged from 1 year (minimum) to 9 years (maximum).
2. Type 2 DM group: Patients who have been diagnosed with Type 2 DM for at least 2 years and whose disease is currently under controlled (Type 2 DM diagnosed by a physician based on medical records, lifestyle factor, and laboratory tests (the fasting plasma glucose value (FPG ≥126 mg/dL (7.0 mmol/L)) or the 2-hour plasma glucose value (2-h PG ≥ 200 mg/dL (11.1 mmol/L)) or HbA1c ≥6.5% (48 mmol/mol)). Patients were taking antidiabetics medications through oral (alfa-glucosidase inhibitors,

biguanides, etc.) for Type 2 DM. Duration of medication use ranged from 2 years (minimum) to 10 years (maximum).

3. Control group: Patients without any systemic disease.

Volume and linear measurements on CBCT images

The pulp and tooth volumes were measured as volumetric measurements, while the pulp and tooth lengths were measured as linear measurements. All CBCT images were obtained a PlanMeca ProMax 3D Mid CBCT unit (Planmeca, Helsinki, Finland) at the following set: 90 kVp, 8.0 mA, 140×52−mm field of view (FOV), and 0.4−mm^3 voxel size.

CBCT image files in Digital Imaging and Communications in Medicine (DICOM) format were transferred into ITK−SNAP v.3.4.0 open access software (Cognitica, Philadelphia, PA, USA) for the volume and linear measurements. ITK-SNAP software is used for segmentation and volume measurements of different anatomical structures including the dental pulp.[2] The volume measurements were performed using semi-automatic segmentation of the software. Firstly, the pulp volume was measured. The regions of interest (ROI) were determined in square areas including the canine tooth by an examiner in all three planar sections (coronal, axial, and sagittal). The 'Segment 3D' tool was used. An appropriate threshold level (-200 to -50 for the lower threshold and 400 to 700 for the upper threshold) was determined. The appropriate level was based on the visual distinction between the pulp and the dentine using the contrast differences on the greyscale images.[16] When the 'Start segmentation' tool was used, the software automatically segmented the pulp in the appropriate level. If necessary, adjustments were made using the 'Paint brush' tool. Thus, the three−dimensional (3D) model of the pulp and the pulp volume in mm^3 were obtained with the software. The ratio of the pulp volume to the tooth volume was evaluated to avoid possible bias due to the change in the pulp volume of the patients.[2] Therefore, the tooth volume was measured by performing the same procedure (Figure 1).

Figure 1. Volumetric measurements of the dental pulp (A) and tooth (B)

The linear measurements were performed after the volume measurements. The greatest length of the pulp and the tooth was measured on coronal section. The greatest length of the pulp was measured as a perpendicular line from the most apical point of the root pulp to the ceiling of pulp chamber. The greatest length of the tooth was measured as a perpendicular line from the most apical point of the root to the most incisal point of the crown. Additionally, the greatest diameter of the pulp and the tooth was measured in cement−enamel junction level on axial section (Figure 2). With obtained linear measurements, 'pulp length/tooth length' and 'pulp diameter/tooth diameter' ratios were calculated.

All volumetric and linear measurements were evaluated by one oral radiologist with 5 years of experience, in a MacBook Air computer (13.3−inch, Apple, California, USA). Image contrast, brightness, and zoom were adjusted in a dimmed−light and silent room. Twenty days after completion of the measurements, 30% of the sample was re−evaluated to provide the intra−observer agreement by the same observer.

Statistical analysis

Sample size calculation was based on the post hoc power analyses using G*Power program (G*Power version 3.1.9; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) (power (1−β) set at 0.80, α=0.05, and effect size d=0,33).[17] The minimum sample size was to be found 90 participants (each group as 30 participants).

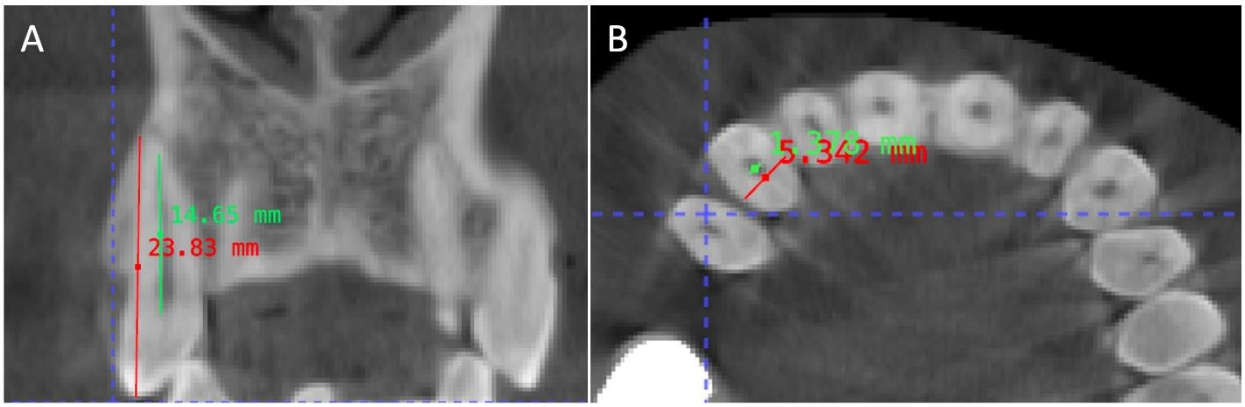

Figure 2. Linear measurements of the dental pulp and tooth (A: the length of the pulp and the tooth, on coronal section; B: the diameter of the pulp and the tooth, on axial section; green line: the pulp measurement; red line: the tooth measurement)

Statistical analysis was performed using IBM SPSS Statistic software window version 23.0 (IBM SPSS Inc., USA). Descriptive statistics was performed for minimum and maximum values, mean and standard deviations. Pearson Chi-square test was used to analyze the difference between sex and the groups. Shapiro–Wilk test revealed that the data normally distributed. Thus, the analysis of variance (ANCOVA) was used to compare age and measurement value between the groups. Intra–observer agreements were assessed by intra–class correlation coefficient (ICC) (<0.40; poor, 0.40–0.59; fair, 0.60–0.74; good, 0.75–1.00; excellent agreement).[18] Statistical significance level was accepted as $p < 0.05$.

RESULTS

A total of 90 participants, 30 participants in each group, were included in the study. Of the participants, 43 (47.7%) were females and 47 (52.3%) were males. The mean age was 51.69±7.71 years. Table 1 shows the distribution of participant characteristics by the groups.

Table 2 shows mean measurement values and statistical analyses obtained by the groups. The mean pulp volume decreased in the HT group (28.13±5.89) and the Type 2 DM group (25.99±3.13) compared to the control group (29.06±5.60). However, the mean pulp volume was not significantly different between the HT, the Type 2 DM, and the control group ($p=0.058$). Therefore, the null hypothesis was accepted. Among the measurements, only the mean tooth volume showed a statistically significant difference between the groups. The mean tooth volume of the Type 2 DM group showed statistically significant differences ($p=0.000$). Other measurements showed no statistically significant difference between the groups.

Table 1. Distribution of participant characteristics by the groups

Participant characteristic		HT group N=30 Mean±Sd (min-max)	Type 2 DM group N=30 Mean±Sd (min-max)	Control group N=30 Mean±Sd (min-max)	Total N=90 Mean±Sd (min-max)	*p−value*
Age		53.63±9.23 (40-67)	52.96±7.32 (40-65)	49.50±6.58 (40-65)	51.69±7.71 (40-67)	*0.094*
Sex#	Female	18 (60%)	13 (43.3%)	12 (40%)	43 (47.7%)	*0.251*
	Male	12 (40%)	17 (56.7%)	18 (60%)	47 (52.3%)	

Sd: Standard deviation, min-max: minimum and maximum values, #: n (%)

Table 2. Mean values of the measurement and statistical analyses according to the groups

Variable	HT group N=30 Mean±Sd (min-max)	Type 2 DM group N=30 Mean±Sd (min-max)	Control group N=30 Mean±S d (min-max)	*p→value*
Pulp volume	28.13±5.89 (20.23-38.59)	25.99±3.13 (19.21-33.13)	29.06±5.60 (21.13-33.14)	*0.058*
Tooth volume	556.32±93.37 (365.78-689.56)	468.79±73.18[a] (362.45-587.60)	529.37±58.40 (412.67-596.78)	*0.000**
Pulp volume/ Tooth volume	0.04±0.13 (0.01-0.07)	0.05±0.01 (0.04-0.08)	0.05±0.01 (0.04-0.08)	*0.058*
Pulp length/ Tooth length	0.63±0.05 (0.55-78)	0.65±0.05 (0.57-0.75)	0.65±0.05 (0.54-0.77)	*0.195*
Pulp diameter/ Tooth diameter	0.25±0.04 (0.19-0.36)	0.27±0.09 (0.18-0.63)	0.26±0.03 (0.20-0.35)	*0.324*

Sd: Standard deviation, min-max: minimum and maximum values, *: p value is statistically significant,
[a]: According to Tukey-test, the Type 2 DM group was statistically different from the other groups.

The intra−observer agreement was found to be excellent for all measurements (ICC: 0.95; 0.96; 0.93; 0.95; 0.98; and 0.98; pulp volume; tooth volume; pulp length; tooth length; pulp diameter; and tooth diameter; respectively).

DISCUSSION

In the present study, we investigated the possible effect of the two most common systemic diseases, HT and Type 2 DM, on the pulp volume using CBCT images. To the best of our knowledge, this is the first study to compare the pulp volume and tooth volume between two disease groups and healthy individuals. According to the findings of the study, no statistical difference was observed between the pulp volumes of the patients with HT, the patients with Type 2 DM, and healthy individuals.

The dental pulp is surrounded by a rigid and inflexible dentin walls that do not allow expansion of the pulp tissue volume.[19] In recent study, the effect of the change in blood pressure on the pulp volume has been investigated by Gomes et al.[2] They reported that the pulp volume was significantly greater in patients with high blood pressure (HT) compared to patients with normal blood pressure.[2] Authors explained the finding by some theories. The first was that increased pressure in pulp tissue, as a result of high blood pressure, would be injury the odontoblastic layer of the internal wall of the canal, impairing the production of seconder dentin by these cells. The second was that increased pressure in pulp tissue, would be damage the predentin of the internal wall of the canal. In contrast to the previous study, there was no statistically significant difference between the pulp volume of the patients with HT and healthy individuals in the present study. This different may mainly be due to the included patients. While, in the present study, patients with HT under control and using antihypertensive drugs were included, the previous study excluded the patients using antihypertensive drugs.[2] Since we aimed to observe the long-term and possible effect of HT on the pulp volume, we included patients who were diagnosed with HT by their own physician and who were taking medication. HT is a chronic, multisystemic disease and one of the best methods of long-term control is the use of medication. Considering the medical habits of our country, it is almost impossible for us to reach patients who have been diagnosed with HT and do not use regular medication. Therefore, we considered it appropriate to include only patients who had a definitive diagnosis of HT by regular measurements, rather than those for whom we had an altered blood pressure in their dental examination and were not taking medication. Also, it should not be forgotten that the pulp is surrounded by a hard dentin wall. And this is the most important internal physical barrier to the conditions that would allow the increase in pulp volume.

DM is a chronic disease, which causes many complications on the diverse organs including the dental pulp in the long-term.[1,7] Many studies found that DM increases the inflammation and calcification formation in the dental pulp.[13,20] Qin et al. investigated the effects of metformin, which used in the treatment of DM, on the proliferation and differentiation of dental pulp cells.[21] The study found that metformin can induce dental pulp cells differentiation and mineralization in an AMPK (adenosine 5′-monophosphate-activated protein kinase) -dependent manner.[21] Inagaki et al. researched the relationship between osteopontin expression and pathologic calcification in rat diabetic pulp.[22] The study showed osteopontin might be a key molecule involved in

the increase of pathologic pulp calcifications, which are frequently observed in diabetic patients.[22] Yeh et al. observed that the amount of pulp cell decreased, and reparative dentin foci were on coronal pulp chamber of diabetic mice.[23] Due to these effects of DM on the pulp, it has been recently suggested to investigate the structural change in the pulp.[13] However, to our knowledge, no other studies have investigated possible pulp volume alteration in Type 2 DM patients on CBCT images. Based on this, we wanted to investigate the possible effect of DM as well as HT on the pulp volume. In the present study, there was no statistically significant difference in the pulp volume between the patients with Type 2 DM and the healthy individuals. This may be due to the fact that Type 2 DM patients, as well as HT patients, are well-controlled, and the pulp is surrounded by hard dentin tissue.

In addition to the effect of DM on the pulp tissue, its effect on enamel-dentine has been shown in many such as in-vivo, in-vitro, and animal studies.[5,24,25] Abbassy et al. noted that the thickness of enamel and dentine decrease in mice with Type 1 DM.[24] Saghiri et al. showed that microhardness of enamel and dentine were negatively affected in diabetic mice group.[5] Siudikiene et al. reported that enamel thickness decreased while enamel hypoplasia and dental caries increased in individuals with DM.[25] In the present study, the tooth volume statistically decreased in the patients with DM compared to the patients with HT and healthy individuals. Since there is no statistical difference in the pulp volume, this decrease may be due to the amount of enamel-dentin. This finding is consistent with previous studies.[5,24,25]

Some factors such as ageing, orthodontic treatment, and regenerative endodontic procedure cause changes pulp volume.[9,26-28] Ageing increases the amount of secondary dentin accordingly the pulp volume decreases.[26] The effect of orthodontic treatment on the pulp volume depends on diverse factors, such as type or direction of movement, distribution, and duration of the force. It has been reported that the pulp volume decrease and the pulp stone increase after the orthodontic treatment.[10] Guler et al. showed that a statistically significant decrease of the pulp volume on CBCT images after surgically assisted rapid palatal expansion.[27] Shetty et al. found that the pulp volume reduced on CBCT images after regenerative endodontic procedure.[28] Since previous treatments may cause changes in the pulp volume, healthy teeth without any previous dental treatment and trauma were included in the study. Additionally, there was not statistical difference between the mean values of the groups.

Many studies suggested that the canine tooth can be used for the linear and volumetric measurements of the pulp space dimension.[2,26,27] The canine tooth is more resistant compared to other teeth. The canine tooth is the single-root tooth with the largest pulp volume. These factors facilitate the measurements of the pulp space dimension.[2] Therefore, the canine tooth was examined in the present study. In addition, pulp volume/tooth volume, pulp diameter/tooth diameter, and pulp length/tooth length ratios were also evaluated to avoid dependence on a single measurement.

The present study has some limitations. One of the limitations may be that the systemic disease of the patients is well-controlled. Maybe that is the reason why there was no difference between the groups. However, since the long-term effects of systemic diseases on the pulp were investigated, it was already expected that the systemic diseases of the patients would be well-controlled. Another limitation was that the large voxel size (0.4 mm^3) could lead to some errors in the volume measurement. Large voxel size may be insufficient to detect small volume differences. However, this was an equal situation for each image, as all samples were the same voxel size.

CONCLUSION

According to the findings of this study, controlled HT and Type 2 DM did not cause a significant change in pulp volume. In other words, it can be said that systemic diseases under control with regular medication use and follow-up do not affect pulp volume.

In future researches, the possible effect of systemic diseases that are not controlled with regular drug use on pulp volume can be investigated. In addition, it would be useful to examine the relationship between the tooth volume, which was the only parameter that showed significant changes in patient with Type 2 DM, and other systemic disease with further research.

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Periapical Radiographs in Determining Peri-Implant Bone Defect Size and Type: A Prospective Clinical Study

Peri-İmplant Kemik Defekti Boyutu ve Türünün Belirlenmesinde Periapikal Radyografilerin Rolü: Prospektif Klinik Çalışma

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ABSTRACT

INTRODUCTION: This study evaluated accuracy of periapical radiographs (PAs) in measuring peri-implant bone defects and identifying defect types in peri-implantitis patients. Additionally, it assessed the consistency of probing depth measurements using plastic and metal periodontal probes.

MATERIAL and METHODS: A prospective clinical study included 28 patients (51 implants, 96 defects) diagnosed with peri-implantitis. Radiographic defect dimensions were measured on PAs using standardized techniques and compared with intraoperative findings. Defect types were classified based on radiographic and surgical observations. Probing depth measurements were performed using metal Williams and plastic UNC-12 probes. Statistical analyses included dependent t-tests, Bland-Altman plots, and Kappa coefficients.

RESULTS: PA radiographs underestimated defect dimensions compared to intraoperative measurements, with mean differences of 0.34 mm (depth) and 0.32 mm (width) ($p < 0.001$). Repeatability of radiographic measurements was excellent (ICC = 0.997). Moderate agreement ($\kappa = 0.47$) was observed between radiographic and intraoperative classifications, with highest concordance for type 1c and 1d defects. Substantial agreement ($\kappa = 0.71$) was found between metal and plastic probe measurements.

CONCLUSION: Standardized PAs provide acceptable accuracy for assessing peri-implant defects, despite slight underestimation. Moderate agreement in defect classification supports their clinical utility. Both probes demonstrated substantial consistency, reinforcing their validity in peri-implantitis diagnostics.

Keywords: *Peri-implantitis, dental implants, bone resorption, radiography, periodontal probing*

ÖZ

GİRİŞ: Bu çalışma, peri-implantitis hastalarında periapikal (PA) radyografilerin vertikal peri-implant kemik defekti boyutlarını ve defekt türlerini belirlemedeki etkinliğini değerlendirmiştir. Ayrıca, plastik ve metal periodontal problarla yapılan sondalama derinliği ölçümlerinin tutarlılığı incelenmiştir.

GEREÇ ve YÖNTEM: Peri-implantitis teşhisi konmuş 28 hasta (51 implant, 96 defekt) dahil edilmiştir. Standardize PA radyografilerde defekt derinlikleri ve genişlikleri ölçülerek intraoperatif ölçümlerle karşılaştırılmıştır. Defekt tipleri radyografik ve cerrahi gözlemlerle sınıflandırılarak uyum analiz edilmiştir. Sondalama derinliği, metal Williams ve plastik UNC-12 problarla ölçülmüştür. İstatistiksel analizler bağımlı t-testleri, Bland-Altman grafikleri ve Kappa analizi ile yapılmıştır.

BULGULAR: PA radyografiler defekt boyutlarını intraoperatif ölçümlere göre daha düşük göstermiştir (derinlik farkı: 0.34 mm, genişlik farkı: 0.32 mm; $p < 0.001$). Radyografik ölçümlerin tekrarlanabilirliği mükemmel bulunmuştur (ICC = 0.997). Defekt sınıflandırmalarında orta düzeyde uyum ($\kappa = 0.47$) belirlenmiş, tip 1c ve 1d en yüksek uyumu göstermiştir. Metal ve plastik problar arasında güçlü uyum ($\kappa = 0.71$) saptanmıştır.

SONUÇ: PA radyografiler, peri-implant kemik defektlerinin değerlendirilmesinde güvenilirdir ancak boyutları bir miktar düşük tahmin eder. Defekt sınıflandırmalarındaki orta uyum, cerrahi öncesi klinik kullanımını desteklemektedir. Metal ve plastik problar, peri-implantitis teşhisinde tutarlı ölçümler sunmaktadır.

Anahtar Kelimeler: *Peri-implantitis, dental implantlar, kemik rezorpsiyonu, radyografi, periodontal sondalama*

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INTRODUCTION

Precise diagnosis of peri-implantitis and peri-implant bone defects comprises a thorough clinical and radiographic examination. Early detection of these defects leadsaround

to a more favorable prognosis, while an inaccurate diagnosis can lead to several undesirable complications including mucosal recession, and loss of implant osseointegration.[1] In order for a bone defect to be detected on radiographs, the reduction in the amount of calcified tissue has to reach approximately 30-50%, which delays the timely and complete detection.[2,3] Histometric,[4] cadaver[5] and clinical studies[6] have demonstrated that radiographic assessment may underestimate peri-implant crestal/marginal bone levels compared to actual measurements. Notably, factors such as arch, implant location, placement timing, and alveolar edge level do not appear to influence this trend.[6] Additionally, measurements of peri-implant bone defects on periapical radiographs (PAs) were found to be between 0.6-2.3 mm less than measurements during surgery.[7-10] The determination of bone level on PAs may be inaccurate due to distortion in bone width and height which depends on the angulation of the x-ray beam.[11] Accordingly, the differences between radiographic measurements and actual defect sizes gain importance in order to prevent delays in treatment through early diagnosis. In addition to radiographic measurements, clinical probing depth evaluations play a crucial role in the diagnosis of peri-implant bone defects. Studies have shown that the type of periodontal probe can influence the accuracy of measurements.[12] Plastic probes, which are often used to avoid damaging implant surfaces, may yield less precise results compared to metal probes due to differences in flexibility and tactile feedback.[13]

In studies comparing the efficiency of various radiographic imaging techniques for assessing crestal bone loss around implants, PAs consistently outperformed panoramic radiography (PR). This is largely attributed to PR's lower spatial resolution and non-linear distortions, which lead to a dimensional deviation of 82% in most cases.[14] Cone beam computed tomography (CBCT) which prevents overlapping of anatomical structures and allows visualization of buccal and lingual cortical bone plates in addition to mesial and distal bone, has been shown to be inferior,[15-18] superior[19,20] or similar[21] to PAs in detecting peri-implant crestal bone losses. In vitro design of these studies limits the interpretation of results since movement artifacts and soft tissue attenuation are not reproducible in experimental conditions.[22] In addition to the measurement of peri-implant bone defect dimensions, determination of the defect type has been suggested as an important indicator of therapeutic outcome of nonsurgical and surgical periodontal treatments.[23] Studies demonstrated that narrower defect angles were more prone to achieve greater radiographic bone fill,[23] and circumferential defects were more conducive to reveal higher changes in probing pocket depth and clinical attachment level at 6 and 12 months compared to other defect morphologies.[24] CBCT has been reported to better detect dehiscence and fenestration defects, whereas PAs were more accurate in the visualization of interproximal defects, emphasizing their continued role in the initial assessment of peri-implant tissues.[25] CBCT images suffer from scattering and beam hardening artifacts, particularly from zirconia dental implants, a drawback that cannot be improved with the use of metal artifact-reduction software.[26]

There is still no consensus in the literature regarding whether the morphological characteristics of the defect have an impact on the prognosis, and therefore initial acquisition of PAs has been recommended[7,27] due to the high radiation dose, cost and the presence of artefacts during CBCT imaging.[27] However, few studies have evaluated the compatibility of PAs with intraoperative measurements for classification and assessing the size of vertical bone defects around implants,[7-9,20] and only three of these studies have been conducted in clinical settings on human subjects.[7-9] Therefore, the aim of this study is to assess the accuracy of PAs in measuring the size of vertical defects around implants in patients diagnosed with peri-implantitis, and to determine the concordance between the defect types identified during surgery and radiologically. Additionally, we aimed to assess the agreement between probing depth measurements obtained using plastic and metal probes at peri-implantitis sites.

MATERIALS and METHODS

Study Design

Patients referred to the Department of Periodontology, following clinical and panoramic radiographic examinations at the Oral Diagnosis & Radiology outpatient clinic, were included in this prospective study in a 6-month period. Those with complaints of bleeding, swelling, and inflammation around dental implants were enrolled. Detailed medical and dental histories were obtained, followed by clinical examinations for all participants.

The general oral clinical examination included the assessment of oral hygiene, periodontal and mucosal diseases, occlusal relationships, prosthetic restorations, and the position and condition of the implants. The clinical evaluation of the implant sites focused on several factors, such as the amount of keratinized mucosa around

the implant, probing depth, and the presence of bleeding. Additionally, the presence of purulent exudation and the mobility of the implants were examined. Peri-implantitis was defined according to Renvert et al.[28] as follows: *1*) visual evidence of inflammation in the peri-implant soft tissues along with bleeding on probing and/or suppuration, *2*) increasing probing pocket depths compared to those recorded at the time of supra-structure placement, *3*) progressive bone loss relative to the radiographic bone level assessed one year after the implant-supported prosthetic reconstruction, and *4*) in the absence of initial radiographs and probing depths, radiographic bone loss of ≥3 mm and/or probing depths of ≥6 mm, combined with profuse bleeding.

Initial radiological evaluations were conducted on panoramic radiographs. Following the assessments, patients with vertical bone defects around the implants were informed about surgical treatment, and those who chose to undergo surgery were included in the study based on the inclusion and exclusion criteria outlined below:

Inclusion Criteria

- Presence of at least one radiographic vertical peri-implant bone defect on a proximal surface, at least one year after prosthetic loading, according to the definition of peri-implantitis as described above,[28]
- Root-shaped, tissue or bone-level design dental implants,
- Implants positioned at an angle of no more than 25° in the vertical plane.
- Class 1 bone defects according to the Schwarz et al.[2] peri-implant defect classification (Type 1b, 1c, 1d and 1e) (Figure 1).
- Consent to participate

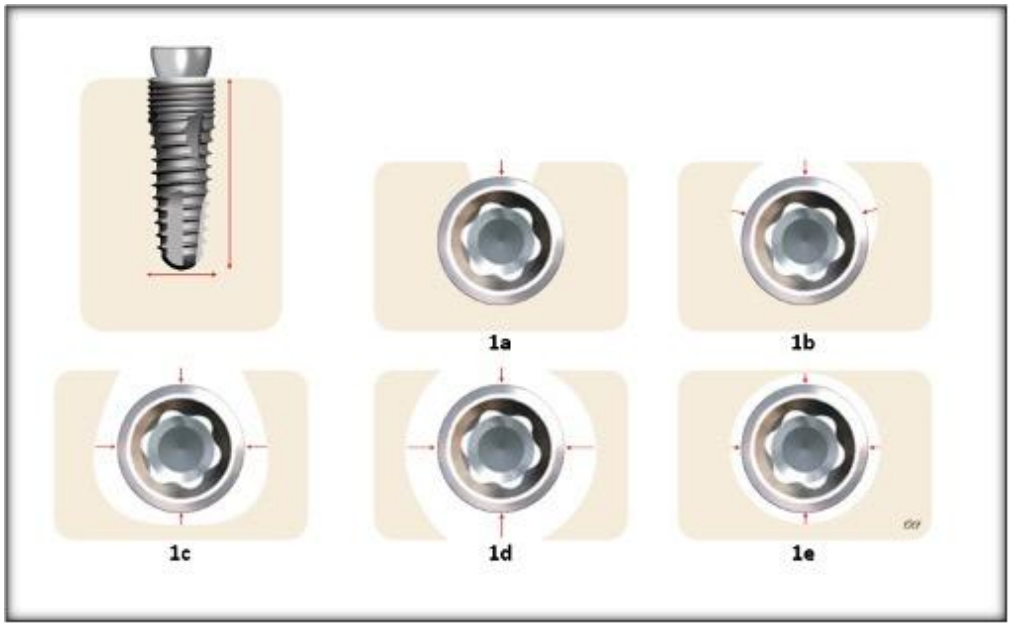

Figure 1: Peri-implant defect classification according to Schwarz et al.[2]

Exclusion Criteria

- Presence of systemic diseases that contraindicate surgery, pregnancy, or lactation,
- Failure to comply with necessary oral hygiene recommendations,
- Cases where the distance between two implants is insufficient to assess vertical/horizontal bone loss,
- Class 2 bone defects.[2]

The study design was approved by the Ethics Committee of Ege University, Faculty of Medicine (2018, Decision No: 18-9/22). Individuals who agreed to participate were required to sign an informed consent form prepared in accordance with the revised Helsinki Declaration from the 64th General Assembly.

Preoperative Clinical Measurements

Preoperative clinical assessments at the initial visit included measurements of the width of keratinized mucosa, modified gingival index and modified plaque index, and probing depth. The keratinized mucosa was measured on the mid-buccal surface of the implants using the Roll technique. Probing depth was measured after removing the suprastructures to minimize errors related

to probing angulation. To ensure the examiner's calibration and assess the repeatability of probing depth measurements, 28 implants (112 surfaces in total) were measured twice, 24 hours apart, on the mesial, distal, buccal, and oral surfaces. Repeatability was evaluated using Weighted Kappa analysis, showing high agreement with a κw of 0.91.[29]

Measurements were performed twice using metal Williams and plastic UNC 12 probes. The values from four surfaces (mesial, distal, buccal, oral) around the implants were rounded to the nearest millimeter and recorded. A gentle force of approximately 0.25 N was applied during probing (Figure 2).

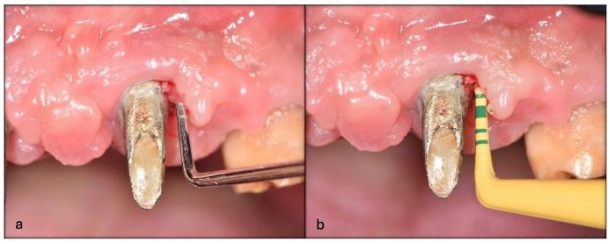

Figure 2: Probing depth measurements using (a) Williams probe and (b) plastic UNC-12 probe on distal aspect of an implant with a peri-implant vertical defect.

Preoperative Radiological Examination

PA radiographs were obtained with the Digora Optime storage phosphor plates (SPP) system (Soredex Corp., Tuusula, Finland) using intraoral film holders (Dentsply/Rinn Corporation, Elgin, IL) to keep the plates parallel to the long axis of the teeth. A size #2 SPP was used for all exposures. Radiographic images were captured before removing the suprastructures to ensure the film holder remained in a fixed and stable position. However, if over-height prosthetic restorations obstructed parallel placement of the film to the implant, images were taken after the restorations were removed. Prior to imaging, two fully round metal wires, each 10 mm in length and 0.6 mm in thickness, were attached parallel to the short and long edges of the phosphor plate, with one wire positioned horizontally and the other vertically. SPPs were exposed with a Gendex Oralix DC dental x-ray unit (Gendex Dental Systems, Milan, Italy) operating at 60 kVp, 7 mA, 0.25 sec., and the plates were scanned immediately after exposure. The images were transferred to a personal computer with 8-bit contrast depth in TIFF format (Toshiba Satellite U50t-A-10P Core i5-4200U) and saved using coded identifiers for each implant surface to mask patient data. The images were examined in a quiet room with appropriate lighting, and the radiographic peri-implant defect type[2] was determined by one of the investigators who was blinded to the patient selection process and initial panoramic radiographical examination (AG).

Linear radiographic measurements were conducted using a Java-based software (Image-J 3.0, NIH, Bethesda, USA), employing the 10 mm wires as reference objects in the relevant planes (Figure 3). The vertical defect depths on mesial and distal surfaces of the implants were measured as the distance from the most coronal point of the alveolar crest (projected onto the implant body) to the deepest point of the defect. Defect width measurements were taken as a horizontal line extending from the mesial and distal surfaces at the most coronal point of the alveolar crest to the implant body (Figure 3). The measurements were conducted by the same blinded examiner who carried out the radiological defect classification (AG). All measurements were repeated 3 times, and the mean of the three measurements was considered as the average defect depth and defect width. The same examiner re-measured defect depths and widths, and re-evaluated defect types on a randomly selected half of the PA images one month later.

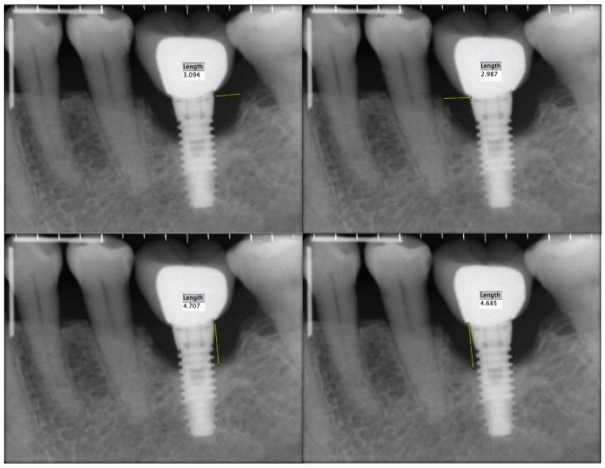

Figure 3: Class 1, type d peri-implant bone defect and two 10 mm metal wires attached to the phosphor plate, aligned in horizontal and vertical planes. Defect width (a, b) and defect depth (c, d) measurements on distal and mesial aspects of an implant with a peri-implant vertical defect.

Surgery and intraoperative measurements

All surgical procedures and intraoperative measurements were conducted by the same investigator responsible for patient selection and the preoperative clinical assessments (AT). Local anesthesia was applied to the surgical site using a solution of 2% lidocaine with 1/100,000 epinephrine (Jetokain®, Adeka İlaç San Tic Aş, Turkiye). A full-thickness flap was raised from both the vestibular and oral surfaces, and granulation tissue within the flap and around the implant was carefully excised. The defect depths on mesial and distal surfaces

of the implants were measured as the distance from the most coronal point of the alveolar crest (projected onto the implant body) to the deepest point of the defect using a blunt-tipped spreader with a plastic stopper (Figure 4). Defect widths were measured as a horizontal line extending from the mesial and distal surfaces at the most coronal point of the alveolar crest to the implant-abutment junction. The distance from the tip of the spreader to the edge of the plastic stopper was then measured using a digital caliper (BTS-12043, Newland Industrial Co, Zhejiang, China) with a precision of 0.01 mm. Each measurement was performed three times, and the arithmetic mean was calculated and recorded. Additionally, the intraoperative peri-implant defect type was determined during this process.[2]

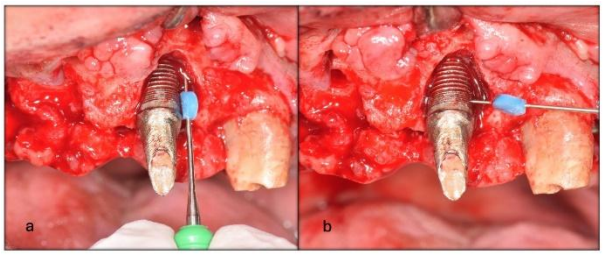

Figure 4: Intraoperative (a) defect depth and (b) defect width measurements on the distal aspect of an implant with a peri-implant vertical defect.

Treatment decisions were based on the prognosis classification by Froum and Rosen.[30] Following measurement completion, interventions such as resective or regenerative peri-implantitis treatment, or implant removal, were chosen according to defect size, implant survival prognosis, and available bone support. Patients were provided with postoperative care instructions and monitored closely for any complications.

Statistical Analysis

The minimum sample size required to evaluate the agreement between radiographic and intraoperative measurements at 80% power and p=0.05 significance level was calculated using G* Power 3.0 software (Heinrich- Heine- Universität, Düsseldorf, Germany), which revealed a sample size of 89 proximal defects.

Descriptive data included the modified gingival index, modified plaque index scores, and keratinized mucosa measurements. Weighted Kappa was applied to evaluate the compatibility of preoperative probing depth measurements using metal Williams and plastic UNC-12 probes. The Kappa coefficient was used to assess interobserver agreement for radiographic defect type classification. The repeatability of radiographic defect depth and width measurements was assessed with intraclass correlation coefficient (ICC).

The agreement between radiographically and intraoperatively identified defect types was evaluated using Kappa coefficient. The differences between radiographic and intraoperative measurements of defect depth and width were assessed using a dependent sample t-test, with Bland-Altman plots presented alongside the analysis. All statistical analyses were performed using SPSS Version 21.0 (IBM, Armonk, NY), with results evaluated at a 95% confidence interval and a significance level of p=0.05.

RESULTS

A total of 88 patients with bleeding, swelling, and inflammation around dental implants were initially assessed. Of these, 37 met the inclusion criteria. Among them, 5 did not attend their scheduled appointments, 3 chose to continue treatment in private clinics, and 1 was excluded due to insufficient communication and cooperation. Therefore, 28 patients were ultimately included in the final analysis.

The study included 28 patients (10 males and 18 females), aged between 35 and 74 years. A total of 51 implants and 96 vertical defects were evaluated across these patients. Among the 51 implants, 34 were located in the mandible (comprising 7 canines, 9 premolars, and 18 molars), while 17 implants were situated in the maxilla (including 3 canines, 8 premolars, and 6 molars). The mean width of keratinized mucosa was determined to be 1.65 ± 1.30 mm, while the modified gingival index was 2.06 ± 0.61 mm, and the modified plaque index was 2.04 ± 0.78 mm.

Probing depth measurements were obtained from 204 surfaces (mesial, distal, buccal, oral) surrounding 51 implants using Williams and UNC-12 probes. The mean probing depth was 6.75 ± 1.41 mm with the Williams probe, and 6.62 ± 1.23 mm with the UNC 12 probe. The compatibility between measurements was assessed using the Weighted Kappa, yielding a κw value of 0.71, indicating a substantial agreement between the two probes (standard error: 0.02, 95% CI: 0.66-0.75).[29]

Defect type

The type and distribution of vertical peri-implant defects as determined on PA radiographs and during surgery are presented in Table 1. The interobserver agreement for radiographic defect type classification was calculated as κ=0.88, signifying a strong level of concordance.[29]

Based on intraoperative evaluations, the most common peri-implant defects were type 1c (39.2%), followed by type 1d (29.4%), type 1e (27.5%), and type

1b (3.9%). The highest agreement between PA radiographs and intraoperative assessments was observed for type 1c (25.4%) and type 1d (23.5%) defects, while the lowest agreement was found for type 1b. The Kappa coefficient for the compatibility between PA radiographs and intraoperative assessments was calculated as 0.47, indicating moderate agreement.[29]

Table 1: The frequency of peri-implant defect types as determined on PA radiographs and intraoperatively.

Defect type	PA radiographs n (%)	Intraoperative n (%)	Agreement between PAs and intraoperational assessments n (%)	Kappa coefficient	SD	%95 CI
1b	0 (0)	2 (3.9)	0 (0)	0.47	0.1	0.28-0.66
1c	21 (41.2)	20 (39.2)	13 (25.4)			
1d	14 (27.5)	15 (29.4)	12 (23.5)			
1e	16 (31.4)	14 (27.5)	8 (15.7)			

Defect depth and defect width

Table 2 presents the mean intraoperative and radiographic measurements of defect depth and width for both mesial and distal peri-implant defects. The repeatability of the measurements on PA radiographs was determined to be excellent, with a high reliability demonstrated by an ICC of 0.997.[31] The intraoperative measurements of defect depths, while comparable, were statistically higher than those obtained from periapical radiographs for both mesial and distal peri-implant defects ($p<0.001$). The average difference between defect depth measurements (both mesial and distal) was calculated as 0.34 ± 0.37 mm, with a 95% CI of [0.74, 1.00] ($p < 0.001$). In none of the cases did PA radiographs overestimated the defect depths compared to measurements during surgery. Figure 5a illustrates the scatter plot comparing mean intraoperative and radiographic defect depth measurements, with the line y=x indicating where the measurements are equal. A greater proportion of data points fall below the y=x line, indicating that radiographic measurements tend to underestimate defect depth compared to intraoperative measurements ($p<0.001$). Additionally, Figure 5b presents a Bland-Altman plot, where the x-axis represents the mean intraoperative and radiographic measurements, while the y-axis displays the difference between these measurements.

Table 2: The mean and SD of intraoperative and radiographic measurements for peri-implant defects (mm).

	Intraoperative defect depth	Radiographic defect depth	Defect depth difference	Intraoperative defect width	Radiographic defect width	Defect width difference
Mesial peri-implant defects	4.27 ± 0.69	3.93 ± 1.05	0.34 ± 0.36 ($p<0.001$) 95 % CI [0.96, 1.38]	2.57 ± 0.42	2.03 ± 0.19	0.54 ± 0.23 ($p<0.001$) 95 % CI [0.75, 1.07]
Distal peri-implant defects	4.43 ± 0.72	4.11 ± 1.13	0.32 ± 0.41 ($p<0.001$) 95 % CI [0.66, 0.97]	2.45 ± 0.65	2.28 ± 0.81	0.17 ± 0.15 ($p<0.001$) 95 % CI [0.63, 0.92]
Mean	4.34 ± 0.59	3.99 ± 0.96	0.34 ± 0.37 95 % CI [0.74, 1.00]	2.13 ± 0.19	1.80 ± 0.13	0.32 ± 0.06 95 % CI [0.74, 0.95]

Similarly, intraoperative defect width measurements were statistically greater than those obtained from PA radiographs, with a mean difference of 0.32 ± 0.06 for both mesial and distal defects and a 95% confidence interval [0.74, 0.95] ($p<0.001$). The measurements from PA radiographs were lower than those obtained during surgery for all cases. The comparison between mean intraoperative and radiographic defect width measurements is presented in Figure 5c, where the y=x line represents equal measurements. Data points below this line indicate that radiographic measurements tend to underestimate defect width compared to intraoperative measurements ($p<0.001$). Figure 5d shows a Bland-Altman plot, with the x-axis representing the mean of intraoperative and radiographic measurements, and the y-axis showing the difference between these values.

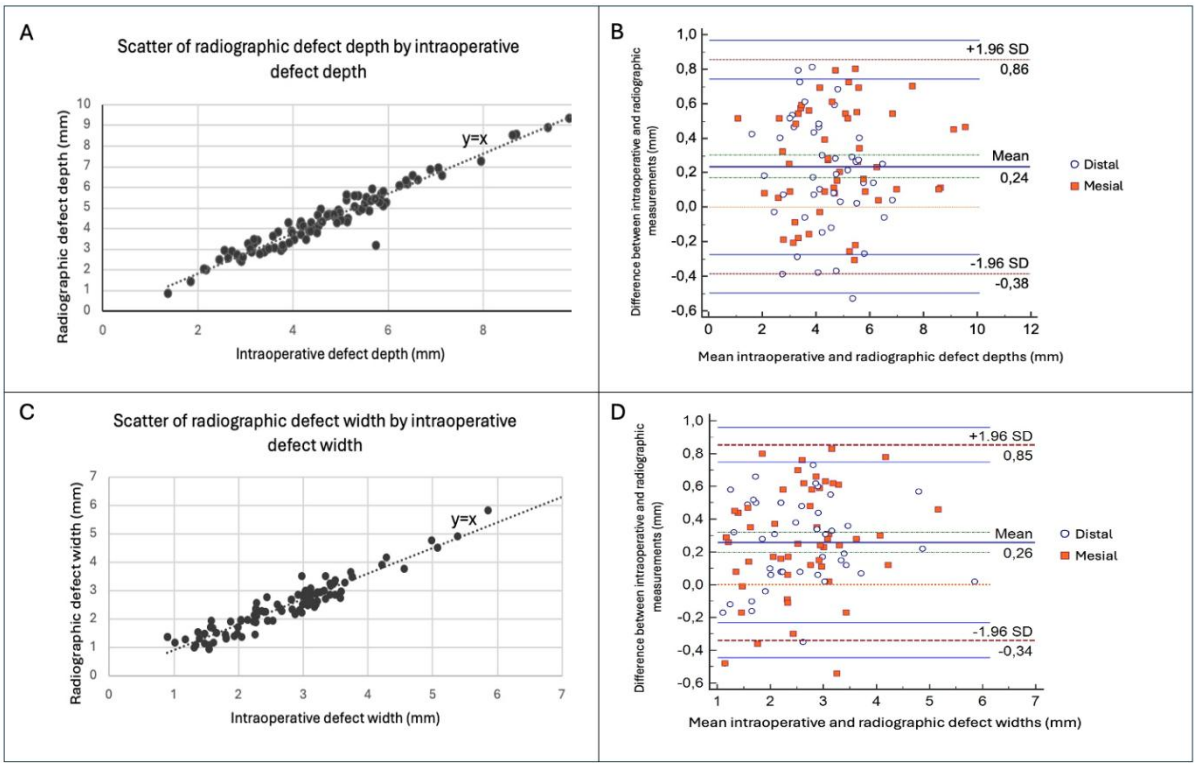

Figure 5: *A*) Scatter plot displaying the defect depth measurements obtained from PA radiographs and during surgery. *B*) Bland-Altman plot-The mean intraoperative and radiographic defect depth measurements, and the difference between these measurements (mm). *C*) Scatter plot displaying the defect width measurements obtained from PA radiographs and during surgery. *D*) Bland-Altman plot-The mean intraoperative and radiographic defect width measurements, and the difference between these measurements (mm).

