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Effect of Silver Diamine Fluoride and Diode Laser as Desensitizer on The Microleakage and Discoloration at Class V Restorations

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ABSTRACT

Aim: The aim of this study was to evaluate the effects of silver diamine fluoride and diode laser applications used for desensitization on microleakage and colour change in the restorations of class V cavities.

Materials and Methods: Twenty human molar teeth were used in this study. ClassV cavities (4x3x3 mm) (n=10) were prepared on the buccal and lingual surfaces. All teeth were divided into 4 groups according to the treatment methods for DH. Group 1 (silver diamine fluoride), Group 2 (940 nm diode laser), Group 3 (940 nm diode laser + silver diamine flouride), Group 4 (no treatment). All cavities were restored with nano-hybrid composite resin. Restorations were polished with discs. Colour changes were measured with a spectrophotometer on 1, 7, 14, 28 days. Colour change was calculated with the CIEDE2000 formula. To evaluate microleakage scores, samples were stained with 0.2% RhodamineB dye and cut bucco-lingually. Dye penetration was scored under a stereomicroscope. Data were statistically analyzed using the Shapiro-Wilks and Tukey HSD test at a 5% significance level.

Results: According to the colour changes, a statistically significant difference was found between Group 1 and Group 3. In Group 2, there was significantly difference between 1-7 and 1-14 days, 1-7 and 1-28 days. The highest microleakage scores were obtained with the laser-used groups.

Conclusion: Despite the use of a solution containing potassium, a colour change above the clinically acceptable threshold was observed in silver diamine used groups. Also, laser used groups have shown unacceptable colour change values.

Sınıf V Kompozit Restorasyonlarda Hassasiyet Giderici Olarak Kullanılan Gümüş Diyamin Florür ve Diyot Lazerin Mikrosızıntı ve Renk Değişmesi Üzerindeki Etkisi

Makale Bilgisi

Makale Geçmişi

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Gümüş diamin florür.

ÖZET

Amaç: Bu çalışmanın amacı, hassasiyet giderici amaçlı kullanılan gümüş diamin florür ve diyot lazer uygulamalarının sınıf V kavitelerin restorasyonlarında, mikrosızıntıya ve renk değişimine olan etkilerini değerlendirmektir.

Gereç ve Yöntemler: Bu çalışmada yirmi adet insan molar dişi kullanıldı. Her bir dişin bukkal ve lingual yüzeylerinde standart Sınıf V kaviteler (4x3x3mm) hazırlandı. Dişler tedavi yöntemlerine göre rastgele 4 gruba (n=10) ayrıldı. Grup 1(gümüş diamin florür), Grup 2 (940 nm diyot lazer), Grup 3 (gümüş diamin florür + 940 nm diyot lazer), Grup 4'teki örneklere hiçbir tedavi protokolü uygulanmadı. Tüm kaviteler, nano-hibrid kompozit rezin ile restore edildi. Restorasyonlar diskler ile cilalandı. Örneklerin renk ölçümü spektrometre cihazı ile 1, 7, 14, ve 28. günlerde yapıldı. Renk değişimi, CIEDE 2000 formülüyle hesaplandı. Örnekler %0.2 Rhodamine B boyası ile boyandı ve bukko-lingual yönde kesildi. Boya penetrasyonu bir stereomikroskop altında skorlandı. Veriler Shapiro-Wilks ve Tukey HSD testi kullanılarak %5 anlamlılık düzeyinde istatistiksel olarak analiz edildi.

Bulgular: Renk değişimi açısından değerlendirildiğinde, Grup 1 ve Grup 3 arasında istatistiksel olarak anlamlı bir fark bulundu. Grup 2'de, 1-7. gün ile 1-14. Gün, 1-7. gün ile 1-28. Gün zaman aralıklarında, renk değişimi farkı istatistiksel olarak anlamlı bulundu. En yüksek mikrosızıntı skorları, lazer kullanılan gruplarda elde edilmiştir.