DISCUSSION

Detection of peri-implant bone loss requires radiographic and clinical assessment with longitudinal monitoring. Accurate detection is essential to prevent complications, preserve implant stability, and ensure favorable outcomes.[1,32] Current evidence supports PA radiography as the first-choice imaging method when peri-implant disease is suspected,[20,32] owing to its accessibility, low cost, patient comfort, and high spatial resolution. Nevertheless, only a few studies[7-9] have directly compared PA findings with intraoperative measurements of vertical bone defects. Serino et al.[7] assessed 46 implants and found PA radiographs underestimated bone loss by 0.6–0.7 mm, with only 21% of radiographic assessments matching intraoperative findings. García-García et al.[8] also reported significant underestimation (0.8 mm mesial, 1.5 mm distal) and poor concordance in defect morphology, with type 1e defects frequently classified as 1d. Christiaens et al.[9] examined 50 implants and noted even greater discrepancies, with PAs underestimating bone levels by an average of 2.3 mm.

Our findings are consistent with these reports,[7-9] confirming the tendency of PA radiographs to underestimate defect size. However, the degree of underestimation in our study (0.34 mm depth, 0.32 mm width) was smaller. This improved accuracy may be attributed to the use of film holders, the paralleling technique, and calibration with vertical and horizontal reference markers, which minimized distortion and improved scaling across planes. Unlike García-García et al.,[8] who reported poor agreement, we observed moderate concordance between PA and surgical classifications. Agreement was highest for types 1c and 1d, the most common defects in our sample. These morphologies, characterized by dehiscence combined with intrabony components, may be easier to recognize radiographically. In contrast, type 1b defects were rare (3.9%), reflecting their lower clinical prevalence and the difficulty of detecting buccal-only defects radiographically. The findings of the present study align with those of the prior reports,[7-9] indicating that PA radiographs tend to underestimate defect dimensions when compared to intraoperative measurements. However, although statistically lower than surgical measurements, the defect measurements on PA radiographs in the present study were less underestimated than previously reported, with a mean difference of 0.34 mm for defect depth and 0.32 mm for defect width. The accuracy and reliability of intraoral radiographs for assessing peri-implant diseases depend heavily on the standardization of technical factors

and X-ray geometry, particularly the spatial alignment between the image receptor plane, the teeth, and the central X-ray beam.[32] Optimal imaging results occur when the X-ray beam is positioned perpendicular to both the long axis of the teeth and the plane of the image receptor, minimizing distortion of the teeth and surrounding periodontal structures. In addition to the use of film holders and the paralleling technique in the present study, the minimized discrepancies between PA radiographs and intraoperative measurements may be attributed to the incorporation of two distinct reference materials-one positioned vertically and the other horizontally-to improve calibration accuracy across multiple planes. This dual-reference approach likely minimized dimensional distortions by providing more precise scaling for measurements, resulting in a closer approximation to intraoperative dimensions. Additionally, unlike the findings of García-García et al.,[8] who reported poor agreement, our results showed a moderate level of agreement between surgical assessments and PA radiographs in determining defect type. The highest agreement between PA radiographs and intraoperative assessments occurred with type 1c and type 1d defects, which were also the most commonly identified defect types during surgery. Type 1c defects, characterized by buccal bone dehiscence in combination with a circumferential defect, and type 1d defects, defined by buccal and oral bone dehiscences along with mesial and distal intrabony defects, may present specific features that enhance their detectability on PA radiographs.[2] The higher prevalence of these defect types in our study population could also enhance radiographic familiarity, potentially increasing diagnostic accuracy for these configurations. By contrast, the frequency of type 1b defects was very low in our sample (3.9%). This may reflect the relative rarity of this defect configuration in clinical settings, as well as the inherent difficulty of detecting buccal-only defects radiographically compared to circumferential or combined morphologies.

Accurate detection of bone defects is influenced by their size, regardless of the imaging modality used, since radiographic evidence becomes visible only after 30-50% of bone has resorbed.[32] PA radiographs may underestimate the extent of bone loss in less extensive defects, particularly in the early stages of periodontal disease,[33] especially when the paralleling technique with film holders is not used during image capture.[34] Furthermore, the two-dimensional nature of PA radiographs limits their assessment in providing a comprehensive view of the bucco-lingual aspects of the interproximal bone.[34] CBCT imaging is the method of choice for early detection of peri-implant bone loss and assessment of defect morphology in these cases. In previous studies, the diagnostic accuracy of CBCT for peri-implant bone loss varied based on study design and defect morphology.[35,36] In cadaver models, CBCT generally showed good sensitivity and specificity for circumferential and infrabony defects but lower accuracy for dehiscences.[37-39] In animal studies, it either overestimated or underestimated defect size, depending on factors such as defect configuration, location, and the presence of imaging artifacts like scattering and beam hardening.[37-39] A recent integrated review[25] on the use of CBCT for detecting peri-implant bone defects noted that CBCT could overestimate or underestimate the severity of bone loss, generally with an error margin within 1 mm. Its accuracy decreased for defects smaller than 3 mm, limiting its sensitivity for detecting early peri-implant bone loss.[40] While CBCT was more effective than PA radiography for identifying dehiscence and fenestration defects, PA radiographs were more precise in assessing interproximal defects, underscoring their importance in the initial evaluation of peri-implant inflammation. Additionally, studies have shown that PA radiographs demonstrate higher inter-observer consistency compared to CBCT in detecting peri-implant bone defects,[41] while both imaging options exhibit clinically acceptable performance for assessing these defects. The primary concern with CBCT examinations lies in the limited evidence supporting its use for diagnosing intrabony and furcation defects,[32,42,43] and its application may not significantly influence treatment decisions to warrant the associated high radiation dose. Therefore, it may be suggested that the use of film holders, the paralleling technique, and reference materials of known length positioned both vertically and horizontally can improve alignment between PA radiographic and surgical measurements, highlighting the continuing potential of calibrated PA radiographs as a reliable and minimally invasive tool for assessing defect depth and type.[32,42,43]

The secondary aim of this study was to evaluate the consistency between probing depth measurements obtained with plastic and metal probes in peri-implantitis-affected areas. While the Williams probe recorded a slightly higher mean probing depth compared to the UNC-12 probe, the results showed substantial agreement between the two, as indicated by a κw value of 0.71. This highlights the reliability and suitability of both probes for assessing peri-implant probing depths and conducting consistent, accurate clinical evaluations of peri-implantitis.

Several limitations should also be considered when interpreting these results. The relatively small sample size may restrict the generalizability of the findings, although this reflects the realities of clinical practice where patients may miss appointments, change treatment preferences, or be unable to complete follow-up. In addition, only Class 1 defects (types 1b–1e) were included, meaning the results cannot be directly extrapolated to other defect morphologies. Another limitation is the absence of CBCT as a complementary reference standard; although intraoperative findings were used as the gold standard, future investigations incorporating CBCT could provide a more

comprehensive three-dimensional assessment of peri-implant bone defects. Finally, the two-dimensional nature of PA radiographs restricts the evaluation of buccal and lingual bone plates, which may lead to underestimation of defect dimensions compared with intraoperative measurements.

CONCLUSION

The PA radiographs, when standardized with film holders, the paralleling technique, and calibrated reference materials, demonstrate reliable accuracy in assessing peri-implant bone defects. Despite a tendency to slightly underestimate defect dimensions compared to intraoperative measurements, the discrepancies were minimal, confirming their clinical applicability. The moderate agreement between radiographic and intraoperative defect classifications, particularly for interproximal defects, further supports the continued use of PA radiographs in initial peri-implant defect evaluations. Additionally, the substantial agreement between probing depth measurements obtained with plastic and metal probes highlights the reliability of both probes for clinical assessment of peri-implantitis.

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Retrospective Evaluation of the Prevalence of the Second Mesiobuccal Canal in Maxillary First and Second Molars Using Cone-Beam Computed Tomography

Maksiller Birinci ve İkinci Molarlarda Mezyobukkal İkinci Kanal Prevalansının Konik Işınlı Bilgisayarlı Tomografi ile Retrospektif Değerlendirilmesi

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ABSTRACT

INTRODUCTION: This study evaluated the prevalence and morphological characteristics of the second mesiobuccal (MB2) canal in maxillary first and second molars using cone-beam computed tomography (CBCT) images obtained from patients who presented to the Faculty of Dentistry at Uşak University.

MATERIAL and METHODS: In this retrospective study, CBCT data from 427 patients obtained from 2018 through 2025 were analyzed. The images were evaluated using RadiAnt DICOM Viewer software by two specialists in oral and maxillofacial radiology and four endodontists. The presence and configuration of the MB2 canal were classified according to Vertucci's classification. The prevalence of MB2 canals was compared according to gender and tooth type using the chi-square test, with a p-value <.05 considered statistically significant.

RESULTS: The MB2 canal was detected in 61.6% of the maxillary first molars and in 38.4% of the second molars. The prevalence of MB2 canals was higher in males than in females in both maxillary first (p =.017) and second molars (p =.039). According to Vertucci's classification, the most frequently observed canal configuration was Type II, followed by Type IV.

CONCLUSION: Although the MB2 canal was more frequently observed in maxillary first molars, it was also detected at clinically relevant rates in maxillary second molars. Gender and tooth type were identified as significant variables influencing the presence of the MB2 canal. Therefore, the use of three-dimensional imaging techniques, such as CBCT, is essential in endodontic treatment planning, particularly for maxillary molars with complex root canal anatomies, in order to enhance treatment success.

Keywords: *Endodontics, Dentistry, Cone-Beam computed tomography, Root canal therapy*

ÖZ

GİRİŞ: Bu çalışmanın amacı, Uşak Üniversitesi Diş Hekimliği Fakültesi'ne başvuran hastaların konik ışınlı bilgisayarlı tomografi (CBCT) görüntüleri aracılığıyla maksiller birinci ve ikinci molar dişlerde mezyobukkal ikinci (MB2) kanalın görülme sıklığını ve morfolojik özelliklerini değerlendirmektir.

GEREÇ ve YÖNTEM: Bu retrospektif çalışmada, 2018–2025 yılları arasında CBCT görüntülemesi yapılan 427 hastaya ait veriler değerlendirilmiştir. Görüntüler, RadiAnt DICOM Viewer yazılımı kullanılarak iki Ağız, Diş ve Çene Radyolojisi ve dört Endodonti uzmanı tarafından analiz edilmiştir. MB2 kanalın varlığı ve konfigürasyonları, Vertucci sınıflamasına göre sınıflandırılmıştır. Cinsiyet ve diş tipine göre MB2 kanalının görülme sıklığı, ki-kare testi ile karşılaştırılmış; p <.05 değeri istatistiksel olarak anlamlı kabul edilmiştir.

BULGULAR: MB2 kanalı, birinci maksiller molar dişlerde %61.6, ikinci molarlarda ise %38.4 oranında saptanmıştır. MB2 kanalı prevalansı, erkeklerde kadınlara göre hem maksiller birinci (p =.017) hem de ikinci molarlarda (p =.039) daha yüksek bulunmuştur. Vertucci sınıflamasına göre en sık gözlenen konfigürasyon Tip II'dir; bunu Tip IV takip etmektedir.

SONUÇ: Mezyobukkal ikinci kanal, maksiller birinci molar dişlerde daha yüksek sıklıkta görülmekle birlikte, maksiller ikinci molar dişlerde de klinik olarak göz ardı edilemeyecek oranlarda tespit edilmiştir. Cinsiyet ve diş tipi, MB2 kanal varlığını etkileyen anlamlı değişkenler olarak belirlenmiştir. Bu nedenle, özellikle kompleks kök kanal anatomisine sahip maksiller molar dişlerde, endodontik tedavi planlamasında CBCT gibi üç boyutlu görüntüleme yöntemlerinin kullanılması, tedavi başarısını artırmak açısından önemlidir.

Anahtar Kelimeler: *Endodonti, Diş hekimliği, Konik ışınlı bilgisayarlı tomografi, Kök kanal tedavisi*

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INTRODUCTION

Achieving a successful outcome in root canal treatment requires comprehensive shaping, thorough microbial elimination, and dense 3D obturation of the complete root canal system.[1] Achieving these targets requires an accurate understanding of root canal morphology and the possible presence of additional canals.[1,2] Inadequate knowledge in this regard can lead to insufficient debridement and obturation, which are among the primary causes of endodontic treatment failure.[3] Root canal treatment of maxillary molars tends to have the greatest rate of clinical failure, largely due to the complex canal configurations in mesiobuccal roots. Failure to detect and treat the second mesiobuccal (MB2) canal is considered one of the main factors adversely affecting the longevity of root canal treated maxillary molars.[4]

The root canal structure of maxillary molars has been analyzed in studies employing various techniques. These analyses have included different cleaning methods applied to extracted teeth, radiographic imaging procedures using endodontic files during treatment, examination of the pulpal floor with scanning electron microscopy, and assessment of serially sectioned teeth.[4] Additionally, the clinical examination of maxillary molar root canal structure has been performed using magnification devices,[5] retrospective analysis of periapical radiographs of previously treated teeth,[6] and advanced imaging techniques such as cone-beam computed tomography (CBCT).[4]

Since its introduction into dentistry in the 1990s, CBCT has provided significant advantages by overcoming the limitations of conventional 2D radiography and offering 3D imaging capabilities.[7] As CBCT enables detailed evaluation of both the internal and external structures of the tooth, it is considered one of the primary imaging techniques recommended for assessing the anatomical and structural features of the root canal system.[8] Scientific studies on CBCT applications have demonstrated their high reliability in endodontic diagnosis and treatment planning. When used within appropriate clinical protocols, CBCT offers critical advantages, such as a limited field of view (FOV), high spatial resolution, and relatively low radiation exposure to the patient, making it particularly valuable for detailed assessment of root canal morphology and 3D reconstruction of the root canal system.[9]

The anatomy of teeth and pulp tissue can vary significantly among individuals. Studies on the internal and external structures of teeth have revealed the presence of complex and diverse anatomical variations across all tooth groups.[10] Several individual factors, such as ethnicity, age, and gender, have been reported to influence the development of these variations in root canal morphology.[2] Therefore, a detailed understanding of root canal anatomy in various ethnic groups are crucial for achieving successful root canal treatment. Both the literature and documented clinical experience consistently report a high occurrence of MB2 canals in maxillary first molars.[11] However, maxillary second molars also exhibit complex root canal anatomies, and failure to detect the MB2 canal in these teeth may adversely affect treatment success and long-term prognosis.[12] The present study aims to raise awareness among clinicians concerning the presence of MB2 canals not only in maxillary first molars but also in maxillary second molars and to provide guidance for clinical practice. Accordingly, this study evaluated the prevalence of MB2 canals in maxillary first and second molars in patients attending the Faculty of Dentistry at Uşak University, with particular attention to gender differences and canal configuration in teeth with MB2 canals. The null hypothesis of the study was that there is no difference in the prevalence of MB2 canals between maxillary first and second molars.

MATERIALS AND METHODS

This study was approved by the Non-Interventional Clinical Research Ethics Committee of Uşak University under decision number 94-94-05. The study followed established ethical norms outlined by the institutional research ethics committee and was conducted in compliance with the Declaration of Helsinki and its subsequent revisions or equivalent ethical guidelines. The sample size was calculated using OpenEpi software. Considering a target population of approximately 305.000 individuals over 15 years of age residing in Uşak province, a minimum of 384 patients was determined to be required for inclusion in the study. The calculation was based on a presumed prevalence of 50% (recommended for unknown proportions), a 5% margin of error, a 95% CI, and a power level of 95%.

The study included cases that met the following selection criteria:

- Patients over the age of 15, to ensure complete root development of all teeth,
- CBCT scans that clearly included both the first and second maxillary molars,
- Absence of any root resorption or calcification in the relevant teeth,
- No history of prior root canal treatment in the teeth of interest (due to the potential negative impact on image quality), and
- Absence of prosthetic restorations or post-applications in the relevant teeth.

In this study, among a total of 12.207 CBCT scans obtained at the Faculty of Dentistry, Uşak University from 2018 through 2025 for dentomaxillofacial problems, 4.327 scans that included the maxillary molar region were identified. Of these, 427 CBCT images that met the inclusion criteria were selected for evaluation. All CBCT scans were acquired using the Gendex GXDP-700 unit (KaVo Kerr, Biberach, Germany) with a FOV of 6 × 4 cm and the following exposure parameters: 90 kV, 13 mA, and 12 seconds. The images were analyzed in detail in axial, coronal, and sagittal planes using RadiAnt DICOM Viewer software (RadiAnt, Poznan, Poland) by a team consisting of 2 oral and maxillofacial radiologists and 4 endodontists. During the evaluation, the observers adjusted the multiplanar images according to the long axis of each root and performed a dynamic assessment.

The investigators examined the occurrence and morphological characteristics of the MB2 canal in the maxillary molars. Each tooth was evaluated independently and categorized based on tooth type, presence of the MB2 canal, age, and gender. The morphology of MB2 canals was determined using Vertucci's classification system, which is based on the anatomical configuration of the main root canal of the tooth root. Vertucci,[1] classified root canal morphology into eight types. Types I–III have a single apical foramen, with internal canal divisions except for Type I. Types IV–VII present two separate apical foramina, whereas Type VIII is distinguished by having three apical foramina (Figure 1). For positioning and measurement, the root canal orifices, defined as the highest points on the pulpal floor, were used as reference landmarks.

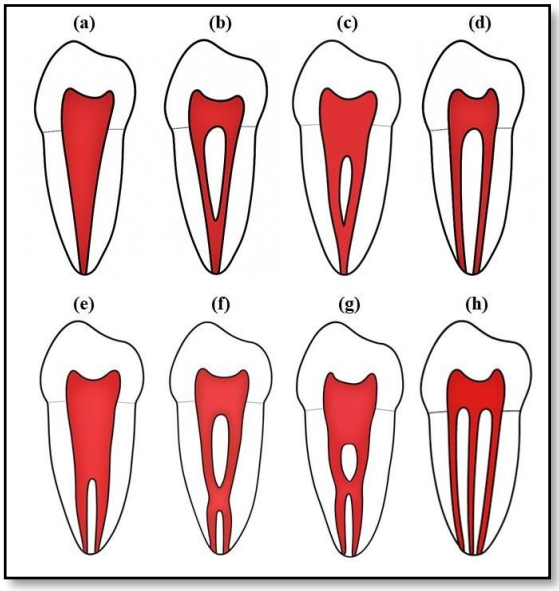

Figure 1. Canal configurations as originally described by Vertucci (1984).[1] The configurations are described as follows: **(a)** Type I, **(b)** Type II, **(c)** Type III, **(d)** Type IV, **(e)** Type V, **(f)** Type VI, **(g)** Type VII, and **(h)** Type VIII.

Statistical Analysis

Descriptive statistics were used to summarize the gender distributions of the study sample. The prevalence of MB2 canals was compared between maxillary first and second molars, and between genders, using chi-square (χ^2) tests.

In addition, binary logistic regression analyses were conducted to assess the independent effect of gender on MB2 canal presence, separately for maxillary first and second molars. The presence of an MB2 canal served as the dependent variable in each model, while gender (male vs. female) was included as predictor variables. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported to indicate effect sizes.

All statistical analyses were performed using jamovi software (version 2.6; The jamovi project, 2024) and R software (version 4.4; R Core Team, 2024). The significance level was set at $p < .05$ for all tests.

RESULTS

This retrospective observational study included a total of 427 maxillary molars obtained from CBCT images taken for routine diagnostic purposes. The sample consisted of 253 female participants (59.3%) and 174 male participants (40.7%), with an average age of 32.3 years, ranging from 15 to 78 years.

Table 1 presents a comparison of MB2 canal prevalence in maxillary first and second molars. The MB2 canal was detected in 61.6% of the maxillary first molars, whereas this rate was 38.4% in the maxillary second molars. The chi-square test revealed a statistically significant difference ($p < .001$), indicating that the prevalence of MB2 canals was significantly higher in maxillary first molars compared with second molars.

Table 2 presents the distribution of MB2 canal presence according to gender in the maxillary first and second molars. In the maxillary first molars, the MB2 canal was observed in 68.4% of the male patients and 56.9% of the female patients, and this difference was statistically significant ($p = .017$). Similarly, in the maxillary second molars, the MB2 canal was detected in 44.3% of males and 34.4% of females, with the difference also reaching statistical significance ($p = .039$). These findings indicate that the prevalence of the MB2 canal is significantly higher in males than in females for both the maxillary first and second molars.

Table 3 presents the distribution of MB2 canals according to Vertucci canal configurations in the maxillary first and second molars. In both tooth groups, the most frequently observed configuration was Type II, detected in 52.5% ($n = 138$) of first molars and 51.2% ($n = 84$) of second molars. This was followed by Type IV (28.9% and 32.9%, respectively), Type III (8.0% and 7.9%), and Type VI (7.6% and 3.0%). Type V and Type VII configurations were the least frequently observed in both tooth groups (Figure 2 and 3).

Table 1. Comparison of MB2 presence between first and second maxillary molars

	First Maxillary Molar		Second Maxillary Molar	
Vertucci Type	n	%	n	%
Type 2	138	52.5%	84	51.2%
Type 3	21	8.0%	13	7.9%
Type 4	76	28.9%	54	32.9%
Type 5	4	1.5%	7	4.3%
Type 6	20	7.6%	5	3.0%
Type 7	4	1.5%	1	0.6%
Total	263	100%	164	100%

*Chi-square (χ^2) test

Table 2. Distribution of MB2 presence in the maxillary molars by gender

Tooth Group	MB2 Present (n, %)	MB2 Absent (n, %)	Total (n, %)	Test Statistics	*p**
First molar	263 (61.6%)	164 (38.4%)	427 (100%)	57.3	**< .001**
Second molar	164 (38.4%)	263 (61.6%)	427 (100%)		

*Chi-square (χ^2) test

Table 3. Vertucci canal configurations of MB2 canals in maxillary molars

Tooth Group	Gender	MB2 Present (n, %)	MB2 Absent (n, %)	Total (n, %)	Test Statistics	*p**
First Maxillary Molar	Women	144 (56.9%)	109 (43.1%)	253 (59.3%)		
	Men	119 (68.4%)	55 (31.6%)	174 (40.7%)	5.74	**.017**
	Total	263 (61.6%)	164 (38.4%)	427 (100%)		
Second Maxillary Molar	Women	87 (34.4%)	166 (65.6%)	253 (59.3%)		
	Men	77 (44.3%)	97 (55.7%)	174 (40.7%)	4.24	**.039**
	Total	164 (38.4%)	263 (61.6%)	427 (100%)		

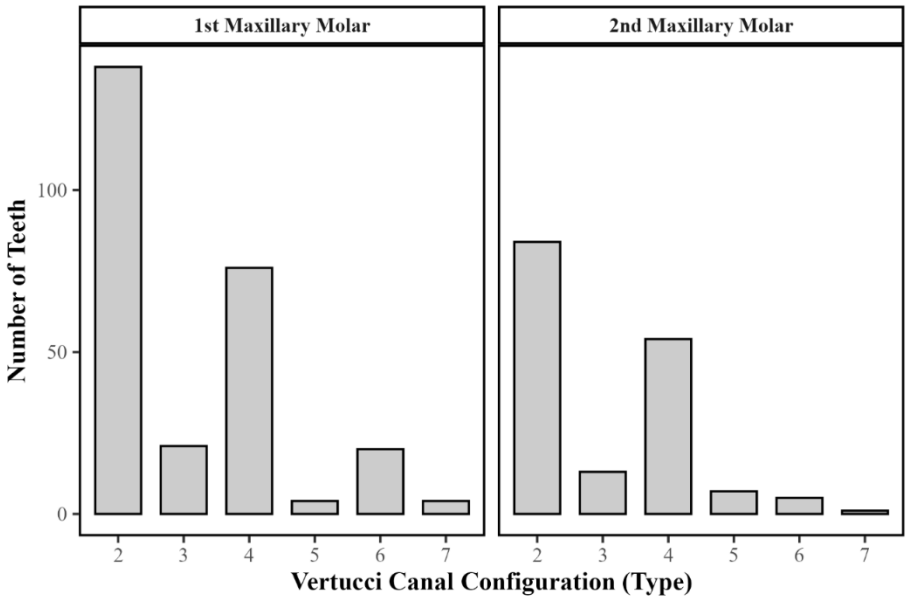

Figure 2. Distribution of MB2 Canal Configurations According to Vertucci's Classification in First and Second Maxillary Molars

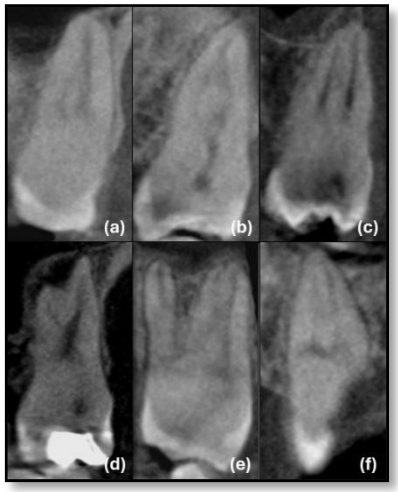

Figure 3. Coronal CBCT images of the mesiobuccal roots of maxillary molars demonstrating different canal configurations, **a)** Vertucci Type II, **b)** Vertucci Type III, **c)** Vertucci Type IV, **d)** Vertucci Type V, **e)** Vertucci Type VI, **f)** Vertucci Type VII.

DISCUSSION

In this study, CBCT images of the maxillary molar region were retrospectively examined in cases that met the inclusion criteria and selected from among patients who underwent CBCT imaging for various reasons at the Faculty of Dentistry, Uşak University. The aims of the study were to determine the prevalence of the MB2 canal, to assess its presence by gender, and to evaluate the canal structure according to Vertucci's classification in teeth where the MB2 canal was detected. The null hypothesis, which proposed that there would be no difference in the prevalence of MB2 canals between maxillary first and second molars, was rejected. The MB2 canal was found to be statistically more frequent in maxillary first molars than in second molars.

CBCT can be effectively utilized in all phases of root canal treatment, including diagnosis, treatment, and follow-up. Due to its high accuracy, minimal distortion, 3D imaging capability, and non-invasive nature, CBCT is widely preferred for the clinical assessment of tooth roots and root canal anatomy.[13] Indeed, the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology recommend the use of CBCT with a limited FOV, particularly for teeth with pulp disease, complex anatomical structures, or suspected additional canals. This detailed and 3D detection capability of CBCT plays a crucial role in accurately identifying the location and complex morphology of root canals, thereby helping to prevent iatrogenic errors, such as over-instrumentation.[14] One study reported that CBCT imaging provides higher accuracy and success in identifying root canals compared with conventional 2D digital radiography.[15] However, the effectiveness of CBCT in detecting MB2 canals remains a topic of debate. Another study indicated that even when an MB2 canal is not visible on CBCT images, there may still be a chance of locating it through clinical exploration.[16]

In our study, the prevalence of the MB2 canal in maxillary first molars was 61.6%, which was significantly higher than the 38.4% observed in maxillary second molars. Our findings are consistent with previous studies[15-17] in the literature, many of which have also reported an increased frequency of MB2 canals in maxillary first molars compared with second molars. For instance, in a study conducted by Lee et al.[17] the MB2 canal was observed in 86.8% of maxillary first molars and 28.9% of maxillary second molars. Similarly, Degerness et al. reported an MB2 incidence of 79.8%,[18] while another study reported a rate of 73.8%.[16] In a study focusing specifically on maxillary second molars, the occurrence of MB2 canals was found to be 42.2%.[19] The differences in incidence rates between the present and previous studies may be attributed to several methodological factors, including sample size, racial characteristics of the population studied, voxel size of the CBCT device used, diagnostic techniques, and reference plane adjustments. Moreover, the notable disparity in MB2 prevalence between first and second maxillary molars may be explained by differences in tooth morphology. In fact, a study conducted on a Chinese population reported that maxillary second molars exhibit greater morphological diversity and complexity than first molars.[20] Accordingly, the lower frequency of MB2 canals observed in second molars may be attributed to these morphological differences. Beyond the statistical significance of our findings, the clinical implications of MB2 canal prevalence should be carefully considered. Undetected MB2 canals are recognized as one of the primary causes of persistent apical pathology and subsequent retreatment in maxillary molars.[21] In our study, although the MB2 canal was significantly more frequent in maxillary first molars, the detection rate of 38.4% in second molars highlights its considerable clinical relevance. This finding underscores that clinicians should not overlook the possibility of an MB2 canal even in maxillary second molars, where its occurrence may be underestimated in daily practice. Careful exploration of the mesiobuccal root using magnification devices and preoperative CBCT evaluation in complex cases are strongly recommended to ensure thorough debridement and obturation of the entire root canal system.[21,22] Ultimately, these measures are crucial to prevent persistent infection, enhance treatment outcomes, and improve the long-term prognosis of endodontically treated maxillary molars.

In the present study, the prevalence of MB2 canals

was higher in male patients than in female patients for both tooth groups. Although some studies in the literature support this finding,[15,23] others have found no significant difference between genders.[24] One study indicated that an increased level of root canal calcification is observed in female patients compared with males.[25] This may explain the lower detection rate of MB2 canals among female patients in the current study.

Vertucci Type I configuration indicates the absence of an MB2 canal, whereas all other Vertucci types reflect the presence of an MB2 canal. In our study, Vertucci classification of maxillary first and second molars in which MB2 canals were identified revealed that the distribution of canal types was similar across both tooth groups. Type II was the most frequently observed configuration, followed by Type IV. These findings are consistent with previous studies.[15,26] One earlier study reported that in cases with undetected MB2 canals, Type IV configurations had a greater negative impact on the success rate of root canal treatment compared with Type II configurations.[15] Therefore, to prevent treatment failures and ensure complete management of the root canal system, a detailed 3D assessment of maxillary molars prior to treatment is strongly recommended.

In our study, the occurrence of MB2 canals in maxillary molars was compared using CBCT data obtained from patients who presented to our faculty with various dentomaxillofacial problems. The findings demonstrated that, although MB2 canals were detected at a higher rate in maxillary first molars, they were also present at a relatively high rate in maxillary second molars. These results highlight the importance of considering the presence of MB2 canals and performing a thorough preoperative 3D radiographic assessment to reduce the risk of treatment failures commonly encountered in root canal treatment. However, this study has certain limitations. Although age ranges were defined in the inclusion criteria during the study planning, age was not included as a variable in the statistical analysis. The literature has suggested that physiological changes associated with aging, such as pulp chamber calcification and secondary dentin deposition, may affect the detectability of MB2 canals.[15,24] Therefore, future studies should consider age as a potential factor associated with the presence of MB2 canals. Another limitation of our study is that the relationship between root length and the presence of MB2 canals was not evaluated. However, previous research has indicated that root length may influence both the presence of MB2 canals[15] and Vertucci canal configurations.[27] Thus, future studies are recommended to investigate the effects of root length on MB2 canal prevalence and configuration patterns. To minimize intra-individual clustering bias and ensure independent observations, only one maxillary first and second molar per quadrant were included in the final dataset, resulting in a maximum of two molars per patient. In future studies, it would be beneficial to evaluate both the right and left sides of the maxilla in the same individuals and to investigate the correlation between these paired teeth. Additionally, in the present study, MB2 canal detection was based solely on CBCT images of the two maxillary molars. However, as previously reported, even when an MB2 canal is not visualized on CBCT, its presence may still be confirmed during clinical examination and exploration.[16] Therefore, clinicians should not rely solely on CBCT findings during root canal treatment of maxillary molars and should always consider the possibility of an MB2 canal, even when it is not radiographically evident.

CONCLUSION

In this retrospective study, CBCT images of individuals who presented to the Faculty of Dentistry at Uşak University were analyzed to evaluate the prevalence and morphological characteristics of the MB2 canal in the maxillary first and second molars. The findings revealed that the MB2 canal was more frequently detected in maxillary first molars than in second molars and was observed more often in male patients than in females. According to Vertucci's classification, Type II was the most commonly observed configuration, with similar morphological distributions identified in both tooth groups. These results underscore the clinical relevance of considering the presence of the MB2 canal, even in maxillary second molars. Accordingly, the use of 3D imaging techniques, such as CBCT, is recommended during treatment planning, and future studies should focus on incorporating individual factors such as age and root length into the evaluation process.

DECLARATIONS

Authors' contributions

OT and H.T.Y designed the study. OT served as the principal investigator. All authors were actively involved in the thorough screening of CBCT images and the analysis of those that met the inclusion criteria. OT and E.C.Ç performed the statistical analysis. All authors revised and contributed to the final version of the manuscript.

Ethics approval

This study was approved by the Non-Interventional Clinical Research Ethics Committee of Uşak University under decision number 94-94-05.

Declaration of Helsinki

The study followed established ethical norms outlined by the institutional research ethics committee and was conducted in compliance with the Declaration of Helsinki and its subsequent revisions or equivalent ethical guidelines.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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18-month Clinical Performance of Prefabricated and Direct Composite Resin Veneers

Prefabrik ve Direkt Kompozit Rezin Venerlerin 18 Aylık Klinik Performansları

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ABSTRACT

INTRODUCTION: In recent years, the increase in esthetic demands and the progress in adhesive systems have brought more attention to the treatment of the anterior region. In this context, direct composite veneers are widely preferred. The aim of the study is to compare the 18-month clinical performances of prefabricated composite veneers and direct composite veneers fabricated with transparent templates.

MATERIAL and METHODS: This randomized, prospective in-vivo study included 21 volunteers and a total of 74 anterior veneers (36 laterals, 38 centrals). Prefabricated veneers were placed using the Edelweiss system; direct veneers were made with U-Veneer templates and Ceram-X Duo SphereTEC. All procedures followed manufacturers' instructions, and no additional mechanical polishing was performed. Clinical evaluations were conducted at baseline, 6, 12, and 18 months by two experienced, blinded examiners using modified Ryge (USPHS) criteria (color match, marginal discoloration/adaptation, anatomic form, secondary caries, retention loss, surface roughness, polish retention, postoperative sensitivity, and patient satisfaction). Statistical analyses used McNemar and Kolmogorov-Smirnov Z tests ($p<0.05$).

RESULTS: After 18 months, both approaches were clinically successful with high patient satisfaction. No statistically significant differences were found between groups. Over time, a significant change was observed only in the polish retention criterion ($p<0.05$).

CONCLUSION: Both techniques are reliable short-to-mid-term options for anterior esthetics. Considering long-term outcomes, fine finishing and polishing of veneer surfaces are recommended with attention to patients' dietary habits.

Keywords: *Composite resin veneers, clear templates, prefabricated composite resin veneers, clinical performance*

ÖZ

GİRİŞ: Son yıllarda estetik taleplerin artması ve adeziv sistemlerdeki ilerlemeler, anterior bölgenin tedavisine olan ilgiyi artırmıştır. Bu bağlamda, direkt kompozit laminalar yaygın olarak tercih edilmektedir. Bu çalışmanın amacı, prefabrike kompozit laminalar ile şeffaf şablonlar kullanılarak yapılan direkt kompozit laminaların 18 aylık klinik performanslarını karşılaştırmaktır.

GEREÇ ve YÖNTEM: Bu randomize, prospektif in vivo çalışmaya 21 gönüllü ve toplam 74 anterior diş (36 lateral, 38 santral) dahil edildi. Prefabrik veneerler Edelweiss sistemi ile uygulandı; direkt veneerler U-Veneer şeffaf şablonları ve Ceram-X Duo SphereTEC kullanılarak yapıldı. Tüm işlemler üretici talimatlarına uygun şekilde gerçekleştirildi ve ilave mekanik polisaj uygulanmadı. Klinik değerlendirmeler; başlangıçta, 6, 12 ve 18. aylarda, modifiye Ryge (USPHS) kriterleri (renk uyumu, marjinal renklenme/uyum, anatomik form, sekonder çürük, tutuculuk kaybı, yüzey pürüzlülüğü parlaklık korunumu, postoperatif hassasiyet ve hasta memnuniyeti) kullanılarak, deneyimli iki kör değerlendirici tarafından yapıldı. İstatistiksel analizlerde McNemar ve Kolmogorov-Smirnov Z testleri kullanıldı ($p<0,05$).

BULGULAR: On sekiz ayın sonunda her iki yaklaşım da yüksek hasta memnuniyetiyle klinik olarak başarılı bulundu. Gruplar arasında istatistiksel olarak anlamlı fark saptanmadı. Zaman içinde yalnızca "parlaklık korunumu" kriterinde anlamlı bir değişim gözlendi ($p<0.05$).

SONUÇ: Her iki teknik de anterior estetik için kısa-orta vadede güvenilir seçeneklerdir. Uzun dönem sonuçlar dikkate alındığında, hastaların diyet alışkanlıklarına da özen gösterilerek veneer yüzeylerinin ince bitim ve polisajının yapılması önerilir.

Anahtar Kelimeler: *Kompozit rezin vener, şeffaf şablon, prefabrik kompozit rezin vener, klinik performans*

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INTRODUCTION

In recent years, the increase in esthetic demands and the progress in adhesive systems have brought more attention to the treatment of the anterior region in line with the principles of minimally invasive dentistry (MID). Minimally invasive dentistry aims to preserve tooth structure as much as possible, delay invasive procedures, and focus on repair-oriented approaches.[1] In this context, direct composite veneers are widely preferred because they can be applied in a single visit, are repairable, and are cost-effective.[1] However, their surface gloss and color stability are affected by diet and oral hygiene habits (tea, coffee, acidic drinks, smoking) and by the finishing and polishing protocols. For this reason, regular check-ups and refurbishing or repolishing are recommended as essential for clinical success.[1]

Ceramic veneers (especially lithium disilicate) are strongly supported in the literature for their translucency, color stability, and long-term predictability. However, the need for a laboratory process, relatively more invasive tooth preparation, and difficulties in intraoral repair may limit their use as the first choice in every case.[1] In contrast, prefabricated composite resin veneers (PCRVs) and clear template–assisted direct veneering techniques have been introduced as minimally invasive alternatives. These options aim to provide predictable form and initial gloss in a single appointment, while also reducing operator dependency and treatment time.[1] PCRVs (e.g., Edelweiss, Componeer) are thin composite shells polymerized under heat and pressure in industrial conditions. They are available in different sizes and shapes, allowing a quick and reproducible veneer restorations for anterior tooth morphology.[1]

However, when it comes to surface strength and color stability, the behavior of composite-based systems is sensitive to both the material's microstructure and the conditions of use. In controlled laboratory studies, prefabricated composite veneers showed a greater increase in surface roughness (Ra) after wear/erosion simulations compared with lithium disilicate and enamel, and this roughness increase has been linked to the loss of gloss observed clinically.[2] Similarly, in evaluations of color change (ΔE) related to wear patterns, some PCRV systems demonstrated color changes approaching or reaching the perceptible threshold, whereas ceramic veneers generally maintained color stability below this threshold.[3] These findings support the clinical importance of initial finishing and periodic repolishing for maintaining the long-term esthetic stability of composite-based restorations.[1–3]

When looking at short-term in vivo studies, PCRVs and direct composite veneers have shown similar clinical performance at around 12 months, with no significant differences reported in parameters such as color, surface texture, marginal integrity, and gingival response.[4] On the other hand, long-term comparisons (especially among indirect systems) provide randomized clinical evidence indicating the superior performance of ceramic veneers in terms of survival and surface stability.[5] Taken together, these findings highlight the need for case-based selection of material and technique, considering factors such as the level of esthetic demand, the goal of tissue preservation, time and cost limitations, and the patient's compliance with maintenance.[1]

Clear template–assisted direct veneering aims to reduce operator variability by facilitating the standardization of form and symmetry, especially in multi-tooth morphology corrections. Manufacturer protocols often promote single-layer applications for a faster finish, which shortens clinical time. However, since the finishing and polishing step defines the microgeometry, careful management of enamel–composite interfaces and the systematic use of fine polishing strategies are recommended.[1] In prefabricated veneers, the vitrified surface layer created during production may be partially removed during clinical finishing; evidence suggests that this could influence long-term gloss and surface roughness.[6]

In clinical research, the standardization of outcome measures allows for the comparability of different materials and techniques. In this context, the modified Ryge (USPHS) criteria provide a reproducible framework that covers esthetic (color match, surface gloss/texture), functional (anatomic form, marginal adaptation), and biological (gingival response, secondary caries) parameters. Recent randomized clinical trials (e.g., direct composite vs. indirect ceramic) have also adopted the USPHS approach,[7] This approach makes clinically relevant aspects of short- to medium-term follow-up (such as polish/gloss retention) quantitatively visible.

The current literature shows that PCRVs and clear template–assisted direct veneers present promising short-term outcomes; however, long-term evidence remains limited.[1,4] One of the most common esthetic challenges in clinical practice which is loss of gloss and increase in surface roughness is associated not only with daily wear and erosion but also with the initial finishing protocol.[2,3,6] Therefore, clinical studies that assess the short to medium term performance of PCRVs and clear template assisted direct veneers under real life conditions, using standardized criteria and regular follow-ups, are valuable in addressing this gap in evidence.

In response to this need, the present study prospectively compares prefabricated composite veneers with clear template–assisted direct composite veneers, reporting evaluations at baseline, 6, 12, and 18 months according to the modified Ryge (USPHS) criteria. The primary aim is to compare the short to medium term clinical success of both approaches in terms of color match, surface ⁄gloss, anatomic form, marginal adaptation, gingival response, retention, and patient satisfaction. The secondary aim is to identify patterns of change over time, particularly in surface-related parameters such as polish/gloss retention. The null hypothesis states that no statistically significant differences will be observed between the groups for the clinical criteria assessed during the follow-up period.

MATERIALS and METHODS

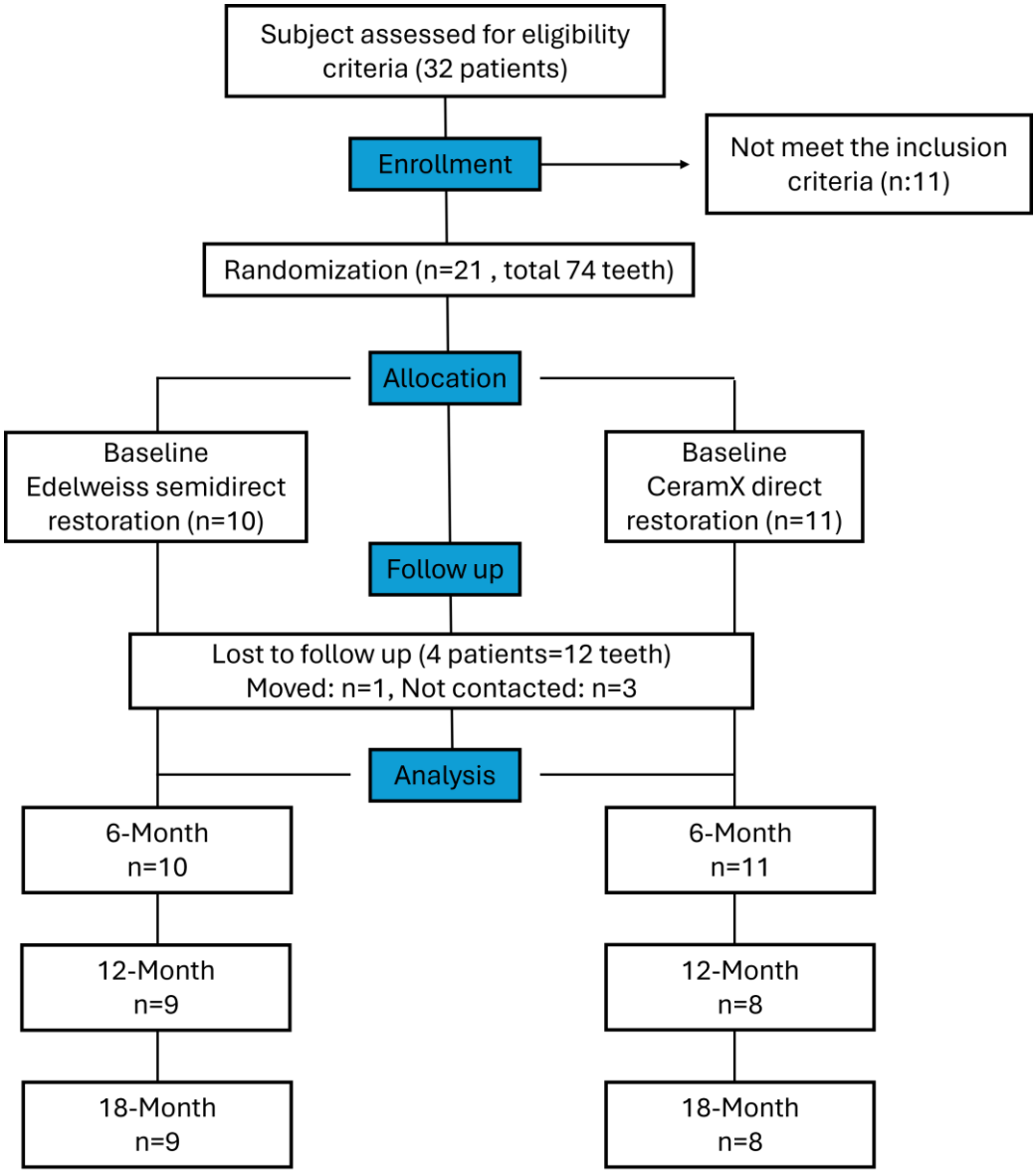
This study was designed as a randomized, prospective clinical trial to compare the clinical performance of two different composite veneer approaches in adult patients presenting with esthetic concerns in the anterior region. The study was conducted at the Department of Restorative Dentistry, Faculty of Dentistry, Ege University, and was approved by the Ethics Committee for Clinical Research of Ege University Faculty of Medicine with approval number Approval No: 18-11.1T/15 on 28.11.2018.