Sonuç: Potasyum içeren solüsyonun kullanılmasına rağmen gümüş diamine florür uygulanan gruplarda renk değişimi eşik değerin üzerinde görüldü. Ayrıca, lazer kullanılan gruplarda da kabul edilemez renk değişimleri gözlendi.

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INTRODUCTION

Dentists are still researching for ideal treatments to overcome dentin hypersensitivity (DH) problems in the cervical area of the teeth.[1] Patients complain of sharp pain, especially as a result of stimuli such as hot, cold, acidic drinks, sweeteners, and chemical agents.[2] DH prevalence is reported between 3 and 57 % in adults.[3] Exposure to dentin in the cervical area can be caused by many factors such as abrasion, attrition, erosion, brushing, and periodontal disease.[4] In 1962, Brannstorm explained the DH with hydrodynamic theory. According to the hydrodynamic theory, the movement of dentinal fluid can cause DH.[5]

Several treatment options for DH have been performed in practice. Although the use of desensitizing gels, solutions, and pastes is more common for the treatment of DH, the use of laser for desensitizing purposes has also become popular.[6,7] The positive effects of laser on DH were reported in some studies.[8,9] Nd: YAG, Er: YAG, CO_2, and Ga-Al-As (diode) lasers are preferred due to the reduction of DH. Researchers and clinicians may prefer lasers in some cases because of the analgesic and anti-inflammatory properties of lasers [8.]The mechanism of laser on dentin tubules for reducing DH depends on the laser type and application parameters.[10]

The effects of lasers on DH can be explained by obstruction of dentinal tubules.[10] On the other hand, it was mentioned that lasers affect the movement of dentinal fluid.[10] It was stated that this type of laser decreases the DH by blocking the depolarization of C-fiber.[12] It was shown that a 940 nm diode laser was effective on DH after flap surgery.[13] Also, in a study on DH, it was found that the application of a 795-nm diode laser decreased DH in a 6-month follow-up period.[14]

Recently, new agents have been applied to treat DH as an alternative to conventional agents. Silver diamine fluoride (SDF) is one of them.[15] Firstly, SDF was introduced in 1969 to arrest carious lesions.[16,17] In the literature, the use of 38% SDF is the most effective concentration in preventing caries. [15,17] SDF has also played role on reducing DH by plugging of dentinal tubules. It was claimed that the insoluble silver iodide precipitate, occluding dentinal tubules, providing immediate sensitivity relief.[18] Riva Star Aqua (RSA) (SDI, Bayswater, Victoria, Australia) is the new non-invasive system to prevent carious lesions and desensitize.[15] RSA can be also used in the same indications with SDF 38%. RSA is a water-based solution without ammonia. The discolouration is the most known side effect of SDF. [15] It was reported that potassium iodide (KI) reduces discolouration.[19] Therefore, the use of KI after SDF can be an option for reducing discolouration.[15, 20] RSA has two different colour capsules. While the silver blue capsule is water-based SDF, the green capsule in the second step is used to prevent discolouration with KI.Researchers stated that it is the best option to use of laser and cover of exposed dentin surface with restorative materials for the treatment of non-carious cervical lesions (NCCL). [21, 22]

Microleakage is one of the most important factors affecting the long-term success of restorations. Microleakage can cause marginal discolouration, post-operative sensitivity, secondary caries, and damage of pulp.[23] Especially, in Class V cavities, microleakage is a problem because it is located below to cemento-enamel junction.[24,25] Although SDF and diode laser are known to reduce DH, there is no study in the literature comparing the microleakage and effects on the composite discolouration of SDF-containing agent and diode laser.

In general, cervical lesions and hypersensitive dentin are observed together in clinical situations.[21] In such cases, restorative treatment is needed to overcome DH and cover cervical lesions after desensitizing procedures.[21]

Therefore, the aim of this study was to compare the effect of using SDF and laser on the colour change (ΔE) and microleakage values in class V resin restorations. The null hypotheses of the study are: 1-) There would be

no significant difference between the ΔE values in groups in which SDF is used 2-) There would be no significant difference between the microleakage scores in groups between laser used and SDF used.

METHODS

This study was approved by Ethical Committee of Okan University.

Tooth Selection

Using the "G*Power statistical program (ver. 3.1.9.4; Foul and Erdfelder, 1998)"; When the Type-1 error is 5%, the effect size is 0.2, and the power is 95%, the sample size is at least 10 cavities per group were found.[26] Thus, a total of 20 non-carious, non-erupted, non-functional human permanent third molars were used in this study. All teeth were scaled with scaling instruments to remove residual tissues and stored in distilled water at room temperature until used in the experiments.

Tooth Preparation

All procedures were performed by single experienced researcher. Standard Class V cavities (4 mm width, 3 mm high, 3 mm depth) were prepared on both the buccal and lingual surfaces of each tooth. Thus, 40 cavities were obtained from 20 teeth. Then each group was divided into four groups depending on the desensitization method.

Treatment and Restoration Procedures:

Group 1: RSA (SDI, Bayswater, Victoria, Australia) was applied using a micro-brush 10 s first with the silver blue capsule. Secondly, the green capsule was applied until the creamy white precipitate turned clear. The cavities were rinsed with water and dried then were etched with 37,5% phosphoric acid for 15 s, rinsed with water and dried. A self-etch bonding agent (Tokuyama Bond Force II, Tokuyama Dental, Tokyo, Japan) was applied and light-cured for 20 s. Supra-nanohybrid composite (Tokuyama Estelite Sigma Quick, Tokuyama Dental, Tokyo, Japan) was applied incrementally and cured 20s.

Group 2: The cavities were irradiated by the 940-nm diode laser (Biolase, CA, USA) with a power of 1 W for 60 s. Then, as in Group 1, the same acid-etch, bonding and restoration procedures were applied.

Group 3: The cavities were irradiated by the 940-nm diode laser (Biolase, CA, USA) with a power of 1 W for 60 s. RSA application procedures were repeated. Then, like the other groups, the same acid-etch, bonding and composite application procedures were applied.

Group 4 (control): No treatment was applied. The same acid etch-bonding and composite application procedures were applied.

For all groups, soflex discs (3M ESPE, St. Paul, MN, U.S.A.) were used for finishing and polishing.The materials used were shown in Table 1.

Table 1. The materials used in this study

Type of Materials	Manufacturers	Compositions
Supra nano-hybrid composite resin	Tokuyama Estelite Sigma Quick, Tokuyama Dental Corporation, Tokyo, Japan	Bis-GMA, UDMA, TEGDMA, Silica-zirconia monodispersing spherical (71% by vol.,82% by weight)
Silver diamine fluoride	Riva Star Aqua, SDI, Bayswater, Victoria, Australia	Silver, fluoride,ammonium hydroxide, potassium iodide and water
Tokuyama bond force II	Tokuyama Dental Corporation, Tokuyama Dental, Tokyo, Japan	Phosphoric acid monomer, Bis-GMA, TEGDMA, HEMA, Alcohol, Water, Camhorquinone

Colour changes were measured with a spectrophotometer (Vita Easyshade Advance 4.0, Germany) using the CIEDE2000 formula [27] (Figure 1) at the following four times: Day 1, 7, 14 and 28. $\Delta L'$, $\Delta C'$ and $\Delta H'$ are described the differences in lightness, chroma and hue between specimens at different time periods.

Figure 1: CIEDE2000 colour formula

$$\Delta E_{00} = \left[\left(\frac{\Delta L'}{K_L S_L} \right)^2 + \left(\frac{\Delta C'}{K_C S_C} \right)^2 + \left(\frac{\Delta H'}{K_H S_H} \right)^2 + R_T \left(\frac{\Delta C'}{K_C S_C} \right) \left(\frac{\Delta H'}{K_H S_H} \right) \right]^{\frac{1}{2}}$$

Microleakage Measurement

Microleakage scores were evaluated using a dye penetration technique. All the specimens were coated with two layers of transparent nail varnish, leaving a 1 mm space around the cavity margins. Samples were dyed with a 0.2% Rhodamine B (Gunduz Chemistry, Istanbul, Turkey) for 24 hours. After the storage, the samples were rinsed, dried and cutted bucco-lingually with a water-cooled, slow-speed diamond blade (Mecatome T180, Presi, France). A stereomicroscope (SMZ1000, Nikon, Japan) was used to determine microleakage values under x40 magnification according to the 4-grade scale (Table 2).[28]