Sample size estimation was conducted using G*Power 3.1 software, employing a 95% confidence level and 90% statistical power. The effect size for the Chi-square test was set at 0.40 based on the primary outcome, which was restoration retention. Assuming a maximum of five degrees of freedom, the required minimum total sample size was calculated to be 70 (n=35 per group). All participants received verbal and written information about the study and signed informed consent forms.

According to the inclusion and exclusion criteria, a total of 74 veneers were applied to the anterior teeth of 21 eligible volunteer patients. The inclusion criteria were: age ≥18 years, good oral hygiene, absence of medical conditions, not being pregnant, no severe bruxism or occlusal dysfunction, and the presence of indications for anterior composite resin veneer (laminate) restorations due to conditions such as diastema, peg-shaped lateral incisors, enamel hypoplasia, or other esthetic reasons. Teeth with extensive caries, pathological mobility, or loss of pulp vitality, as well as patients with temporomandibular joint (TMJ) disorders or currently undergoing orthodontic treatment, were excluded. Randomization was performed by an independent clinician not involved in the study. Participants were allocated to treatment groups using a random number table generated through the ‘Research Randomizer Program’ (http://www.randomizer.org/form.htm).

The study was designed in accordance with the 2010 Consolidated Standards of Reporting Trials (CONSORT) guidelines (Table 1).

Table 1. Consort flow chart of the study



Restorations were randomly assigned to two groups:

a) Semi-direct group: Restorations using prefabricated composite resin veneers (Edelweiss, Edelweiss Dentistry, Wolfurt, Austria) cemented onto teeth.

b) Direct group: Direct composite resin veneers shaped with the aid of a clear template (U-Veneer, Ultradent, South Jordan, Utah, USA + Ceram-X Duo SphereTEC, Dentsply Sirona, Konstanz, Germany).

Each patient's dental and medical history was recorded, and intraoral examinations were performed. Treatment options, including prosthetic and orthodontic alternatives, were explained to patients in terms of clinical protocols, long-term outcomes, advantages, and disadvantages. Patients who agreed to participate after receiving this information provided written informed consent. Prior to treatment, all patients underwent professional scaling and polishing.

The distribution of veneers according to tooth numbers is presented in Table 2 (teeth 12, 11, 21, and 22; n=38 semi-direct group, n=36 direct group; total n=74).

Table 2. Distribution of teeth numbers by technique used

Tooth no	*Semi-direct Technique*	*Direct Technique*	*Total*
12	9	9	18
11	10	9	19
21	10	9	19
22	9	9	18
Total	**38**	**36**	**74**

Three photographs (smile, occlusion, and open-mouth views) were taken from each patient at baseline, after treatment, and during follow-up visits.

Clinical Application Protocols

1. Semi-Direct Technique (Edelweiss)

The shade selection was performed using the "Button Try" technique with Edelweiss nanohybrid resin composite. Appropriate prefabricated veneer sizes were determined based on tooth morphology using the manufacturer's clear guide. Isolation was achieved with a disposable mouth retractor (OptraGate, Ivoclar Vivadent, Liechtenstein) to ensure moisture control and sufficient mouth opening.

Initial cervical margin adaptation was verified by trial placement of the prefabricated veneers without adhesive application. Margins were refined with Super-Snap Rainbow polishing disks (SHOFU, Kyoto, Japan) without water cooling, and the same adjustments were made for mesio-distal width. To enhance internal retention, the inner surfaces of the veneers were micro-roughened using fine-grit, yellow-banded diamond burs.

Tooth surfaces were etched with 34% phosphoric acid gel (Caulk Tooth Conditioner Gel, Dentsply Sirona, Konstanz, Germany) for 30 seconds, rinsed, and dried with oil-free air sprey. A universal adhesive (Prime&Bond Universal, Dentsply Sirona, Konstanz, Germany) was applied to the tooth surfaces with friction for 20 seconds, air-thinned, and light-cured (D-Light Duo, GC Europe, Leuven, Belgium).

After cleaning the veneer's inner surface with alcohol, a veneer-specific bonding agent (Veneer Bond, Edelweiss Dentistry, Wolfurt, Austria) was applied. The veneer was loaded with Edelweiss nanohybrid composite resin and positioned on the tooth. An initial light cure was applied from the incisal edge to stabilize its position, excess composite resin was removed, and final polymerization was performed with a LED curing unit for 40 seconds per surface (D-Light Duo).

In the final step, cervical adaptation of the restoration was re-evaluated using finishing and polishing discs from the Super-Snap Rainbow Technique Kit (SHOFU). All restorations were checked for premature contacts using articulating paper and adjusted with fine grit finishing burs (Komet, Germany) at low speed under water cooling. Interproximal finishing strips were used to achieve optimal proximal contacts and contour.

2. Direct Technique (U-Veneer and Ceram-X Duo)

In the direct group, shade selection for dentin and enamel was performed using the "Button Try" technique with Ceram-X Duo SphereTEC composite resin (Dentsply Sirona). Clear U-Veneer templates (Ultradent, South Jordan, Utah, USA) were trial-fitted to determine the appropriate size. Isolation was achieved with OptraGate mouth retractors.

Enamel surfaces were etched with 34% phosphoric acid gel (Caulk Tooth Conditioner Gel) for 30 seconds, rinsed, and dried. Prime&Bond Universal (Dentsply Sirona) was applied and light cured. A dentin-shade composite was applied in layers to the labial surfaces and cured. Subsequently, an enamel-shade composite was placed onto the inner surface of the U-Veneer template, which was positioned and adapted to the tooth under gentle pressure. Excess material was removed using a fine-tipped spatula (LM-Arte Applica, LM Dental, Parainen, Finland), and polymerization was completed with 20 seconds of light curing per surface (D-Light Duo). Final polishing and adjustments were performed according to the protocol described for the semi-direct group.

Evaluation and Follow-up

All restorations were evaluated at baseline (immediately after placement) and at 6-, 12-, and 18-months follow-ups by two independent examiners experienced in esthetic restorations and not involved in the study. The Modified Ryge (USPHS) criteria were used to score color match, marginal discoloration, marginal adaptation, anatomic form, secondary caries, loss of retention, surface roughness, polish retention, and postoperative sensitivity (A: excellent, B: clinically acceptable, C: clinically unacceptable / needs replacement, X: not assessable) (Table 3).

Statistical Analysis

Data was analyzed using SPSS 25.0. The McNemar test was applied to evaluate time-dependent changes within each group, while the Kolmogorov-Smirnov Z test was used for group comparisons. A significance level of $p = 0.05$ was adopted.

Table 3. Modified Ryge Criteria (USPHS Criteria)

Modified Ryge Criteria (USPHS Criteria)		
Criteria	**Scores**	**Clinical condition**
Color Match	Alpha: Bravo: Charlie:	Complete match with the tooth in terms of color, shade, or brightness. Slight mismatch within normal clinical limits. Clear mismatch or unaesthetic appearance.
Marginal Discoloration	Alpha: Bravo: Charlie:	No discoloration between restoration and adjacent tooth. Localized, superficial discoloration removable by polishing. Discoloration progressing toward the pulp level.
Marginal Integrity	Alpha: Bravo: Charlie:	No visible gap along the margin. Visible and detectable gap with a probe. Gap exposing dentin or base.
Secondary Caries	Alpha: Bravo:	No secondary caries. Presence of secondary caries.
Anatomic Form	Alpha: Bravo: Charlie:	Restoration maintains continuity with the tooth. Partially disrupted but clinically acceptable. Completely disrupted, replacement required.
Post-operative Sensitivity	Alpha: Bravo:	No sensitivity. Presence of sensitivity
Retention	Alpha: Bravo: Charlie:	Restoration is intact. Partial loss or damage present. Restoration has completely fallen out.
Surface Roughness	Alpha: Bravo: Charlie:	Surface as smooth as surrounding tooth tissue. Surface rougher than surrounding tooth. Surface shows fracture, requires replacement.
Polishing Retention	Alpha: Bravo: Charlie:	Surface has same brightness as surrounding tooth. Partially less bright in certain areas. Noticeably duller than surrounding tooth.

RESULTS

A total of 74 anterior veneer restorations were placed in 21 patients: 38 prefabricated composite veneers (Edelweiss) using the semi-direct technique and 36 direct composite veneers (U-Veneer + Ceram-X Duo SphereTEC) using the clear template–assisted direct technique. All restorations were performed according to the manufacturers' instructions, and no additional mechanical polishing was applied to the surfaces. Clinical evaluations were performed at baseline (after placement), and at 6th, 12th, and 18th months.

At the 18-month follow-up, 34 restorations from the semi-direct group and 28 restorations from the direct group were included in the statistical analysis. In the semi-direct group, 38 restorations in 10 patients were evaluated at baseline and 6 months, while 34 restorations in 9 patients were evaluated at 12 and 18 months due to one patient moving to another city. In the direct group, 36 restorations in 11 patients were evaluated at baseline, whereas 28 restorations in 8 patients were assessed at 12th, and 18th months because 3 patients could not be reached.

According to the McNemar test results evaluating time-dependent changes, a statistically significant difference was found only for the criterion of "polish retention" in both groups ($p < 0.05$).

- **Semi-direct group (Edelweiss):** Statistically significant differences were detected in all time-point comparisons except for 6th vs. 12th months ($p = 0.063$) and 12th vs. 18th months ($p=0.125$). Significant differences were observed between baseline and 6th months ($p=0.001$), baseline and 12th months ($p=0.000$), baseline and 18 months ($p=0.000$), and 6th vs. 18th months ($p=0.004$).
- **Direct group (U-Veneer + Ceram-X Duo SphereTEC):** Statistically significant differences were observed in all comparisons except for 6th vs. 12th months ($p=1.000$). Significant changes were found between baseline and 6th months ($p=0.000$), baseline and 12th months ($p = 0.004$), baseline and 18th months ($p=0.000$), 6th vs. 18th months ($p=0.008$), and 12th vs. 18th months ($p=0.016$).

In the Kolmogorov-Smirnov Z test comparing the two techniques at the same time points, no statistically significant differences were found between the groups for any of the criteria ($p>0.05$). Detailed scores according to USPHS criteria are presented in Table 4 and Table 5.

Table 4. USPHS evaluation scores obtained at each recall for the semi-direct technique performed with Edelweiss.

	Patient	1				2				3				4				5		6		7		8				9		10				11			
	Tooth #	12	11	21	22	12	11	21	22	12	11	21	22	12	11	21	22	11	21	11	21	12	22	12	11	21	22	12	22	12	11	21	22	12	11	21	22
Colour Match	Baseline	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	6 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	12 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	A	A	A	A
	18 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	A	A	A	A
Marginal Adaptation	Baseline	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	6 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	B
	12 months	A	A	A	A	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	A	A	B	B
	18 months	A	A	A	A	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	A	A	B	B
Marginal Discolorati on	Baseline	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	6 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	A	A	A	A
	12 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	B	A	A	A	A
	18 months	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	B	A	A	A	A
Surface Roughnes s	Baseline	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	6 months	B	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	12 months	B	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	A	A	A	A
	18 months	B	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	B	A	A	A	A	A
Anatomic Form	Baseline	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	6 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	A	A	A	B	B	A	A	A	B	A	A	A	A
	12 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	B	A	A	A	A
	18 months	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	B	A	A	A	A
Retention	Baseline	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	6 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	A	A	A	A	A	A	A	A
	12 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	A	A	A	A
	18 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	A	A	A	A
Caries Formation	Baseline	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	6 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	12 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	A	A	A	A
	18 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	A	A	A	A
Post-op Sensitivity	Baseline	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	6 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	12 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	A	A	A	A
	18 months	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	A	A	A	A
Polish Retention	Baseline	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	6 months	B	A	A	B	A	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	B	B	A	A	A	A	A	A	B	B	B	B
	12 months	B	A	A	B	A	B	B	A	A	A	A	A	A	A	A	A	B	A	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	A	A	A	A	B	B	B	B
	18 months	B	A	A	B	B	B	B	B	A	A	A	A	A	A	A	A	B	B	A	A	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	B	B	B	B	B	B	B	B

Table 5. USPHS evaluation scores obtained at each recall for the direct technique performed with Ceram-X Duo and U-veneer clear templates.

During follow-up appointments, polish retention scores showed a shift toward Bravo over time; in some cases, Bravo scores were also recorded for marginal adaptation/marginal discoloration and surface roughness. Although minor chipping at the incisal edge was observed in some patients, these findings were considered clinically acceptable (Bravo) (Figures- 1, 2).

Figure 1. Two different patients receiving direct anterior restorations performed with U-veneer clear templates and Ceram-X duo on teeth 11,21,12,22.

Figure 2. Two different patients receiving anterior restorations performed with prefabricated Edelweiss veneers on teeth 11,21 and 11,21,12,22

Considering the cumulative USPHS (Ryge) scores and patient-reported satisfaction, both direct composite resin veneers and prefabricated Edelweiss veneers demonstrated clinically acceptable and successful performance. For the Edelweiss group, the mean gloss score decreased from 100% Alpha to 41% at 18 months, while for the U-veneer group, it decreased from 100% Alpha to 43%. A slight loss of polished surface gloss was observed in both groups as early as the first year. However, these changes were minor; the dullness was noticeable only after air drying and did not negatively affect the patients' esthetic perception.

DISCUSSION

In this prospective clinical study, after 18 months of follow-up, both prefabricated composite veneers and direct composite veneers demonstrated success rates that confirm the clinical reliability of minimally invasive approaches. These techniques provide repairability and high patient satisfaction, supporting their role as conservative esthetic solutions. Our findings are largely consistent with randomized clinical trials and systematic reviews published over the past decade, and they contribute to building a rational framework for material selection, especially when compared with ceramic veneers.

Ceramic veneers are supported by a strong body of long-term evidence spanning 10–20 years, consistently showing excellent survival rates. The main causes of failure are fractures and marginal defects.[8–11] For example, Beier et al.[8] reported high survival up to 20 years (mostly feldspathic), while Layton and Walton confirmed clinical success up to 21 years. [9] Similarly, Peumans et al.'s[10] performed 10-year prospective study supported the long-term durability of ceramics, and Gurel et al.[11] highlighted the role of planning quality in outcomes through the using esthetic pre-evaluative temporaries. This long-term perspective provides a valuable benchmark for interpreting short to medium term composite veneer data.

However, direct comparisons between composite resin and ceramic veneers remain limited. In a split-mouth randomized clinical trial with 48 veneers and up to 10 years of follow-up, Gresnigt et al.[5] reported 100% cumulative survival for ceramics versus 75% for indirect composite resins, with all failures (debonding or fracture) occurring in the composite resin group. Surviving ceramic veneers also showed superior performance in parameters such as color match, surface roughness, and wear resistance,[5] underlining how material aging impacts clinical quality through surface integrity and plaque accumulation.

By contrast, a recent randomized clinical trial published in 2024 (120 veneers; 24 months) comparing direct composite resin veneers and indirect ceramic veneers found no significant differences in survival, with an overall survival rate of 94.2%. However, surface quality changes such as discoloration and roughness were more frequently reported in the composite resin group.[7] This study focused on multiple diastema closures, where reshaping tooth form was a key indication, and direct composite resin veneers provided predictable esthetic outcomes. Nevertheless, a two-year follow-up is insufficient to fully weigh the long-term advantages of ceramic veneers, and short to medium term equivalence should always be interpreted alongside considerations of surface stability and maintenance requirements.[7]

Our 18-month results are in line with this picture, showing satisfactory functional and esthetic outcomes, reparability advantages, and a tendency for composite resin veneers to require closer maintenance in parameters related to marginal and color stability. This supports a case-specific material selection strategy: ceramic veneers may be preferred where maximum long-term color stability and gloss are required, whereas composites are rational in cases prioritizing minimal invasiveness, single-visit treatment, cost-effectiveness, and repairability. [1–7,12]

Prefabricated composite resin veneers offer rapid esthetic rehabilitation in a single session with a minimally invasive protocol, as they provide pre-formed anatomic contours and polished surfaces. Although in vivo evidence remains limited, a 2020 clinical evaluation found no early clinical differences between prefabricated and direct composite resin veneers, with comparable performance in marginal adaptation and staining after one year.[4] Case reports and series particularly highlight their advantages in extensive malformations (e.g., amelogenesis imperfecta) or in young patients, allowing rapid esthetic restoration with minimal tissue removal.[13]

From a surface quality perspective, laboratory studies show that prefabricated composite resin veneers initially start with lower roughness and higher gloss, but under clinical conditions, brushing, acidic diets, and thermal/functional stresses inevitably lead to micro-wear.[2,6] Dederichs et al.[2] reported comparable short to medium term wear resistance for prefabricated composite resin veneers, enamel, and some ceramics, although long-term clinical correlation is still needed. Karveli et al.[6] emphasized the role of filler particle distribution and prepolymerized surface design in determining roughness and color stability. Clinically, these findings suggest that the early surface advantage of prefabricated composite resin veneers can be maintained with proper polishing protocols and patient compliance.[2–7]

In high-risk or early-age cases such as amelogenesis imperfecta, prefabricated composite resin veneers may represent an alternative to crown preparations by avoiding pulpal risks and margin exposure. Indeed, a case

report documented the use of prefabricated composite resin veneers in a young patient with amelogenesis imperfecta, demonstrating esthetic and psychosocial benefits in a single minimally invasive session.[13] This application positions prefabricated composite resin veneers as a "semi-direct" bridge between direct composite resin veneers and indirect ceramic veneers.[13]

In addition, recent single-visit case evidence has described anterior rehabilitation—including replacement of discolored composites and management of peg laterals—using prefabricated composite veneers, emphasizing minimal labial preparation, customizable contours, and chairside efficiency. While immediate esthetic integration is achievable, the authors note that longitudinal monitoring is needed to confirm stability in form and color over time, underscoring the current limitation of short follow-ups.[14]

Technique-oriented case reports further attribute practical advantages to a high degree of pre-polymerization of the veneer shell, and a micro-retentive inner surface designed to improve wetting and bonding, which together provide a mechanistic rationale for efficient single-session workflows; however, these data remain case-level and should be interpreted against longer-term ceramic benchmarks.[15]

Narrative comparisons position prefabricated composite veneers as a bridge between direct additions and porcelain laminates—thin pre-polymerized nanohybrid shells that can be trimmed and bonded with the same hybrid composite to approximate a quasi-monoblock, thus combining bondability and chairside efficiency with enhanced esthetics, while acknowledging porcelain's superior long-term gloss and color stability.[16]

Finally, clinical case literature reports a monoblock concept (cementation with the same composite) with compressive strength values comparable to enamel and symptom-free 1-year follow-up supporting short-term function and repairability in minimally prepared cases, yet still calling for controlled, longer-term studies to corroborate durability claims.[17]

Direct composite resin veneers remain the most flexible and repairable option for minimally invasive esthetic restoration. Systematic reviews and cohort studies show acceptable long-term survival, with the most frequent complications related to surface staining, roughness, and marginal integrity.[18] Studies highlighted that operator skill and technique standardization are decisive factors for success, regardless of material selection.[18,19]

Although no dedicated studies on the U-Veneer clear template technique exist, this approach can be considered a variant of direct composite veneering. The use of templates allows standardization of form, contact, and symmetry, reducing operator dependency and improving reproducibility in contouring and finishing. Therefore, outcomes with U-Veneer can reasonably be expected to parallel those of conventional direct composite resin veneers, provided similar composites, adhesives, isolation, and polishing protocols are employed. Importantly, the modern minimally invasive philosophy stresses that new techniques must be supported by evidence rather than marketing claims.[1,12]

In our study, contour standardization with U-Veneer templates improved marginal adaptation and papillary fill. Limited marginal discoloration observed at 18 months is consistent with early surface changes reported in direct composite resin studies and can usually be managed with simple polishing or refinishing.[18]

Surface gloss loss in composite resins is related to water sorption, degradation of the matrix–filler interface under thermo-mechanical stress, and increased roughness. After 10 years, Gresnigt et al.[5] reported superior performance of ceramics in surface roughness, color stability, and wear resistance. Similarly, in our 18-month follow-up, minor discolorations and roughness were observed but were manageable with non-invasive polishing techniques, reflecting the repairability advantage of composite resins.[5,18]

Surface roughness is also linked to biofilm accumulation, which can affect both esthetics and periodontal health.[5] Therefore, multi-step polishing protocols and regular recall appointments are crucial for long-term success. Although ceramics may experience glaze layer wear, their overall surface stability is superior to that of composite resins.[5]

With respect to antagonist wear, ceramics demonstrate material-dependent variability, whereas composite resins tend to be less abrasive to opposing dentition in the long term.[12] This provides a biomechanical rationale for composite resin selection in patients with bruxism tendencies or preexisting enamel loss.[12]

Similar two-year survival outcomes reported in both material groups in a recent trial confirm that composites represent a strong alternative for patients seeking cost-effective esthetic solutions in the short to medium term.[7] However, in cases where high expectations of color stability and gloss exist, or when risk factors such as smoking or pigment-rich diets are present, ceramic veneers remain the more predictable option.[5,7,20]

Taken together, our findings support a pragmatic, condition-based algorithm for veneer selection: when esthetic demands are high and durable gloss and color stability are paramount, ceramic veneers preferably bonded to enamel should be prioritized;[8–11] where minimally invasive, single-visit care, reparability, and cost-effectiveness are decisive, prefabricated or direct composite resin veneers are appropriate alternatives;[1,2,4,6,7,12,13,18] in patients with bruxism, erosive wear, or concerns about antagonist abrasion, composite

resins may confer biomechanical advantages due to their comparatively lower abrasiveness to opposing teeth.[12,20]

Ceramics continue to offer superior long-term stability in gloss and color, particularly in patients with high esthetic demands. Ultimately, clinical decisions should be tailored to each patient, balancing esthetic expectations, invasiveness, cost, and maintenance requirements.[1,5,7-12,20–23] Based on the existing literature, that if regular polishing and maintenance procedures had been included in the clinical protocol, the scores for polish retention and color stability would be better. However, we did not perform routine polishing during the follow-up sessions in order to observe the outcomes that developed over time.

Strengths of this study include its prospective design, standardized operator protocol, and the application of both semi-direct and direct techniques within the same center and under comparable indications. Limitations include the relatively short follow-up period of 18 months, which is insufficient to fully assess the long-term advantages of ceramics (10–20 years), and the absence of dedicated clinical studies on the U-Veneer template technique, requiring us to extrapolate its evidence base from the direct composite resin literature.[1,12] Although the restorations in our study were performed with the aid of templates, the restorative material was identical to the composite resin used in freehand techniques. For this reason, the articles reporting freehand composite restorations were also considered when making our comparisons. In addition, patient-specific risk factors (e.g., smoking, diet, parafunctional habits) may influence surface-related outcomes over longer periods.

CONCLUSION

Both materials showed a loss of gloss over time. Therefore, contrary to manufacturer recommendations, we advise polishing composite veneers fabricated with clear templates. In contrast, since polishing may compromise the vitrified glass-like surface of prefabricated composite resin veneers, polishing should be limited to patients with high exposure to staining agents such as coffee, tea, or tobacco; in other patients, the surfaces should be left untreated. Considering these findings, we believe that further long-term in vivo and in vitro studies are needed to achieve a more comprehensive understanding of the performance and characteristics of these materials and techniques.

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Assessment of the Knowledge and Awareness Levels of Final-Year Dental Students Regarding Molar Incisor Hypomineralization: A Cross-Sectional Study

Büyük Azı Keser Hipomineralizasyonu Hakkında Son Sınıf Diş Hekimliği Öğrencilerinin Bilgi ve Farkındalık Düzeylerinin Değerlendirilmesi: Kesitsel Bir Çalışma

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ABSTRACT

INTRODUCTION: Knowledge and awareness of molar incisor hypomineralization gained during undergraduate dental education have a direct influence on future clinical practice. This cross-sectional study aimed to evaluate final-year dental students' knowledge and awareness of MIH.

MATERIAL and METHODS: A previously validated questionnaire was administered face-to-face to fifth-year dental students. The survey assessed students' knowledge and awareness of MIH, including its diagnosis, prevalence, etiology, and management, and was structured into two sections: knowledge/awareness and clinical application. Descriptive statistics were used to analyze all responses.

RESULTS: Of the 320 eligible students, 297 participated in the study (92.8%), and all were familiar with MIH (100%). Although most students had theoretical knowledge, only 16.8% felt very confident in diagnosing MIH, and 66.3% reported difficulty distinguishing it from similar enamel defects. Yellow/brown opacities were the most frequently recognized lesions (49.5%), and 28.1% had observed MIH-like defects in teeth other than first permanent molars and incisors. Genetic predisposition was the most frequently selected etiological factor (88.6%). Composite resin was the most preferred restorative material for MIH-affected teeth, while desensitizing toothpaste (73%) and fluoride applications (70–56%) were widely chosen for sensitivity management. Nearly all students expressed the need for additional MIH-focused clinical training, particularly in diagnosis (83.8%) and treatment (82.5%).

CONCLUSION: Although final-year dental students demonstrate high awareness of MIH, gaps persist in diagnostic confidence, differentiation from similar defects, and practical clinical management.

Keywords: *Molar incisor hypomineralization, Knowledge, Awareness, Dental students*

ÖZ

GİRİŞ: Lisans düzeyindeki diş hekimliği eğitimi sırasında kazanılan büyük azı keser hipomineralizasyonu (BAKH) ile ilgili bilgi ve farkındalık, gelecekteki klinik uygulamaları doğrudan etkilemektedir. Bu kesitsel çalışmanın amacı, son sınıf diş hekimliği öğrencilerinin BAKH konusundaki bilgi ve farkındalık düzeylerini değerlendirmektir.

GEREÇ ve YÖNTEM: Daha önce geçerliliği kanıtlanmış bir anket, beşinci sınıf diş hekimliği öğrencilerine yüz yüze uygulanmıştır. Anket; BAKH'nın tanısı, prevalansı, etiyolojisi ve yönetimini kapsayan bilgi ve farkındalık düzeylerini değerlendirmiş ve iki bölümden oluşmuştur: bilgi/farkındalık ve klinik uygulama. Tüm yanıtların analizinde tanımlayıcı istatistikler kullanılmıştır

BULGULAR: Çalışmaya, katılım kriterlerine uygun 320 öğrenciden 297'si katılmıştır (%92,8) ve tüm katılımcıların BAKH hakkında bilgisi olduğu saptanmıştır (%100). Öğrencilerin çoğu teorik bilgiye sahip olmasına rağmen, yalnızca %16,8'i BAKH tanısı koyma konusunda kendini çok yeterli hissettiğini belirtmiş, %66,3'ü ise BAKH'u benzer mine defektlerinden ayırt etmede zorluk yaşadığını ifade etmiştir. Sarı/kahverengi opasiteler en sık tanınan lezyonlar olup (%49,5), öğrencilerin %28,1'i birinci daimî molarlar ve kesici dişler dışında da BAKH benzeri defektler gözlemlediğini bildirmiştir. Genetik yatkınlık en sık seçilen etiyolojik faktör olmuştur (%88,6). BAKH'lu dişlerde en çok tercih edilen restoratif materyal kompozit rezin iken, hassasiyetin yönetiminde desensitize edici diş macunları (%73) ve flor uygulamaları (%70–56) yaygın olarak tercih edilmiştir. Öğrencilerin neredeyse tamamı, özellikle tanı (%83,8) ve tedavi (%82,5) alanlarında BAKH'a yönelik ek klinik eğitime ihtiyaç duyduklarını belirtmiştir.

SONUÇ: Son sınıf diş hekimliği öğrencileri BAKH konusunda yüksek farkındalık düzeyine sahip olmakla birlikte, tanısal güven, benzer mine defektlerinden ayırt etme ve pratik klinik yönetim alanlarında eksiklikler bulunmaktadır.

Anahtar Kelimeler: *Büyük Azı Keser Hipomineralizasyonu, Bilgi, Farkındalık, Diş hekimliği öğrencileri*

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INTRODUCTION

Molar Incisor Hypomineralization (MIH) was first defined in 2001 by Weerheijm et al. as a qualitative developmental defect of enamel mineralization, characterized by demarcated opacities affecting at least one first permanent molar, with or without involvement of the permanent incisors.[1, 2] The prevalence of MIH varies considerably across studies, ranging from 2% to 40% worldwide with an estimated global prevalence of 14.2%, and between 5.2% and 14.9% in studies conducted in Turkey.[3-9] Current evidence indicates that MIH has a multifactorial etiology resulting from the interaction of systemic, genetic, and epigenetic factors.[10, 11] Therefore, MIH is considered a developmental enamel defect influenced by multiple contributing factors rather than a condition attributable to a single cause.[10, 11]

MIH is clinically characterized by the presence of enamel opacities ranging from white to yellow–brown in color, with a demarcated line between the lesion and healthy enamel depending on the severity of the condition.[12, 13] Hypomineralized enamel is susceptible to post-eruptive breakdown and hypersensitivity, and it is prone to the development of carious lesions and pain.[12, 13] The affected enamel exhibits a lower mineral density and higher protein content compared to healthy enamel, which has been shown to reduce bonding success, particularly in adhesive restorative procedures, and to complicate clinical management.[14, 15] Inadequate local anesthesia, increased sensitivity, restoration failures, and the need for repeated treatments are commonly reported clinical challenges.[16, 17] When these factors are considered collectively, MIH has been demonstrated to exert a substantial detrimental influence on both patients' quality of life and clinicians' treatment planning.[14-17]

Considering the challenges of clinical management and its adverse effects for patients, MIH is recognized as a significant public health issue.[18] Therefore, MIH should be included as a fundamental learning outcome in educational curricula. However, studies conducted in different countries indicate that awareness of MIH and competence in its clinical management among dentists and dental students are not insufficient.[19-24] In this context, assessing future dentists' level of knowledge and awareness of MIH is critical to understanding the effectiveness of current dental education and for guiding curriculum development efforts. Therefore, the aim of this study is to comprehensively evaluate fifth-year dental students' knowledge levels, clinical experiences, management perceptions, and educational needs regarding MIH; and to contribute to the existing literature and the strengthening of undergraduate dental education programmes with the findings obtained.

MATERIALS and METHODS

Study Design

The present cross-sectional observational study was conducted to evaluate the knowledge and awareness levels of fifth-year students regarding MIH at two dental faculties (Faculty of Dentistry, Izmir Katip Celebi University University and Ege University). The sampling frame consisted of all fifth-year dental students enrolled in both participating dental faculties during the 2024–2025 academic year. Students who were present during the data collection period and agreed to participate voluntarily were included in the study, whereas students who were absent during the data collection sessions or declined participation were excluded. The study was conducted with the approval of the Health Research Ethics Committee of Izmir Katip Celebi University (report no: 2024-0305), in accordance with the ethical principles of the Declaration of Helsinki and current data protection regulations.

Sample Size

The sample size was calculated using the Steven K. Thompson formula, which incorporates a finite population correction. The confidence level was set at 95% ($Z = 1.96$), the margin of error at 5% ($d = 0.05$), and the estimated prevalence at a conservative level of 0.5 ($p = 0.5$). Assuming a total population of 320 fifth-grade students were accessible, the minimum required sample size was calculated to be 175. In consideration of the 15% non-response rate, the final target sample size was determined to be a minimum of 202. In this study, the primary outcome used for the sample size calculation was defined as the proportion of students who were aware of MIH. Since no previously reported data were available for this proportion in the target population, a conservative estimate of $p = 0.5$ was used.

Data Collection

Data regarding dental students' knowledge and awareness of MIH were collected through a face-to-face questionnaire consisting of 23 closed-ended questions, including dichotomous, single-choice, and multiple-choice items (Supplementary File 1). Before beginning the questionnaire, participants were provided with an informative statement explaining the purpose and scope of the study titled *"Assessment of the Knowledge and Awareness Levels of Final-Year Dental Students Regarding Molar Incisor Hypomineralization: A Cross-Sectional Study."* This text stated that participation was voluntary, responses would be kept confidential, and students could withdraw from the study at any stage. Apart from the informative statement, the questionnaire consisted of two main sections: (1) Questions assessing students' familiarity with MIH, their sources of information, their knowledge of MIH-related etiological factors and clinical features, their level of confidence in diagnosing MIH, the difficulties experienced in

distinguishing MIH from other developmental enamel defects, the frequency of encountering such defects, and their level of knowledge regarding the prevalence of MIH in the population. (2) Questions evaluating the most preferred restorative materials for MIH-affected teeth, the factors influencing material selection, the clinical challenges encountered in the management of MIH, and the perceived need for clinical training on MIH. The terms awareness, knowledge, and diagnostic confidence in this study refer to students' self-reported familiarity with MIH, their responses to knowledge-related questionnaire items, and their perceived confidence in diagnosing MIH. These variables were evaluated descriptively based on individual questionnaire responses rather than a composite scoring system.

The questionnaire items were adapted and synthesized from previously published surveys assessing knowledge and perceptions of MIH among dental students and dentists.[19-24] The questionnaire was prepared in Turkish and reviewed by the research team to ensure clarity and relevance to the study objectives. Prior to the data collection process, a pilot study was conducted with ten fifth-year students to evaluate the clarity and readability of the questionnaire items. Based on the feedback obtained from this study, it was determined that no major modifications to the questionnaire items or response options were necessary. Since the data obtained from the pilot study did not represent the final questionnaire responses, they were not included in the study's dataset. Following the completion of the pilot phase, the questionnaires were administered face-to-face to participants between April and July 2025. The questionnaires were administered by three members of the research team. Each questionnaire was conducted by a single interviewer who read the questions aloud and recorded the responses. To ensure consistency, all interviewers followed the same standardized explanatory script during the administration of the questionnaire. Eligible students were approached in person while they were present at the faculty and were invited to participate in the study. Participation was voluntary and no incentives were provided. All responses were anonymized and stored securely in accordance with confidentiality principles. Before statistical analysis, the data were organized using Microsoft Excel (Microsoft Corp., WA, USA).

Statistical Analyses

Descriptive statistics, including frequencies and percentage distributions, were calculated for all items assessing students' knowledge and awareness related to MIH. In addition, comparative analyses were performed using the chi-square test to evaluate potential associations between selected variables (e.g., gender, exposure to MIH cases, and primary source of MIH information) and key outcomes such as knowledge of diagnostic criteria and diagnostic confidence. All descriptive analyses were performed using IBM SPSS Statistics for Windows, Version 22.0 (Armonk, NY: IBM Corp.).

RESULTS

A total of 320 students were considered eligible to participate in the study. All eligible students were approached during the data collection period. Of these, 297 students agreed to participate and completed the questionnaire, resulting in a response rate of 92.8%. Among the participants, 163 (54.9%) were female and 134 (45.1%) were male. Twenty-three students did not participate because they were either absent during the data collection sessions or declined participation. As the questionnaire was administered face-to-face, all participating students completed the survey in full, resulting in the effectiveness rate of the questionnaire was 100%.

Students' responses regarding their self-reported knowledge and perceptions of MIH are summarized in Table 1. All participants (100%) reported being familiar with MIH, and the majority (92.9%) indicated that their primary source of information was undergraduate education, followed by books (32.3%), internet sources (31.6%), and seminars (12.5%). Regarding the clinical criteria to diagnose of MIH, 66% of the students reported that they were aware of the diagnostic criteria for MIH and knew how to apply them clinically, whereas 18.2% stated that they were aware of the criteria but did not know how to implement them. Concerning the diagnostic definition of MIH, 62.3% of the students identified the condition as requiring the involvement of at least one permanent molar and one permanent incisor, 27.9% believed that only one molar needed to be affected, and 3.4% selected "at least one incisor." Knowledge levels differed significantly according to the primary source of MIH information, with students reporting undergraduate education as their main source demonstrating higher correct response rates for the diagnostic criteria question. Since all participants were final-year dental students exposed to the same curriculum, this difference may be related to individual engagement with theoretical instruction rather than differences in educational content.

Students attributed MIH to a wide range of etiological factors. The most frequently selected factor was genetic predisposition (88.6%), followed by chronic medical conditions during pregnancy (67.3%) and maternal antibiotic use (63.3%).

Students' self-reported confidence in diagnosing MIH exhibited significant variation. 16.8% of respondents reported being "very confident," while 66.3% indicated "confident," 14.5% reported "slightly confident," and 2.0% stated ''no confidence''. Two-thirds of the participants (66.3%) reported difficulty differentiating MIH from other dental conditions. Among

these, enamel hypoplasia (54.8%), amelogenesis imperfecta (35.3%), and dental fluorosis (19.9%) were the most frequently cited challenging differential diagnoses.

The majority of students (82.8%) reported being aware of the estimated MIH prevalence in Turkey and 94% expressed agreed that investigating national prevalence would be valuable. With respect to clinical exposure, 32.7% stated that they had never encountered MIH during their clinical training, while 35.4% encountered MIH annually and 23.2% monthly. When the appearance of the lesions was evaluated, yellow/brown opacities (49.5%) were the most frequently selected option. Additionally, 28.1% of the participants reported that demarcated opacities were also observed in teeth other than the first permanent molars and incisors, most commonly in second permanent molars (12.5%), premolars (12.1%), permanent canines (11.4%), and 6.7% primary molars.

Table 1: Students' responses on knowledge, attitudes and believes towards MIH diagnosis and prevalence

	Question		N (%)
Q1	Are you familiar with MIH?		
		Yes	297 (100%)
		No	0 (0%)
-	If yes, how did you hear about it?†		
		Undergraduate education (Lectures, Clinical Observations)	276 (92.9%)
		Books	96 (32.3%)
		Dental Courses	31 (10.4%)
		Seminar	37 (12.5%)
		Internet	94 (31.6%)
		Dental journals	16 (5.4%)
		Brochures	3 (1%)
		Others	3 (1%)
Q2	Do you know if there are clinical criteria to diagnose MIH?		
		Yes, and I know how to implement them	196 (66%)
		Yes, but I don't know how to implement them	54 (18.2%)
		No, I have no idea at all.	47 (15.8%)
Q3	Which teeth must be affected for the diagnosis of MIH?		
		At least one molar and one incisor	185 (62.4%)
		At least one molar tooth	83 (27.9%)
		At least one incisor tooth	10 (3.4%)
		All incisors + at least one molar	10 (3.4)
		No idea	9 (3%)
Q4	Which factor(s) do you think are involved in the etiology of MIH?†		
		Genetic factors	263 (88.6%)
		Chronic medical conditions affecting the mother during pregnancy	200 (67.3%)
		Antibiotics/medications taken by the mother during pregnancy	188 (63.3%)
		Chronic medical conditions affecting the child	160 (53.9%)
		Antibiotics/medications taken by the child	158 (53.2%)
		Acute medical conditions affecting the mother during pregnancy	140 (47.1%)
		Acute medical conditions affecting the child	113 (38.8%)
		Environmental pollutants	112 (37.7%)
		Fluoride exposure	102 (34.3%)
		I have no idea	6 (2%)
		None of these	3 (1%)
Q5	How confident do you feel when diagnosing MIH?		
		Very confident	50 (16.8%)
		Confident	198 (66.3%)
		Slightly confident	43 (14.5%)
		Not confident at all	6 (2%)
Q6	Do you have difficulty distinguishing MIH as a developmental defect of enamel that differs from other tooth		

	conditions?		
		Yes	197 (66.3%)
		No	100 (33.7%)
-	If yes, which ones? †		
		Dental fluorosis	59 (19.9%)
		Enamel hypoplasia	163 (54.8%)
		Amelogenesis imperfecta	105 (35.3%)
		Dentinogenesis imperfecta	29 (9.8%)
		Others	0 (0%)
Q7	Are you aware of the prevalence of MIH in Turkey?		
		Yes	246 (82.8%)
		No	51 (17.2%)
Q8	Where do you estimate the prevalence of MIH in Turkey to be?		
		<10%	100 (32.7%)
		10%-25%	181 (60.9%)
		>25-50%	16 (5.4%)
Q9	Do you think it would be worthwhile investigating the prevalence in Turkey?		
		Yes	279 (94.0%)
		No	18 (6%)
Q10	How often do you see teeth with MIH in your clinical courses?		
		Never seen	97 (32.7%)
		Weekly basis	25 (8.4%)
		Monthly basis	69 (23.2%)
		Yearly basis	105 (35.4%)
Q11	Which of the following features do you most frequently notice regarding severity of the defect?		
		White demarcation	118 (39.7%)
		Yellow/brown demarcation	147 (49.5%)
		Post-eruptive enamel breakdown	32 (10.8%)
Q12	In clinic, have you encountered demarcated hypomineralized defects in permanent teeth other than the first permanent molars and incisors?		
		Yes	83 (28.1%)
		No	212 (71.9%)
-	If yes, please name the tooth/teeth†		
		Canines	34 (11.4%)
		Premolars	36 (12.1%)
		Second permanent molars	37 (12.5%)
		Primary molars	20 (6.7%)
Q13	How frequently do you notice demarcated hypomineralized lesions in the second primary molar tooth in comparison to the first permanent molar tooth?		
		More frequently	33 (11.1%)
		Less frequently	102 (34.3%)
		The same as for the first permanent molar	22 (7.4%)
		Never seen it	138 (46.5%)

†Multiple choices were allowed
MIH: Molar Incisor Hypomineralization

Table 2: Knowledge, attitudes, and beliefs on management and education need of students towards MIH

	Question		N (%)
Q14	Do you think MIH is a clinical problem?		
		Yes	251 (84.5%)
		No	46 (15.5%)
-	If yes, what do you experience problems with? †		
		Diagnosis	161 (64.1%)
		Esthetics	165 (65.7%)
		Achieving adequate local anesthesia	133 (53%)
		Providing adequate restorations	145 (57.8%)
		Long-term success of restorations	171 (68.1%)
		Achieving patient comfort (for function, oral hygiene)	85 (33.9%)
Q15	Considering your clinical courses, have you observed that these teeth require retreatment?		
		Yes	150 (50.5%)
		No	147 (49.5%)
Q16	Which factors influence your choice of restorative material? †		
		Adhesion	224 (75.4%)
		Esthetics	223 (75.1%)
		Patient/parent preference	81 (27.3%)
		Durability	239 (80.5%)
		Remineralization potential	170 (57.2%)
		Sensitivity	188 (63.3%)
		Personal experience	99 (33.3%)
		Research findings	80 (26.9%)
Q17	Which material do you use MOST in treating MIH teeth? †		
		Amalgam	5 (1.7%)
		Composite resin	176 (59.2%)
		Flowable composite resin	82 (27.6%)
		Indirect Restorations (inlay/onlay)	104 (35 %)
		Compomer	125 (42.1%)
		Glass Ionomer/Resin Modified Glass Ionomer Cement	136 (45.3%)
		Preformed crowns	110 (37%)
		ICON/Resin Infiltration	101 (34.4%)
		Desensitizing toothpaste	132 (44.4%)
		Fluoride treatments (gel/varnish)	165 (55.6%)
		Others	0 (0%)
Q18	What are your choices for sensitivity management in MIH? †		
		Amalgam	1 (0.3%)
		Composite resin	67 (22.6%)
		Flowable composite resin	31 (10.4%)
		Indirect Restorations (inlay/onlay)	17 (5.7%)
		Compomer	37 (12.5%)
		Glass Ionomer/Resin Modified Glass Ionomer Cement	38 (12.8%)
		Preformed crowns	20 (6.7%)
		ICON/Resin Infiltration	27 (9.1%)
		Desensitizing toothpaste	218 (73.4%)
		Fluoride treatments (gel/varnish)	208 (70%)
		Others	0 (0%)
Q19	What are your preferred restorative materials for cavitated MIH-affected anterior teeth? †		

	Amalgam	1 (0.1%)
	Composite resin	223 (75.1%)
	Flowable composite resin	122(41.1%)
	Indirect Restorations (Inlay/onlay)	58 (19.5%)
	Compomer	117 (39.4%)
	Glass Ionomer/Resin Modified Glass Ionomer Cement	79 (26.6%)
	Preformed crowns	56 (18.8%)
	ICON/Resin Infiltration	60 (20.2%)
	Desensitizing toothpaste	62 (20.9%)
	Fluoride treatments (gel/varnish)	55 (18.5%)
	Others	0 (0%)
Q20	What are your preferred restorative materials for cavitated MIH-affected posterior teeth? †	
	Amalgam	16 (5.4%)
	Composite resin	220 (74.1%)
	Flowable composite resin	111 (37.8%)
	Indirect Restorations (Inlay/onlay)	115 (38.7%)
	Compomer	139 (46.8%)
	Glass Ionomer/Resin Modified Glass Ionomer Cement	136 (45.8%)
	Preformed crowns	133 (44.8%)
	ICON/Resin Infiltration	73 (24.6%)
	Desensitizing toothpaste	56 (18.9%)
	Fluoride treatments (gel/varnish)	54 (18.1%)
	Others	0 (0%)
Q21	Would you suggest including clinical training regarding MIH in your dental course?	
	Yes	297 (100%)
	No	0 (0%)
Q22	If yes, in which area(s) do you think you need to know/be taught about the most? †	
	Diagnosis	249 (83.8%)
	Etiology	174 (58.6%)
	Treatment	245 (82.5%)
	Prevention	106 (35.7%)
Q23	Would you refer a child showing signs of MIH to a pediatric dentist?	
	Yes	290 (97.6%)
	No	7 (2.4%)

†Multiple choices were allowed
MIH: Molar Incisor Hypomineralization

The responses given by students with regard to treatment preferences, clinical challenges associated with MIH, and educational needs are summarized in Table 2. The majority of participants (84.5%) considered MIH to be a clinical problem, identifying long-term restoration success (68.1%), and esthetic concerns (65.7%) as the most prominent problems. Students reported durability (80.5%), adhesion (75.4%), esthetics (75.1%), and sensitivity management (63.3%) as the most influential factors in selecting restorative materials for MIH-affected teeth.

The majority of students expressed a preference for composite resin in the management of MIH-affected teeth, with flowable composite and compomer also being frequently selected. Resin-modified glass ionomer cement showed a comparable level of use,, whereas preformed crowns were chosen more often in posterior lesions than for anterior ones. For sensitivity management, desensitizing toothpaste (73%) and fluoride treatments (70–56%) were the most commonly reported options. In cavitated anterior teeth, composite resin remained the dominant material (75%), whereas in cavitated posterior teeth it was again the primary choice (74%) with increased use of compomer, RMGIC, and preformed crowns. Amalgam demonstrated consistently minimal preference across all situations (≤5%).

Interest in MIH education, all students (100%) indicated that MIH-related clinical training should be included in the curriculum. The areas in which students felt they most needed additional instruction were diagnosis (83.8%) and treatment (82.5%), followed by etiology (58.6%) and prevention (35.7%). Almost all respondents (97.6%) stated that they would refer a child exhibiting MIH symptoms to a pediatric dentist.

Additional comparative analyses were conducted to further explore associations between selected variables. No statistically significant difference in MIH knowledge was observed between female and male students (χ^2 test, $p = 0.082$). However, students who reported encountering MIH cases more frequently demonstrated significantly higher diagnostic confidence (χ^2 test, $p < 0.001$). Clinical exposure to MIH was also significantly associated with correct identification of diagnostic criteria (χ^2 test, $p < 0.01$). Furthermore, knowledge levels differed significantly according to the primary source of MIH information, with students reporting undergraduate education as their main source demonstrating higher correct response rates in identifying the diagnostic criteria for MIH (χ^2 test, $p < 0.05$).

DISCUSSION

Molar Incisor Hypomineralization (MIH) is a developmental enamel defect that poses significant challenges in clinical management and can negatively affect patients' quality of life.[14,25,26] Early diagnosis and preventive approaches may help reduce long-term treatment costs and the overall burden on public health.[25,26] Therefore, evaluating the knowledge and awareness of dental students regarding MIH is important for identifying educational gaps and improving dental curricula.

This study is one of the first to comprehensively assess the knowledge, attitudes, clinical experience/observations, and educational needs of fifth-year dental students in Turkey regarding MIH. The high participation rate compared and the 100% completion rate of the questionnaires are noteworthy with similar studies.[19-24] These outcomes are likely related to the face-to-face administration of the questionnaire. The survey was implemented using a digital format while the questions were read aloud by a researcher and the responses were recorded directly, which helped minimize incomplete responses and participant drop-out commonly observed in self-administered online surveys.[19-24] In addition, this approach ensured standardized delivery of the questions and allowed immediate clarification when needed.

When the results of this study were analyzed, the fact that all participating students had heard of the term MIH suggests that they are familiar with the concept of the condition. This finding is largely consistent with the results of studies conducted in various countries. For example, Hamza et al. in Switzerland reported 100% familiarity among students, while Tarazona-Valero et al. in Spain reported 97%, Gunay et al. in Turkey reported 98.1%, and Elhennawy et al. in Germany reported 97% familiarity with MIH.[19, 22-24] In contrast, studies conducted in Egypt showed lower levels of awareness, with El-Sheikh et al. reporting 70.7% and Yehia et al. reporting 69.2%.[21, 22] The lowest familiarity rate was reported in Saudi Arabia by Silva et al., where only 28.4% of students had heard of the term MIH.[27] Although MIH has been recognized in the dental literature for approximately 25 years,[1] its systematic integration into university curricula and the corresponding improvement in students' knowledge levels through academic instruction is a gradual process. The differences observed between countries may be attributed to how extensively MIH is covered in dental education programs and to the fact that the studies were conducted in different periods. At the universities where the present study was conducted, MIH is included in the pediatric dentistry curriculum at different class levels—specifically in the second year at Izmir Katip Celebi University and in the fourth year at Ege University. This inclusion in the curriculum is considered a contributing factor to the high level of awareness observed among the students.

Sixty percent of the students in this study estimated the prevalence of MIH in Turkey to be approximately 10–25%. This finding is broadly consistent with both the global average prevalence and previously reported prevalence ranges in Turkey (5–15%).[6-9] This findings suggests the students' responses regarding prevalence were broadly consistent with established epidemiological data. However, approximately 32% of the students reported that they had *never* encountered MIH in the clinic, and approximately 35% stated that they saw only one patient per year. This indicates that their clinical exposure to MIH is relatively limited. Similar observations have been reported in studies conducted in Germany, Switzerland, and Egypt, where students rarely encounter MIH in clinical settings.[19, 20, 22, 23] Although MIH is a relatively common condition,[6] students' limited clinical familiarity may be attributed to to difficulties in recognizeing MIH-affected patients are routinely assigned to students for treatment. Taken together, these findings highlight a gap between theoretical knowledge and clinical practice. Supporting this interpretation, present study revealed that clinical exposure to MIH cases was significantly associated with correct identification of diagnostic criteria, suggesting that increased clinical experience may contribute to improved diagnostic understanding.

In this study, most students identified genetic factors as the most important contributors to MIH etiology, followed by maternal medical conditions, medication use during pregnancy, and childhood illnesses. These findings closely parallel those from studies conducted in

Germany, Switzerland, Saudi Arabia, and Spain.[19, 21, 22, 27] The literature consistently emphasizes that MIH has a multifactorial etiology shaped by interactions among prenatal, perinatal, and postnatal factors, and the fact that students selected multiple contributing factors reflects this understanding.[8-10, 12]

Although most students reported having heard of MIH, their self-reported confidence in applying this knowledge clinically was relatively limited**.** Sixtysix percent of the students reported being aware of the diagnostic criteria for MIH and knowing how to apply them clinically, a substantial proportion either reported being unable to apply the criteria (18.2%) or had no knowledge of them (15.8%). The proportion of students who felt "very confident" in diagnosing MIH was only 16.8%. These findings are consistent with reports from Switzerland and Germany, where more than 80% of students expressed lack of confidence in diagnosing MIH,[19, 23] and parallel results from Egypt, Switzerland, Germany, and Spain, where "very confident" rates were below 20% and the proportion of students familiar with diagnostic criteria generally remained below 30%.[19, 20, 22, 23] This lack of confidence may be influenced by MIH's heterogeneous clinical presentation, its potential confusion with other enamel and dentin developmental defects, and the limited clinical exposure experienced by students. In addition, further comparative analysis performed in this study showed that students who reported encountering MIH cases more frequently demonstrated significantly higher diagnostic confidence. This finding supports the interpretation that limited clinical exposure may be an important factor underlying students' lower confidence in diagnosing MIH.

Supporting these findings, the present study also showed that most students reported difficulty distinguishing MIH from other developmental enamel defects. The anomalies most frequently confused with MIH were enamel hypoplasia, dental fluorosis, and amelogenesis imperfecta. This findings are consistent with previous reports in the literature. For example, in Spain, dental fluorosis (49.3%) and enamel hypoplasia (29.1%)were most frequently confused with MIH; in Germany, enamel hypoplasia (47%), amelogenesis imperfecta (48%), and fluorosis (34%); in Switzerland, amelogenesis imperfecta (58%), enamel hypoplasia (49%), and fluorosis (23%); and in Egypt, enamel hypoplasia (58%), amelogenesis imperfecta (27.6%), and fluorosis (18.6%) have been reported as the anomalies most commonly mistaken for MIH.[19–23] This consistency indicate that MIH diagnosis cannot be reliably achieved through theoretical knowledge alone. Approximately two-thirds of the dental students identified yellow–brown opacities as the most frequently observed defect. Previous studies have suggested that such lesions are less likely to be confused with fluorosis, enamel hypoplasia, or early carious white-spot lesions, which may explain this finding.[19–23] Conversely, post-eruptive enamel breakdown was reported as the least frequently observed condition, possibly due to its masking by caries or atypical restorations. Taken together, these findings emphasize that MIH education should not be limited to theoretical instruction. Integrating practice-oriented approaches—such as case-based learning, diagnostic scenarios supported by clinical photographs and videos, standardized clinical examples, and structured observation forms—into the curriculum is likely to play a critical role in improving diagnostic confidence.

In the present study, only 28.1% of the students reported that MIH-related demarcated opacities may occur in permanent or primary teeth other than the first permanent molars and incisors. This finding indicates that a substantial proportion of students still perceive MIH as a condition limited strictly to its typical tooth locations. When compared internationally, the proportion reported in the present study is similar to that observed in studies conducted with dental students in other countries.[19–23,27] Among students who stated that they observed MIH-like lesions beyond the first permanent molars and incisors, 12.5% identified second permanent molars, 12.1% premolars, 11.4% canines, and 6.2% primary molars. The relatively similar frequencies across these tooth groups suggest that this knowledge may be derived more from theoretical instruction than from clinical experience.

A high proportion of students (84.5%) reported that MIH presents significant clinical challenges. The most frequently highlighted concerns were long-term restoration failure, esthetic problems, and hypersensitivity. MIH-affected enamel is characterized by lower mineral density, higher protein content, and an acid-resistant irregular surface, all of which reduce the ability to achieve reliable bonding with restorative materials and consequently diminish treatment success.[18, 25, 26] This findings are consistent with the difficulties and treatment trends reported in contemporary literature on MIH management.[18,25,26] Structural differences from sound enamel, the inflammatory response of the dentin–pulp complex, and the increased difficulty in behavior management in pediatric patients collectively reflect the scientific basis of the clinical challenges described by the students.

When students were asked which material they most commonly use in the treatment of MIH-affected teeth, without specifying lesion characteristics or clinical context, a wide and relatively homogeneous range of materials was selected. Composite restorations and fluoride applications were among the most frequently chosen options. However several other materials—including glass ionomer/RMGIC, desensitizing toothpastes, compomer, prefabricated crowns, indirect restorations, and ICON infiltration were also selected at relatively high rates. This broad distribution likely reflects the absence of information regarding lesion

severity, enamel integrity, or clinical needs, which may have prompted students to default to general restorative strategies rather than MIH-specific decision-making. However, when students were asked about their treatment approaches for hypersensitive non-cavitated teeth and for cavitated MIH lesions in the anterior and posterior teeth, a clearer pattern emerged. For non-cavitated but hypersensitive teeth, students most frequently preferred remineralization agents and desensitizing toothpastes. This aligns with minimally invasive approaches reported in the literature.[25, 26, 28] For cavitated lesions in both the anterior and posterior teeth, composite resin restorations were most frewuently preferred option. The strong preference composite resin is likely related to their familiarity with this material.

Current studies and systematic reviews indicate that stainless steel crowns achieve significantly higher success rates than composite restorations in posterior MIH cases with post-eruptive breakdown.[29-31] However, in the present study, students selected this option considerably less frequently than composite resin restorations. This finding may be ttributed to the limited exposure and insufficient hands-on training during their education. Although remineralization agents were commonly preferred for hypersensitive teeth, students' tendency to choose restorative approaches rather than contemporary minimally invasive options, such as resin infiltration or microabrasion suggests gaps in their knowledge in this area. These clinical preference patterns further supports students' strong demand for more MIH-focused clinical training and their identification of diagnosis and treatment as the areas in which they feel the greatest need for instruction. Similarly, the high rate at which students reported referring children with MIH to a pediatric dentist indicates limited confidence in managing MIH cases and highlights perceived deficiencies in this area.

The present study provides valuable insights into dental students' knowledge and awareness of molar incisor hypomineralization, as it evaluates these aspects through a face-to-face questionnaire format. However, the study also has certain limitations. First, as it was conducted at a single city, the findings may not fully represent dental students across Turkey. Second, as with all questionnaire-based studies, students may have provided responses they believed were expected of them. Future studies that incorporate standardized clinical photographs or videos to objectively assess students' diagnostic accuracy and treatment-planning skills would yield more reliable and robust results. In addition, because the questionnaire was administered anonymously and no institutional identifiers were collected, responses could not be analyzed separately by university, which may limit the assessment of potential institutional differences.

CONCLUSION

The findings of this study indicate that final-year dental students report familiarity with the theoretical aspects of MIH, however, their levels of understanding and awareness regarding diagnosis, differential diagnosis and clinical management need further improvement. Given the limited clinical exposure to MIH cases, it is suggested that dental curricula be strengthened by incorporating more clinical practice, case-based learning, and training focused on differential diagnosis.

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Knowledge, Attitudes, and Practices of Dental Students and Dentists on Hepatitis B Infection, Infection Control, and Vaccination: A Cross-Sectional Study

Hepatit B Enfeksiyonu, Enfeksiyon Kontrolü ve Aşılanmaya Yönelik Diş Hekimliği Öğrencilerinin ve Diş Hekimlerinin Bilgi, Tutum ve Uygulamaları: Bir Kesitsel Çalışma

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ABSTRACT

INTRODUCTION: Dental clinics pose unique risks for transmission of infection, particularly bloodborne pathogens such as hepatitis B virus (HBV). Ensuring that students have sufficient knowledge of and adherence to infection control protocols is critical for the safety of patients and healthcare providers. The aim of this study is to evaluate and compare the knowledge levels of infection control and practices of dental students at a university in Turkey, with a particular focus on HBV awareness and prevention.

MATERIAL and METHODS: This cross-sectional study included 125 dental students from Muğla Sıtkı Koçman University and 35 practicing dentists in Muğla, Turkey. Participants voluntarily completed a 23-item structured questionnaire covering sterilization, usage of personal protective equipment, HBV transmission, and vaccination. Chi-square and independent t-tests were used for comparisons.

RESULTS: A total of 160 volunteers including 125 dentistry students and 35 graduate dentists, participated in the study. Awareness of primary transmission routes was high (n=129; 80.1%). Although 84 (52.5%) participants changed masks and gloves after treating each patient, students replaced masks less frequently than graduates (p<0.05). Only 24 (15%) recognized Mycobacterium tuberculosis as the most likely airborne pathogen, with graduates scoring significantly higher (p<0.05). Moreover, 74 (46.25%) identified autoclaving as the most suitable sterilization method in dentistry, yet graduates showed significantly greater knowledge regarding autoclave use (p<0.05). Graduates' knowledge and compliance scores were also significantly higher than those of fifth-year students (p<0.05). While 65 (40.6%) had not received HBV vaccination, only 33 (20%) gained immunity after vaccination; both vaccination and immunity rates were significantly higher among graduates (p<0.05). Awareness of HBV transmission and airborne disease control was limited in both groups, with students scoring significantly lower. Overall knowledge was moderate.

CONCLUSION: This study indicates that infection control practices are particularly insufficient among dental students, and awareness regarding HBV remains limited. These findings underscore the importance of reinforcing training on infection prevention throughout the dental curriculum, integrating theoretical knowledge with practical training, and ensuring that students are adequately protected by the institution until sufficient vaccination awareness and coverage are achieved.

Keywords: *Dental Education, Dental Student, Hepatitis B Infection, Infection Control, Knowledge level, Vaccination*

ÖZ

GİRİŞ: B virüsü (HBV) gibi kan yoluyla bulaşan patojenler açısından enfeksiyon bulaşması için özgün riskler taşımaktadır. Öğrencilerin enfeksiyon kontrol protokollerine ilişkin yeterli bilgiye ve uyuma sahip olmaları, hasta ve sağlık çalışanı güvenliği için kritik öneme sahiptir. Bu çalışmanın amacı, Türkiye'deki bir üniversitede diş hekimliği öğrencilerinin enfeksiyon kontrol bilgisi ve uygulamalarını, özellikle HBV farkındalığı ve önlenmesi açısından değerlendirmek ve karşılaştırmaktır.

GEREÇ ve YÖNTEM: Bu kesitsel çalışmaya, Muğla Sıtkı Koçman Üniversitesi'nden 125 diş hekimliği öğrencisi ve Muğla'da görev yapan 35 pratisyen diş hekimi dâhil edilmiştir. Katılımcılar, sterilizasyon, kişisel koruyucu ekipman (KKE) kullanımı, HBV bulaş yolları ve aşılama konularını içeren 23 maddelik yapılandırılmış bir anketi gönüllü olarak doldurmuştur. Karşılaştırmalarda Ki-kare ve bağımsız t-testi kullanılmıştır.

BULGULAR: Toplam 160 gönüllü, 125 diş hekimliği öğrencisi ve 35 mezun diş hekimi çalışmaya katılmıştır. Temel bulaşma yollarına ilişkin farkındalık yüksek bulunmuştur (n=129; %80,1). Katılımcıların 84'ü (%52,5) her hastanın tedavisinden sonra maske ve eldivenlerini değiştirmesine rağmen, öğrenciler maskelerini mezunlara kıyasla daha az sıklıkla değiştirdiği görülmüştür (p<0,05). Katılımcıların yalnızca 24'ü (%15) en yüksek olasılıkla hava yoluyla bulaşan patojenin Mycobacterium tuberculosis olduğunu bilirken, mezunların bilgi düzeyi öğrencilerden anlamlı derecede yüksekti (p<0,05). Bunun yanında, 74 (%46,25) katılımcı diş hekimliğinde sterilizasyon için en uygun yöntemin otoklav olduğunu bilmektedir, ancak mezunların otoklavlama sürecinde kullanılan sterilizasyon yöntemine ilişkin bilgi düzeyi istatistiksel olarak anlamlı derecede daha yüksekti (p<0,05). Mezun diş hekimlerinin bilgi ve uyum puanları, 5. sınıf öğrencilerine kıyasla anlamlı derecede daha yüksekti (p < 0.05). Katılımcıların 65'i (%40,6) HBV aşısı yaptırmamışken, 33'ü (%20) HBV aşılaması sonrası bağışıklık kazanmıştır; bağışıklık ve aşılama oranları mezun gruplar arasında istatistiksel olarak anlamlı derecede daha yüksektir (p<0,05). HBV bulaşı ve havayolu ile bulaşan hastalıkların kontrolüne ilişkin farkındalık her iki grupta da sınırlı olup, öğrenciler anlamlı derecede daha düşük puan almıştır. Genel olarak bilgi puanı orta düzeyde bulunmuştur.

SONUÇ: Bu çalışma, enfeksiyon kontrol uygulamalarının özellikle diş hekimliği öğrencileri arasında yetersiz olduğunu ve HBV farkındalığının sınırlı kaldığını göstermektedir. Bu bulgular, enfeksiyon önleme eğitiminin diş hekimliği müfredatı boyunca güçlendirilmesi, teorik bilginin klinik pratiğinde oluşana kadar izlenmesi ve öğrencilerin yeterli aşılama farkındalığı sağlanana kadar okul tarafından korunmasının temin edilmesinin önemini vurgulamaktadır.

Anahtar Kelimeler: *Diş Hekimliği Eğitimi, Diş Hekimliği Öğrencileri, Hepatit B Enfeksiyonu, Enfeksiyon Kontrolü, Bilgi Düzeyi, Aşılama*

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INTRODUCTION

Dental practice carries a significant risk of infectious disease transmission through cross-contamination between patients, practitioners, and the clinical environment. Implementing proper infection control (IC) measures is crucial to mitigate these risks and ensure patient and provider safety.[1]

Infection control represents both a professional obligation and an ethical responsibility for dental practitioners. Patients rightfully expect a safe treatment environment, necessitating comprehensive IC education for dental students during their undergraduate training. Dental schools must incorporate evidence-based IC protocols into their curricula and ensure student compliance with immunization programs.[2-4]

Core IC measures include meticulous hand hygiene, proper use of personal protective equipment (PPE), and appropriate waste management. However, the World Health Organization (WHO) reports suboptimal compliance with hand hygiene protocols among healthcare workers.[5-8] Additional precautions are required during aerosol-generating procedures, including pre-procedural mouth rinses and rubber dam isolation. Surface disinfection with hydrogen peroxide or sodium hypochlorite solutions has proven effective in clinical settings. [9-12]

Bloodborne pathogens - particularly Hepatitis B virus (HBV), Hepatitis C virus (HCV), and Human Immunodeficiency Virus (HIV) - pose substantial occupational hazards. HBV presents the highest transmission risk in dental environments (up to 30%), with demonstrated viability on surfaces for up to one week and potential transmission through percutaneous or mucosal exposure. Vaccination remains the most effective preventive measure against HBV, offering 98-99% immunity rates. Nevertheless, vaccination coverage and awareness among dental professionals require improvement.[13,14]

It is crucial that dental students and dentists must be educated on their awareness and knowledge levels regarding HBV and clinical infection control, as well as how to protect both themselves and their patients from transmission during clinical practice. However, it has been observed that there are few studies on this topic in our country. Therefore, this study aims to evaluate the knowledge levels, attitudes, behaviors, and hepatitis B vaccination and serological statuses of dental students and dentists, who are in a high-risk group, regarding hepatitis B and clinical infection control. The study was based on the hypothesis that infection-control knowledge, attitudes, and practices would not differ significantly across participants with different professional roles (students vs. dentists), assuming that clinical exposure level rather than role identity would be the primary determinant.

MATERIAL and METHODS

This cross-sectional study was conducted at the Faculty of Dentistry, Muğla Sıtkı Koçman University (MSKU), and among practicing dentists in the city of Muğla, Turkey. Ethical approval was obtained from the Medical Sciences Ethics Committee of MSKU (Approval Date: 06/06/2024; Protocol No: 240094). Participation was voluntary, and all respondents provided informed consent.

This study included third-, fourth-, and fifth-year dental students enrolled at the Faculty of Dentistry, Muğla Sıtkı Koçman University (MSKU), as well as practicing dentists currently working in Muğla. The target population comprised all students in these three academic years. Although the aim was to reach the entire population, participation was based on voluntary consent. A power analysis was performed to determine the required sample size for four groups, with a power of 0.85 and alpha set at 0.05. Accordingly, a minimum of 137 participants was needed; however, to increase reliability, the final sample included 160 individuals.

The 23-item structured questionnaire used in this study was developed based on previously published instruments evaluating infection-control knowledge, attitudes, and behaviors among dental and medical students,[2,14] with item wording adapted to the local educational and clinical context. Content relevance and linguistic clarity were further reviewed by two experts in infection control.

Before data collection, the draft questionnaire underwent a pilot pre-test with 10 specialist dentists, who were selected because they were best suited to evaluate the clinical relevance, clarity, comprehensibility, and conceptual accuracy of the questionnaire items, in line with methodological recommendations for pilot studies.[15] Minor wording refinements were made based on the feedback obtained, and no pilot data were included in the final analysis.

During the 2023–2024 academic year, there were 135 eligible students across the third, fourth, and fifth years. Of these, 125 students participated in the study, in addition to 35 practicing dentists. Student recruitment was conducted via brochures distributed by class representatives, inviting voluntary participation in an online survey titled “Evaluation of the Knowledge, Attitudes, and Behaviors of Dental Students and Dentists Regarding Hepatitis B, Clinical Infection Control, and HBV Vaccination and Serological Status.” The survey link was sent by a researcher unaffiliated with the study team. Graduate dentists were contacted through professional networks and invited to complete the same questionnaire either in print or electronically, depending on preference and availability. Participation required acceptance of an online informed consent form at the beginning of the questionnaire. No personal identifiers were collected.

Individuals in the first and second years of dental

school, and those with less than two years of clinical experience, were excluded from the study.

The data were collected using a self-administered 23-item structured questionnaire developed based on a comprehensive literature review and guided by the six essential components of cross-infection control in clinical settings[14]: (1) use of personal protective equipment, (2) procedures following contact with contaminated materials, (3) post-exposure protocols and prophylaxis, (4) sterilization assurance and monitoring, (5) clinical waste management, and (6) standard precautions with all patients. The first three questions collected demographic data, including age, gender, academic year (for students), and professional experience (for dentists). Questions 4 and 5 focused on participants' knowledge of transmission routes in dental clinics. Question 6, presented in a multiple-choice format, evaluated attitudes and practices concerning hand hygiene. Question 7 addressed the proper use of personal protective equipment, particularly mask usage duration and glove replacement between patients. Questions 8 and 9 assessed knowledge related to airborne transmission and associated preventive measures. Questions 10 and 11 investigated participants' responses to sharps-related injuries, including both behavioral and knowledge-based aspects. Questions 12 through 14 measured knowledge regarding sterilization procedures. Questions 15 to 17 explored attitudes, behaviors, and knowledge related to Hepatitis B, including transmission and protection. Questions 18 and 19 examined awareness of medical waste management protocols. Questions 20 and 21 assessed participants' practices for reducing airborne transmission. Question 22 investigated the sources from which participants obtained their information on clinical infection control. Finally, question 23 evaluated participants' vaccination status against Hepatitis B and their awareness of their serological immunity. (Table 1).

Table 1: Questionnaire Items

Item No.	Question and Response Options
1	Age: 20–25 / 25–35 / 35–55 / >55
2	Gender: Male / Female
3	Professional experience: (Students) 3rd year / 4th year / 5th year — (Graduates) <5 years / 5–10 years / >10 years
4	Routes of infection transmission in dental clinics (multiple answers allowed): Direct/indirect contact / Bloodborne / Airborne
5	Patient group requiring stricter infection control measures: Flu, measles, enterocolitis / HIV–HBV–HCV–Tuberculosis / All patients
6	Hand hygiene practices (multiple answers allowed): Prefer alcohol-based disinfectant / Wash–disinfect after every patient / Before touching the patient / After contact with relatives or equipment
7	Do you change your mask and gloves before treating a new patient?: Only mask / Only gloves / Both
8	When should the dental chair/unit/table be disinfected? (multiple answers allowed): After HBV–HCV–HIV–TB patients / After flu, measles, enterocolitis / After all patients / Not required
9	Highest transmission risk via saliva: Tuberculosis / Influenza / HBV / Herpes simplex virus
10	Sharp-instrument injury in professional life (multiple answers allowed): Bulb broken in hand / Instrument puncture / Needle-stick during treatment / Never
11	Management after injury (multiple answers allowed): Applied pressure and dressing / Covered wound / Washed with soap and water / Cleaned with antiseptic / Went to hospital for testing / Did nothing
12	Difference between sterilization and high-level disinfection: Sterilization eliminates all microorganisms including spores that high-level disinfection cannot / High-level disinfection eliminates all microorganisms including spores that sterilization cannot
13	Most appropriate method for sterilization of dental hand instruments: Moist heat / Dry heat / Chemical disinfectants / Ultrasonic bath / All of the above
14	Method used for sterilization in an autoclave: Dry heat / Moist heat
15	Correct statements regarding HBV transmission (multiple answers allowed): Contact with blood/body fluids of infected person / Sharp injury contaminated with blood/body fluids of infected person / Sexual contact / Contaminated water / Fecal–oral route
16	Prevention of HBV infection for dentists (multiple answers allowed): Vaccination / Personal protective equipment (mask, gloves, goggles) / Avoid treating HBV-infected patients / Multivitamins / Post-exposure antibiotics / Avoid sharp injuries / Avoid contaminated water / Avoid undercooked food
17	Asymptomatic transmission statement: An HBV-infected individual may transmit without symptoms; therefore, patients without a history should be treated as potentially HBV-positive. (True / False)
18	All waste in dental clinics (packaging, masks, gloves, objects contaminated with blood/body fluids) is medical waste and must be discarded in red bags. (True / False)
19	Sharp and piercing wastes (ampoules, scalpel blades, dental syringe needles) should be stored together with other waste in red bags. (True / False)
20	Use of PPE during examination and treatment: Always / Often / Sometimes / Rarely / Never
21	Do you ask patients to rinse with mouthwash before dental treatment?: Always / Often / Sometimes / Rarely / Never
22	Primary source of information on infection control and transmission: Undergraduate courses / WHO or similar websites / Scientific articles / Social media / University seminars
23	HBV vaccination and serological status: Vaccinated / Did not check antibody titer after vaccination / Vaccine-induced protective immunity / HBV carrier

Statistical Analysis

Knowledge scores were calculated by assigning one point for each correct answer, yielding a maximum score of 18. Participants were categorized based on their academic year (3rd, 4th, 5th) or as practicing dentists. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarize participant characteristics and response patterns.

For group comparisons, the normality of data was assessed using the Shapiro–Wilk test. Independent samples t-tests were used to compare mean knowledge scores between students and graduates. One-way ANOVA or Kruskal–Wallis tests were used for comparisons among multiple academic years, depending on data distribution. Chi-square tests were employed for categorical variables such as PPE usage, awareness of airborne transmission, and HBV vaccination status. Statistical significance was set at $p < 0.05$. All analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Distribution of Participants' Demographic Characteristics

Statistical analyses were performed using Jamovi software version 2.3.23. A total of 160 individuals participated in the study, including 125 dental students (78.1%) and 35 practicing dentists (21.9%). Among the students, 55 (34.4%) were in their third year, 35 (21.9%) in the fourth year, and 35 (21.9%) in the fifth year. In terms of age distribution, 126 participants (78.8%) were between 20 and 25 years old, 31 (19.4%) were between 26 and 35 years old, and 4 (2.5%) were between 36 and 55 years old (Table 2). Statistical comparisons were made based on gender and professional experience.

Table 2. Demographic Characteristics of Participants by Gender and Study Year

Age	N (%)
20-25	126 (78.3)
25-35	30 (19.3)
35-55	4 (2.5)
Gender	
Male	73 (45.3)
Female	87 (54.7)
Occupational Experience	
Student: 3. grader	55 (34.2)
Student: 4. grader	35 (20.5)
Student: 5. grader	35 (14.3)
Graduated	21.0)

Knowledge Level of Participants' Transmission Routes

When participants were asked to identify the primary routes of infection transmission in dental clinics, 129 individuals (80.1%) correctly indicated direct and indirect contact, bloodborne transmission, and airborne transmission. There was no statistically significant difference between dental students and practicing dentists in this regard ($p > 0.05$; Table 3). A small group of participants (n = 12; 7.5%) incorrectly believed that infection could occur only through physical contact.

Regarding the question on which patient group should be managed with greater caution in infection control procedures, 114 participants (70.8%) correctly answered "all patients," reflecting adherence to standard precautions. Again, no significant difference was found based on professional experience ($p > 0.05$). However, 44 participants (27.3%) incorrectly indicated that heightened precautions were only necessary for patients with infectious diseases such as HIV, HBV, HCV, or tuberculosis.(Table 3).

Table 3: Summary of participants' responses regarding transmission routes and patient groups requiring infection control precautions in dental clinical settings

Question / Topic	Main findings	Result
Main routes of infection transmission in dental clinics	Correctly identified multiple routes (direct/indirect contact, bloodborne, airborne)	**80.1% (n = 129)**
	Only bloodborne transmission mentioned	**2.5% (n = 4)**
	Only airborne transmission mentioned	**1.9% (n = 3)**
	Incomplete or incorrect combinations	**7.5% (n = 12)**
Patient groups requiring greater caution in infection control	All patients should be treated equally with standard precautions	**70.8% (n = 114)**
	Only high-risk patients (HIV/HBV/HCV/TB)	**27.3% (n = 44)**
	Other infectious diseases (flu/measles/enterocolitis)	**1.2% (n = 2)**

Percentages were calculated over the total sample (N = 160).

Hand Hygiene and Personal Protective Equipment Usage Behaviors

Focusing on hand hygiene practices in clinical settings, 79 participants (49.4%) reported that they "wash/disinfect their hands after every patient." However, responses differed significantly by gender ($p < .001$). Female participants were significantly more likely to report proper hand hygiene compliance compared to males. Conversely, male participants showed a higher preference for using disinfectant over soap and water. These findings are presented in Table 3.

In response to the multiple-choice question, "Please mark the options that apply to you regarding hand hygiene," it was found that third-year students (32.7%) reported significantly higher use of hand sanitizer compared to practicing dentists ($p = .003$).

When asked, "Do you change your mask and gloves when treating a new patient?", 84 participants (52.5%) gave the correct answer, while 75 participants (46.9%) responded that they only change their gloves. Notably, responses varied by professional experience ($p = .034$). Fifth-year students were significantly more likely than dentists to choose the option "I only change my gloves. (Table 4)

Table 4: Summary of participants' self-reported hand hygiene behaviors and personal protective equipment practices in dental clinical settings.

Question / Topic	Main findings	Result
Hand hygiene practices	Wash/disinfect hands after every patient	**49.4% (n = 79)**
	Prefer alcohol-based disinfectants over soap and water	**23.1% (n = 37)**
	Wash/disinfect after contact with patient relatives or staff	**21.9% (n = 35)**
	Wash/disinfect before touching the patient	**5.6% (n = 9)**
Changing protective equipment between patients	Change both mask and gloves	**52.5% (n = 84)**
	Change only gloves	**46.9% (n = 75)**
	Change only mask	**0.6% (n = 1)**

Percentages were calculated over the total sample (N = 160).

Knowledge About Controlling Airborne Transmission and Behavior Preventing Airborne Transmission

When participants were asked, "In which of the following situations should the dental chair, unit, and table be disinfected before treating a new patient?", 153 participants (95.0%) provided the correct answer. However, responses differed significantly by gender ($p = .006$). Female participants were significantly more likely to select the response "I disinfect after each patient," whereas male participants more frequently chose alternative options.

In response to the question "Which agent carries the highest risk of transmission?", only 24 participants (15%) correctly identified the appropriate pathogen. Interestingly, 69 participants (43.1%) selected herpes simplex virus (HSV), while 37 (23.1%) chose hepatitis B virus (HBV), and 30 (18.8%) chose influenza. Responses to this question varied significantly based on professional experience ($p = .002$), with practicing dentists more frequently selecting tuberculosis compared to students (Table 5).

When asked about their habits related to the use of personal protective equipment (PPE) during patient examination and treatment, 103 participants (64.4%) responded with "always." The distribution of responses differed significantly by gender ($p = .027$). Female participants were more likely to report "frequent" use of PPE, while male participants more often selected "sometimes."

Regarding the question "Do you ask your patients to gargle before dental treatment?", only 18 participants (11.3%) gave the correct answer. Additionally, 59 participants (36.9%) answered "sometimes," and 32 (20%) answered "often." There were no statistically significant differences between students and dentists in response to this question ($p > 0.05$)(Table 5).

Table 5: Summary of participants' knowledge and self-reported practices related to airborne transmission control in dental clinical settings

Question / Topic	Main findings	Result
Disinfection of dental chair/unit/table between patients	Disinfection after every patient	**95.0% (n = 153)**
	Only after HBV/HCV/HIV/TB patients	**4.4% (n = 7)**
	Only after common infections (flu, measles, etc.)	**0.6% (n = 1)**
Highest perceived transmission risk	Herpes Simplex Virus selected as highest risk	**43.1% (n = 69)**
	HBV considered high-risk	**32.1% (n = 23)**
	Tuberculosis / Influenza less frequently selected	**15.0% (n = 24) / 19.0% (n = 30)**
Use of protective equipment (gloves, masks, aprons)	Always use PPE	**64.5% (n = 104)**
	Often / Sometimes use PPE	**22.5% (n = 36) / 9.0% (n = 15)**
	Never use PPE	**2.0% (n = 3)**
Having patients gargle before treatment	Sometimes / Often	**37.0% (n = 59) / 20.0% (n = 32)**
	Never	**18.0% (n = 29)**
	Always	**11.0% (n = 18)**

Percentages were calculated over the total sample (N = 160). HBV = Hepatitis B virus; HIV= Human Immunodeficiency Virus; HCV= Hepatitis C virus; PPE = Personal protective equipment; TB = Tuberculosis.

Behavior and Knowledge Level Assessment of Sharps Injuries and Knowledge Level of Sterilization

39 participants (24.2%) reported having had an instrument puncture injury, while 30 participants (18.6%) indicated that they had sustained injuries such as a broken bulb or a needle stick during treatment when they were asked, "Have you ever experienced a sharps injury during your professional life?". Responses to this question differed significantly by professional experience ($p < .001$). Practicing dentists were significantly more likely than students to report injuries such as "a bulb broke in my hand," "a needle stuck in my hand during treatment," or "a sharp instrument punctured my hand."

In response to the question, "How did you manage the wound following an occupational injury?", 59 participants (44.7%) provided the correct answer. Additionally, 44 participants (33.3%) stated they washed the wound with soap and water, while 10 participants (7.6%) believed that no action was necessary in case of injury. There was no statistically significant difference between students and dentists in responses to this question ($p > 0.05$; Table 6).

When asked, "What is the difference between sterilization and high-level disinfection?", 138 participants (85.7%) responded correctly, whereas 23 participants (14.3%) mistakenly believed that high-level disinfection is more effective than sterilization. No significant difference was found between students and dentists in this regard ($p > 0.05$).

In response to the question, "What is the most appropriate method for sterilizing dental hand instruments?", 74 participants (46.3%) gave the correct answer. However, 49 participants (30.6%) believed that dry heat was the preferred method, and 27 (16.9%) selected "all methods are appropriate." Responses to this question did not vary significantly by professional experience.

When asked, "Which method is used for sterilization in an autoclave?", 99 participants (62.3%) responded correctly. Responses to this item showed significant variation by professional experience ($p = .004$), with practicing dentists selecting "moist heat" significantly more often than students. Gender-based differences were also observed ($p = .018$), with female participants more frequently selecting "dry heat," while male participants more often identified "moist heat" as the correct sterilization method (Table 6)

Table 6: Summary of participants' knowledge of sterilization and their self-reported practices related to sharps injuries in dental clinical settings

Question / Topic	Main findings	Result
Sharp object injuries during professional practice	Combined incidents (e.g., bulb break + instrument injury)	**32.5% (n = 51)**
	Isolated instrument-related injuries	**24.2% (n = 39)**
	No injury experience	**17.4% (n = 28)**
Management of occupational injuries	Washed with antiseptic	**44.7% (n = 59)**
	Washed with water and soap	**33.3% (n = 44)**
	Sought medical testing	**4.5% (n = 6)**
	Did nothing or only applied pressure	**~7% each (n = 20 total)**
Understanding of sterilization vs. high-level disinfection	Correct understanding of differences	**85.7% (n = 138)**
	Confused the two processes	**14.3% (n = 23)**
Preferred method for sterilizing dental instruments	Moist heat (autoclave) / Dry heat	**46.0% (n = 74) / 30.5% (n = 49)**
	Ultrasonic bath / Disinfectants	**5.0% (n = 8) / 1.0% (n = 2)**
Sterilization principle in autoclaves	Correctly identified moist heat	**62.0% (n = 99)**
	Incorrectly thought dry heat	**38.0% (n = 61)**

Percentages were calculated over the total sample (N = 160).

Knowledge Level, Attitudes, and Behaviors Regarding HBV and Participants' HBV Vaccination and Serological Status Information

When participants were presented with a question assessing their knowledge about the hepatitis B virus (HBV), only 8 individuals (5%) selected the correct answer. No statistically significant difference was observed between students and dentists in this regard ($p > 0.05$). The majority ($n = 110$) correctly identified transmission through contact with the blood and bodily fluids of infected individuals. However, misconceptions were common: 20 participants believed HBV is spread via the fecal–oral route, while 4 thought it is transmitted exclusively through sexual contact. (Figure 1).

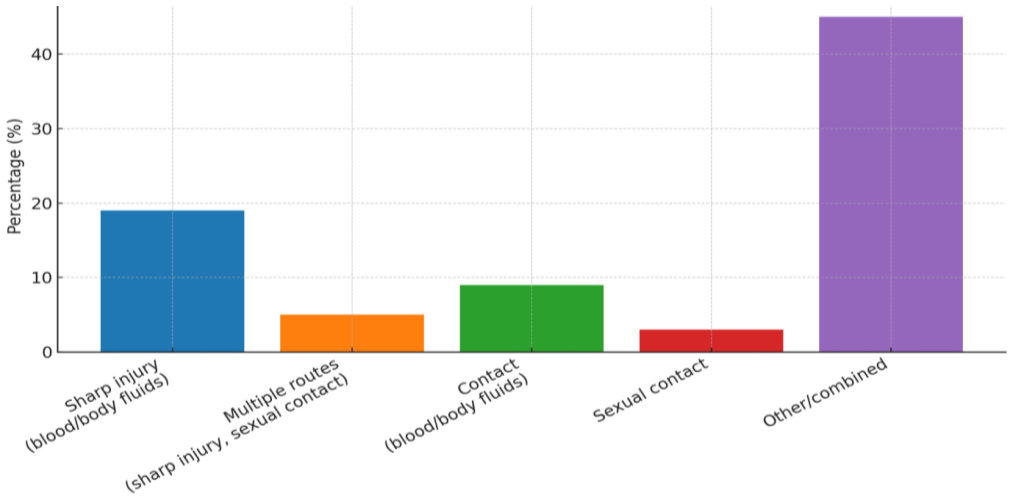

Figure 1. Distribution of participants' responses regarding HBV transmission routes.

This bar chart presents the frequency of selected responses concerning the presumed transmission routes of hepatitis B virus (HBV). A considerable proportion of participants provided combined or incorrect responses, indicating ambiguity or misconceptions, whereas only a minority accurately identified exposure to blood or body fluids from infected individuals, with or without sharp injuries, as the principal route of transmission.

When asked about protective strategies against HBV, only 55 participants responded accurately, with no significant variation between groups ($p > 0.05$). Although 133 participants (56.6%) correctly emphasized avoiding sharp object injuries, some held incorrect beliefs. Specifically, 35 considered avoiding contaminated water a preventive measure, 11 believed multivitamins were protective after exposure, 7 pointed to antibiotics, and 17 thought uncooked food posed a risk. Additionally, 68 participants inaccurately identified the fecal–oral route as a mode of HBV transmission (Table 7).

Given that HBV can be transmitted even in asymptomatic individuals, participants were asked whether patients without known hepatitis B history should still be treated as potentially infectious. Nearly all (n = 157; 98.1%) answered this correctly, with no significant difference across groups ($p > 0.05$)(Table 7).