Table 2. Dye Penetration scores used in the study

Dye Penetration Scores
Score 0: no leakage
Score 1: dye penetration to the enamel or cementum aspect of the preparation wall
Score 2: dye penetration to the dentin aspect of the preparation wall, but not including the pulpal wall
Score 3: dye penetration including the pulpal wall of the preparation

Statistical analyses

Data were analyzed with IBM SPSS V23. Generalized linear models method was used to compare Delta E values according to group and time.The test of normality was performed using the Shapiro-Wilks test. Multiple comparisons were analyzed with the Tukey HSD test. Analysis results were presented as mean ± standard deviation. The significance level was taken as $p<0.050$. Kruskal Wallis test was used to analyze microleakage values.

RESULTS

When compared to the groups according to the ΔE_{00} values, statistically significant difference was found between Group 1and Group 3 (p=0.020). The highest colour change was observed in Group 2 at the end of the 28th day.

According to the effect of time period on total ΔE_{00} values, a significant difference was found between 1-7 and 1-28 days, 1-14 and 1-28 days (p<0,001).

When comparing the groups according to the time period, a significant differences were found in Group 2, between 1-7 and 1-14, 1-7 and 1-28 days. (p<0,001).

Multiple comparisons of ΔE values were shown in Table 3.

Table 3. Comparison of ΔE_{00} values between groups

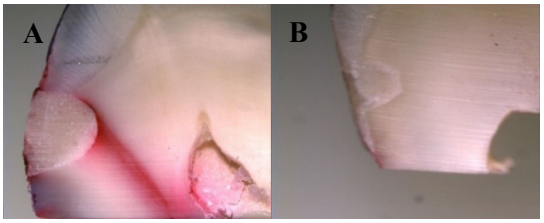
Time period	Groups				Total
	Group 1	Group 2	Group 3	Group 4	
1-7. Day	9.29 ± 3.54^{A}	2.8 ± 1.32^{C}	6.78 ± 1.25^{AB}	7.18 ± 2.01^{AB}	6.51 ± 3.2^{b}
1-14. Day	6.44 ± 1.69^{ABC}	7.34 ± 1.25^{AB}	5.01 ± 1.26^{BC}	5.15 ± 1.71^{BC}	5.98 ± 1.73^{b}
1-28. Day	8.99 ± 4.26^{A}	9.81 ± 2.03^{A}	7.69 ± 1.77^{AB}	7.69 ± 4.11^{AB}	8.55 ± 3.25^{a}
Total	8.24 ± 3.48^{a}	6.65 ± 3.32^{ab}	6.49 ± 1.8^{b}	6.67 ± 2.94^{ab}	7.01 ± 3.01

A-C: There is no difference between interactions with the same letter. a-b: No difference between with the same letter.

No significant difference was observed in terms of microleakage values at the gingival surface beween the groups (Table 4).

For microleakage values at occlusal surface, SDF and laser combined used group (Figure 2A) showed significantly higher microleakage values than Group 4 (Figure 2B) (control) group (p=0.011) (Table 4).

Figure2A: Representive microscopic image of tooth of Group II with score 3 both occlusal and gingival margins. **Figure2B**: Respresentive microscopic image of tooth of Group IV with score 0 on the occlusal marginal and score 1 on the gingival margin



The highest microleakage values were observed both of gingival and occlusal surface in SDF and laser combined used group (Table 4).

Table 4. Pairwise comparison of groups concerning microleakage (p<0.05)

	Groups				
	Group 1	Group 2	Group 3	Group 4	p
	Mean ± SS	Mean ± SS	Mean ± SS	Mean ± SS	
gingival	1.06 ± 0.93	1.56 ± 0.89	1.62 ± 1.26	1.06 ± 0.93	0.224
occlusal	0.81 ± 0.66^{ab}	1.38 ± 0.72^{ab}	1.62 ± 1.02^{a}	0.75 ± 0.86^{b}	**0.011**

Kruskall Wallis H test, a-b: No difference between with the same letter.