In a follow-up question about participants' HBV vaccination and serological status, 33 (20.6%) reported having protective immunity through vaccination, whereas 65 (40.6%) indicated they had not received the vaccine. These responses differed significantly based on professional experience ($p = .001$), with practicing dentists more frequently reporting vaccine-induced immunity compared to students.(Figure 2)

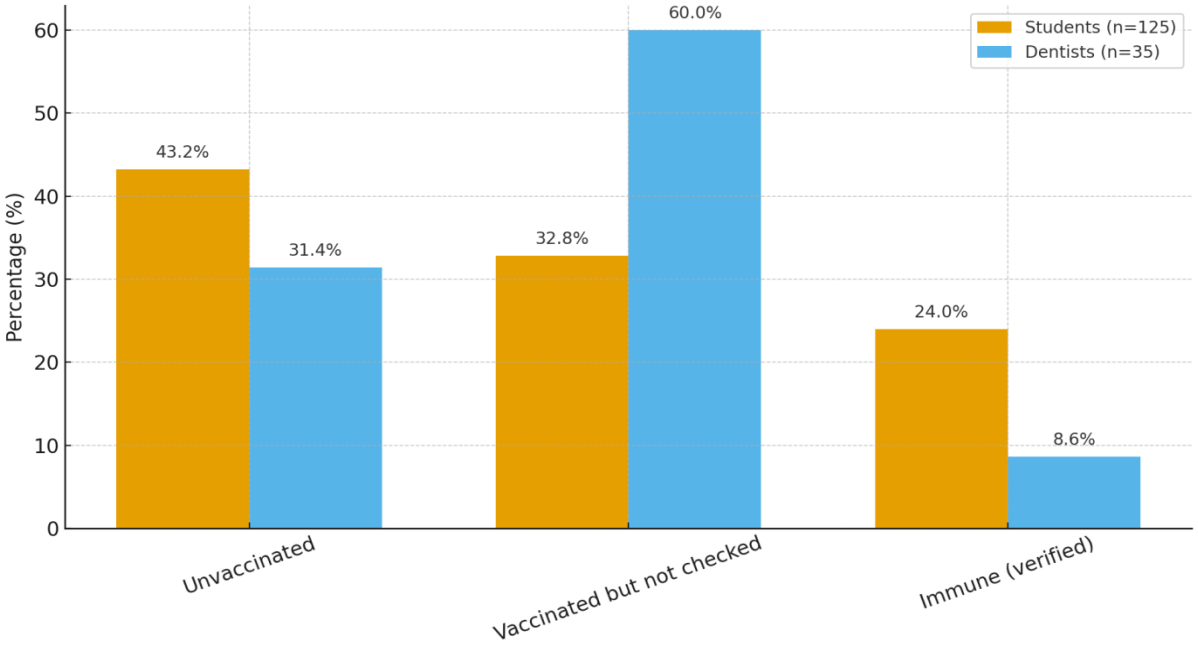

Figure 2. HBV vaccination and serological immunity status stratified by professional group.
This figure compares the vaccination history and serologically verified immunity between dental students and practicing dentists. Dentists demonstrated a higher prevalence of documented post-vaccination immunity, whereas students more frequently reported either lack of vaccination or vaccination without subsequent serological confirmation.

Table 7: Summary of participants' responses regarding protection from HBV infection and recognition of asymptomatic carriers

Question / Topic	Main findings	Result
Protective measures against HBV infection	Vaccination only	**8.0% (n = 13)**
	Vaccination + PPE	**5.0% (n = 8)**
	Vaccination + PPE + avoiding sharp injuries	**34.0% (n = 55)**
	Avoiding sharp injuries only	**0.5% (n = 1)**
	Using PPE only	**1.25% (n = 2)**
	Other combined responses	**60.25% (n = 81)**
"Asymptomatic HBV carriers can still transmit infection"	Correct (treat all patients as potentially infectious)	**98.1% (n = 157)**
	Incorrect	**1.9% (n = 3)**

Percentages were calculated over the total sample (N = 160). HBV = Hepatitis B virus; PPE = Personal protective equipment.

Knowledge Level Regarding Medical Waste Management and Participants' Information Source of Clinical Infection Control

In order to determine the waste management knowledge levels of the participants, the question was asked whether all waste generated in dental clinics (packaging waste, masks, gloves, blood and body fluids, and contaminated objects) is considered medical waste and is thrown into red bags. n the question assessing knowledge of medical waste classification, 54 participants (33.8%) selected the correct response, while 106 (66.2%) believed that all waste generated in dental practice qualifies as medical waste. There was no statistically significant difference between students and dentists in this item ($p > 0.05$).

Participants were also asked whether sharp and piercing items—such as ampoules, scalpel blades, and dental syringe needles—should be disposed of in red bags along with other waste. A total of 120 participants (75.0%) answered correctly, recognizing that these items require separate storage. Still, 40 individuals (25%) incorrectly believed that such waste does not need to be segregated. No significant difference in responses was observed based on professional experience ($p > 0.05$; Table 8).

When asked about the primary source of their knowledge regarding infection control and transmission routes, most participants (n = 132; 82.0%) reported having learned this information through undergraduate lectures. An additional 13 participants (8.1%) cited university seminars and courses. Interestingly, gender differences were statistically significant ($p = .005$), with male participants more likely than females to report social media and university-based continuing education as their main sources of information (Table 8).

Evaluation of Total Knowledge Level

Objective test scores were also used to evaluate knowledge levels across participants. For each correct answer, 1 point was awarded, and the total possible score was 18. To investigate whether the average total score differed by gender, experience, and age, independent samples t-test and Kruskal-Wallis tests were employed. "The total knowledge scores obtained by participants ranged from a minimum of 4 (22.3%) to a maximum of 14 (77.7%) out of 18. The overall mean score was M = 8.39, which corresponds to 46.61% of the total possible score. These findings reflect a moderate level of knowledge among participants regarding infection control and HBV-related practices."No significant difference in total scores was observed between male (M = 8.11) and female (M = 8.63) participants ($p = 0.075$). A statistically significant difference was found across age groups ($p = 0.038$), with the 25–35 age group scoring significantly higher (M = 9.10) than the 20–25 group (M = 8.21) ($p = 0.032$). When comparing professional experience levels, the mean scores were found to be M = 8.45 for 3rd-year students, M = 8.34 for 4th-year students, and M = 7.60 for 5th-year students, while dentists had a significantly higher mean score of M = 9.11 ($p < 0.05$) (Figure 3).

Table8: Summary of participants' responses regarding medical waste management and source of infection-control knowledge

Question / Topic	Main findings	Result
18. "All waste generated in dental clinics should be discarded in red bags."	Correct	**66.2% (n = 106)**
	False	**33.8% (n = 54)**
19. "Sharp/piercing waste (ampoules, scalpel tips, dental syringes) should be discarded in red bags with other waste."	False (correct practice: stored separately)	**75.0% (n = 120)**
	Correct	**25.0% (n = 40)**
22. Main source of knowledge on infection control	From lectures	**82.0% (n = 132)**
	From university courses/seminars	**8.1% (n = 13)**
	From scientific articles	**5.0% (n = 8)**
	From WHO/professional organization websites	**3.1% (n = 5)**
	From social media	**1.9% (n = 3)**

Percentages were calculated over the total sample (N = 160).

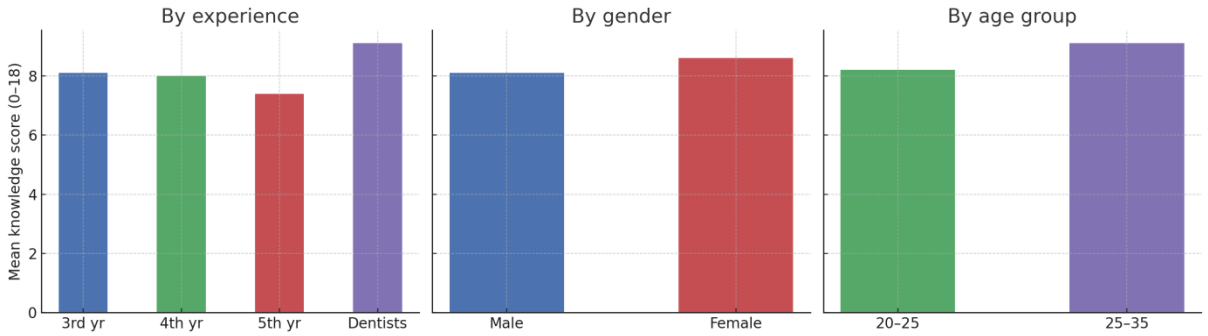

Figure 3. Mean Knowledge Scores by Experience, Gender, and Age

Bars present the mean total knowledge scores (0–18) across gender, age, and professional experience groups. No significant difference was detected between male and female participants ($p > 0.05$), whereas scores differed significantly by age and by professional experience ($p < 0.05$).

DISCUSSION

Contrary to the initial hypothesis, the findings demonstrated statistically significant differences between senior students and practicing dentists in several infection-control domains, indicating that professional role and clinical experience level do influence knowledge and behavioral outcomes

Several studies from Türkiye have examined infection control awareness and HBV-related knowledge among health-professional trainees. A multicenter study of healthcare students reported that although vaccination coverage was relatively high, it remained below national targets, and gaps persisted in HBV-related knowledge and preventive behaviors.[16] Among dental cohorts, findings are mixed but broadly consistent with our results: some studies documented variable vaccination uptake and knowledge shortfalls in dental students, while others showed high awareness of specific HBV transmission routes but still highlighted areas needing reinforcement (e.g., practical compliance, serology follow-up).[17-20] Taken together, these data suggest that the gaps we observed are not institution-specific and align with patterns reported in Turkish student populations.

While participants demonstrated general awareness of transmission routes, significant gaps persist in key areas of clinical practice. Our findings align with regional studies showing moderate knowledge levels (46.61% mean score), though they reveal concerning deficiencies in HBV understanding and preventive behaviors.

The observed 80.1% accuracy in identifying transmission routes compares favorably with studies from Saudi Arabia (51.6-58.2%), yet the 5% correct response rate for HBV-specific questions underscores substantial educational needs. This aligns with Lima-based research showing dental students' limited awareness of infection risks.[21-23] The disparity between general IC knowledge and pathogen-specific understanding suggests curricular imbalances requiring attention.

PPE compliance patterns mirrored global trends, with 64.4% reporting consistent use - higher than German cohorts (17%) but revealing gender disparities ($p<0.001$).[13] Females demonstrated better hand hygiene adherence, while males preferred alcohol-based sanitizers, particularly among junior students (32.7%, $p=0.003$). These findings support the need for gender-tailored training interventions.[24]

Environmental disinfection rates (95%) exceeded mouth rinse utilization (11%), contrasting with Saudi (55%) and Romanian studies. This discrepancy between surface and aerosol precautions highlights potential complacency regarding airborne risks - a critical concern in post-pandemic practice.[4,25]

Sharps injury reports (24.2%) fell below most literature values (31-82%), possibly reflecting underreporting. The 44.7% correct wound management rate signals urgent needs for standardized post-exposure protocols.[21-24] Sterilization knowledge showed paradoxical results: while 85.7% distinguished sterilization from disinfection, only 46.3% identified proper methods - suggesting theoretical knowledge outweighs practical application.

Hepatitis B virus (HBV) is the bloodborne pathogen with the highest transmission risk in dental settings, making accurate knowledge and preventive behavior crucial.[26-28] In our study, participants demonstrated lower knowledge regarding HBV transmission compared to previous findings.[4,29,30] A common misconception was that HBV is transmitted primarily through contact, reported more frequently than in other studies.[30]

Only 34% of participants identified appropriate protective strategies, markedly lower than rates in previous research. For instance, Kamil et al. found that 96.6% of respondents acknowledged the protective role

of HBV vaccination.[28] Similarly, knowledge regarding sharp injury prevention and PPE use was less satisfactory than reported elsewhere.[31]

Vaccination status and serological awareness were also suboptimal. While 40% of participants were unvaccinated, previous studies reported higher coverage: 85.7% in Saudi Arabia and 88.1% in Iran. Only 20.6% of our participants had protective immunity, though rates were higher among graduates.[32,33] This contrasts with findings from Kenya, where only 12.8% of healthcare workers were vaccinated, and supports calls for mandatory HBV vaccination policies in dentistry.[34]

Notably, our participants showed more positive attitudes toward treating patients with suspected hepatitis compared to earlier reports.[35] This is vital, as asymptomatic carriers may not display early signs, reinforcing the importance of universal precautions.

Finally, 82% of participants cited undergraduate education as their main source of infection control knowledge, highlighting the critical role of dental curricula. This contrasts with Saveanu et al., who found lower reliance on formal instruction.[4]

In the faculty where the present study was conducted, infection control is taught as a compulsory preclinical course within a single term and covers core domains such as transmission routes, hand hygiene, standard precautions, the use of personal protective equipment, instrument sterilization, waste management, environmental control, and post-exposure procedures; however, the moderate levels of knowledge and attitudes observed in our sample suggest that the provision of theoretical content alone does not guarantee its translation into clinical behavior. The transition from cognitively acquiring infection-control principles to consistently integrating them into routine decision-making appears to require time, reinforcement, and supervised clinical exposure, which may partly explain the present findings. This interpretation is further supported by international studies showing that incomplete adherence to hand hygiene and PPE protocols among health-science students is a recurrent finding across various countries and educational systems, even where structured training is provided.[36,37] Likewise, the substantial proportion of participants who were either unvaccinated or unaware of their HBV serostatus aligns with recent reports indicating gaps in hepatitis B protection among future healthcare professionals.[38,39] Furthermore, several studies have demonstrated that theoretical instruction alone does not ensure behavioral adherence in infection control practice without repeated reinforcement and clinically supervised integration.[40] Taken together, these converging lines of evidence indicate that the current results reflect a systemic translation gap rather than an institution-specific educational deficit.

This study has several limitations. First, it was carried out at a single institution, which may limit the generalizability of the findings. Second, reliance on a self-administered questionnaire introduces the potential for response bias and may not accurately reflect real-world clinical behavior. Although the total sample exceeded the a priori calculated size for four-group comparisons (3rd-, 4th-, 5th-year students and graduates), the graduate subgroup was relatively smaller. This imbalance is therefore regarded as an interpretive rather than a methodological limitation, as it may reduce the precision of subgroup comparisons. In addition, detailed background characteristics of dentists (e.g. year of graduation, specialty status, or alma mater) were not collected. This was consistent with the initial hypothesis that infection-control knowledge, attitudes, and practices would not vary according to experience or academic background; however, the omission of these variables precludes more granular stratified analyses within the dentist subgroup.

Future research should employ multicenter sampling with more balanced subgroup representation and use observational or performance-based assessments to complement self-report data. Longitudinal or intervention-based designs are also warranted to determine whether infection-control knowledge and attitudes can be sustained over time and effectively translated into consistent clinical practice.

CONCLUSION

Notably, although graduate dentists demonstrated higher knowledge and compliance in areas such as vaccination rates and sterilization procedures, students did not apply their theoretical knowledge at the same level in clinical practice. This finding supports the hypothesis that while professional experience enhances adherence to infection control measures, students often fail to translate learned theoretical concepts into practice to the same extent, highlighting a persistent gap between knowledge acquisition and practical implementation. The overall mean knowledge score (46.61%) underscores significant deficiencies in infection control training, emphasizing the need to strengthen curricular education, ensure effective translation of theory into practice, and provide institutional support to safeguard students until they achieve sufficient practical competency and vaccination awareness.

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Comparison of Violence Risk Factors and Anxiety Levels in Dentists

Diş Hekimlerinde Şiddet Risk Faktörleri ve Kaygı Düzeylerinin Karşılaştırılması

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ABSTRACT

INTRODUCTION: The aim of this study was to determine the characteristics of violence experienced by dentists working in different branches, the frequency of violence, the distribution of the frequency of violence by branches, the aetiological factors and the effect of violence on dentists' anxiety levels and risk factors.

MATERIAL and METHODS: A questionnaire consisting of 33 questions was applied to dentists working in public and private university hospitals, state hospitals, health centers and dental offices to evaluate the types of violence, violent groups, gender, the situation of the dentist during and after the violence and the attitude of the workplace. Anxiety levels were determined with state and trait anxiety scale forms.

RESULTS: 83.6% of dentists reported having experienced violence. Paediatric dentists were the most exposed to violence with 91.1%, followed by general dentists with 85.3%. The mean state and trait anxiety scales for dentists were 39.9 and 41.2, respectively. The highest mean violence scores were found in the 25-34 age group. It was determined that both state and trait anxiety levels increased as the frequency of experiencing violence increased.

CONCLUSION: Most of the dentists are exposed to violence. Violence increases both state and trait anxiety levels of dentists.

Keywords: *Violence, dentist, anxiety levels*

ÖZ

GİRİŞ: Bu çalışmanın amacı, farklı branşlarda çalışan diş hekimlerinin karşılaştıkları şiddetin niteliklerinin belirlenmesi, şiddete uğrama sıklıklarını, branşlara göre şiddet sıklıklarının dağılımını ve etiyolojik faktörlerin tespit edilmesi, şiddetin diş hekimlerinin kaygı düzeyine ve risk faktörlerine etkisinin belirlenebilmesidir.

GEREÇ ve YÖNTEM: Kamu ve özel üniversite hastaneleri, devlet hastaneleri, ağız ve diş sağlığı merkezleri ve muayenehanelerinde çalışan diş hekimlerine şiddet türleri, şiddeti uygulayan gruplar, cinsiyetleri, diş hekiminin şiddet esnasında ve sonrasındaki durumu ve işyerinin tutumunu değerlendirmeye yönelik 33 sorudan oluşan anket uygulandı. Durumluk ve sürekli kaygı ölçeği formları ile kaygı düzeyleri belirlendi.

BULGULAR: Diş hekimlerinin %83,6'sı şiddet gördüklerini belirtti. En fazla şiddete maruz kalan diş hekimleri % 91,1 oranı ile çocuk diş hekimleri, ardından %85,3 oranıyla diş hekimleri yer aldı. Diş hekimleri için durumluk ve sürekli kaygı ölçeği ortalamaları sırasıyla 39,9, ve 41,2 olarak bulundu. Hem durumluk hem de sürekli kaygı puanı ortalamaları en yüksek 25-34 yaş aralığında tespit edildi. Şiddet olayı yaşanma sıklığı arttıkça hem durumluk hem de sürekli kaygı düzeyinin arttığı belirlendi.

SONUÇ: Diş hekimlerinin büyük kısmı şiddete maruz kalmaktadır. Şiddet diş hekimlerinin hem durumluk hem de sürekli kaygı düzeylerini arttırmaktadır.

Anahtar Kelimeler: *Şiddet, Diş Hekimi, Kaygı Düzeyleri*

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INTRODUCTION

Violence is one of the most common causes of death that can lead to the end of human life.[1] It is one of the problems of contemporary society that affects the whole world and needs to be solved. It is a means of social gain. Aggressive behaviour is known to play a role in the development of violence, which is a destructive behaviour. The World Health Organization defines violence as "the conscious use of force against individuals and/or communities that is likely to result in physical or verbal injury, deprivation, or death."[2] Violence can be physical, verbal or passive in nature. People of all ages can commit violence; however, adolescents and young adults are more likely to be violent. It is important to remember that patients with violent tendencies often have poor coping mechanisms and suppress their anger due to social norms. When under pressure, it is more difficult to suppress these impulses. These patients may commit violence against healthcare workers due to the stressful structure of the emergency department or psychiatry unit. The basis of violent behaviour may be biological factors, pathological problems, drug use, alcohol, narcotic drugs and psychiatric disorders.[3] Biological causes include genetic disorders, hormonal imbalances, substance abuse and drug use. Psychological causes include bipolar mood disorder, schizophrenia, major depression, generalised anxiety disorder and antisocial personality disorder. Socioeconomic causes include social, economic and cultural conditions that can lead to physical violence.[1,4]

Violence can cause physical harm as well as psychological harm. Several psychological disorders, including post-traumatic stress disorder, dissociative identity disorder and borderline personality disorder, are associated with experiencing or witnessing violence. Other psychological symptoms such as depression, anxiety and mood disorders are common in victims of violence. People who experience or witness violence may develop a range of problems including anxiety, depression, insecurity, anger, poor anger management, poor social skills, pathological lying, manipulative behaviour, impulsivity and lack of empathy.[5,6]

People may be subjected to violence in the form of verbal, physical, psychological harassment, threats and abuse during their duties.[7] One of the areas where violence is most prevalent is in health care settings.[8] It has been reported that verbal violence is the most common type of violence in health care settings.[9] These attacks on health workers continue to increase and affect public health.[10] Violence is a major public health problem in both the workplace and the community, and its prevalence is increasing. Azoda et al conducted a survey to investigate violence against dentists and dental assistants and reported that the most common type of violence was verbal violence, in 2011.[11] Shouting and intimidation were found to be the most common types of violence used by patients.

Although violence is an international problem, it has become an increasing social problem in our country, especially in the field of health, which needs to be solved as soon as possible. There are many studies on violence against healthcare workers. however, there is no study that covers dentists working in all branches and that investigates the aetiological factors of violence and its effect on anxiety levels. Therefore, this study was designed to address all aspects of the violence experienced by dentists in our country and to provide solutions to this issue.

The aims of this study were to determine the characteristics of violence experienced by dentists working in different specialties, to determine the frequency of violence, the distribution of frequency of violence by specialty, aetiological factors and consequences of violence, and anxiety levels, to compare paediatric dentistry with other specialties and dentists, and to determine the impact of differences on anxiety levels and risk factors for violence.

MATERIAL AND METHODS

This descriptive and cross-sectional study was planned to determine the type, source and factors affecting the violence encountered by dentists in different branches and to determine the measures to be taken for prevention.

Place and Time of the Study

The study was conducted between 27.07.2020-27.11.2020 with dentists in different branches actively working in Turkey.

The study was conducted with dentists working in public and private university hospitals, state hospitals affiliated to the Ministry of Health, oral and dental health centers, working in their practices, randomly selected dentists who participated voluntarily in the study.

Population and Sample of the Study

All healthcare professionals constitute the population of the study. The sample of the study consists of dentists and dentists in all branches living and working in Turkey. The research group consisted of dentists who we were able to contact and who participated in the study.

Characteristics of Participants

Dentists and dental staff from different branches were included in the study, considering the inclusion and exclusion criteria.

Inclusion criteria for dentists or collaborating healthcare personnel

- Being between the ages of 18-65

- Being actively working

- Specialist dentist and dentist

- Being open to communication

- Volunteering to participate in the research

Exclusion criteria for dentists or allied health professionals

- Under 18 years of age and over 65 years of age

- Not being actively working

- Not being a specialist dentist and dentist,

Not volunteering to participate in the research.

Data Collection Tools

The following forms were used to collect data in the study:

- Diagnostic form on the descriptive characteristics of the specialist dentist and dentist (created jointly by the researcher and the consultant to collect data in the study). The study was first applied to 3 lecturers and necessary corrections were made with the feedback received.

- Form with the characteristics of the event of the attack

- State and Trait Anxiety Scale Form

-Identification Form for Descriptive Characteristics of Specialized Dentists and Dentists

This form was created for dentists or health personnel working with them.

The form for dentists included 7 questions on age, gender, marital status, education level, institution of employment, field of specialization, if any, and length of service in the profession.

Form with the characteristics of the event of the attack

The second section, which included 33 questions about information on violence in the workplace, consisted of multiple-choice questions about the types of violence, the groups perpetrating the violence and their gender, the attitude of the dentist or the health personnel working with him/her during and after the violence, and the policy of the institution.

Implementation of the Survey

The questions prepared in the study and the Spielberger State and Trait Anxiety Scale[12] were converted into an online form via Google Forms. Data were obtained by first obtaining consent from the participants. The data were collected by the researcher from dentists working in public and private university hospitals, state hospitals, oral and dental health centers and private dental offices. A link was created for the form. It was sent to the members of the Turkish Dental Association, the Chambers of Dentists and their members via e-mail and social media accounts (whatsapp, facebook and telegram groups) via the internet and the information was stored in the computer environment.

Ethical Aspects of the Study

Ethics committee permission (Meeting Date: 22/07/2020, Meeting No: 2020/17) was obtained from Izmir Demokrasi University Non-Interventional Clinical Research Ethics Committee before the start of the study. Written informed consent was obtained from the dentists who volunteered to participate in the study.

Statistical Analysis

PASS 11 (Version 11.0.8) package program was used for power analysis in sample size calculation. It was calculated that at least 404 individuals should be included to estimate the 95% confidence interval for a population frequency of 0.5 within the limits of ±0.05 (0.45-0.55) to reach the largest sample size, the proportion of exposure to violence in the target population was accepted as P=0.5 /50%).

SPSS program (SPSS Inc.version18 IBM, Chicago, IL) was used for statistical analysis of the data obtained from the study. Descriptive statistics were given as frequency and percentage. Validity and reliability analyses of the scale were performed.

Cronbach's Alpha reliability analysis was performed, and Kolmogorov-Smirnov and Shapiro-Wilk analyses were used to determine whether the scale was normally distributed. It was found that it did not show normal distribution ($p<0.05$). Mann Whitney U was used for comparison between two groups and Kruskal Wallis H was used when there were more than two groups.

Incidents of violence in dentists were statistically evaluated according to educational level, age, gender, institution of employment and professional experience. Chi-square statistics were used for the relationships between variables.

Limitations of the Study

The study was limited to dentists working in public and private health institutions including University Hospital, State Hospital, Oral and Dental Health Center in Turkey. Therefore, the results of the study represent only the dentists included in this study.

RESULTS

The results of the research are as follows.

The scores of the participants who did not answer all the scale questions were excluded from the evaluation

because they could not be calculated correctly. The survey data were evaluated with 500 dentists.

Information on Participants' Experiences Related to Violence

When the experiences of the participants regarding physical, verbal or psychological violence were analysed, it was determined that 54.2% (271) were exposed to violence 1-3 times, 14.4% (72) 4-6 times and 14.8% (74) 7-10 times while performing their duties. The rate of employees who had never been exposed to violence during their duties was 16.4% (8).

311 times by patients, 269 times by patients' relatives, 86 times by managers and 49 times by coworkers.

Dentists stated that they were subjected to violence 354 times by men and 247 times by women.

In 329 cases of violence, they reported being subjected to violence by people aged 26-45, in 187 cases by people aged 46-60, in 55 cases by people aged 18-25 and in 40 cases by people aged 61 and over.

Dentists responded that 197 of the perpetrators of violence were of medium, 153 of low and 80 of high socioeconomic status.

They reported that 145 people who had used violence against them had a medium level of education, 213 had a low level of education and 72 had a high level of education.

Participants identified 253 perpetrators as aggressive, 126 as having psychological problems, 28 as having anxiety, 8 as alcohol/substance dependent and 6 as mentally retarded.

Participants reported that 291 people inflicted verbal violence, 196 people inflicted psychological violence and 24 people inflicted physical violence on them.

The location of the violence was determined as outpatient clinic in 299 cases, office in 151 cases, emergency room in 20 cases, and laboratory in 3 cases.

The times of violence were between 08.00-16.00 in 375 cases, between 16.00-24.00 in 96 cases, between 00.00-08.00 in 39 cases, and during weekend shifts in 26 cases.

Dentists thought that the most common reason for violence was that patients felt neglected due to the psychology of the disease (238), followed by lack of communication/misunderstanding (213), patients' dissatisfaction with treatment (170), delayed treatment due to excessive workload (116), alcohol/substance abuse/personality disorder (68) and inadequate environmental conditions (46).

Dentists reported that they did not react the most (216), responded (153), reported to security (117), reported to hospital management (61), and at least used white code (35).

It was reported that 75.8% of cases of violence were not reported.

When the physicians who reported that they did not file a report after the cases of violence were asked about the reasons, they stated that they did not file a report because they thought that nothing would change and that it was unnecessary (299), that it became routine and they got used to it (67) and that they were afraid of the negative consequences (33).

84.1% of participants reported that they had not received any training on what to do in the event of violence.

After the incident of violence, 44.4% of the employees stated that they did not need help, 43.5% stated that they did not receive help/support and 12.2% stated that they received help/support.

The people who received support from the employees who participated in the study were 38.7% coworkers, 25.8% professionals, 21% managers of the organization, 11.3% family, 3.2% friends.

The rate of employees who considered quitting their job after the violent incident was 16.4%.

After the incident of violence, 84.4% of the employees continued to work without ever leaving their jobs. The rate of those who left their jobs for a few hours was 11%, 1.4% for 1 day, 1.6% for 1 week, and 1.6% for 1 month or more.

The employees who participated in the study stated that the reason for continuing to work without leaving their job after the violence was not deemed necessary by 78.6%, not being allowed to do so by the workplace by 9.7%, fear of losing their job by 7.6% and fear of being reacted by 4.1%.

In response to the question "How did the violent incident affect your relationship with patients afterwards (if the aggressor was a patient/patient relative)?", 44.6% responded "it did not affect", 20.3% responded "my attitude towards patients has changed", 19.9% responded "I am very careful and protect myself", 11.7% responded "I do not like my job as much as I used to", and 3.5% responded "I feel scared".

The responses of the employees about taking official/legal action regarding the incident of violence are as follows.

Yes, I experienced violence once and legal action was taken. 8.3

Yes, I have experienced many incidents of violence and legal action has been taken in all cases. 1.5

Yes, I have experienced many incidents of violence and some of them have resulted in legal action 5.8%.

No, I experienced 1 incident of violence, and no legal action was taken. 49.1%

No, I have experienced violence many times and no legal action has been taken. 35.3

The rate of those who continued to provide health care services to the perpetrator of violence was 34.1%. The participants who continued to provide health care services stated that 37.2% of them wanted to do so, 21.9% stated that they were forced to do so, 22.6% stated that they had to do so because there were no other physicians to provide services, and 18.9% stated that health care services were provided by another colleague they worked with in the same clinic.

In response to the question 'What factor(s) do you think causes violence? (You can choose more than one option)', the most common answer was patients' attitudes (311). This was followed by the health care system (218), all options (159) and the attitudes of service providers (49).

The rate of the dentists who felt safe while providing healthcare services was 29.9%.

In response to the question 'How would you describe the emotions you felt after being subjected to violence? (You can choose more than one option)', the participants responded anger (338), followed by rage (275), loss of trust (209), burnout (194), helplessness (141), fear of the patient (70), all (45), and self-blame (41).

The dentists thought that the most important reason for violence in health was lack of education (325). The following reasons were identified as sociocultural problems (301), all other options (265), health policies (233), economic problems (206) and media (166), respectively.

When the rate of experiencing violence during their professional life is evaluated, the youngest age group (89.8%) was the 25-34 age group (89.8%). After that, the age group reporting the highest rate of violence was the oldest group, aged 65 and over (79.2%). According to age groups, dentists who reported experiencing the least violence were in the 55-64 age group (72.7%).

A statistically significant difference was found between the groups, in the evaluation of the rates of exposure to violence according to gender ($p<0.05$). It was found that female dentists were exposed to violence 1-3 times (56.1%), 4 or more times (31.3%) and overall (87.4%) more than their male colleagues.

A statistically significant difference was found between the groups, in the evaluation of the rates of exposure to violence according to the marital status of the dentists ($p<0.05$). Single dentists (91.6%) reported that they were exposed to violence more than married dentists (79.5%).

A statistically significant difference was found between the groups in the evaluation of the rates of exposure to violence according to the type of institution in which the dentists worked ($p<0.05$). The dentists working in public institutions were found to be the most exposed to violence (94.4%), in the study.

A statistically significant difference was found between the groups in the evaluation of the rates of exposure to violence according to the branches of dentists ($p<0.05$). Among the dentists who participated in the study, 83.6% stated that they had experienced violence. Paediatric dentists were found to be the most exposed to violence with a rate of 91.1%. Dentists ranked second with a rate of 85.3%. This was followed by orthodontists (83.3%), (Table 1).

55.6% of paediatric dentists reported having been exposed to violence 1-3 times and 35.6% 4 or more times during their professional life. Paediatric dentists reported being most exposed to verbal violence (52.17%). This was followed by psychological violence (47.82%) and physical violence (4.34%). A statistically significant difference was found between the groups in the evaluation of the rates of exposure to violence according to the professional experience of the dentists ($p<0.05$). Dentists with 6-10 years of professional experience (93.5%) were the most exposed to violence. The following percentages were found to be 0-5 years (90.4%), 16-20 years (87.2%) and 21 years or more (72.7%).

Total score reliability, another type of item reliability or scale internal consistency correlations were found. It was calculated between 0.34 and 0.72 on the trait anxiety scale and between 0.42 and 0.85 on the state anxiety scale.

The mean state and trait anxiety scale was 39.90±12.34 for questions 1 to 20 and 41.23±8.73 for questions 21 to 40.

The highest mean trait anxiety score was found in the 25-34 age range (42.82±8.79) and the lowest in dentists aged 65 and over (35.00±5.62).

The mean state anxiety scores were 42.16±12.30 and 36.70±11.70 in female and male dentists, respectively. The mean state anxiety scores were higher in female dentists and the difference between them, and males was statistically significant ($P<0.05$).

The mean trait anxiety scores were 43.19 ± 8.73 and 38.37 ± 7.93 in female and male dentists, respectively. The mean trait anxiety scores were higher in female dentists and the difference between them, and males was statistically significant ($P<0.05$).

The mean state anxiety scores were 42.58±11.70 and 38.57±12.38 in single and married dentists, respectively. The mean state anxiety scores were higher in single dentists and the difference between them, and married dentists was statistically significant ($P<0.05$).

Table 1. Evaluation of the Rates of Exposure to Violence among Dentists According to Branches (n,%)

Branch	Violence			*p*
	None	1-3 times	4 and over	
Dentist (n=258)	38 (%14,7)	152 (%58,9)	68 (%26,4)	*0.004
Oral and Maxillofacial Surgeon (n=34)	10 (%29,4)	8 (%23,5)	16 (%47,1)	
Oral and Maxillofacial Radiologist (n=12)	0(0,0%)	6(50,0%)	6(50,0%)	
Paediatric Dentists (n=45)	4(8,9%)	25(55,6%)	16(35,6%)	
Endodontist (n=28)	5(17,9%)	19(67,9%)	4(14,3%)	
Orthodontist (n=30)	5(16,7%)	14(46,7%)	11(36,7%)	
Periodontist (n=39)	7(17,9%)	26(66,7%)	6(15,4%)	
Prosthodontist (n=34)	9(26,5%)	14(41,2%)	11(32,4%)	
Restorative Dentist(n=19)	4(21,1%)	7(36,8%)	8(42,1%)	
Total (n=499)	82	271	146	
	16,4%	54,3%	29,3%	

The mean trait anxiety scores were 42.79± 8.56 and 40.39± 8.71 in single and married dentists, respectively. The mean trait anxiety scores were higher in single dentists and the difference between them, and married dentists was statistically significant (P<0.05).

When scores on the state and trait anxiety scales were evaluated according to the institution of employment, the following results were obtained.

It was determined that the difference between the mean state anxiety scores was statistically significant (P<0.05). The highest mean state anxiety scores were found in dentists working in public hospitals (43.72±13.24) and the lowest in dentists working in private hospitals (38.00±13.20) or private practices (38.22±11.98). When the mean trait anxiety scores were evaluated according to the institution of employment, the difference between the institutions was not statistically significant (P>0.05).

When the state and trait anxiety scale scores were evaluated according to the branches of dentists, the difference between the averages in the comparison of both state and trait anxiety scores was not statistically significant (P>0.05). The dentists with the highest mean state anxiety scores were oral and maxillofacial radiologists (41.75±9.04), followed by paediatric dentists (41.65±11.34), prosthodontists (41.40±12.24), orthodontists (41.28±15.75), dentists (40, 03±12.29), oral and maxillofacial surgeons (39.96±10.86), periodontologists (37.74±13.08), endodontists (36.76±13.10) and the dentists with the lowest mean score were conservative treatment specialists (35.85±11.73) (Table 2).

The dentists with the highest mean trait anxiety scores were oral and maxillofacial radiologists (47.00±8.06), followed by endodontists (43.14±11.07), paediatric dentists (43.00±9.21), dentists (41.11±8.35), orthodontists (41, 10±7.52), oral and maxillofacial surgeons (40.44±7.53), periodontologists (40.38±10.01), prosthodontists (39.12±9.05) and the dentists with the lowest mean score were conservative treatment specialists (39.05±8.66).

When state and trait anxiety scale scores were evaluated based on work experience, the difference between the mean state anxiety scores was statistically significant (P<0.05). The dentists with the highest mean state anxiety score were the group with 11-15 years of experience (42.25±11.13), while the group with the lowest mean state anxiety score was the group with 21 years or more of professional experience (37.09±11.29).

The group with the highest mean trait anxiety score was the group with 0-5 years of experience (44,64± 8,74), and the group with the lowest mean state anxiety score was the group with 21 years or more of professional experience (38,66± 7,79).

Table 2. State and Trait Anxiety Scale Scores by Branches

Branches			State Anxiety Scale Scores	Trait Anxiety Scale Scores
Dentist	n		230	226
	Median		38,0000	41,0000
	Minimum		20,00	23,00
	Maximum		75,00	66,00
	Q1	25	31,0000	35,0000
	Q3	75	49,0000	47,0000
Oral and Maxillofacial Surgeon	n		33	29
	Median		40,0000	40,0000
	Minimum		22,00	27,00
	Maximum		67,00	54,00
	Q1	25	32,0000	36,0000
	Q3	75	44,5000	46,0000
Oral and Maxillofacial Radiologist	n		12	10
	Median		44,5000	46,0000
	Minimum		26,00	31,00
	Maximum		56,00	58,00
	Q1	25	32,7500	43,2500
	Q3	75	46,0000	54,2500
Paediatric Dentists	n		43	42
	Median		42,0000	43,0000
	Minimum		20,00	28,00
	Maximum		74,00	64,00
	Q1	25	33,0000	35,0000
	Q3	75	48,0000	49,0000
Endodontist	n		26	27
	Median		33,0000	43,0000
	Minimum		20,00	22,00
	Maximum		63,00	67,00
	Q1	25	28,0000	36,0000
	Q3	75	46,0000	49,0000
Orthodontist	n		28	28
	Median		41,5000	40,5000
	Minimum		20,00	28,00
	Maximum		76,00	54,00
	Q1	25	28,0000	36,7500
	Q3	75	51,0000	46,7500
Periodontist	n		35	31
	Median		37,0000	38,0000
	Minimum		20,00	28,00
	Maximum		73,00	71,00
	Q1	25	26,0000	33,0000
	Q3	75	43,0000	45,0000
Prosthodontist	n		30	31
	Median		41,0000	39,0000
	Minimum		20,00	27,00
	Maximum		69,00	64,00
	Q1	25	31,7500	34,0000
	Q3	75	51,0000	42,0000
Restorative Dentist	n		14	19
	Median		34,5000	39,0000
	Minimum		20,00	27,00
	Maximum		59,00	61,00
	Q1	25	26,0000	31,0000
	Q3	75	44,2500	44,0000
p			0,467	0,103

*Kruskal-Wallis Test p<0,05

When state and trait anxiety scale scores were assessed based on exposure to violence, the difference between the mean state anxiety scores was statistically significant (P<0.05). The state anxiety scale score was 34.83± 9.97 in dentists who were not exposed to violence, 38.98± 11.88 in dentists who were exposed to violence 1-3 times during their professional life, 44.04± 13.88 in dentists who were exposed to violence 4-6 times during their professional life, and 44.45± 12.12 in dentists who were exposed to violence 7-10 times. (Table 3)

Table 3a. State and Trait Anxiety Scale Scores According to Frequency of Exposure to Violence

Violence			State Anxiety Scale Scores	Trait Anxiety Scale Scores
none	n		72	73
	Median		33,5000	39,0000
	Minimum		20,00	22,00
	Maximum		63,00	67,00
	Q1	25	27,0000	33,0000
	Q3	75	41,0000	43,0000
1-3 times	n		244	243
	Median		37,5000	40,0000
	Minimum		20,00	23,00
	Maximum		76,00	66,00
	Q1	25	30,0000	34,0000
	Q3	75	46,0000	46,0000
4 and over	n		135	127
	Median		45,0000	43,0000
	Minimum		20,00	27,00
	Maximum		75,00	71,00
	Q1	25	33,0000	38,0000
	Q3	75	53,0000	49,0000
p			**<0,001***	**<0,001***

*Kruskal-Wallis Test p<0,05

The trait anxiety scale score was 39.12± 9.00 in dentists who were not exposed to violence, 40.67± 8.78 in dentists who were exposed to violence 1-3 times during their professional life, 43.49± 8.05 in dentists who were exposed to violence 4-6 times during their professional life. (Table 3)

Table 3b. Pairwise comparison results Dunn (Bonferroni corrected) Test

	State Anxiety Scale Scores	Trait Anxiety Scale Scores
No x 1-3 times	0,033	0,549
No x 4 and over	<0,001	0,001
1-3 times x 4 and over	<0,001	0,003

DISCUSSION

This study was carried out to determine the characteristics of violence faced by dentists working in different branches, to determine the frequency of violence, the distribution of violence frequency according to branches, etiological factors and post-violence effects and anxiety levels, and to determine the effect of differences on anxiety levels and violence risk factors by comparing different branches of dentistry. Since there is no other study that investigates the risk factors of violence, etiologic factors and their effects on anxiety level according to the branches of dentists, the results of the study can be used in the research on violence against health professionals in general.

Çamcı et al. reported that the group of healthcare workers with the highest rate of exposure to violence was nurses.[8] On the other hand, Ayrancı et al. reported that general practitioners were the most likely to be exposed to violence, followed by nurses.[13] That female healthcare workers were exposed to violence more than male healthcare workers (36.81%) was reported in this study. When Polat et al. compared the type of violence with gender, they reported that women were more exposed to verbal violence, while men were exposed to verbal and

physical violence.[14] Erkol et al. reported that male health workers were more likely to be subjected to violence,[16] in contrast to Ayrancı et al.,[15] who reported that the victims of violence were mostly female health workers. Jakson and Ashley reported that women are more likely to be exposed to verbal violence and men are more likely to be exposed to physical violence.[17] Egici and Öztürk reported that 55% of healthcare workers exposed to violence were female healthcare workers.[18] Canbaz et al. also reported that female healthcare workers were exposed to violence more than male healthcare workers.[19] Işıklı and Arslan reported that men were exposed to violence at a higher rate in their study.[20] When the rates of exposure to violence according to gender were evaluated, female dentists were found to have been subjected to violence 1-3 times (56.1%), 4 or more times (31.3%) and the total amount of violence (87.4%) more than their male colleague, in this study. Dentists stated that they were subjected to violence 354 times by men and 247 times by women.

Polat and Çırak reported that the average age of physicians who were subjected to violence was 41.6 years.[14] Egici and Öztürk reported in their study that approximately 83% of healthcare workers exposed to violence were younger than forty years of age.[18] Işıklı and Arslan found an average age of 37.5 years.[20] Jakson and Ashley reported that healthcare workers aged 55 years and older were less likely to be subjected to physical violence.[17] When the rate of experiencing violence throughout their professional lives was evaluated, the age group that reported experiencing violence the most was the youngest age group (89.8%) between the ages of 25-34, in this study. Then, the age group that reported experiencing violence the most was the oldest age group, 65 years and over (79.2%). According to age groups, dentists in the 55-64 age group reported experiencing the least violence (72.7%). Dentists reported being subjected to violence by people aged 26-45 in 329 cases, 46-60 in 187 cases, 18-25 in 55 cases and 61 and over in 40 cases.

A statistically significant difference was found between the groups in the evaluation of the rates of exposure to violence according to the branches of dentists. Among the dentists who participated in the study, 83.6% stated that they had been subjected to violence. Paediatric dentists were found to be the most exposed to violence with a rate of 91.1%, in this study. Dentists ranked second with 15.7%. This was followed by orthodontists (83.3%), endodontists and periodontologists (82.1%).

Paediatric dentists reported being most exposed to verbal violence (52.17%), followed by psychological violence (47.82%) and, to a lesser extent, physical violence (4.34%). 55.6% of paediatric dentists reported having been exposed to violence 1-3 times and 35.6% reported having been exposed to violence 4 or more times during their professional life.

Can and Beydağ reported that the incidence of violence was higher in health workers with less than five years of professional experience.[21] When the rates of exposure to violence were evaluated according to the professional experience of the dentists, it was found that the dentists most exposed to violence were those with 6-10 years of professional experience (93.5%), in this study. This was followed by 0-5 years (90.4%), 16-20 years (87.2%) and 21 years or more (72.7%), respectively.

The dentists stated that the most important cause of violence was lack of education, followed by sociocultural problems, health policies, economic problems and media, in this study. Dentists stated that violence was perpetrated 354 times by men and 247 times by women.

Only 44.6% of the dentists were not affected by the violence in their relations with patients, 20.3% changed their attitudes, 11.7% did not like their work as much as before, and 3.5% were afraid while doing their work. 70.1% of dentists reported that they did not feel safe while providing healthcare services.

Regarding taking official/legal action regarding the incident of violence, it was determined that 49.1% of dentists who experienced violence once and 35.3% of those who experienced violence many times did not take legal action. Fernandes et al. stated that 67% of the physicians working in Canada who were exposed to violence took legal action.[22] It is observed that physicians have different attitudes towards reporting the violence they experience depending on the differences in health policies on a country basis.[8]

It can be observed that physicians do not report the violence they experience to the official authorities and remain indecisive about taking legal action due to country policies and the thought that no results will be obtained.[8] 34.1% of the dentists stated that they continued to provide health services to the patient who perpetrated violence. Among the participants who continued to provide health care services, 37.2% stated that they wanted to do so, 21.9% stated that they were forced to do so, 22.6% stated that they had to do so because there were no other physicians to provide services, and 18.9% stated that health care services were provided by another colleague they worked with in the same clinic.

It has been reported in some studies that state and trait anxiety scores increase in healthcare workers with increasing age, but the difference between them is not significant.[23] When state and trait anxiety scale scores were evaluated according to age, it was determined that the difference between the averages was statistically significant in the comparison of both state and trait anxiety scores, in this study. The highest mean state and trait anxiety scores were found in dentists aged 25-34 years and the lowest in dentists aged 65 and over. The

highest mean trait anxiety score was found in dentists aged 25-34 years (42.8) and the lowest in dentists aged 65 and over (35.0).

Table 4. State and Trait Anxiety Scale Scores by Professional Experience

How many years have you been actively practising your profession?			State Anxiety Scale Scores	Trait Anxiety Scale Scores
0-5 years	n		104	99
	Median		42,5000	45,0000
	Minimum		20,00	23,00
	Maximum		74,00	66,00
	Q1	25	33,2500	39,0000
	Q3	75	51,0000	50,0000
6-10 years	n		89	83
	Median		39,0000	40,0000
	Minimum		20,00	22,00
	Maximum		76,00	64,00
	Q1	25	30,0000	35,0000
	Q3	75	49,5000	46,0000
11-15 years	n		60	58
	Median		41,5000	41,5000
	Minimum		22,00	28,00
	Maximum		70,00	63,00
	Q1	25	33,5000	37,7500
	Q3	75	49,5000	46,2500
16-20 years	n		42	41
	Median		37,0000	41,0000
	Minimum		20,00	24,00
	Maximum		73,00	71,00
	Q1	25	29,7500	33,0000
	Q3	75	48,2500	48,0000
21 years and over	n		154	160
	Median		34,5000	38,0000
	Minimum		20,00	23,00
	Maximum		75,00	59,00
	Q1	25	29,0000	33,0000
	Q3	75	46,0000	43,0000
p			0,006*	<0,001*

*Kruskal-Wallis Test p<0,05

It has been reported that male healthcare workers have lower scores than female healthcare workers, in evaluating the mean trait anxiety scores of healthcare workers by gender.[24-25] Although the mean state and trait anxiety scores were not statistically significant, they were found to be higher in female health care workers than in male health care workers.[23] In another study, it was reported that there was no difference in anxiety levels according to gender .[26] When state and trait anxiety scale scores were evaluated according to gender for dentists, both state and trait anxiety scores were higher in female dentists and the difference between them and men was statistically significant, in this study. The mean state anxiety scores were 42.1 and 36.7 in female and male dentists, respectively. The mean trait anxiety scores were 43.1 and 38.3 in female and male dentists, respectively.

As there is no other study that measures state and trait anxiety by dental specialty, it cannot be compared and discussed with this study. When the state and trait anxiety scale scores were evaluated according to the branches of dentists, the dentists with the highest mean state anxiety scores were oral and maxillofacial radiologists (41.7) and pediatric dentists (41.6), in the present study.

The dentists with the highest mean trait anxiety score were oral and maxillofacial radiologists (47.0), followed by endodontists (43.1), paediatric dentists (43.0), dentists (41.1) and orthodontists (41.1), oral and maxillofacial surgeons (40.4), periodontist (40.3), prosthodontists (39.1) and the dentists with the lowest mean score were restorative dentist (39.0).

It was reported in a study that increasing the duration of professional experience did not change the state anxiety score in health care workers working in health centers, however, the level of trait anxiety was significantly higher in health care workers working more than ten years.[23] In another study, it was stated that the level of trait anxiety was found to be significantly higher in healthcare professionals who worked for more than five years than those who worked for less time.[24] When state and trait anxiety scale scores were evaluated according to professional experience, the difference between the mean state anxiety scores was statistically significant, in this study. The dentists with the highest mean state anxiety score were in the group with 11-15 years of experience (42.2), and the dentists with the highest mean trait anxiety score were in the group with 0-5 years of experience (44.6). Both state (37.0) and trait (38.6) anxiety scores of dentists with 21 years or more of professional experience were lower than other age groups. In a study conducted by Canbaz et al.[19] When the state and trait anxiety scale scores were evaluated according to the exposure to violence in this study, it was observed that the difference between the mean state anxiety scores was statistically significant, and both state and trait anxiety levels increased as the frequency of violence increased.

CONCLUSION

Dentists were found to be exposed to both verbal and physical violence. Female dentists and young dentists were most exposed to violence. Both state and trait anxiety were found to be higher in female dentists. Although the rates of exposure to violence varied, high rates were found in all branches. Both state and trait anxiety were found to increase with the frequency of exposure to violence. Most dentists do not report the violence to the official authorities and continue to provide health services to the violent patient.

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Hybrid Ceramics

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ABSTRACT

Rapidly developing computer-aided design/computer-aided manufacturing (CAD-CAM) technology has brought diversity to prosthetic restorations by expanding existing material options to include material types such as hybrid ceramics. Hybrid ceramics are a combination of resin composites and porcelain. This dual-phase structure combines the positive properties of ceramics and composites. It offers advanced features such as easy workability, superior edge compatibility and fracture resistance, as well as sufficient flexibility and resistance to chewing forces. However, it causes less wear on the opposing tooth than ceramic restorations. The lower hardness allows these blocks to be milled much faster. If any crack occurs, the crack is stopped before it progresses too far with the polymer in its structure. Since their elasticity modules are close to the teeth, they have indications in minimally invasive restorations. It can be processed better than ceramic, thus providing better results in areas where restorations are thinner. It does not require baking after milling. New generation hybrid blocks remain up to date, and studies are being carried out to increase clinical and laboratory success and indication areas. This review has been prepared to present the general characteristics of hybrid ceramics.

Keywords: *Hybrid ceramics, CAD/CAM, resin matrix ceramic*

ÖZ

Hızla gelişen bilgisayar destekli tasarım/bilgisayar destekli üretim (CAD-CAM) teknolojisi hibrit seramikler gibi malzeme türlerini de içermek üzere var olan materyal seçeneklerini genişleterek protetik restorasyonlara çeşitlilik kazandırmıştır. Hibrit seramikler rezin kompozitlerin ve porselenlerin birleşimidir. Bu çift fazlı yapı seramik ve kompozitlerin olumlu özelliklerini birleştirmektedir. Kolay işlenebilirlik, üstün kenar uyumu ve kırılma direnci gibi gelişmiş özelliklerin yanı sıra yeterli esneklik ve çiğneme kuvvetlerine karşı dayanıklılık sunmaktadır. Bununla birlikte, seramik restorasyonlara göre karşıt dişte daha az aşınma yapar. Sertliğinin az olması bu blokların çok daha hızlı frezelenmesini sağlar. Herhangi bir çatlak oluşması halinde yapısında bulunan polimer ile çatlak fazla ilerlemeden durdurulur. Elastisite modülleri dişe yakın olduğu için, minimal invaziv restorasyonlarda endikasyonları bulunmaktadır. Seramiğe göre daha iyi işlenebilir böylece restorasyonların inceldiği bölgelerde daha iyi sonuçlar verir. Frezeleme sonrası fırınlama işlemi gerektirmez. Yeni nesil hibrit bloklar güncelliğini korumakta, klinik ve laboratuvar başarılarının ve endikasyon alanlarının arttırılması konusunda çalışmalar yapılmaktadır. Bu derleme hibrit seramiklerin genel özelliklerini sunmak amacıyla hazırlanmıştır.

Anahtar Kelimeler: *Hibrit seramikler, CAD/CAM, rezin matriks seramik*

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INTRODUCTION

Fixed prostheses are types of prostheses used to replace missing teeth and provide an aesthetic smile. Porcelain is a frequently preferred material for these prostheses. Porcelain is preferred because it provides the closest appearance to natural teeth in terms of aesthetics, is not affected by tooth color, and is compatible with the tissue. Due to its physical properties, porcelain can be used directly or with metal support. Fixed prostheses have different types, including implant-supported prostheses and bridge prostheses. In implant-supported prostheses, titanium implants are placed in the jawbone, and porcelain teeth are placed on them. In bridge prostheses, the missing tooth is replaced using prosthetic teeth supported by adjacent teeth, utilizing either porcelain or metal-supported porcelain. Fixed prostheses provide a practical and aesthetically pleasing solution by replacing missing tissue. Dentists design and implement appropriate fixed prostheses based on the needs of their patients. Patients can attain a beautiful and natural smile in this method.[1,2]

Dental prostheses, which are used to replace missing or damaged tooth structures, are made from dental ceramics. For almost 150 years, dental ceramics have been utilized in dentistry. Dental ceramics are made using a methodical and intricate technique. Raw minerals and metal oxides are combined to create a unique mixture in the first stage. This mixture is then formed and molded. Subsequently, it is fired at high temperatures to form ceramic. At this stage, additional processes may be applied to impart the desired aesthetic properties and durability to the ceramic.[3,4,5]

Table 1. Components and Functions of Dental Ceramics [3,6]

Component Name	Function
Feldspar	• The component that solidifies and fuses the ceramic constituents into a solid mass ensures the formation of the main structure of the ceramic.
Silica (Quartz)	• It strengthens the fired porcelain restoration. • It provides a framework for the ceramic components, contributing to the stability of the mass during the firing process.
Kaolin (Al2 O3 2 SiO2 2H2 O)	• It functions as a binder. • It enhances the moldability of porcelain before firing and provides opacity to the finished porcelain product.
Glass modifiers (Eg: K, Na, Ca oxides or basic oxides)	• They disrupt the integrity of the silica network, act as fluxes, and lower the melting point of the glass.
Colour Pigments or Frits (Eg: MgO, TiO2 Fe/Ni oxide, Cu oxide ve Co oxide)	• To create suitable color shades for the restoration.
Zr oxide, Ce oxide, Sn oxides or Uranyum oxide	• To create suitable opacity for the restoration.

In dentistry, porcelain is a frequently used material either alone or with metal support due to its aesthetic and biocompatible properties, as well as its physical characteristics.[1]

Full ceramic restorations do not have a metal substructure. Compared to metal-ceramic restorations, they exhibit better light transmission and yield superior results in aesthetic regions.[1]

Full ceramic systems can be classified in various ways based on their manufacturing technique, light transmittance, and the material used in the substructure. Classification systems should be designed to allow for the easy incorporation of newly developed materials.[1]

The Current Classification of Full Ceramic Restoration Systems.[7]

Dental Ceramics and Ceramic-Like Materials.	
Glass Matrix Ceramics	• Feldspathic • Synthetic (Leucite Based, Lithium Disilicate and Derivatives, Fluorapatite Based) • Glass infiltration (Alumina, Alumina and Magnesium, Alumina and Zirconia)
Polycrystalline Ceramics	• Alumina • Stabilised zirconia • Alumina reinforced with zirconia • Zirconia reinforced with alumina
Resin Matrix Ceramics	• Resin nanoceramic • Resin matrix infiltrated zirconia silica ceramic • Resin matrix infiltrated glass ceramic (hybrid ceramics)[8,9]

In 2013, the American Dental Association defined ceramics as "pressed, fired, polished, or etched materials that predominantly contain an inorganic structure, such as porcelain, glass, ceramic, and/or glass-ceramic." These newly developed materials have been classified as ceramic-like materials due to their inorganic content exceeding 50% by weight and the presence of a small amount of organic phase.[8]

The term "hybrid" originates from the Latin word *Hybrida*, meaning "mixed" or "crossbred." It defines a new type that emerges from the combination of two different materials. In this regard, modern dental hybrid ceramic materials introduced for use today are classified within the group of resin matrix ceramics.[8]

1. Resin Matrix Ceramics

These materials, in which ceramic and composite are combined under high temperature and high pressure to form a new microstructure, achieve strong mechanical properties and low shrinkage. As a result, the amount and size of defects in the microstructure are reduced, preventing crack formation.[10,11]

Resin matrix ceramics have an elastic modulus similar to dentin.[12,13] They can be easily milled and adapted intraorally, and they can be polished.[13] Since they are used with CAD/CAM systems, they also incorporate the advantages of this system.[14] These materials can be used as an alternative to ceramics containing a high glass filler in terms of mechanical performance.[15]

The development of new polymerization techniques, such as high temperature (HT) or the combination of high temperature and high pressure (HT-HP), has facilitated the advancement of new microstructures produced with CAD/CAM systems. Pressure has been applied to these new resin materials to enhance infiltration and reduce polymerization shrinkage, as they cannot be infiltrated solely through capillary action. With high infiltration pressure, improved mechanical properties, reduced shrinkage, and decreased internal stresses have been achieved. The HT/HP (high temperature/high pressure) technique reduces the number and size of defects in the composite microstructure and enables the formation of highly dense HT/HP polymerized composites. Nguyen and colleagues emphasized that high mechanical properties in composite blocks can be obtained by applying HT/HP polymerization to the resin-infiltrated glass-ceramic network, highlighting their suitability for CAD/CAM applications. [16]

In 1980, the concept of an interpenetrating microstructure was introduced for the first time, leading to the development of the InCeram system (Vita Zahnfabrik), in which a porous ceramic network (alumina, zirconia, spinel) is infiltrated with low-viscosity glass. The first-generation material that combined the properties of newly developed ceramics and composites was a polymerized resin composite based on a resin composite filled with 85% zirconia and silica particles (Z100 3M, ESPE, St. Paul, Minn, USA) (Paradigm MZ100 3M, ESPE). Later, Lava Ultimate (3M ESPE) was developed, primarily consisting of 80% resin nanoceramic, based on the structure of Filtek Supreme Ultra (3M ESPE). Other similar resin matrix materials include Cerasmart (GC, Tokyo, Japan), which contains 71% filler, Shofu Block (Shofu Block HC, Shofu, Kyoto, Japan), and Ambarino High-Class (Ceramed, Marburg, Germany), both containing 60% inorganic filler. In recent years, the polymer-infiltrated ceramic-network (PICN) material Vita Enamic (Vita Zahnfabrik, Bad Säckingen, Germany) has been introduced. In this material, ceramic particles are partially sintered before being infiltrated with low-viscosity polymer. Unlike resin composites, PICN consists of two bonded network structures, one polymer and one ceramic.[16]

The advantages of resin matrix ceramics are similar to those of resin composites. Some of their key advantages include requiring less preparation, causing less wear on the opposing tooth, being easily repairable with similar resin composites, and having chemical compatibility with adhesive resin cements. These newly developed materials are more resistant to marginal edge

chipping and cracking during milling compared to ceramics, are less brittle, and have lower porosity. Unlike ceramics, these materials do not require heat treatment after shaping, allowing for faster restoration fabrication. Their high fracture toughness, minimal enamel wear, and rapid production process are among their significant advantages. This new generation of polymer-containing ceramics exhibits higher flexural strength due to their elastic modulus being close to dentin, while demonstrating lower fracture resistance.[16]

Albero et al. determined that resin matrix or resin nanoceramics have flexural strength, elastic modulus, and lower hardness values closer to dental tissue compared to ceramics and that they could be a potential alternative as a restorative material.[16]

Chavali et al., in their study on a resin nanoceramic and polymer-infiltrated ceramic materials, determined that both materials exhibit high machinability and demonstrate less chipping and fracture compared to lithium disilicate and zirconia-containing materials. Shetty et al. reported that resin matrix ceramics could be used as an alternative to glass ceramics in prosthetic dentistry, particularly in areas with reduced masticatory forces.[16]

Resin matrix ceramics are divided into three subgroups based on their inorganic fillers.[8,15]

1. Resin nanoceramic
2. Interpenetrated zirconia-silica ceramic within the resin matrix.
3. Interpenetrated glass-ceramic within the resin matrix.

1.1. Resin nanoceramic

The first block in this group is Lava Ultimate (3M ESPE, Minnesota, United States). Lava Ultimate consists of nano-ceramic (80%) particles embedded in a highly polymerized organic resin matrix (20%). The inorganic nano-ceramic component comprises silica nano-particles (200 nm in size) and zirconia nano-particles (4-11 nm in size). This inorganic structure is surrounded by a resin matrix containing bisphenol-A glycidyl methacrylate (Bis-GMA), urethane dimethacrylate (UDMA), bisphenol ethoxylated bisphenol-A dimethacrylate (Bis-EMA), and triethylene glycol dimethacrylate (TEGDMA). [8]

Lava Ultimate has a flexural strength of 200 MPa, and its fracture resistance is higher compared to glass-ceramics. Due to its flexibility, it is highly resistant to fractures and cracks during mastication. The material can maintain a high-gloss surface quality for a longer duration compared to conventional CAD/CAM blocks. Indications for use include veneers, inlays, and onlays.[8]

Cerasmart (GC, Tokyo, Japan) was introduced to the market in 2014. It contains 71% inorganic filler particles by weight. The filler particles consist of silica (20 nm in diameter) and barium glass fillers (300 nm in diameter), while the organic component includes 2,2-bis 4-methacryloxypolyethoxyphenyl propane (Bis-MEPP), urethane dimethacrylate (UDMA), and dimethacrylate (DMA). [8]

Cerasmart has small and homogeneously distributed particles, ensuring excellent marginal adaptation in restorations. When compared in terms of flexural strength, it stands out as the material with the highest value.[8]

The surface treatment that provides the best bond strength values for Cerasmart and Lava Ultimate is the combination of Al_2O_3 sandblasting and silane application.[8]

Resin nanoceramics can be easily milled, adapted, and repolished. They exhibit excellent wear resistance and are resistant to discoloration. Additionally, compared to glass ceramics, they cause less wear on opposing teeth. They do not require a second firing, reducing the need for extensive laboratory procedures. They possess high flexural strength (200 MPa).[8]

1.2. Interpenetrated zirconia-silica ceramic within the resin matrix.

It contains more than 60% inorganic content by weight. This group includes Paradigm MZ100 (3M ESPE, Minnesota, United States) and Shofu Block HC (Shofu Inc., Kyoto, Japan).[15]

Paradigm MZ100 was introduced in 2000. It is the first polymer-infiltrated composite block material in which ceramic was added to the Z100 composite material developed by the same company. It consists of 85% inorganic structure and 15% organic matrix. While zirconia-silica ceramic particles form the inorganic component, the organic matrix is composed of Bis-GMA, TEGDMA, and a triple activator system, with ceramic particles being completely surrounded by this organic matrix. [8]

Upon completion of the polymerization process, zirconia-silica ceramic particles acquire enhanced mechanical properties. These particles exhibit a flexural strength of approximately 150 MPa, indicating high durability.[8]

For long-term provisional restorations, these materials can be used for single crowns, inlays, and onlays, as they can absorb forces in individuals with bruxism. Some in vitro studies have reported that the material demonstrates good performance in terms of fatigue resistance. Like other resin matrix systems, they allow for more conservative tooth preparation. Coloring,

finishing, and polishing processes are easy to perform, and they can be easily adapted intraorally. [8]

Lava Ultimate, which has been polymerized under different temperature and pressure conditions with enhanced mechanical properties, has replaced Paradigm MZ100.[8]

1.3 Interpenetrated glass-ceramic within the resin matrix.

This group includes Enamic (VITA, Bad Säckingen, Germany), which was introduced in 2013. These block-shaped materials, designed exclusively for CAD/CAM systems, are classified as "Hybrid Ceramics."[8,9]

1.3.1. Vita Enamic (Vita, Bad Säckingen, Germany);

It has a dual-phase microstructure with an interpenetrated porous ceramic network.[17] Its hybrid structure is formed by the light-curing of a monomer infiltrated into a porous ceramic substructure.[18]

Vita Enamic has an elastic modulus similar to dentin. It consists of 86% inorganic content (ceramic) by weight and 75% by volume, while the organic content (polymer) makes up 14% by weight and 25% by volume.[19] The ceramic component consists of 58-63% silicon dioxide, 20-23% aluminum oxide, 9-11% sodium oxide, 4-6% potassium oxide, 0.5-2% boron trioxide, <1% zirconia, and <1% calcium oxide by weight. The organic component is composed of UDMA (urethane dimethacrylate) and TEGDMA (triethylene glycol dimethacrylate). [20,21]

Its fracture resistance is higher compared to full ceramics, and its fabrication procedure using CAD/CAM systems is more efficient.[20,21]

First, the powder is sintered to approximately 70% of the porcelain's density, followed by monomer infiltration to complete the production process. It has a flexural strength of 160 MPa and an elastic modulus of 38 GPa.[22]

This material successfully combines the favorable properties of both ceramics and composites, achieving a balance between durability and elasticity, allowing it to effectively withstand masticatory forces. Its optical properties resemble those of natural teeth, and due to its lower hardness value compared to ceramics, it causes less wear on opposing teeth. However, this lower hardness also makes the material more prone to wear over time compared to feldspathic ceramics.[8]

Hampe et al. reported that in a study evaluating fracture resistance before and after thermal cycling, Enamic demonstrated the highest value after thermal cycling.[23] Similarly, in another study, while a decrease in flexural strength was observed in Lava Ultimate and Cerasmart after thermal cycling, no significant change was detected in Enamic.[24] A clinical study reported that after a three-year clinical follow-up, Enamic demonstrated a 95-98% clinical success rate and satisfactory performance.[25] An in vitro study determined that aging did not reduce fracture resistance. Clinical studies have reported that Enamic demonstrated acceptable results in terms of color stability, indicating that the material can be successfully used for aesthetic purposes. The color stability and natural appearance of Enamic are significant factors in its preference for clinical applications.[26,27]

Hybrid ceramics have high fracture resistance and a lower elastic modulus compared to conventional ceramics. It also offers advantages such as being finely scraped without fractures or cracks and being easily and quickly milled using diamond tools. However, some researchers have noted that the weak polymer matrix can easily separate from the ceramic network, leading to increased surface roughness. [8]

Another study demonstrated that the polymer component in the hybrid ceramic system is more sensitive to saliva content compared to conventional full-ceramic systems, which consequently results in a decrease in surface microhardness.[8]

The ceramic network, which is predominantly present in these materials, is reinforced with a fully integrated polymer network. The issue of crack propagation, commonly encountered in ceramic materials, is mitigated by the polymer network structure. [28]

As with other materials, the optical properties of hybrid ceramics are influenced by monomer composition, chemical content, filler particle size, and distribution.[28]

After the restoration is fabricated, color characterization can be performed using the staining technique with Vita Enamic Stains liquid. Firing is not required for this material. There are light-curing stain and glaze materials available. If necessary, additional modifications can be made using 'Vita VM LC' veneer composite.[21,29]

Indications include inlays, onlays, anterior and posterior crowns, implant-supported crowns, minor defect reconstructions (cervical defects), occlusal veneers, and non-prep veneers.[7] They can only be used for single-tooth restorations.[20,21] Their use is not recommended for bridge fabrication and in patients with parafunctional habits.[7]

2. Color Change in Hybrid Ceramics

Color stability is important for ensuring an **aesthetic appearance** in **dental restorations**. **Dental materials** are continuously exposed to **food and beverages** in the **oral cavity**. Since these **foods and drinks** (such as **black tea, red wine, curry, and cola**) contain **pigments**, they can cause **color changes in dental materials**. This may result in the **aesthetic failure** of restorations. [30]

To maintain **color stability**, **dental restoration materials** are generally composed of **compounds with a low potential for discoloration**. These materials undergo a **special treatment** to **minimize color changes** and ensure the **long-term preservation of their shade**.[30]

Although ceramic materials have a very low potential for color change, this tendency is significantly higher in composite materials. In terms of color stability, a comparison between direct composites, indirect composites, and glass-ceramic materials (LIT) revealed that, after 15 days of staining in coffee, direct composites exhibited significantly greater color change. The lowest color change was observed in the glass-ceramic group. [30]

The color stability of CAD/CAM composites is higher compared to manually polymerized resin composites and glass ceramics. The color changes in glass ceramics and CAD/CAM composites remain below the clinically acceptable threshold and can be eliminated through polishing.[30]

The results of an in vitro study using CAD/CAM hybrid and nano-ceramic materials determined that polymer-infiltrated network ceramic (VITA Enamic) exhibited greater color stability compared to resin nanoceramic (Lava Ultimate) and hybrid nanoceramics with nanoparticle-filled composite resin structures (Cerasmart). In the polishing process of CAD/CAM resin ceramics, the use of diamond-filled spiral polishing wheels and aluminum oxide abrasive polishing discs does not create a significant difference in terms of color stability.[31]

3. Cementation of Hybrid Ceramics:

One of the most important factors in the clinical success of indirect restorations is the cementation process. The cementation success of resin-based restorative materials depends on the effective treatment of the resin surface. The bonding of resin-based restorative materials should be achieved through both mechanical and chemical means.[32,33]

Resin matrix ceramics combine the durability and color stability of ceramics with the high flexural strength and low wear properties of resin composites. These materials have been referred to by various names, including resin nanoceramics, hybrid ceramics, resin-matrix ceramics, dual-network materials, ceramic-based interpenetrating phase composites, or PICN.[16]

Campos et al. investigated the effect of different surface treatment applications on the micro-bond strength between hybrid ceramics and resin cements. In their study, they reported that applying 10% HF acid for 60 seconds provided the highest bond strength values for Vita Enamic blocks.[7] Research has shown that abrasion of the Vita Enamic surface through sandblasting enhances adhesion. Therefore, sandblasting is recommended in clinical applications.[19,35,36]

According to the manufacturer's instructions, light-cured or dual-cured composite resins are used for adhesive cementation in the Vita Enamic cementation process. Depending on the thickness of the restoration, flowable dual-cure composites are preferred for crown cementation. Light-cured composites are recommended, nonetheless, because dual-cure composites may change color after curing in thin restorations.[16]

The restoration is first cleaned in an ultrasonic bath, and after the internal surface is wiped with alcohol, 5% hydrofluoric acid is applied for 60 seconds. It is then rinsed for 60 seconds and dried for 20 seconds. Silane is applied to the etched surface, followed by the application of adhesive cement. After placing the restoration, it is light-cured, and any excess cement is removed.[16]

4. CAD-CAM and Hybrid Ceramics

Since the introduction of computer-aided design/computer-aided manufacturing (CAD/CAM) technology in dentistry by Mörmann in the 1980s, CAD/CAM systems have rapidly evolved and become widely utilized.[16,37,38] CAD/CAM technology lowers expenses while making it possible to fabricate restorations with recently created, superior materials that provide functionality, biocompatibility, and aesthetics. Numerous dental ceramic and composite materials with various qualities and applications are used in contemporary dentistry.[16, 39]

Dental ceramics possess high chemical resistance, along with excellent mechanical and optical properties and high biocompatibility.[16,40] Ceramic materials have high flexural strength and elasticity modulus. However, due to these properties, dental ceramics do not absorb occlusal forces, are not flexible, and are brittle.[16,34] In the study conducted by Beier et al., the clinical follow-up of full-ceramic inlay, onlay, veneer, and crown restorations revealed a success rate of 93.5% after 10 years, 85.8% after 15 years, and 78.5% after 20 years. The primary cause of failure was reported to be ceramic fractures.[16,41] Ceramic materials are more difficult to abrade compared to composites; however, they offer greater wear resistance and better biocompatibility. The repair of dental ceramics can be challenging. In contrast, composite materials are easier to handle and repair. However, compared to ceramics, composites exhibit lower wear resistance, reduced biocompatibility, and weaker mechanical properties.[16,40]

Dental composites, with advancements in CAD/CAM blocks, represent a wide and complex range of materials due to the incorporation of new polymerization methods, updated microstructures, and diverse components. Despite this broad variety of materials, there are

significant differences between these materials and the properties of dentin and enamel. [16,42]

With the increasing demand for aesthetics in recent years, the use of materials with lower elasticity than enamel (polymer composites) or higher elasticity than enamel (crystalline ceramics) has become a prominent consideration. [16,42] Due to their aesthetic properties and similarity to dentin, resin composites have a wide range of applications in dental restorations. [16,43,44] In recent years, new alternative materials that combine the favorable properties of ceramics and composites and can be shaped using CAD/CAM technology have been introduced to the market. These newly developed materials contain an organic matrix highly filled with inorganic ceramic particles.[15,16]

CONCLUSION

Hybrid ceramics, developed in recent years for dentistry, are a new type of machinable CAD/CAM material that has emerged from the combination of composite and ceramic materials. They combine the advantages of polymers and ceramics. With their dual-network structure, hybrid polymer-ceramic materials exhibit superior hardness, damage tolerance, flexibility, and fracture resistance compared to porous ceramics.

Unlike glass matrix and polycrystalline ceramics, resin-based materials or polymer-infiltrated ceramic network (PICN) hybrid materials have been developed to combine the durability and color stability of ceramics with the flexibility and low abrasiveness of composites.

For their cementation, either light-cured resin cement or dual-cure resin cement (polymerized by both light and chemical activation) can be used. The bonding should be achieved through both mechanical and chemical means.

There are no long-term clinical follow-up studies available on these newly developed materials. For this purpose, in addition to in vitro and in vivo studies, long-term clinical follow-up studies are also needed to evaluate their use and success in intraoral restorations.

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Endodontic Apical Surgery

Endodontik Apikal Cerrahi

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ABSTRACT

In cases where conventional root canal therapy is inadequate for the treatment of teeth with persistent periapical lesions, endodontic apical surgery is the most appropriate course of action. In cases where anatomical abnormalities, calcified root canals, and inaccessible apical regions via the conventional approach are present, as well as in instances of unsuccessful root canal treatments, this procedure is recommended. The primary objective is to prevent bacterial leakage from the root canal system to the periradicular tissues. This is achieved by excising the contaminated apical tissues, resecting the root-tip, and placing biocompatible root-end filling-material. A comprehensive medical and dental history is obtained, along with detailed clinical and radiographic examinations, prior to the initiation of the preoperative assessment. In addition, the patient's general-health and dental-hygiene should be considered prior to surgery. The outcomes of surgery may vary depending on the techniques and materials used. The success of the treatment is significantly enhanced using ultrasonic-tips, biocompatible filling-materials, microsurgical procedures, and a dental microscope. The selection of appropriate cases and the use of the most appropriate surgical techniques are essential for achieving successful results. The objective is to provide an overview of the current indications, techniques, and treatment outcomes for apical surgery.

Keywords: *Apicoectomy, surgery (oral), microsurgery, endodontics, periapical diseases, root canal therapy*

ÖZ

Endodontik apikal cerrahi, geleneksel kök kanal tedavisinin yetersiz kaldığı olgularda periapikal lezyonlu dişlerin tedavisi için uygulanan cerrahi işlemdir. Bu yöntem, anatomik sapmalar, tıkalı kök kanalları, başarısız kök kanal tedavisi gibi durumlarda tercih edilmektedir. Cerrahinin temel amacı, enfekte olmuş apikal dokuların çıkarılarak kök ucunun rezeksiyonu ve ardından biyouyumlu bir kök ucu dolgusu yerleştirerek kök kanal sisteminden periradiküler dokulara bakteri sızıntısını önlemektir. Preoperatif değerlendirme, kapsamlı bir tıbbi ve dental geçmişin yanı sıra radyografik incelemelerle yapılmaktadır. Cerrahi işlem öncesinde, hastanın ağız hijyeni ve genel sağlığı dikkate alınmalıdır. Apikal cerrahinin sonuçları, kullanılan teknik ve malzemelere bağlı olarak değişkenlik göstermektedir. Mikrocerrahi tekniklerinin uygulanması, mikroskop, ultrasonik uç ve biyouyumlu dolgu materyallerinin kullanımı, tedavinin başarısını oldukça artırmaktadır. Uygun vaka seçimi ve doğru cerrahi teknikler, başarılı sonuçlar elde edilmesi için kritik öneme sahiptir. Bu derlemenin amacı, apikal cerrahinin mevcut endikasyonlarını, tekniklerini ve sonuçlarını açıklamaktır.

Anahtar Kelimeler: *Apikoektomi, cerrahi (oral), mikrocerrahi, endodonti, periapikal hastalıklar, kök kanal tedavisi*

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INTRODUCTION

Apical resection is a surgical procedure used for the treatment of lesions located in the periapical area when intraradicular interventions are insufficient.[1]Indications for endodontic surgery can be summarized as follows:[2] [3]

1. ***Failure of Root Canal Treatment***
   a. Anatomical variations, including:
      - Apical deltas,
      - Accessory canals,
      - Severely curved root anatomy,
      - Additional apical and lateral foramina.
   b. Obstruction of the root canal, making orthograde access to the apex impossible due to:
      - Calcifications,
      - Presence of non-removable posts.
   c. Persistent symptoms despite adequate root canal treatment.
   d. Operator-related errors.
2. ***Inability to Adhere to Endodontic Treatment Sessions***
   - Due to the patient's socioeconomic status,
   - Making it impractical for the patient to complete multiple treatment sessions.
3. ***Need for Biopsy in the Presence of Apical Lesions***
   a. Radiographic images that do not conform to endodontic pathology criteria,
   b. History of malignancy,
   c. Paresthesia or anesthesia in the lip region.
4. ***Apical Root Fractures Due to Trauma***
   - In cases where the apical segment needs to be removed due to a fracture in the apical third of the root.

Contraindications for Endodontic Surgery

Leiblich stated that apical resection should not be performed on teeth with:

- Pocket depths greater than 5 mm,
- Bone loss exceeding 25% of the root length, and
- Tooth with a history of root fracture.[4]

Chong et al. classified the contraindications for apical surgery into general and local factors.[5]

General Factors

1. **Patient-Related Factors:**
   - Systemic diseases such as:
     - Psychological conditions and
     - Bleeding disorders.
2. **Operator-Related Factors:**
   - Skill and experience of the operator,
   - Availability of adequate equipment.

Local Factors

1. **Tooth-Related Factors:**
   - Restorability of the tooth,
   - Root length,
   - Periodontal support,
   - Patient's oral hygiene status.
2. **Anatomical Factors:**
   - Proximity to neurovascular structures.
3. **Surgical Access Factors:**
   - In the posterior region of the mandible:
     - Width of the external oblique ridge, and lingually positioned molar roots limit visibility and accessibility during surgery.

Preoperative Evaluation

Preoperative evaluation includes a detailed medical and dental history, extraoral and intraoral clinical examination, and radiographic imaging.[6] Radiographs should be taken using the parallel technique to provide accurate diagnostic results. The radiograph should clearly show:

- The entire length of the roots, and
- Approximately 2-3 mm of the periradicular area.[6]

Before performing the surgical procedure, the surgeon must be familiar with the anatomical structures adjacent to the surgical site.[7]

Utilizing cone beam computed tomography (CBCT) in endodontic surgical treatment planning provides three-dimensional information about the jawbone anatomy and root canal configuration. 3D imaging allows for:

- Precise identification of the anatomical relationship between the root tips and adjacent anatomical structures from various directions.[8]
- Assessment of the distance between the buccal bone surface and the root apex, which is crucial for endodontic surgical planning.

Factors Affecting Buccal Bone and Apex Distance

The distance between the buccal bone surface and the root apex can be influenced by:

- Age,
- Gender,
- Adjacent teeth, and
- Root canal configuration.[9]

Preoperative Disinfection

It is recommended to use a 0.2% chlorhexidine gluconate mouth rinse for one minute before the surgical procedure.[10] Chlorhexidine helps in:

- Reducing the microbial load in the oral cavity,
- Providing disinfection, and
- Accelerating postoperative healing by decreasing the risk of infection.[10]

Incision and Flap Design

An appropriate flap design should provide adequate surgical access to bone, root structure, and lesion, while facilitating soft tissue healing without complications.[11]

Over the years, various flap designs have been introduced for endodontic surgery.

Semilunar Flap: The semilunar flap involves a curved incision entirely within the mucosa.[12] However, it is no longer preferred due to:

- Limited access to larger periradicular defects,
- Delayed healing,
- Increased postoperative swelling and pain, and
- Higher potential for scar formation compared to other flap designs.

These issues are primarily due to compromised blood circulation in the flap.[13]

Single Vertical Incision Over the Root: Similarly, a single vertical incision over the root is not recommended due to the increased risk of postoperative infection.

Intra-sulcular incision and submarginal incision are two flap designs that are most commonly used today.[14]

Intra-sulcular Incision is a full-thickness flap that maintains blood flow and promotes primary wound healing. Variations include:

- *Triangular flap* with one vertical incision,
- *Rectangular flap* with two vertical incisions.

For the surgery of a single tooth, the triangular design provides sufficient access. When addressing a large periapical lesion or performing surgery on multiple teeth, a rectangular design is needed.

Advantages:

- Successful postoperative healing, and
- Minimal postoperative pain and swelling.[15]

Disadvantages:

- Moderate gingival recession may occur, especially in aesthetic areas, such as the maxillary anterior region, posing aesthetic concerns.[13] (Figure 1)

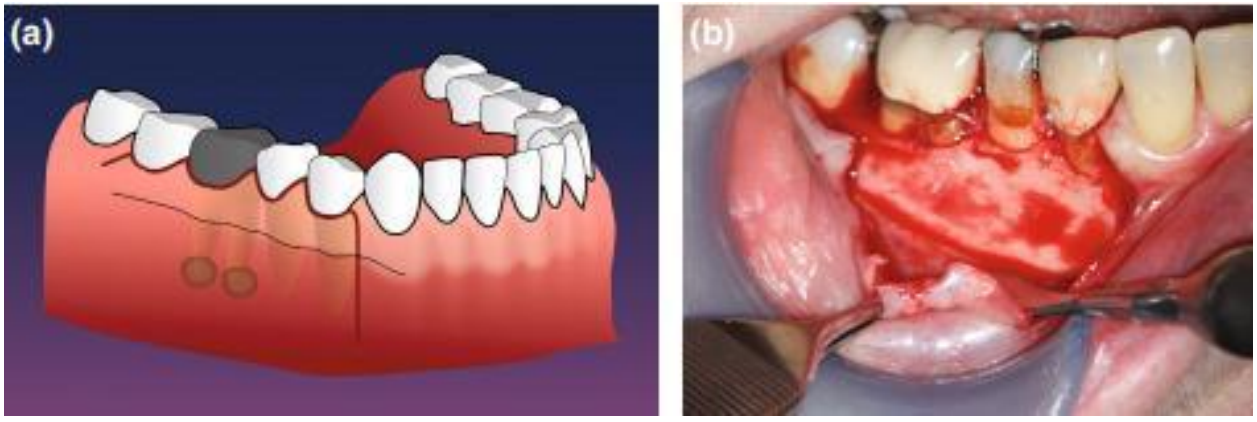

Figure 1: Intra-sulcular incision (**a**) and clinical representation (**b**).[16]

Submarginal Incision (Luebke-Ochsenbein): The Submarginal incision differs from the intra-sulcular incision by preserving the free gingival tissue surrounding the teeth.[17] It is particularly beneficial when:

- The attached gingiva is wide,

- Especially in aesthetic regions like the maxillary anterior area,
- Allowing for aesthetic healing without altering gingival contours.[17]

Contraindications:

- Limited surgical access, or
- Presence of a large periradicular lesion extending in the corono-apical direction may limit the applicability of this flap design. (Figure 2)

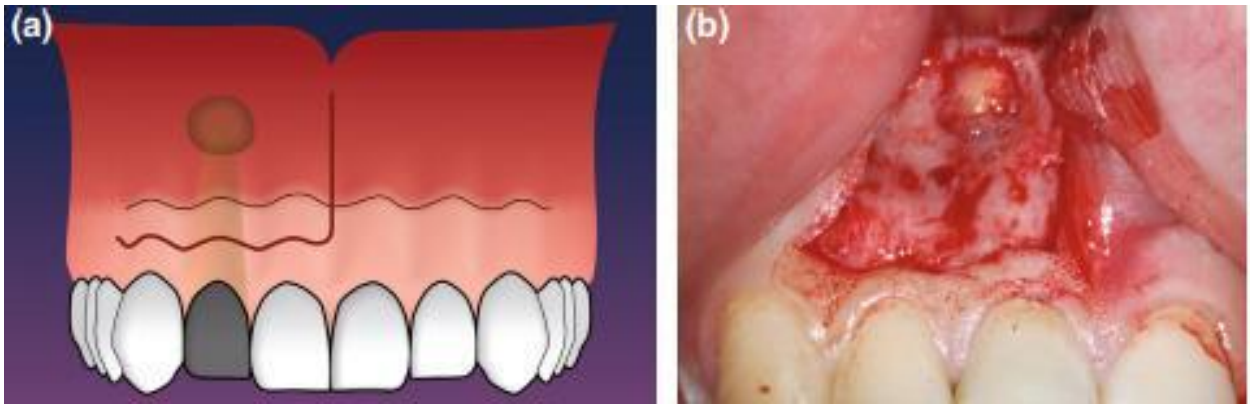

Figure 2: Submarginal incision (**a**) and clinical illustration (**b**).[16]

Apical Resection

In endodontic surgery, pathological tissues should be removed, and if necessary, apical bone reduction should be performed to eliminate the existing pathology. Afterward, an appropriately sized cavity should be created to allow visualization and reshaping of the apex.[18]

Extent of Apical Resection

Studies show that removal of at least 3 mm of the apical portion is necessary to eliminate approximately 98% of the lateral canals present at the root apex.[19 20] No significant difference was observed in the number of lateral canals when 4 mm apical cuts were made; therefore, it has been reported that removal of 3 mm from the apical end is sufficient. In this way, the remaining root length averages 7-9 mm, providing adequate strength and stability. However, if less than 3 mm is cut from the apical end, all apical ramifications and lateral canals may not be removed, increasing the risk of reinfection.[19 20]

Angle of Apical Resection

It is recommended that apical resection be performed at a right angle to the long axis of the root.[21 22] This approach reduces the number of exposed dentinal tubules, thereby minimizing the risk of periradicular leakage. Kim et al. suggested performing the resection at a shallow bevel angle between 0° and 10° to expose fewer dentinal tubules by using advanced magnification and illumination techniques.[20]

Apical (Retrograde) Preparation and Retrograde Filling

Ideal Retrograde Preparation

Ideal retropreparation is defined as using ultrasonic instruments, an operating microscope, and microsurgical tools to create a Class-I preparation that is at least 3 mm deep, parallel-walled, and within the anatomical boundaries of the pulp chamber.[23]

Purpose of Retrograde Preparation

The most crucial step in achieving apical sealing is the preparation of the apical cavity. The objective is to create a cavity of appropriate dimensions for placing the retrograde filling material, and to avoid unnecessary damage to the apical root structure. The success of the surgical procedure is directly related to how accurately the canal system is cleaned and be shaped.[24, 25]

In the past, small-headed hand instruments with rotating burs were used for this purpose. However, with the development of diamond-coated ultrasonic tips specifically designed for this procedure, ultrasonic tips have become the preferred choice for apical preparation.[26] The ultrasonic tip should be used along the long axis of the root, and under low magnification (4×–8×). Different angled tip variations are available to accommodate the positional differences of teeth within the jaw. Although there are concerns about potential crack formation in dentin during apical preparation using ultrasonic instruments, clinical evaluations have shown no significant disadvantages.[27]

Inspection and Cleaning of Retrograde Cavity

Before placing the retrograde filling material the retrograde cavity should be dried using a micro-irrigator, and the cavity should be inspected under high magnification using micro mirrors to confirm complete removal of filling residues.[22]

Root-End Filling Materials

The root-end filling material should exhibit:[28-33]

- Good adhesion to the root canal walls,
- Dimensional stability,
- Resistance to corrosion,
- Solubility resistance,
- Ease of use with an adequate working time.