DISCUSSION

The SDF application has been commonly used and researched in children.[28] Besides to caries-arresting and antibacterial effect of SDF, it plays a role in the desentisizing of dentin tubules.[15,29] Castillo et al. concluded that SDF showed safe and effective performances on DH in their study.[30] Due to of desensitization property, it is conceivable that SDF could be used as a desensitizer prior to the restoration of non-carious cervical lesions. Also, Sinha et al. reported that SDF can be used as a remineralization agent and indirect pulp capping process. [31]

Spectrophotometers are frequently used to determine and evaluate colour change objectively.[32] CIElab and CIEDE2000 systems are frequently used in the calculation of colour differences. In this study, colour measurement was calculated with the CIEDE2000 system. In studies, it was reported that the CIEDE2000 system provides better detectability and acceptability than the CIELab in the evaluation of translucency and colour change in dental materials.[33,34]

Colour stability is an important factor for restorative materials. In the study conducted by Paravina et al, [27] they reported that according to the CIEDE2000 system, the clinically acceptable threshold value was determined to be greater than 1.8. In all of the tested groups, the ΔE_{00} values were above the clinically acceptable value at all time periods.

The one of noted side effects of SDF is discolouration [15]. It is also recommended to use KI solutions for reducing discolouration before restoration in root surface lesions when SDF is going to be used for desensitization. Roberts et al. reported that the use of KI after SDF application had a reducing effect on discolouration.[35] Nguyen et al. found that the use of KI after SDF application had a reducing effect on the discolouration of various restorative materials used in the restoration of Class I cavities.[36] However, it has been also reported that the use of KI has no effect on reducing discolouration.[15] In all groups using SDF, the colour change was found to be above the acceptable values even though KI containing solution was used. According to these results, the KI in green capsule was no effect in reducing discolouration. In the present study, colour change was observed significantly difference between Group 1 and Group 3. no So, null hypothesis 1 was rejected.

In the laser-used group, ΔE_{00} values were found significantly different between 1-7 and 1-14, 1-7 and 1-28 days. Also, the highest ΔE values were determined at the end of the 28th day in the laser-used group.

Tate et. al. mentioned that GaAlAs lasers might increase the deposition of tertiary dentin by odontoblast cells.[38] Liu et. al. found that the use of 980 nm diode laser on DH was more effective than the placebo.[39] In a study, comparing the effectiveness of 940 nm diode lasers with conventional desensitizer gels (fluoride stannous and potassium nitrate gel) on reducing DH, the 940 nm diode laser group showed the highest reduction.[40] In the present study, a 940 nm diode laser was also prefered to

reduce DH. Ranjan et al. used a 940 nm diode laser in one group and diode laser and SnF together in another group and found that the diode laser group was effective in decreasing DH and SnF can increase the efficiency of the laser.[41] Inspired by this approach, the combination of SDF and laser was used in this study.

Although there was no significant difference in microleakage values on the gingival surface between the laser group and the other groups, higher microleakage values were obtained in the laser-used group compared to the SDF-used and control group. Liu et al. reported that variation in dentin structure occurred due to temperature increase after laser irradiation.[39] The higher microleakage scores and ΔE values may be caused by this variation in dentin structure at laser-used groups.

The SDF and laser combined group showed significantly higher microleakage values than the control group. Besides this, the highest microleakage values were observed on both gingival and occlusal surfaces in the SDF and laser-combined groups. According to these results, the second hypothesis was partially accepted.

CONCLUSIONS

The study was performed under *in vitro* conditions without imitating the oral environment. Within this limitation, the followings can be concluded;

1. Although it was thought that the KI would mask the discolouration association with SDF, the colour changes were within unacceptable values in all groups that SDF used.
2. Colour changes in laser-applied groups were above the clinically acceptable values. In future studies, colour change can be evaluated after laser application with different parameters.
3. Highest microleakage scores were obtained at gingival and occlusal surfaces in the laser-used groups
4. Since both colour change and microleakage values are high in laser-used groups, the use of conventional agents (desensitizing gels, solutions, and pastes) for desensitization can be considered.