Additionally, it should not cause discoloration of the tooth or surrounding tissues, be radiopaque, and exhibit osteogenic and cementogenic properties.

In the past, various materials have been used as root-end filling materials, including:

- Temporary materials: SuperEBA, IRM, Cavit, etc.
- Permanent restoration materials: Gold, amalgam, resin composite, glass ionomer cement, compomer, etc.

Critical Properties for Success as a Retrograde Filling Material

Three key properties significantly influence the success of a retrograde filling material:[28]

1. Microporosity
2. Nanoporosity
3. Wettability

Tricalcium silicate-based cements (bioceramic cements) form an interface that enhances the bond between the biomaterial and root dentin by:

- Increasing bond strength,
- Minimizing voids,
- Reducing permeability.[28]

Due to these advantages, bioceramic cements are the most commonly used materials for retrograde fillings. Among them, Mineral Trioxide Aggregate (MTA) is regarded as the gold standard due to its numerous advantages.[33] Comparative clinical studies indicate that MTA has a higher success rate compared to other materials.[29 30 31 32 33] In a study conducted by Çalışkan et al., where 90 teeth treated with apical resection using MTA were followed, the success rate was reported as 80%.[30]

Despite being a costly material and requiring operator familiarity, MTA offers several significant advantages, including excellent biocompatibility, ideal adhesion to cavity walls, and low solubility.[34] New cement formation through cementogenesis on the cut root surface can provide deposition on exposed dentin and the MTA surface.[32 35] MTA's sealing ability is attributed to its hydrophilic nature, causing it to expand when setting in a moist environment. Studies suggest using MTA in 3-4 mm thickness to ensure adequate sealing.[36] However, two studies using periapical radiographs reported that the coronal thickness of retrograde root-end filling material (whether ≤2 mm or >2 mm) had no significant effect on periapical healing.[37 38] Von Arx Kach et al. also reported that the coronal thickness, width of the MTA filling, and the thickness of peripheral root dentin surrounding the material did not significantly affect periapical healing. It was mentioned that apical surgery was performed by an experienced oral surgeon, The average coronal thickness of the root-end filling was 2.02±1.24 mm (width: 0.78-3.80 mm), the peripheral root dentin was ≥1 mm in all cases, more than 90% of retro-cavities were prepared parallel to the long axis of the root.[39] It was stated that the coronal height and width of apical preparation can vary depending on the quality of the existing root canal treatment, the vertical axis of the canal, and the remaining peripheral root dentin thickness.[39]

In recent years, new calcium silicate-based materials with properties similar to MTA have been developed, including Biodentine (Septodont, Saint-Maur-des-Fossés, France) and BioAggregate (Innovative BioCeramix, Vancouver, Canada)

Biodentine offers several advantages, including:

- Ideal biocompatibility and sealing ability,
- Osteoinductive effect,
- Dimensional stability, and
- Resistance to biological fluids.
- It also has easy handling properties due to its high viscosity.[40]

Unlike MTA, Biodentine does not contain calcium aluminate, or calcium sulfate. This results in higher mechanical strength, and shorter setting time.[41]

The 1-5 year success rate for using bioceramic materials as retrograde root-end filling materials in apical surgery is reported as 86.4%-95.6%.[42]

BioAggregate is an aluminum-free bioceramic containing calcium phosphate or silica. While BioAggregate demonstrates stable bonding and sealing properties, it has been reported to have relatively weak mechanical properties.[43 44]

To prevent discoloration associated with MTA usage, newer calcium silicate cements have been developed,

including RRM (EndoSequence, Brasseler, Savannah, USA) – A capsule-based material with much smaller particle size than Biodentine, and injectable form for easy application.[45] Advantages of RRM include dimensional stability, high pH, and short setting time.[45]

Three comparative studies found no significant differences between RRM and MTA in terms of antimicrobial activity, biocompatibility, and sealing ability.[46] [47] [48]

In *in vivo* studies comparing RRM and MTA as root-end filling materials RRM demonstrated similar cement-like tissue formation as MTA, and no inflammation or very low inflammation observed in the surgical site.[49]

Postoperative Care and Suturing

At the end of the procedure, the surgical area should be carefully inspected and irrigated before wound closure.

Adaptation of wound edges should be achieved using fine suture material (5-0, 6-0, 7-0) with interrupted sutures. Gentle pressure with gauze is recommended to ensure contact between the periosteal tissue and the bone. Sutures are typically removed 3–5 days after surgery.

Antibiotic Prescription

Although opinions vary on prescribing antibiotics after the operation, literature suggests no immediate benefit for postoperative healing after apical surgery.[31]

Healing and Follow-Up

The evaluation and follow-up of treatment outcomes in endodontic apical surgery should be conducted clinically and radiographically. In practical terms, healing is typically assessed 1 year after surgery. For clinical healing, there should be no signs or symptoms such as:

- Pain,
- Sinus tract formation,
- Swelling,
- Sensitivity on palpation or percussion.[50]

Longer follow-up periods may be required because both positive and negative outcomes may occur in the long term.[51] [52]

Radiographic Classification of Healing

The radiographic classification of treatment outcomes after endodontic surgery, as described by Molven et al., is commonly used because it correlates well with histological evaluation.[51]

This classification includes four categories:

1. Complete Healing
2. Incomplete Healing (Scar Tissue)
3. Uncertain Healing
4. Failure

It has been observed that cases initially classified as 'Uncertain Healing' may show complete healing after long-term follow-up.[51] [52]

Differences in endodontic surgical outcomes have been evaluated through systematic reviews and meta-analyses based on the techniques used. Traditional techniques using straight surgical hand instruments, angled root resection, and amalgam as a retrograde filling material were associated with a low success rate of approximately 59%.[53] In contrast, the use of magnification, ultrasonic root-end preparation, and biocompatible filling materials increased the success rate to approximately 86%.[54]

In endodontic surgical procedures using similar techniques and materials, it was found that: operating microscopes providing higher magnification compared to loupes increased the success rate from 91.4% to 94.4%.[53] [55] [56] This highlights the significance of magnification in endodontic apical surgery.

CONCLUSION

Endodontic apical surgery is performed as a second-line procedure in the management of failed non-surgical root canal treatment, or previously unsuccessful apical surgery. In the past, there was a prejudice that apical surgery resulted in lower periapical healing rates. However, the causes of failure in root canal treatment can be due to biological factors such as persistent intra/extraradicular infection or cysts, or biomechanical factors such as fractures, cracks, or weakening of the tooth structure. Factors positively affecting prognosis are:

- Use of advanced equipment, tools, and materials,
- Clinician's experience, and
- Application of microsurgical techniques.

For predictable outcomes, proper case selection and accurate decision-making during the procedure are crucial.

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Use of Hypnosis in Pediatric Dentistry

Çocuk Diş Hekimliğinde Hipnoz Kullanımı

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ABSTRACT

Dentistry, by its nature, is one of the fields where anxiety needs to be managed and communication skills are actively used. Especially in pediatric dentistry, strategies are needed to manage discomfort, improve patient compliance, and enhance the acceptability of procedures. Managing the stress and anxiety experienced by pediatric patients during the treatment process is critical for both patient comfort and treatment success. Hypnosis, a complementary and alternative method, is considered an effective tool that dentists can use in managing stress associated with dental treatments in addition to their technical knowledge and skills. Hypnosis is a unique state of consciousness in which the individual's awareness of environmental stimuli is reduced through focused attention and the capacity to respond to subconscious suggestions is increased. This state of consciousness makes it possible to change the individual's emotions, thoughts, perception, memory and behavior. Hypnosis in pediatric dentistry is thought to be an effective method for alleviating pain associated with diseases and dental interventions, managing stressful experiences, transforming pain perception and increasing treatment motivation. In this context, this review aims to examine the areas of use of hypnosis in pediatric dentistry and its contributions to treatment processes in light of current literature.

Keywords: *Hypnosis, medical hypnosis, hypnodontics, pediatric dentistry*

ÖZ

Diş hekimliği, doğası gereği anksiyetenin yönetilmesi gereken ve iletişim becerilerinin aktif olarak kullanıldığı alanlardan biridir. Özellikle pediatrik diş hekimliğinde, tedavi sırasında hissedilen rahatsızlığın kontrol altına alınması, hastaların tedaviye uyumunun artırılması ve dental prosedürlerin daha kabul edilebilir hale getirilmesi için çeşitli stratejilere ihtiyaç duyulmaktadır. Çocuk hastaların tedavi sürecinde yaşadığı stres ve kaygının yönetilmesi, hem hasta konforu hem de tedavi başarısı açısından kritik bir öneme sahiptir. Tamamlayıcı ve alternatif bir yöntem olan hipnoz, diş hekimlerinin teknik bilgi ve becerilerinin yanı sıra, dental tedavilerle ilişkili stresin yönetiminde kullanabilecekleri etkili bir araç olarak değerlendirilmektedir. Hipnoz, bireyin çevresel uyaranlara yönelik farkındalığının odaklanmış dikkat yoluyla azaltıldığı ve bilinçaltına verilen telkinlere yanıt verme kapasitesinin arttığı özel bir bilinç durumudur. Bu bilinç durumu sayesinde, bireyin duygularında, düşüncelerinde, algısında, belleğinde ve davranışlarında değişiklikler yapılması mümkün hale gelmektedir. Pediatrik diş hekimliğinde hipnozun, hastalıklar ve dental girişimlere bağlı olarak ortaya çıkan ağrının hafifletilmesi, stresli deneyimlerin yönetilmesi, ağrı algısının dönüştürülmesi ve tedavi motivasyonunun artırılması açısından etkili bir yöntem olduğu düşünülmektedir. Bu bağlamda, hipnozun pediatrik diş hekimliğinde kullanım alanlarını ve tedavi süreçlerine katkılarını güncel literatür ışığında incelemek bu derlemenin amacını oluşturmaktadır.

Anahtar Kelimeler: *Hipnoz, medikal hipnoz, hipnodonti, çocuk diş hekimliği*

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INTRODUCTION

Hypnosis, a traditional and complementary medicine treatment, is a state of consciousness in which environmental awareness is reduced, and suggestibility and responsiveness are increased through increased concentration. Hypnosis, which originated in ancient times and has reached the present day with various methods of use over the centuries, is a method whose therapeutic effects are still being proven. Although more controlled clinical studies on hypnosis are needed, considering evidence based hypnosis applications and current research, it is seen that its use in medicine, dentistry and psychology is promising. In dentistry, it has been successfully used to relieve anxiety and fear, control nausea reflex, bruxism cases, control of orofacial pain and anesthesia, acclimatization to appliances and prostheses, pediatric dentistry practices, and prevent parafunctional habits.[1-3]

The use of hypnosis in stage shows in popular culture has led to misunderstandings on the part of patients and the perception that it is possible to exercise power over others through hypnosis. Contrary to popular belief, hypnosis is a dynamic process that does not consist of a state of sleep and cannot be forced on anyone. It should not be overlooked that hypnosis can only be applied by those who have been trained in this field and are authorized to apply it, and that practicing physicians can only use hypnosis in treatment procedures related to their field. In addition, the person or their parents should be adequately informed about the treatment and verbal, and written consent should be obtained before the hypnosis session.

There are a limited number of situations where the use of hypnosis is not appropriate. Hypnosis is not recommended for patients who cannot communicate, patients with severe mental retardation, and patients with psychiatric disorders such as obsessive-compulsive personality disorder/psychosis and neurosis/paranoid disorder.[4] Another limitation of hypnosis in clinical practice is that it requires a quiet and isolated environment, more time for anamnesis and consultation, and more patience on the practitioner's part. There are no known and proven hypnosis related complications or inability to come out of hypnotic trance reported in the literature. There is no evidence that adverse effects such as dizziness, headache, drowsiness and feeling anxious, which are rarely observed and transient after hypnotherapy, are caused by hypnosis itself. Researchers have mentioned that these effects may be related to previous sensitivities of patients during and after hypnosis, the practitioner being unprofessionally untrained or trying to use hypnosis outside of their field, the use of inappropriate suggestions and metaphors, and the patient being brought out of the hypnotic trance too quickly.[5]

Before the patient is put into a hypnotic trance, it would be appropriate to determine their openness to suggestion and hypnotic predisposition. The ability to visualize and respond to suggestions is defined as hypnotic susceptibility. It is known that not every individual responds to hypnotic techniques to the same degree. Standardized methods are used to determine hypnotic susceptibility. After the person is informed about hypnosis and their hypnotic predisposition is determined, hypnosis begins with induction, which usually includes a series of preliminary instructions and suggestions. All external practices that initiate the trance period, in which the boundary between consciousness and subconsciousness is crossed and the mind can accept the instructions given without judgment, are called “hypnotic induction”. The trance state is a state of consciousness in which the response to environmental stimuli is reduced but alertness and awareness are maintained. The individual in trance is given suggestions that may be helpful for the condition to be treated. The suggestions given to the person are selected according to age, socio-economic level, cultural level, and cognitive awareness. The individual is guided to respond to suggestions for behavioral changes due to emotions, thoughts, sensations or personal experiences.

Physiology of Hypnosis

In neuroimaging studies, it has been determined that more than one brain region is affected in the initiation of hypnosis. Jiang et al. concluded that the prefrontal cortex, dorsal anterior cingulate cortex, and insular lobe make essential contributions to the experience of hypnosis.[6] During sensory hypnotic experiences involving vision, hearing and touch, it has been reported that regions of the brain specific to these senses are activated, and these areas are activated as if the experience is being experienced. Hypnosis can alter not only the response to sensory triggers but also the sensation itself and the way it is perceived, making it a powerful tool for modulating anxiety as well as pain and suffering.[7]

Hypnosis induces a transient suppression of the brain's frontal cortex, which plays a pivotal role in judgment, decision making, self-awareness, and memory function. During hypnosis, the diminished activity in the prefrontal cortex allows an individual to suspend critical judgment and readily accept suggestions temporarily. MRI (magnetic resonance imaging) studies have shown that hypnotic trance causes an increase in functional connections between different brain regions. This increase allows for more effective communication between brain regions during trance and a more straightforward response to changes in cognitive processes.[8] There are also studies showing that hypnosis modulates spinal and supraspinal pain pathways, measurably altering pain perception and reducing pain intensity.[9] The ability of hypnosis to stimulate metabolic

changes such as heart rate, control of regional blood flow, saliva flow and regulation of hormonal responses to stress is based on its effect on the functioning of the autonomic nervous system. In the autonomic nervous system, the parasympathetic nervous system is responsible for relaxation and regulates the body's rest and digestive system. Hypnosis increases the activity of the parasympathetic system during or after the experience, leading to relaxation of the body and a decrease in anxiety and pain perception.[10]

When different types of brain waves are analyzed with an EEG (Electroencephologram), they provide characteristic information about states of consciousness such as sleep, wakefulness and trance. Theta waves monitored on EEG are associated with cognitive states such as emotional arousal, drowsiness, attention, reasoning, storage, or modification of memories. In their study, Jensen et al. found high theta waves in the trance state obtained with hypnosis, unlike sleep and wakefulness.[11] In another study, it was reported that functional changes in brain activity could be obtained using hypnosis and that people with a high susceptibility to hypnosis showed more theta wave activity.[8]

Hypnosis in children

Looking at the historical development of pediatric hypnosis, studies have increased since the 1970s. Until today, many studies with positive results have been conducted in this field such as pain management, anxiety, cessation of harmful habits, sleep disorders and treatment of juvenile migraine, alleviation of the adverse effects of chemotherapy (such as nausea and vomiting) in children with cancer, and changes in respiratory function in children with cystic fibrosis and asthma.[12-14]

There exists no distinction between adults and children concerning hypnotic induction techniques and principles of trance. Nevertheless, children exhibit a greater susceptibility to hypnosis, as they can suppress their conscious awareness more swiftly owing to their enhanced imaginative capabilities.[15] Children's lack of prejudices and misconceptions regarding hypnosis, coupled with their more excellent receptiveness to guidance compared to adults, facilitates their ability to enter a trance state more readily. At the same time, since the concept of conscious mind is less mature in children, they more readily accept and internalize directed ideas without criticism and judgment. The use of hypnosis in children may be the approach of choice as long as they can understand and respond to the suggestions given. Hypnotic techniques cannot be used in severely mentally disabled children, hearing and speech impaired children and children under the age of 3 years due to their level of cognitive development. There is still no consensus in the literature regarding the age of hypnosis use in children. Although children are more susceptible to hypnosis than adults, the currently accepted general view is that hypnotic capacity is only very low in children younger than 3 years of age, peaks in mid-childhood (7 and 14 years), declines during adolescence, and remains stable in adulthood.[16-17]

In a study conducted with pediatric nurses in which the use of hypnotic language was taught, it was aimed to reduce the pain and stress on the other side by using a hypnotic language while opening an intravenous line. Twenty two cancer patients were included in the study and a decrease in anxiety and pain levels was reported.[18] In another study conducted on children with cystic fibrosis, the participants were divided into two groups, a group trained in self-hypnosis and a control group, and the effects of hypnotherapy on the participants' general health status, self-confidence, anxiety and maximal expiratory rate were investigated. The results showed that the treatment group significantly improved self-confidence, general health, and maximal expiratory flow rate substantially more than the control group.[19]

In addition to the clinical use of hypnotherapy in the literature, studies at the cellular level argue that hypnotherapy increases immunity by activating the immune system and accelerates wound healing.[20] In some published case studies, it has been reported that hypnosis can be successfully used in the treatment of conditions such as sleepwalking, Tourette Syndrome with tics, nocturnal enuresis, as well as dermatological disorders, including atopic dermatitis and chronic eczema in children.[21-22]

Due to children's heightened susceptibility to hypnosis, this technique has been effectively utilized as a supportive or alternative method in pediatric medical treatments throughout history. While it is important to emphasize that hypnosis is not a miraculous solution, it serves as a highly effective adjunct; therefore, further studies in this domain should be encouraged to enhance its viability as a preferred approach in the future. The application of hypnosis in pediatric dentistry can be categorized into various groups, with detailed information about each category provided below.

Use of hypnosis in the management of dental anxiety

Dental anxiety is an emotional state that occurs during dental procedures and is characterized by psychophysiological responses to stress, especially in pediatric patients. The most challenging aspect of treating children is to get them to accept the treatment easily and to end the collective treatment effectively. The fact that children are often anxious and noncompliant during dental visits may be attributed to dental treatments that involve unusual sensory triggers. Sensory triggers such as sight, sound, smell, vibration and pressure may cause the child's psychological state to change during the treatment and cause the child to feel anxiety about the unknown. Suppose this state of fear and anxiety

experienced by the child in the dental chair is not managed correctly. In that case, the trusting relationship between the physician and the child may be damaged, the child's cooperation may decrease, the duration of dental procedures may be prolonged, it may prevent the treatment of the patient, the cost of treatment may increase and most importantly, it may cause an unpleasant experience for the child.[23]

Many methods have been developed to help children cope with dental treatments and reduce the stress they experience. Different communication and behavior guidance techniques and nonpharmacological methods can be used alone or in combination. However, these techniques may sometimes be inadequate when factors such as differences in children's personalities, past experiences, the social environment in which they grow up, and the attitudes of family members are considered. Treatment with sedation and general anesthesia, which are pharmacological methods, cannot be applied in all patients due to possible complication risks, systemic diseases that are not suitable for the procedure, drug allergies and cost. Hypnosis, a psychotherapeutic method to which children are predisposed, was included among the "Nonpharmacological Advanced Behavior Guidance Techniques" in the "Nonpharmacological Behavior Guidance for the Pediatric Dental Patient" published by the American Academy of Pediatric Dentistry (AAPD) in 2023.[24]

In a study involving sixty children aged eight to twelve years, the investigation focused on the effects of hypnotic suggestions on dental anxiety in this demographic. The participants were divided into two groups: one group received hypnotherapy, while the other served as the control group. According to the data collected during the treatment, it was observed that the hypnotherapy group exhibited significantly lower levels of anxiety and fear compared to the control group, along with a notable decrease in predetermined anxiety metrics anxiety.[25] Erappa et al. conducted a research study comparing the efficacy of hypnosis, acupuncture, and audiovisual aids in alleviating anxiety among two hundred children aged between six and ten years, who required inferior alveolar nerve block and were undergoing local anesthesia for the first time. In the course of this study, the children were assigned to four distinct groups: hypnosis, acupuncture, audiovisual aids, and a control group, all directed towards reducing their anxiety before the administration of local anesthesia. Anxiety scores, the rate of anxiety progression, and parameters such as pulse rate and respiratory rate were recorded at three separate time intervals and subsequently subjected to statistical analysis. The findings revealed that the pulse rate, respiratory rate, and anxiety ratings exhibited significant reductions at all measured time intervals across all three groups compared to the control group, with hypnosis emerging as the most effective intervention for anxiety reduction.[26]

In a separate investigation, Tieri et al. conducted a comparison between nitrous oxide-oxygen sedation and hypnosis as methods for alleviating anxiety and fear that complicate dental procedures in pediatric patients. The study involved one hundred and fifty children, during which pain levels and heart rates were assessed across two experimental groups and a control group, the latter of which utilized only basic behavior guidance techniques. The findings indicated significant differences between the experimental and control groups. The application of hypnotherapy demonstrated considerable effectiveness in managing pain and behavior in children, suggesting it may serve as a valid alternative in circumstances where nitrous oxide-oxygen sedation is unsuitable contraindicated.[27]

Use of hypnosis in dental pain control and anesthesia

Pain management through hypnoanesthesia originates in the 18th century, when chemical anesthetics were not yet adequately developed or commonly employed. Hypnosis has been utilized as a substitute for anesthesia in various procedures, including dental extractions, both minor and major surgical operations, and limb amputations, since the inception of hypnosis applications.[28,29] The initial documented utilization of hypnosis in dentistry, as reported by Arthur Turner regarding the extraction of 40 teeth through hypnoanesthesia, was published in the British Dental Journal 1890.[30]

The methods employed during dental procedures must ensure a painless experience, prioritizing the patient's comfort and maintaining a safe and effective working environment for the physician. Hypnosis can potentially modify sensory experiences and distract the patient from the pain sensation. Evidence suggests that hypnosis effectively diminishes pain and discomfort associated with needle usage, particularly in pediatric patients and adolescents.[31] Arabzade Moghadam et al. conducted a single-blind clinical study involving thirty two volunteers to evaluate the efficacy of hypnosis in alleviating pain associated with infiltration anesthesia. The findings indicated that the application of hypnosis before the injection of dental infiltration anesthesia significantly diminished the intensity of pain experienced before the administration of the anesthetic injection.[32]

The extensive production and application of effective and safe anesthetic agents have significantly reduced the necessity for hypnosis in anesthesia. Nonetheless, the employment of pharmaceutical agents may be contraindicated in intolerant reactions and allergies, rendering the use of anesthetic agents unfeasible. Hypnosis can serve as a protective measure for patients with systemic disorders, shielding them from the adverse effects of pharmacological drugs while simultaneously

enhancing the efficacy and duration of anesthetic agents.[33]

Hypnosis, recognized for its lack of known side effects, can be safely utilized in adults and children. Additionally, it is considered a more cost-effective alternative to pharmaceutical interventions. Furthermore, it has been documented to have an impact on both acute and chronic conditions pain.[34,35] Thompson et al. examined eighty five relevant studies addressing hypnosis's analgesic effect. The findings indicated a substantial reduction in both the perception and severity of pain among individuals with moderate to high susceptibility to hypnosis. The review ultimately concluded that hypnotic intervention may serve as an effective analgesic effect.[36]

Use of hypnosis in bruxism

Bruxism is a recurrent activity involving the masticatory muscles, characterized by the clenching or grinding of the teeth and the supporting or pushing of the lower jaw when the individual is not swallowing chewing. Bruxism, classified as a parafunctional habit, is referred to as nocturnal when it transpires during sleep and diurnal when it manifests during wakefulness. Reports indicate that the frequency of grinding is more pronounced at night, whereas clenching may be observed during both daytime and nighttime.[37] The etiology of bruxism is multifactorial and can be seen in children and adults. It has been reported that nocturnal bruxism can develop as early as 4 years of age and reaches its peak between the ages of 10 and 14.[38]

Bruxism typically constitutes a complex diagnostic challenge, predominantly diagnosed through clinical evaluation. It may manifest symptoms including temporomandibular joint pain, discomfort in the masticatory muscles, limited mouth opening, and tenderness in the head and neck regions muscles. It may also cause intraoral findings such as wear on the incisal and occlusal surfaces of the teeth, cracks and fractures in the teeth, failure of dental restorations, enlargement of the periodontal ligament, prominence of the linea alba, and traumatic teeth marks on the tongue.[39] For children, the most reliable diagnostic tool besides clinical diagnosis is the report of teeth grinding by parents or caregivers.[40]

Currently, bruxism is addressed through a variety of approaches, including occlusal arrangements and the utilization of splints, psychotherapy and behavioral therapies, pharmacological interventions, relaxation and balance therapies, the application of botulinum toxin to the masticatory muscles, as well as physical therapy methods hypnotherapy.[38,41] The objective of bruxism treatment is to address the underlying causes following a thorough anamnesis. In addition to dental and pharmacological therapies, hypnosis, recognized as a behavioral and cognitive method, emerges as a viable alternative. Once the dental etiologies have been managed, it is essential to address individual stressors and underlying subconscious factors to effectively mitigate bruxism. Modifications within the subconscious mind can be facilitated through hypnosis, alongside the cultivation of self-control and relaxation techniques such as self-hypnosis. Furthermore, the muscles can be conditioned to respond appropriately through suggestions provided in a hypnotic state trances.

Golan investigated the effect of hypnosis on bruxism in a study involving a 17 year old patient who was treated with traditional treatment methods by multiple clinicians for 8.5 years due to bruxism and temporomandibular joint pain and who could not achieve regression in symptoms. As a result, he reported that there was a strong interaction between emotional states and bruxism, and hypnosis provided relaxation by controlling body mechanisms. It thus was a successful method in the treatment of bruxism.[42] To investigate the effect of medical hypnosis on pain symptom reduction in temporomandibular joint (TMJ) disorders, Simon et al. evaluated the effectiveness of hypnotherapy in patients who did not respond to conservative treatments in a study. As a result of the study, the use of medical hypnosis was shown to be an effective method in reducing both symptoms and the need for medical intervention in TMJ disorders.[43]

Hypnosis is regarded as a complementary and alternative treatment modality about traditional therapeutic approaches to bruxism.[44]

Use of hypnosis in adaptation to appliances and prostheses

In pediatric patients, dental appliances and prostheses are employed as an integral component of orthodontic treatment, functioning as either fixed or removable space maintainers or as pediatric prostheses designed to address aesthetic concerns and functional deficiencies. Given that these appliances and prostheses may induce a foreign body sensation in the oral cavity, they can impact the child's nutritional intake and speech, making the adaptation process particularly challenging. Ensuring patient cooperation and maintaining motivation are critical aspects clinicians should not overlook, especially in long term orthodontic treatments. In this regard, it has been reported that hypnosis may be utilized to enhance patient motivation through suggestive techniques.[45]

Trakyalı et al. investigated the effect of hypnosis on patient motivation in using extraoral orthodontic appliances, specifically cervical headgear, in a sample of 30 patients aged 9 to 11 years. Participants were divided into two groups: a hypnosis group and a control group. Both groups were instructed to wear their cervical headgear appliances for 16 hours daily. A cervical headgear equipped with a timing module was provided to all participants, and they were required to record their

usage durations on a time log. Patients were recalled for follow up visits every four weeks, during which the timing modules were read and compared with the self-recorded usage times. At the end of the six month follow up period, no decrease in appliance wear time was observed in the hypnosis group, whereas a decline in usage was noted in the control group throughout treatment. This study demonstrated that hypnosis has a positive effect on improving patient cooperation during orthodontic treatment.[2] Additionally, hypnotic suggestions aimed at alleviating issues such as gag reflex, responsibility related anxiety, and social concerns have been shown to enhance patient adaptation to treatment while also contributing to reductions in treatment duration, costs, and clinical workload.

Use of hypnosis in the prevention of nausea and gag reflex

The gag reflex is a protective natural mechanism that stops unwanted foreign body entry into the oral cavity and oropharynx from passing into the upper respiratory tract. The degree of reflex response varies from person to person. Some patients have diminished or absent reflexes, while others have prominent reflexes to the point of vomiting. In patients with a pronounced gag reflex, stimuli such as intraoral films, dental instruments, dentist's fingers, appliances, and prostheses that come into contact with the oral cavity during dental treatments may make it difficult or impossible for the patient to perform dental treatments. In some patients, this condition may even prevent the performance of basic principles of oral hygiene such as tooth brushing, and patients with nausea and gag reflex are known to avoid oral care and dental treatments. Many techniques have been described to try to overcome this problem. Distraction, placing salt on the anterior region of the tongue, gargling with water diluted form of topical anesthesia, and applying local anesthetics around the posterior palatine foramen are frequently preferred in clinical practice.[46] In cases with severe gag reflex and when routine techniques do not work, the use of pharmacological agents such as conscious sedation or general anesthesia can be used.[47]

In a case report, Venkiteswaran et al. evaluated the effect of hypnosis on the gag reflex in a 13 year old patient who needed orthodontic treatment for anterior crossbite and had a gag reflex. Hypnosis was applied to the patient during impression taking and fitting of the upper jaw appliance. The patient was also taught the self-hypnosis method to continue wearing the appliance during the treatment period. The patient's orthodontic treatment continued as planned during the follow up, proving the technique's success. At the same time, the patient, who could not swallow oral medications due to gag reflex, was informed by her parents that she could swallow oral medications after the hypnosis session. As a result of this study, the ability to swallow the medication was characterized as a secondary successful outcome of hypnosis.[48]

Hypnosis as a nonpharmacologic method enables dental treatment procedures in patients with gag reflex. Suggestions can be used in symptomatic treatment or dental treatment can be planned in multiple sessions to identify and alleviate the patient's unconscious fears.

Use of hypnosis to control saliva and bleeding

When triggered by sensory states, the unconscious system can show psychosomatic effects and directly affect mechanisms such as body secretions and blood circulation. The fact that hypnotic suggestions can affect the unconscious system indicates that the exact mechanism can be created.

The isolation of saliva during dental procedures is critical for ensuring a favorable treatment prognosis and providing the practitioner with a clear field of vision. Aspiration devices and rubber dams are employed to manage excessive saliva and bleeding. The application of rubber dams, which is commonly utilized in dentistry, may not be readily accepted by certain patients suffering from respiratory conditions and by pediatric patients. Research regarding saliva control has indicated that hypnosis can effectively reduce saliva flow for a specific duration and may be utilized to restore saliva control following radiotherapy targeting the head and neck region. [49,50]

Satzl et al. evaluated the effect of direct and indirect hypnotic suggestions on salivary flow rate in a randomized controlled crossover study. As a result, they reported that hypnotic methods are a simple and inexpensive tool to reduce salivation, thus creating a more comfortable treatment environment for both patients and dentists.[49]

There are findings that anxiety increases bleeding and thrombosis formation in patients with hemostatic disorders. Hypnosis helps treatment in this patient group by providing both bleeding control and relaxation during the operation. Studies have reported that hypnosis reduces bleeding during invasive intervention and effectively controls bleeding in the postoperative period.[52]

The use of hypnosis for quitting harmful habits

Some children may develop mechanisms including parafunctional habits to cope with anxiety and stress factors, feeling insecure, and peer bullying at school age. Nail biting, pencil biting, finger sucking, swallowing incorrectly, pulling out their hair, various tics, bed wetting are the most common of these harmful habits. While some children may be able to break their habits spontaneously when they are freed from these repulsive external factors, others may need professional support.

Hypnosis has been reported to be effective in helping children break these harmful habits.[53]

One of the most essential harmful habits concerning pediatric dentistry is thumb sucking. This habit, which is especially common among young children and can be considered normal until 2-3 years of age, should be stopped spontaneously around 6 years of age at the latest. Finger sucking habit that lasts longer than usual has been attributed to theories such as the child's sucking need not reaching sufficient satisfaction during infancy, emotional disorder, and enjoyment of the sucking habit. Long term finger sucking habit in children causes dental findings such as increased overjet, anterior open bite, maxillary stenosis and crossbite.[54] In cases not treated early, treatment plans ranging from orthodontic treatments to orthognathic surgical interventions may be required due to dental malocclusions. Bad taste treatment, intraoral fixed or removable appliances, and glove or finger appliances can be applied to abandon this habit.[55]

Grayson mentioned in one of his studies that no response was obtained from any conventional method applied to a seven year old girl with a thumb sucking habit. As a result of the study, it was reported that the child completely abandoned the habit of thumb sucking after hypnotherapy sessions, and there was no recurrence of the habit in the controls performed at 6, 13 and 20 months.[56] Hypnosis can be used in combination with conventional methods in the symptomatic treatment of thumb sucking habit or as an alternative method.

CONCLUSION

The application of hypnosis in dental practice offers significant advantages for patients. Hypnosis appears to be particularly effective in managing stress and alleviating anxiety, which represent substantial barriers encountered during dental procedures, especially in pediatric patients who are inherently more susceptible to such challenges. Furthermore, hypnosis is considered an economically viable and free of adverse effects intervention that can improve the cooperation of pediatric patients and alleviate the challenges linked to invasive procedures when executed by trained professionals employing suitable techniques.

Additionally, it may facilitate the child's ability to cultivate internal resources, explore new possibilities, and achieve both physiological and psychological modifications that are lasting in nature. Notwithstanding the encouraging outcomes observed, the integration of hypnosis within pediatric dentistry remains relatively limited. Consequently, further advocacy and investigation in this domain are essential. As the empirical foundation supporting hypnosis continues to strengthen, its adoption by healthcare practitioners and patients as a viable treatment modality is likely to increase.

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A Review On Professional Risk Factors In Dentistry

Diş Hekimliği Mesleki Risk Etmenleri Üzerine Bir İnceleme

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ABSTRACT

Along with technological advances, there are a wide variety of problems affecting the safety and health of workers in modern dentistry. Dentists and other dental personnel face risks specific to their profession and work area. Risks cause problems that develop instantly and/or over years. There are many physical, chemical and biological factors among the risks encountered in dentistry. Accidents caused by these factors can cause injuries, loss of limb, function and even death. In working life, dental professionals are exposed to many physical risk factors such as hitting, hitting, falling, sharps injuries, noise, vibration, thermal comfort conditions, radiation. Chemical substances used in dentistry can cause poisoning, allergic reactions, carcinogenic effects, respiratory disorders. In addition, the dental profession is faced with the danger of many bacteria, viruses and micro-organisms capable of causing disease throughout their working life. In addition to these biological risks, the new coronavirus disease (covid-19) has also been added today. In addition to these factors, dentistry professionals can be exposed to risk factors such as ergonomics and stress. The aim of this study is to investigate the risk factors affecting dental professionals,to reveal their possible effects and to make suggestions for measures to be taken against these effects.

Keywords: *Dentist, Occupational safety, risk effect*

ÖZ

Teknolojik ilerlemeler birlikte, modern diş hekimliğinde çalışanların güvenliğini ve sağlığını etkileyen çok çeşitli sorunlar bulunmaktadır. Diş hekimleri ve diğer diş hekimliği personeli mesleğe ve çalışma alanına özgü riskler ile karşı karşıyadır. Riskler anlık ve/veya yıllar içinde gelişen sorunlara neden olmaktadır. Diş hekimliğinde karşılaşılan risk etmeleri arasında fiziksel, kimyasal, biyolojik birçok etmen yer almaktadır. Bu etmenler sonucu oluşan kazalar, yaralanmalara, uzuv, işlev kayıplarına ve hatta ölüme sebep olabilmektedir. Çalışma hayatın içerisinde diş hekimliği meslek mensupları vurma çarpma, düşme, kesici delici alet yaralanmaları, gürültü, titreşim, termal konfor şartları, radyasyon gibi birçok fiziksel risk etmenine maruz kalmaktadır. Diş hekimliğinde kullanılan kimyasal maddeler zehirlenmelere, alerjik reaksiyonlara, kanserojen etkilere, solunum rahatsızlarına sebep olabilmektedir. Ayrıca diş hekimliği meslek grubu çalışma hayatı boyunca birçok bakteri, virüs ve hastalık yapma kabiliyetine sahip mikro organizma tehlikesi ile karşı karşıya kalmaktadır. Bu biyolojik risklere ilave olarak günümüzde yeni koronavirüs hastalığı (covid-19) da eklenmiştir. Bu etmenlerin yanı sıra diş hekimliği meslek grubu çalışanları ergonomi ve stres gibi risk faktörlerine maruz kalabilmektedir. Bu çalışmanın amacı, diş hekimliği meslek mensuplarını etkileyen risk etmenlerini araştırmak, türlerini tespit etmek, olası etkilerini ortaya koymak ve bu etkilere karşı alınacak tedbirler için önerilerde bulunmaktır. Bu çalışma, makalenin amacına uygun bulunan kaynaklardan derlemeler yapılarak hazırlanan bir çalışmadır.

Anahtar Kelimeler: *Diş hekimliği, İş Güvenliği, Risk Etmenleri*

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INTRODUCTION

Dentistry is defined as a field of medicine that examines the structures, functions, diseases, disorders and conditions of the oral cavity, jaw, facial region and teeth, and includes the prevention, diagnosis and treatment of diseases that occur in these areas.[1]

The concept of 'occupational hazard', which is defined as the risk arising from one's work and affecting one's health, includes accidents that occur in the workplace, the environment that predisposes to diseases, the materials used, chemical substances, work processes and environmental effects.[1]

Dental professionals (dentists, oral and dental health auxiliary personnel, dental prosthesis technicians, etc.) face many physical, chemical, biological and ergonomic risk factors. In addition to physical injuries such as sharp-piercing tool injuries, hitting-impacting objects such as tools, devices, etc. in the workplace, employees face accidents caused by chemical substances used in dentistry and hazards caused by biological agents encountered due to the nature of the work. In addition, many occupational hazards such as stress, allergic reactions, high noise, radiation, musculoskeletal disorders, etc. also threaten workers.[1] These cause the emergence of various personalized disorders.[1] All these factors cause the emergence of various personalized disorders and cause diseases and disease complexes that are accepted as occupational diseases.[2]

The aim of this study is to reveal the risk factors affecting dental professionals and their possible effects and to present measures to be taken against these effects.

A literature review was conducted on the occupational health hazards of dental professionals, including articles published in peer-reviewed journals between 1976 and 2024. The literatures were searched in Google Scholar, Research Gate, Scopus search engines with related keywords such as occupational health, occupational safety, occupational disease, etc. Studies published in Turkish and English were included in the review. The titles, keywords and abstracts of the scanned articles were evaluated in terms of their relevance to the subject. Articles that were considered relevant to the study were used (Figure 1).

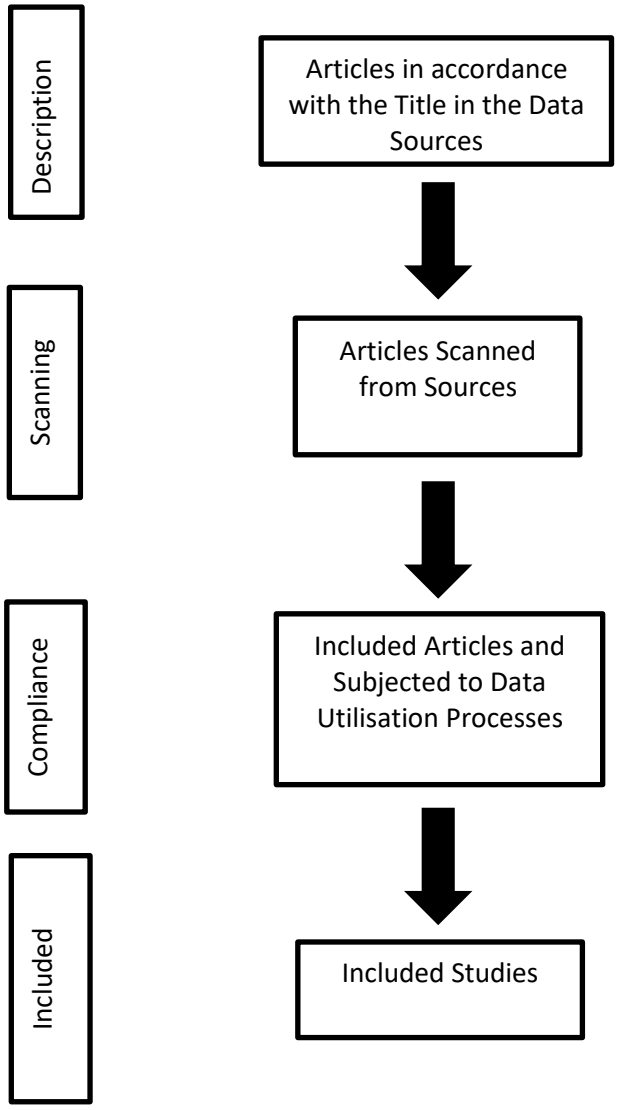

Figure 1. Flow Chart

Occupational Health Hazards and Effects in the Dentistry Profession

Occupational risk factors faced by dental professionals and the problems caused by these factors are presented in Table 1.

Table 1. Risk factors and caused by them

Risk factors	Problems causing accidents and diseases
Physical factors	- Eye injuries - Percutaneous injuries - Hearing system problems - Vibration - Radiation

Chemical factors	- Allergic reactions - Disturbances caused by acrylate compounds - Hazards from nitrous oxide gas - Poisoning
Biological factors	- Viral Hepatitis - Corona virus disease (Covid-19 - Tuberculosis - Human immunodeficiency virus (HIV-AIDS
Ergonomic factors	- Musculoskeletal disorders
Psycho-social factors	- Stress

As occupational risks, dentists emphasize biological risks, physical strains, and stress experienced in relationships with patients.[3] They also state that they are uncomfortable with the long time spent in the office and the lack of personal time.[4]

Research among Lithuanian dentists reveals that the majority of dentists (95.1%) feel that their profession affects their general health and more than half (52.4%) experience frequent or very frequent health complaints.[5]

A study conducted in India reported that 47% of dentists had an occupational injury due to sharps use in the last six months and 70.6% reported back pain. The same study also emphasizes anxiety and wrist pain complaints among employees.[6]

A study among dental students at the University of Cartagena reported that 80% of students experienced muscle pain due to clinical practice; pain increased in surgical and periodontology clinical work and 15% of pain was concentrated in the neck and lower back.[7] A large study conducted in Lithuania reported that 55.1% of dentists reported chronic back pain, 88.7% reported headaches and 86.5% reported musculoskeletal symptoms.[8] A study among dentists in southern Iran showed that 33% of dentists complained of low back pain and 28% of dentists complained of neck pain.[9] A study of the prevalence of hearing problems among dentists and dental assistants in Riyadh over the past five years reported that 16.6% complained of tinnitus, 30% had difficulty distinguishing speech in background noise and 30.8% had tinnitus.[10]

In a study conducted in Australia, it was reported that 9% of dental staff had latex allergy and 22% had glove dermatitis.[11]

Risk Factors in the Dental Profession

1.1. Physical hazards and the problems they cause

Particularly noticeable material fragments from the oral cavity (dental tissues, saliva, milling cutter fragments, etc.), sharp tool and needle trauma, working environment air conditioning conditions, radiation from equipment used in the working environment are among the physical risk factors. These risk factors can cause occupational accidents resulting in injury and occupational diseases caused by infectious diseases.[12]

1.1.1. Eye injuries

High-speed devices (aerator, micromotor, laboratory motor, etc.) used during the procedures cause splashing of fragments from the oral cavity (teeth, saliva, etc.) and the material being worked with (plaster, acryl, pumice, etc.). These fragments can cause injury and the bacterial and viral aerosols they contain can cause infection. In addition, intense ultraviolet (UV) rays in the polymerization process are known to damage the naked eye. [13]

1.1.2. Percutaneous injuries

Dentists may be exposed to percutaneous injuries due to sharp, penetrating instruments such as burs, syringe tips and suture needles. Percutaneous injuries are one of the most common factors of occupational accidents among health professionals.[14] Needle and sharps injuries in particular [15] are a common problem among dentists. This exposure is related to the fact that dentists work in an area with limited access and restricted visibility and frequently use sharp instruments. One study reported that the most common instrument causing injury in dentists was the probe.[16]

In the United States, more than 800,000 needlestick injuries are reported to occur each year, despite ongoing education and prevention efforts.[14]

According to one study, the prevalence of needlestick and sharps injuries in dentists during the previous six months of the year of the study was reported to be 19.2%.[17] Reports from another study conducted in Washington, D.C. revealed that 66.7% of percutaneous injuries occurred during procedures performed by dentists [18], with the majority of injuries (70%) occurring during the administration of local anesthesia, dental cannula closure, and surgical procedures.[13] In needlestick injuries, contamination of body fluids is also a concern in terms of infection.[13]

The 2001 revisions to The Needlestick Safety and Prevention Act (NSPA) and The Occupational Safety and Health Administration (OSHA) have been observed to help minimize the risk of exposure of all healthcare workers to bloodborne pathogens.[19] The mandatory use of safety-engineered medical devices (SEMDs) in

countries implementing the legislation has also been reported to significantly reduce wig injuries.[20]

The risk of infection after accidents involving contact with contaminated blood depends on several factors, including the type of exposure, size of inoculum, amount of infectious material and blood.[21] Percutaneous exposure events facilitate the transmission of bloodborne pathogens such as human immunodeficiency virus (HIV), hepatitis C virus (HCV) and hepatitis B virus (HBV).[17] Estimates based on data from the Centers for Disease Control and Prevention suggest that a healthcare provider has a 0.3% risk of acquiring HIV infection as a result of exposure to a wig injury from an HIV-infected device.[18] Close contact with patients facilitates the risk of transmission of the airborne coronavirus (Covid-19) virus to workers.

1.1.3. Hearing system problems

In a study conducted among dentists and dental assistants, 16.6% of subjects reported tinnitus, 30% had difficulty distinguishing speech, and 30.8% distinguished speech in background noise.[10]

Zubick et al. reported that hearing loss was associated with the use of high-speed handpieces. They reported that especially right-handed dentists had more hearing problems in the left ear in relation to proximity to the noise source. reported that the same situation was not observed in the medical doctors selected as the control group. They showed that the level of hearing loss varied depending on the intensity, duration and frequency of the noise of the instruments used.[22]

Dental practice classrooms are characterized by higher noise levels than other teaching spaces due to the acoustic environment, the exaggerated noise generated by some of these devices and the use of noise generating equipment by many users at the same time. Özmen et al. In their 2020 study, Özmen et al. recorded the noise levels of devices used in dentistry as 114 dB(A) for amalgamator, 113.9 dB(A) for saliva extractor, 117.8 dB(A) for surgical aspirator, 96.3 dB(A) for aerator, 86.3 dB(A) for micromotor-angulator.[23] Therefore, it should be guaranteed that the sound levels in such educational buildings will not be detrimental to learning activities. Prolonged exposure to high noise levels has a detrimental effect on students and lecturers. Higher noise levels can have physical (accelerated pulse rate, increased blood pressure, constriction of blood vessels, etc.) and psychological consequences (irritability, mental fatigue, emotional frustration and low productivity, etc.) on workers. These effects occur especially at noise levels above 80 db and vary depending on the intensity, distance from the source, total duration of the noise, age, physical condition and sensitivity of the person.[24]

Ultrasonic scalers used to effectively remove attachments and calculus from the tooth surface can be a potential hazard to both users and patients' hearing systems. It is possible for ultrasonic engraving to damage the hearing system due to airborne sub-harmonics. Vibrations during scraping can cause damage as they are transmitted through the bones of the skull to the inner ear. This is more pronounced when cleaning molars.[25]

Vibration

The main source of vibration is hand instruments that emit strong vibrations at high frequencies in the vibration spectrum,[26] such as low and high speed hand instruments used by dentists, ultrasonic instruments [27]

Rytkönen et al. In a 2006 study, vibration levels of instruments used in dentistry were found to be 0.01-0.04 m/s^2 for aerotor and 0.2-0.9 m/s^2 for micromotor. However, measurements were made in only one direction.[28] The time spent using the handpiece per patient ranged from 0.2 to 4.5 minutes and the results were reported to be below the exposure action value of 2.5 m/s^2 of the European Union Vibration Regulation.[29] In this study, the vibration frequency of the aerotor was reported to be lower than the micromotor frequency.[28]

Hjortsberg et al. compared 10 male dental technicians who had been working for more than 7 years and frequently used devices that produced vibrations up to 40 kHz with 10 male individuals who were not exposed to occupational vibration. As a result of the study, it was reported that the response time to stimuli was longer in the fingers of the technicians and that there was damage to myelinated and unmyelinated fibers in their fingers.[30]

The study comparing the sensory perception of both hands was conducted among physicians with at least 10 years of experience in clinical dentistry and those with less than 5 years of experience. In the study, subjects' responses to vibration, temperature and heat pain were measured. It was reported that some subjects had symptoms such as tingling, numbness and decreased manipulative dexterity, but none of the subjects had neurological symptoms in their non-dominant hand. Long-term exposure to ultrasonic devices was found to cause a high rate of neurological damage in the dominant hand.[31]

Akesson et al. evaluated 60 dentists and 60 dental assistants exposed to vibrations from high-speed heads and ultrasonic scrapers in terms of manual performance, tactility, strength, etc. They observed neurologic and functional impairments in the hands of female dental staff and reported that vibrations may cause a decrease in finger strength, tactile sensitivity and performance due to impaired blood and nerve supply to the fingers.[32]

1.1.4. Radiation

Dentists are exposed to both ionizing and non-ionizing forms of radiation. Ionizing radiation is the type of radiation found in imaging devices containing X-rays

such as periapical X-rays, panoramic radiography, computed tomography (CT), etc. It is the type of radiation found in imaging devices containing X-rays. Non-ionizing radiation is caused by imaging techniques such as Magnetic Resonance Imaging, Ultrasound, Thermography. Ionizing radiation is a well-known risk factor for cancer.[33] Only a few studies have evaluated the exposure of dentists to ionizing radiation and the associated potential cancer risk.

Non-ionizing radiation has been found to be a significant risk with the use of blue light and ultraviolet light to cure various dental materials. Exposure to radiation from these devices can damage various structures of the eye, including the retina and cornea.[34]

Occupational ionizing radiation doses among dentists and ancillary personnel have reportedly decreased markedly since the 1950s.[35] Cancer incidence among dental workers is lower than in the Canadian cancer incidence population for all cancers except cutaneous melanoma.[36] Secondary radiation scattered from the bones in the patient's head represents the largest source of radiation received by dentists.[37]

1.2. Chemical hazards and the problems they cause

The chemical environment is one of the fastest expanding components of the working environment, with new chemicals and solutions being introduced on a regular basis. The health effects of many of these chemicals are unknown and many of them can cause health problems that take years to manifest.[38] There are many materials with toxic effects that have the potential to pose a health hazard if appropriate precautions are not taken in the field of dentistry. Hazardous chemicals used in clinical dentistry include mercury, powdered natural rubber latex (NRL), disinfectants and nitrous oxide (N2O). The most important and dangerous of these agents is mercury.[39]

1.2.1. Allergic reactions

Gloves can be used by dentists during patient care to reduce the possibility of transmission of infectious organisms and to prevent skin contact with a variety of chemicals such as sterilization solutions, impression materials, and uncured restorative materials.[40] In the mid-1980s, the Center for Disease Control set a standard for blood and body fluid precautions that should be applied to all patients at all times under Universal Precautions. Surgical gloves are an important component of Universal Precautions. It acts as a deterrent against the transmission of pathogens such as hepatitis B virus and HIV. To prevent any anticipated contact between the healthcare worker and the patient's blood or body fluids, the healthcare worker is required to wear gloves.[41]

They can cause allergic reactions. Occupational allergic reaction, especially to the hands, is a common problem among dental personnel.[42] Latex gloves dusted with cornstarch powder are the most commonly used,[42] and frequent exposure to latex products is reported to be the most important risk factor for immediate allergies.[43,44] Sensitization can occur by inhalation of airborne dust or through the skin. Inhaled glove dust can induce type 1 hypersensitivity reactions , but the most common type of allergic reaction is delayed hypersensitivity or allergic contact dermatitis.[43]

Atopy is another important factor contributing to the increasing number of allergic cases. One study reported that atopy was 2.2-4.5 times more common in healthcare workers allergic to latex than in those without allergies. It is estimated that 2.8-17% of healthcare workers are allergic to latex. 8.8% of dentists were found to be allergic.[44] Glove dermatitis allergy was reported in 22% and latex allergy in 9% of dental students in Australia.[45]

1.2.2. Ailments caused by acylate compounds

In dentistry, a variety of different polymer materials are used. Curing of restorative materials and adhesives is initiated chemically by mixing the two components or by visible light. In both cases, polymerization is incomplete and unreacted monomers are released.[46] These free monomers can cause a wide range of health problems, including irritation of the skin, eyes or mucous membranes, allergic dermatitis, asthma and paresthesia of the fingers. They can also cause central nervous system disorders such as headaches, pain in the extremities, nausea, loss of appetite, fatigue, sleep disturbances, irritability, memory loss, and changes in blood parameters.[13]

Dental polymer materials based on methacrylate, acrylate polymer and polyelectrolytes are the main cause of contact dermatitis in dental staff.[47]

Allergic respiratory problems due to dental materials are also a significant occupational hazard. One study reported occupational asthma, conjunctival symptoms and allergic contact dermatitis among dental technicians exposed to acrylate compounds.[48] Studies suggest that a peak concentration of methacrylate vapor of 100ppm over an 8-hour working period and a time weighted average of 400ppm would provide adequate protection for dentists.[49]

1.2.3. Hazards from nitrous oxide gas

N_2O, also called laughing gas, is an anesthetic substance used in operating rooms. Workers are exposed to N_2O during the administration of anesthetic gas to patients. In 1994, the National Institute for Occupational Safety and Health (NIOSH) warned hundreds of thousands of medical, dental and veterinary professionals who work with N_2O that workers may be at risk of serious health effects from exposure to this gas, even if

preventive measures such as sweeping systems are implemented in the workplace.[50]

Recent studies have shown significantly reduced fertility in female workers exposed to N_2O.[47] It has been documented that occupational exposure to N_2O can cause reduced fertility, spontaneous abortions, neurological disorders, kidney and liver disease, and decreased mental performance, audiovisual ability and mental manual dexterity in susceptible individuals.[50]

1.2.4. Poisoning

The use of amalgam and amalgam capsules for restorations in dentistry, storage and disposal of amalgam cause mercury poisoning.[51]

Chemicals used in radiology can also cause health problems and poisoning from time to time.

During the disinfection and sterilization stages, many chemicals are used for dissolving, cleaning and neutralization processes.[52] These chemicals include acetic acid, diethyl glycol, glutaraldehyde, hydroquinone, potassium hydroxide, etc., which cause poisoning.[52] Mixing of chemicals causes decomposition of sulfide and release of sulfur dioxide gas. Exposure to these processes can cause acute bronchospasm. During the disinfection and sterilization stages, ammonia is released as a result of the breakdown of chemicals. This substance is a highly respiratory irritant by-product. [52]

1.3. Biological hazards

Biological hazards are posed by human infectious agents and include viruses, bacteria and fungi.[53] These agents can be found in the saliva, blood and inhaled air of infected persons. Needlestick and other sharps injuries and contact with contaminated instruments, aerocell-forming processes, etc. are considered as sources of transmission.[54] The infectious diseases for which the agents pose a risk are HIV, HBV, HCV and Tuberculosis. [54] As of 2020, Covid-19 has been added to these diseases.

1.4. Ergonomic hazards and diseases caused by them

Ergonomics is defined as the discipline of designing the working and living environment in accordance with human characteristics. It is the design of tools, equipment, workspace and tasks to make the work suitable for the worker.[55]

1.4.1. Musculoskeletal disorders

The dental profession requires skillful preparation with great precision and control. The muscles used for this purpose are at risk of fatigue and discomfort to the dentist. Dentists are known to be susceptible to postural problems due to limited access and restricted vision, making them vulnerable to occupational risks.[56]

Musculoskeletal pain is a common ailment in dentists that begins as soon as they start their professional training.[57] Musculoskeletal pain experienced during professional practice, which also affects the spine, neck, shoulders and hands, stays with them throughout their lives.[57] Musculoskeletal disorders in the neck (85%), shoulders (70%) and lower back (68%) are frequently reported.[58]

Dentists work in a tense posture in both standing and sitting positions for 37.7% of their working time.[59] Prolonged awkward postures often become ischemic, causing misalignment of the spine.[60] This leads to overstressing of the spine and limbs. Excessive stress has a negative impact on the musculoskeletal system and the peripheral nervous system, affecting the peripheral nerves of the upper limbs and the nerve roots of the neck.[61] Postures that can put more pressure on the intervertebral disc and prolonged spinal hypomobility have been proven to be among the major factors causing degenerative changes in the lumbar spine and low back pain.[61]

Musculoskeletal disorders cause various degenerative disorders in muscles, tendons and nerves. These disorders can cause pain and functional impairment affecting many parts of the body, such as the neck, upper and lower back, shoulders, elbows, wrists and hands.[61] Early symptoms include decreased strength, pain, swelling and numbness. Other symptoms may include excessive fatigue in the shoulders and neck, poor hand grip and hypersensitivity in the hands and fingers.

Polat et al. In their 2007 study involving 120 individuals, they reported that the most common symptoms were foot and leg pain (30.95%) and headache (29.05%). [62]

The prevalence of musculoskeletal pain in dentists ranges from 64% to 93%, with the most affected areas being the back and neck.[63] Operations during tooth extraction not only stress the elbow joint and wrist joint, but can also cause chronic tendon sheath inflammation. The long-term effect of all these adverse conditions occurring in the dentist's work can lead to diseases described as cumulative trauma disorders.[64] Median nerve and cubital nerve defects are seen in many dentists. In acroparasthesia an early syndrome of a defective median nerve is seen. A consequence of a defective median nerve in the carpal nerve is the so-called tunnel syndrome. The early stage is dominated by paroxysmal parasthesia of the thumb and index finger, which occurs almost without exception and is accompanied by sensomotor disturbances of the thumb and index finger.[64] Rafie et al. 2015 study of 130 dentists (84 men and 46 women) showed that 82.8% of the subjects were at risk of musculoskeletal disorders.[64]

Spinal degeneration leads to back pain syndromes that are frequently reported in dental staff. Cervical

discopathy results in cervical pains or cervico-acromial pains, which are particularly common among dentists.[65] The posture the dentist takes at work, with neck bent and flexed, arm in abduction, repetitive and precise movements of the hand, is a common cause of neck syndrome and pain in the shoulders and upper limbs.[66] In Finland, 30% of dentists reported musculoskeletal symptoms in the back and neck region.

Lumbar and lumbosacral discopathy causes pain in the lower back and radiates to the lower extremities, more often to the left. This can be explained by the fact that the doctor has more stress on the right side of the body when working with a seated patient.[16] The dentist makes continuous monotonous movements that strain the wrist and elbow joints. It is also a consequence of the mechanical vibrations transmitted to the hands and arms produced by some dental equipment such as ultrasonic scalers and handpieces. Whatever the cause of the symptoms, neurological disorders are potentially serious in an occupation where precise hand movements are required.[13]

It has been determined that high levels of ergonomic risk do not occur after many years of workload, but that high ergonomic risk potentials are caused by possible unfavorable movement patterns that occur in the early stages of dental education.[67]

1.5. Psycho-social risk factors

1.5.1. Stress

Although stressors are rarely discussed, they should be considered in the light of occupational hazards. Although dentists are generally considered to be in good health and are less likely to be absent during their working life compared to all health care workers [68], sickness and sick leave are known to increase with age.[13]

1.5.1.1. Sources of stress

Examples of stressful situations include administering anesthesia to patients, overcoming pain and fear, unexpected emergencies such as when a patient's life is suddenly in danger, and an uncertain prognosis.[69] Improper planning of treatment can be a source of frustration and pain associated with failure for both the physician and the patient.[69]

The most common stressors reported by dentists in New Zealand were treating difficult children (52%), time pressure (48%) and maintaining high concentration levels (43%).[70]

CONCLUSION

Occupational health and safety hazards are encountered in many sectors and professions. Despite technological advances, many occupational health and safety hazards still exist in the dental profession. Dentists are faced with many risk factors such as Physical, Chemical, Biological, etc. Studies show that the risk of accidents and occupational diseases is still high. Dentists have reported many accidents and illnesses involving various risk factors.

Careful behavior of the healthcare worker in percutaneous injuries is important in terms of injuries and accidents. With the legislation enacted in 2001 in the international arena regarding this issue, the USA and other countries implementing the legislation have succeeded in minimizing percutaneous accidents experienced by healthcare workers. It is thought that wig injuries can be prevented in our country with the correct and mandatory implementation of legislation and laws with these features.

Noise is a common risk factor among dentists. Physicians are exposed to high noise levels in the workplace. The noise levels and exposure times of the devices used create hearing problems for dentists. Determining the noise levels of the working environment and reducing the noise levels and exposure times of the devices used can eliminate the risk of hearing loss.

Vibration risk factor to which dentists are exposed is one of the neglected risk issues. Knowing the vibrations of the devices, tools and equipment used and the amount of exposure time is important in preventing accidents and diseases. Exposure to vibration from dental heads is high. For this reason, it is recommended that dentists can use vibrating instruments for an average of 75 minutes a day.[37]

The health sector is a working area rich in chemical resources. Gloves used as barriers are indispensable protective equipment. The use of gloves made of different materials may cause allergic reactions. Latex, the material from which gloves are commonly produced, is reported to cause allergies in the user. The choice of material is important in preventing this type of discomfort. Physicians are exposed to many chemicals in their work areas. Nitrous oxide gas (N_2O), mercury, substances containing acrylate compounds, etc. are the main sources of danger. Exposure to these substances causes various diseases and accidents. To protect against health risks associated with N_2O, operating rooms are equipped with cleaning systems that remove the gases.[48] It is also important to open silver recovery units in a well-ventilated area to reduce vapor release and eliminate exposure.[52]

Ergonomics and musculoskeletal disorders are mostly caused by the wrong posture and working style of physicians during their student years. In the following periods, the risk of occupational disease increases due to posture disorder and ergonomics emerges as a risk factor.

Exposure to the factors that are tried to be defined causes accidents and various occupational diseases in the working life of dentists. Developing technology will

require the use of new materials and methods. Changing situations will eliminate some risks and bring new risks to the agenda. Evaluating the risks related to the profession in the dynamics of change and development, and taking measures to reduce and take precautions from the beginning of education will contribute to reducing the negative situations that may be caused by risks.

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Risk Factors of Peri-implant Diseases

İmplant Çevresi Hastalıklarda Risk Faktörleri

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ABSTRACT

Dental implants provide to eliminate the lack of function caused by tooth loss and restore impaired aesthetics. Implants are known as a reliable treatment method and have a high survival rate. However, the increase in peri-implant diseases also cause the long-term success of the implant to be lower than the survival rate. Peri-implant mucositis is defined as inflammation of the mucosa around the implant, while peri-implantitis is defined as a pathological condition associated with microbial plaque, which is characterized by inflammation of the mucosa and progressive loss of supporting bone around the implant. Risk factors that may be effective in peri-implant diseases have been tried to be identified by many studies conducted so far. History of periodontitis, insufficient plaque control, lack of maintenance therapy, smoking systemic diseases, insufficient keratinized mucosa, cement residues, implant-abutment connection and metal particle release may be associated with peri-implant diseases. While it is accepted that the evidence is strong that a history of periodontitis, insufficient plaque control and lack of maintenance therapy are related to implant-related diseases, it is reported that researches investigating the other risk factors are not sufficient yet. The aim of this review is to evaluate the possible risk factors of peri-implant diseases.

Keywords: *Peri-implant health, peri-implant mucositis, peri-implantitis, risk factors*

ÖZ

Dental implantlar, diş kaybının neden olduğu fonksiyon eksikliğini gidermeyi ve bozulmuş estetiği geri kazandırmayı sağlarlar ve kullanımları yaygınlaşmıştır. İmplantlar, güvenilir bir tedavi yöntemi olarak bilinmektedir ve yüksek sağkalım oranına sahiptir. Bununla birlikte artan implant uygulamalarıyla beraber implant çevresi hastalıklarda da izlenen artış implantın uzun vadeli başarısının sağkalım oranından daha düşük olmasına neden olmaktadır. Peri-implant mukozitis implant çevresi mukozanın enflamasyonu olarak tanımlanırken peri-implantitis implant çevresi mukozanın enflamasyonu ve destekleyici kemiğin progresif kaybı ile karakterize olan mikrobiyal plakla ilişkili patolojik bir durum olarak tanımlanır. Bu hastalıkların oluşmasında etkili olabilecek risk faktörleri günümüze değin yapılan bir çok araştırmayla ortaya koyulmaya çalışılmıştır. Periodontitis geçmişi, yetersiz plak kontrolü, idame tedavisinin eksikliği, sigara, alkol, diyabet, osteoporoz, genetik faktörler, yaş, cinsiyet, yetersiz keratinize mukoza, siman artıkları, aşırı okluzal kuvvet, fiksasyon tipi, iatrojenik faktörler, implant dayanak birleşimi tasarımı, implantın fonksiyon süresi ve topografik özellikleri, metal partikül salınımı gibi faktörlerin implant çevresi hastalıklarla ilişkili olabileceği düşünülmektedir. Bu faktörlerden periodontitis geçmişinin, yetersiz plak kontrolünün ve idame tedavisi eksikliğinin implant çevresi hastalıklarla ilişkili olduğuna dair kanıtların güçlü olduğu kabul edilirken; diğer faktörler için araştırmaların henüz yeterli olmadığı bildirilmektedir. Bu derlemenin amacı implant çevresinde gözlenen hastalıklara sebep olabileceği düşünülen risk faktörlerinin değerlendirilmesidir.

Anahtar Kelimeler: *Peri-implant sağlık, peri-implant mukozitis, peri-implantitis, risk faktörleri*

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Classification

At the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions, periodontal diseases and conditions were categorized into periodontal health, gingival diseases and conditions, periodontitis, and other conditions affecting the periodontium. Additionally, for the first time, peri-implant diseases and conditions were included in the classification. Accordingly, peri-implant diseases and conditions were classified as peri-implant health, peri-implant mucositis, peri-implantitis, and peri-implant soft and hard tissue deficiencies.[1]

Examination of Peri-Implant Tissues

Renvert et al. outlined the clinical and radiographic examination steps required to detect peri-implant conditions.[2] According to this:

1. The soft tissues around the implants should be clinically examined, and the presence of biofilm on implants and restorations, as well as overall oral hygiene, should be evaluated.
2. Implants should be visually assessed and examined routinely and periodically, at least once a year, in a manner similar to natural teeth.
3. Probing around implants should be performed with light force (approximately 0.25 N), and the probing depth around implants should generally be ≤5 mm.
4. In implant sites defined as healthy, there should be no bleeding during probing. If bleeding occurs during probing, it should be carefully evaluated using light force to avoid the potential effects of trauma caused by the procedure.
5. Changes in bone levels around the implant should be evaluated using intraoral radiographs to distinguish between health and disease conditions. In radiographic assessment, a reference point on the implant should be identified, implant threads should be clearly visible, and mesial and distal bone levels should be examined in relation to these reference points.
6. There should be no bone loss beyond the initial bone remodeling. During the first year following implant function, alveolar bone remodeling may depend on the type and location of the implant. However, after the implant begins functioning, alveolar bone loss should not exceed 2 mm. Changes equal to or greater than 2 mm are considered pathological regardless of whether they occur during the first year or at any time thereafter.

Peri-Implant Health

Clinically, peri-implant health is characterized by the absence of visible signs of inflammation and no bleeding on probing. Implants with normal or reduced bone support can also exhibit peri-implant health. Clinically healthy mucosa around the implant forms a tight seal around the transmucosal component of the implant, abutment, or restoration. Following the placement of the implant in the tissue, the height of the surrounding soft tissue influences the initial probing depth.[2] While it is not possible to define a specific range for probing depths compatible with peri-implant health, it has been reported that the probing depth should be ≤5 mm.[3]

The criteria for peri-implant health include the absence of signs of inflammation around the implant upon visual examination, pink-colored mucosa, and a firm, non-edematous consistency. No bleeding is observed during probing. Following initial healing, bone loss greater than 2 mm should not occur. Probing depths may vary depending on the height of the soft tissue at the implant site; however, an increase in probing depth is inconsistent with peri-implant health.[2]

Peri-Implant Mucositis

Peri-implant mucositis is defined as a reversible inflammatory reaction in the mucosa surrounding an osseointegrated implant. This condition is limited to the soft tissues, with no bone loss around the implant.[4] There is strong evidence that peri-implant mucositis is caused by plaque and can be reversed with plaque removal.[5] Typical clinical signs of peri-implant mucositis include mucosal edema, redness, and bleeding on gentle probing. As a result of inflammation and edema, probing depths may increase. Schou et al. reported in their study comparing the penetration of periodontal probes around implants and teeth that the probe could penetrate deeper in the presence of peri-implant mucositis.[6]

The criteria for peri-implant mucositis include red color, unlike pink, edematous tissue, and soft tissue consistency, unlike the firm consistency of the tissue. Bleeding and/or suppuration in the form of a line or drop during probing is observed. There is an increase in probing depths compared to initial measurements. Beyond changes in crestal bone levels caused by remodeling, no bone loss is observed.[2]

Peri-Implantitis

Peri-implantitis is a pathological condition associated with microbial plaque, characterized by inflammation in the peri-implant mucosa and progressive loss of supporting bone.[3] Studies have shown that inflammation observed in peri-implantitis is

more widespread compared to periodontitis.[2] Peri-implantitis is likely to occur following peri-implant mucositis caused by plaque accumulation around the implant.[3] In a study conducted by Costa et al. involving 212 individuals to determine the incidence of peri-implantitis in those with peri-implant mucositis, 80 individuals diagnosed with peri-implant mucositis at the initial examination were examined again after 5 years. It was reported that individuals with prior peri-implant mucositis who did not receive supportive therapy had a higher incidence of peri-implantitis.[7] Schwarz et al. noted that the histopathological and clinical conditions leading to the progression from peri-implant mucositis to peri-implantitis are not yet fully understood.[8] Fransson and Tomasi examined a total of 419 implants in 182 patients to evaluate the amount and pattern of bone loss one year after the completion of implant-supported restorations. The researchers reported an average bone loss of 1.68 mm around implants during the first year of function and 2 mm of bone loss in 32% of the implants. They noted that bone loss associated with peri-implantitis is often characterized by non-linear progression, with the rate of bone loss increasing over time.[9] Typically, the development of peri-implantitis occurs within the first few years of the implant's functional period. Although there is no predictable model to foresee the progression of peri-implantitis,[2] Sanz et al. reported that bone loss greater than approximately 2 mm is indicative of peri-implantitis.[10]

The diagnostic criteria for peri-implantitis; include bleeding and/or suppuration on probing, an increase in probing depth compared to measurements obtained during implant-supported restoration placement, and increased bone loss as determined by radiographic evaluation one year after prosthesis placement. In the absence of initial radiographs and probing depth measurements, peri-implantitis is indicated by a bone level ≥3 mm and/or probing depth ≥6 mm, accompanied by bleeding.[2]

Risk Factors for Peri-Implant Mucositis

Insufficient oral hygiene and plaque accumulation are strongly associated with peri-implant mucositis. Another factor related to plaque accumulation is keratinized mucosa.[11] In 2018, Renvert et al. reported that smoking, lack of keratinized tissue, excess cement, or systemic conditions such as diabetes might be potential risk indicators for peri-implant mucositis.[12] Lin et al. stated that the presence of keratinized mucosa could be important in reducing plaque and bleeding indices, mucosal recession, and clinical attachment loss.[13] Wada et al. emphasized the need for more prospective and randomized studies on the importance of keratinized mucosa in preventing peri-implant mucositis.[11] During the 2017 World Workshop, smoking and radiation, in addition to plaque accumulation, were identified as risk indicators for peri-implant mucositis.[1] Similarly, Renvert and Polyzois reported that smoking is a risk indicator for peri-implant mucositis.[12] The presence of excess cement has also been suggested to be closely associated with the development of peri-implant mucositis.[8]

Risk Factors for Peri-Implantitis

1. History of Periodontitis

Chrcanovic et al. reported that individuals with a history of periodontal disease exhibit higher rates of peri-implantitis and implant failure compared to those without periodontal disease.[14] Karoussis et al., in their clinical and radiographic evaluation of patients who received implants, found that implant survival rates and biological complications were less favorable in patients who lost their teeth due to periodontitis compared to those who lost teeth for reasons other than periodontitis.[15] Roccuzzo et al. stated that patients with a history of periodontitis had lower implant survival rates and greater bone loss compared to periodontally healthy individuals.[16] Similarly, Dhingra et al., in a retrospective study involving 108 implants in 47 patients with severe periodontitis and 78 implants in 41 patients without a history of periodontitis, concluded that patients with severe periodontitis history are more prone to developing peri-implantitis.[17]

In conclusion, there is strong evidence supporting the notion that a history of periodontitis is a significant risk factor for peri-implantitis.[8]

2. Poor Plaque Control and Lack of Regular Maintenance Therapy

The 2017 World Workshop identified plaque-induced inflammation as the primary cause of peri-implantitis.[3] Costa et al. reported that in a five-year follow-up study of 80 patients diagnosed with peri-implant mucositis, the incidence of peri-implantitis was 18% in patients receiving maintenance therapy and 44% in those who did not. The researchers associated the absence of preventive care with a high incidence of peri-implantitis, emphasizing the importance of plaque control in preventing the condition.[7] Serino and Ström highlighted the significance of regional factors, such as accessibility for oral hygiene in implant areas, in relation to the presence of peri-implantitis. They found that 65% of non-cleanable areas exhibited peri-implantitis, whereas only 18% of cleanable areas were affected.[18] Roccuzzo et al., in a study involving 112 patients, reported that after 10 years, patients who did not adhere to maintenance therapy (41%) required significantly more peri-implantitis treatment compared to those who attended follow-up sessions (27%).[16] Monje and Wang observed that over an average follow-

up period of 3.8 years, patients who underwent maintenance therapy after implant placement had a lower likelihood of being diagnosed with peri-implantitis compared to those who did not.[19]

Evidence-based research has established that poor plaque control and the absence of regular maintenance therapy are significant risk factors for peri-implantitis.[8]

3. Smoking

Smoking can disrupt the nutrition of the bone and soft tissue surrounding the implant, impair blood circulation, and increase the likelihood of bone resorption progression.[11] Clementini et al., in a meta-analysis examining the impact of patient-related risk factors on bone loss around implants, reported that smoking increased annual bone loss by 0.164 mm/year.[20] Karoussis et al., in a 10-year cohort study, found that 18% of implants in smokers developed peri-implantitis, whereas only 6% of implants in non-smokers were affected by peri-implantitis.[15] However, Krebs et al. reported that smoking did not have a significant impact on the prevalence of peri-implant diseases.[21]

According to studies, the criteria for the smoking factor show significant variations. Therefore, the evidence linking smoking and peri-implantitis is limited.[8]

4. Alcohol

The negative effects of alcohol on the coagulation mechanism and immune system cells are well known. Alcohol consumption after implant procedures negatively affects the healing of oral tissues and inflammatory responses.[22] Carr and Boggess retrospectively investigated whether alcohol consumption at varying levels affects implant health and surrounding tissues, and found that mild to moderate alcohol consumption was associated with a lower incidence of peri-implantitis. However, heavy alcohol consumption was linked to an increase in the incidence of peri-implantitis.[23]

There is strong evidence that alcohol consumption is a risk factor for peri-implant diseases, but further prospective studies are needed to confirm this.[24]

5. Diabetes

Diabetes mellitus/hyperglycemia has been reported to be associated with a higher risk of peri-implantitis, independent of smoking, but not with peri-implant mucositis.[25] Ferreira et al. reported that 24% of individuals using medication for glycemic control or having a fasting blood glucose ≥126 mg/dL at the last examination showed peri-implantitis, while only 7% of non-diabetic patients had peri-implantitis.[26] Daubert et al., in an 11-year follow-up study of 226 implants in 96 patients, found that diabetic patients had a 3-fold higher risk of peri-implantitis at the implant level.[27] In some studies, diabetes has not been defined as a definitive risk factor for peri-implantitis. In a retrospective study by Costa et al., which aimed to determine the incidence of peri-implantitis in 212 patients, it was reported that diabetic patients diagnosed with peri-implant mucositis did not have a higher risk of peri-implantitis compared to non-diabetic patients.[7]

Although a positive relationship between diabetes and peri-implantitis development has been found in current studies, there is insufficient data to confirm whether diabetes is a definitive risk factor for peri-implantitis.[8]

6. Osteoporosis

Osteoporosis, a metabolic bone disease, is known to decrease bone quality. It may be a potential risk factor for peri-implantitis as it can lead to bone resorption around implants.[11] In a meta-analysis conducted by Medeiros and Kudo, although no difference was found in implant survival rates between patients with and without osteoporosis, a significant difference was detected in the marginal bone loss around implants.[28] In a systematic review by Dreyer and Grischke, it was reported that there is insufficient evidence to consider osteoporosis as a risk factor for peri-implantitis.[29]

7. Genetic Factors

There are studies in the literature suggesting that genetic predisposition may be a risk factor for peri-implantitis. Most of these studies focus on IL-1 and address the potential relationship between various gene polymorphisms and the development of peri-implantitis.[8] Laine et al. reported that the IL-1RN gene polymorphism is associated with peri-implantitis and may be a risk factor for peri-implantitis.[30] Rakic et al. indicated that the CD14-159 C/T and TNFa-308 A/G polymorphisms are associated with peri-implantitis and concluded that these parameters may serve as biomarkers for peri-implantitis. The researchers stated that the detection of these genetic markers could positively influence treatment approaches, allow for treatment to be adjusted according to the existing genotype, and thereby contribute to treatment planning and prognosis.[31]

Although prospective clinical studies with sufficient sample sizes are still lacking, the current evidence suggests that various gene polymorphisms may have a potential effect on the pathogenesis of peri-implantitis.[8]

8. Age

Older patients are more susceptible to systemic diseases and potentially have longer healing times. Additionally, bone quality and quantity may be compromised. Moy et al. reported that advanced age increases the risk of implant failure, with the risk being twice as high in patients over 60 years of age.[32] Dreyer and Grischke found that a patient's age was not associated with peri-implantitis.[29] Poli et al., in a retrospective study of 103 patients, found that patients over 65 years of age and those who were non-compliant were more susceptible to implant-related diseases. Early diagnosis and a systematic maintenance program are particularly necessary to preserve peri-implant tissue health, especially in older patients.[33]

9. Gender

Studies in the literature investigating the relationship between gender and peri-implantitis have shown conflicting results. In a study by Ferreira et al., which analyzed potential risk variables for peri-implant diseases, it was found that men are more prone to peri-implantitis.[26] On the other hand, Swierkot et al. reported in a prospective long-term cohort study that women are more susceptible to peri-implantitis.[34] Koldsland et al. found that peri-implantitis occurred in 63.3% of women, but there was no significant relationship between gender and peri-implantitis.[35]

More prospective studies are needed to validate the accuracy of the relationship between peri-implantitis and gender.[8]

10. Antidepressant

It has been suggested that antidepressants may affect bone metabolism, potentially increasing the risk of implant failure. Silva et al. reported a risk ratio of 3.73 for implant failure in patients using antidepressants compared to those who did not. However, it has been noted that the studies lacked methodological rigor, and the medications used were not standardized.[36] Strooker et al. stated that there is insufficient evidence to support a potential relationship between antidepressant use and peri-implantitis.[37]

11. Keratinized Mucosa

Lin et al. reported that the lack of sufficient keratinized mucosa around implants is associated with increased plaque accumulation, tissue inflammation, mucosal recession, and attachment loss.[13] In a prospective study of 80 patients, Perussolo et al. found that implant sites with less than 2 mm of keratinized mucosa tend to show more bone loss, discomfort during brushing, plaque accumulation, and soft tissue inflammation around the implant compared to areas with adequate keratinized mucosa. They also found that having 2 mm or more of keratinized mucosa around the implants had a protective effect on peri-implant tissues.[38] A retrospective study by Mameno et al., which analyzed 1535 implants in 514 patients, reported that having less than 2 mm of keratinized mucosa is a risk indicator because it leads to changes in marginal bone levels.[39] In a study where Ladwein et al. followed 211 patients with 967 implants for an average of 8 years, they found that implant sites without keratinized mucosa had significantly higher plaque and bleeding on probing scores compared to those with keratinized mucosa. However, they reported no significant difference in radiographic peri-implant bone levels.[40] Rocuzzo et al. also observed that even in patients with good oral hygiene and supportive periodontal treatment, if the implant is not surrounded by keratinized mucosa, plaque accumulation and soft tissue recession were seen.[41]

While studies suggest that the absence or insufficient amount of keratinized mucosa may negatively affect oral hygiene, there is still insufficient evidence to consider this factor a definitive risk factor for peri-implantitis.[3]

12. Excess Cement

Korsch and Obst reported that excess cement were detected in 59.5% of 126 implants in 71 patients. Among implants with excess cement, 80% showed bleeding on probing, and 21.3% exhibited suppuration. After the removal of the excess cement and resealing, the researchers observed a 76.9% reduction in bleeding on probing, and no suppuration was detected around the implants.[42] Staubli et al. reported that the rough surface structure of excess cement facilitates biofilm formation and that excess cement may serve as a potential risk indicator for peri-implant diseases. To reduce the risk of peri-implant diseases associated with excess cement, they recommended creating a crown margin at the mucosal border level, allowing the patient to maintain oral hygiene, and regular follow-up of patients after the placement of the upper restoration.[43]

The presence of excess cement has been suggested to be closely associated with the development of peri-implant mucositis or peri-implantitis.[8]

13. Occlusal overload

Kozlovsky et al. evaluated the effect of occlusal overload on the bone level around implants in the presence of healthy or inflamed peri-implant tissues. The researchers found that, if the mucosa is not inflamed, occlusal overload might cause a slight decrease in marginal bone level, but this resorption did not exceed the implant neck. In the study, when inflammation was present around the implant, occlusal

overload were found to exacerbate plaque-induced bone resorption.[44] Heitz-Mayfield et al., in their animal study, reported that occlusal overload for 8 months in the presence of healthy peri-implant mucosa did not result in osseointegration loss or marginal bone loss.[45] Katsuta et al. reported that lateral overload on the implant's upper restoration could cause loosening of the abutment screw, potentially leading to a marginal gap.[46]

It is generally accepted that there is insufficient evidence to support that occlusal overload contribute to the initiation or progression of peri-implantitis.[8]

14. Fixation Type

In a systematic review published by Millen et al., no significant difference in failure incidence was reported between screw-retained and cement-retained restorations. However, they noted that cement-retained restorations exhibited a higher incidence of technical and biological complications. Furthermore, the researchers found that the incidence of technical complications was more strongly related to the type of prosthesis and fixation rather than the prosthetic or abutment material.[47] In a meta-analysis, Lemos et al. reported that cement-retained restorations caused less marginal bone loss compared to screw-retained restorations.[48] Kotsakis et al. stated that there is no relationship between prosthetic fixation type and peri-implant diseases; they also indicated that with appropriate cement selection and removal of excess cement, cement retention is not a risk factor for peri-implant diseases.[49]

Currently, there is no consensus regarding the superiority of screw-retained or cement-retained implants in preventing peri-implantitis.[8]

15. Iatrogenic Factors and Implant-Abutment Connection Design

At the 7th European Workshop on Periodontology, it was reported that the onset and progression of peri-implantitis could be influenced by iatrogenic factors, such as improper restoration-abutment placement, restorations with large contours, or incorrect implant positioning.[50] Duque et al. reported the prevalence of peri-implant mucositis and peri-implantitis one year after implant loading, with platform switching implants showing 90% and 6.6%, respectively, and traditional implants showing 81.2% and 15.6%.[51] Pimentel et al. found that the likelihood of peri-implantitis developing was lower in platform switching implants compared to traditional implants.[52] Lemos et al. reported that the implant-abutment connection type did not affect the prevalence of peri-implantitis or survival rates, but internal connections caused less marginal bone loss than external connections.[48]

Further research is needed to evaluate the effect of implant-abutment connection design on peri-implantitis.[8]

16. Function Duration

Marrone et al. evaluated 103 patients with 266 implants that had been in function for at least 5 years and reported that the prevalence of peri-implantitis was 38.4% in individuals with implants functioning for more than 10 years, compared to 17.6% in those with a shorter functional duration.[53] Maximo et al. reported positive correlations between the implant function duration and peri-implant diseases.[54] However, studies by Koldsland et al.[35], which examined the relationship between selected risk indicators and the severity of peri-implantitis, and by Ferreira et al.[26], which analyzed potential risk variables associated with peri-implant diseases, found no correlation between implant function duration and peri-implantitis.

17. Implant Surface Topography

It is well-known that implants with rough surfaces improve early osseointegration.[11] In a review by De Bruyn et al., which investigated whether long-term peri-implant bone loss is influenced by implant surface roughness, they found that implants with minimally and moderately rough surfaces caused less bone loss around the implant compared to implants with highly rough surfaces. However, they also noted that due to the presence of many factors contributing to bone loss, surface roughness alone has a minimal and highly limited clinical effect on bone loss and peri-implantitis risk.[55] Additionally, it is believed that plaque accumulation on rough surfaces could lead to more inflammation around the implant compared to smooth-surfaced implants.[11] Saulacic et al. reported that in short-term follow-ups, implants with rough surfaces were more conducive to plaque accumulation, while in the long term, smooth-surfaced implants were associated with more plaque and greater bone loss around the implant. The survival rate for both implant surfaces was similar. The researchers also stated that there is no clear evidence that rough implant surfaces increase the incidence of peri-implantitis compared to smooth surfaces.[56]

Although current studies suggest that rough and moderately rough implants may carry a higher risk for peri-implantitis, well-designed long-term prospective clinical studies are needed to either confirm or refute these findings.[57]

18. Metal Particle Release

Titanium particles dispersed in the tissues adjacent to the implant are considered foreign bodies and are thought to potentially cause negative effects.[57] Fretwurst

et al. reported the presence of titanium and iron elements in soft and hard tissue biopsies taken from peri-implantitis areas, but stated that additional research is needed to understand the specific immune reactions induced by the metal elements/particles found in the surrounding tissue of the implant.[58] Although studies cannot definitively confirm the relationship between titanium content in the tissue and inflammation around the implant, many studies mention the negative effects of these residues on cells and tissues.[58] In an *in vitro* study by Pettersson et al., investigating the cytotoxic and inflammatory effects of metals used in implants, it was reported that the presence of titanium-based particles and ions stimulated osteoclast activity and intensified the inflammatory response.[59] Olmedo et al. found that ions/particles released from implants could remain in the surrounding environment of the implant in both healthy and diseased implant areas. Furthermore, higher concentrations of titanium were observed in patients with peri-implantitis.[60]

CONCLUSION

With the increase in implant procedures worldwide, the prevalence of peri-implant diseases has also risen. Research has identified numerous factors that contribute to peri-implant diseases. Potential risk factors include a history of periodontitis, inadequate plaque control, lack of maintenance therapy, smoking, diabetes, osteoporosis, insufficient keratinized mucosa, excess cement, occlusal overload, certain systemic conditions, alcohol, fixation type, genetics, iatrogenic factors, surgical procedures, age, antidepressants, gender, implant function duration, topographical characteristics of the implant, and metal particle release. Among these factors, a history of periodontitis, inadequate plaque control, and lack of maintenance therapy have been found to have a strong relationship with the development of peri-implant diseases.

To reduce the incidence of peri-implant diseases and prevent them, several precautions should be taken. Providing proper oral hygiene education to patients rehabilitated with implants and ensuring accessible prosthetic designs that allow proper cleaning around the implants are crucial. Additionally, supportive periodontal treatment and routine monitoring programs must be implemented to prevent the onset of peri-implant diseases.

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