CONFLICT OF INTEREST

Ethical Approval

The necessary ethical approval for this study was received by the Istanbul Okan University Ethics Committee Non-Drug and Medical Device ethics committee (08.11.2023- Decision no: 13).

Financial Support

The authors declare that this study received no financial support.

Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: ZBK, HU, Data collection or access: ID, Analysis and comments: ZBK, Literature search: ZBK, ID, Writing: ZBK, ID.

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The Effect of Staining Solutions and a Cleanser Tablet on the Surface Roughness and Color Stability of Various Artificial Tooth Types: An In Vitro Study

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ABSTRACT

Aim: This study aimed to evaluate the effect of different solutions and a cleaning tablet on the color stability and surface roughness of different types of artificial teeth.
Materials and Methods: Conventional polymethylmethacrylate (PMMA), cross-linked isosite (CLI), and double cross-linked acrylic (DCA) teeth were allocated into 4 groups according to the immersion protocol to be applied as AS (artificial saliva immersion for 14 days), AS+C (artificial saliva immersion for 14 days and then applying Corega for 1 week, 8 hours a day), Co (immersion in coffee solution for 14 days), Co+C (immersion in coffee solution for 14 days and then applying Corega for 1 week, 8 hours a day). The specimens' color (L*, a* and b* values) and surface roughness variables were measured at the baseline and after immersion protocols. The color changes (ΔE) of the specimens were calculated using the CIEDE2000 formula. Data were evaluated by the Kruskall Wallis H and the ANOVA test. The Wilcoxon Sign and Bonferroni tests were used for comparisons (α=0.05).
Results: The lowest ΔE00 value was found in Group PMMA exposed to Corega suspension after immersion in artificial saliva [Group PMMA-AS+C: 2.33(1.72)]. According to the ΔE00 values, there was no statistically significant difference according to the materials of both the solution and the artificial teeth ($p>0.05$). None of the test groups showed significant difference in baseline surface roughness values ($p>0.05$). However the protocol Co+C increased the surface roughness of CLI teeth ($p<0.05$). Also, PMMA teeth showed higher surface roughness for protocols AS and AS+C.
Conclusion: According to the results of this in-vitro study, coloring solutions affected surface roughness to varying degrees. Clinicians should consider cost-effective aspects for aesthetic expectations when choosing artificial teeth.

Boyama Solüsyonlarının ve Temizleme Tabletinin Çeşitli Yapay Diş Tiplerinin Yüzey Pürüzlülüğü ve Renk Stabilitesi Üzerindeki Etkisi: İn Vitro Çalışma

Makale Bilgisi

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ÖZET

Amaç: Bu çalışmada farklı solüsyonların ve temizleme tabletinin farklı tipteki yapay dişlerin renk stabilitesi ve yüzey pürüzlülüğü üzerindeki etkisi değerlendirildi.
Gereç ve Yöntemler: Konvansiyonel polimetilmetakrilat (PMMA), çapraz bağlı izosit (CLI) ve çift çapraz bağlı akrilik (DCA) dişler uygulanacak immersiyon protokolüne göre AS (14 gün boyunca yapay tükürük immersiyonu), AS+C (14 gün boyunca yapay tükürük immersiyonu ve ardından 1 hafta boyunca günde 8 saat Corega uygulaması), Co (14 gün boyunca kahve solüsyonu immersiyonu), Co+C (14 gün boyunca kahve solüsyonu immersiyonu ve ardından 1 hafta boyunca günde 8 saat Corega uygulaması) olmak üzere 4 gruba ayrıldı. Numunelerin renk (L*, a* ve b* değerleri) ve yüzey pürüzlülüğü değişkenleri başlangıçta ve daldırma protokollerinden sonra ölçülmüştür. Numunelerin renk değişimleri (ΔE) CIEDE2000 formülü kullanılarak hesaplanmıştır. Veriler Kruskall Wallis H ve ANOVA testi ile değerlendirilmiştir. Karşılaştırmalar için Wilcoxon İşaret testi ve Bonferroni testleri kullanılmıştır (α=0.05).
Sonuçlar: En düşük ΔE00 değeri, yapay tükürüğe daldırıldıktan sonra Corega süspansiyonuna maruz bırakılan Grup PMMA'da bulunmuştur [Grup PMMA-AS+C: 2,33(1,72)]. ΔE00 değerlerine göre, hem solüsyon hem de yapay dişlerin materyallerine göre istatistiksel olarak anlamlı bir fark bulunmamıştır ($p>0.05$). Başlangıç yüzey pürüzlülüğü değerlerinde, test gruplarının hiçbiri anlamlı farklılık göstermemiştir ($p>0.05$). Ancak Co+C protokolü CLI dişlerin yüzey pürüzlülüğünü arttırmıştır ($p<0.05$). Ayrıca, PMMA dişler AS ve AS+C protokolleri için daha yüksek yüzey pürüzlülüğü göstermiştir.
Sonuç: Bu in-vitro çalışmanın sonuçlarına göre, renklendirme solüsyonları yüzey pürüzlülüğünü farklı derecelerde etkilemiştir. Klinisyenler yapay diş seçimi yaparken estetik beklentiler için maliyet-etkinlik yönlerini göz önünde bulundurmalıdır.

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INTRODUCTION

Removable dentures have been used for a long time to restore the impaired functions of edentulous and partially edentulous patients. [1] Artificial teeth, essential structural components of removable prostheses, are frequently used for both fixed and removable restorations on implants in today's prosthetic dental treatment.[2] Artificial teeth should have adequate mechanical properties to withstand the forces of chewing during everyday use, such as being resistant to abrasion, fracture, and pH changes.[3] They should also offer optimum aesthetic properties to fulfill the demands of patients.[3,4]

Color stability is one of the most clinically important aesthetic features of artificial teeth. Because color change indicates ageing or deterioration of the prosthesis.[5] Discoloration or staining may occur due to intrinsic or extrinsic factors.[1,3] Extrinsic staining is caused by plaque accumulation on artificial tooth surfaces or stains caused by coloring substances such as coffee, tea, and tobacco. The effect of these factors may increase by poor oral hygiene or inappropriate and low-frequency application of cleaning agents. On the other hand, intrinsic factors depend on the physical and chemical characteristics of the artificial teeth material. They may increase the artificial tooth's reaction with the coloring agents or the absorption of coloring solutions.[6,7]

Another factor related to staining is the surface properties of the material. Micro-cracks, micro-gaps, and pores on the surface prepare a suitable environment for the penetration of solutions that cause staining.[8] The process of cleaning easier and prevent accumulation of plaque and bacterial colonization, artificial teeth should have a smooth surface.[9] Denture cleanser immersion and daily brushing are examples of artificial cleaning techniques.[9,10] Effervescent tablet forms of denture cleaners are generally used to remove calculus effectively and debris from denture surfaces.[11] However, daily use of such denture cleaners may affect artificial teeth' physical and surface properties by increasing surface roughness, which may result in discoloration.[12,13] Therefore, it is of importance to know the surface characteristics and color stability of different artificial teeth and their reactions to different cleaners.[1,2,6]

The most used materials in the production of artificial teeth include methacrylate resin, reinforced methacrylate resin, and composite resin.[1] Artificial teeth materials have also diversified significantly with the developing dental industry, including new-generation acrylic teeth with highly cross-linked isosite material, acrylic resin teeth with interpenetrating polymer network, and composite resin teeth with different filling sizes.[2] Given the wide variety of artificial teeth on the market, evaluation of surface roughness and color stability will guide clinicians and laboratory technicians when selecting artificial teeth.

Previous studies have examined the color stability of artificial teeth with different properties in different staining solutions but failed to obtain a consistent result. [1,7,14] Moreover, the evaluation of new-generation artificial teeth is scarce in the literature. Therefore, the aim of this study was to evaluate the color stability and surface roughness of artificial teeth with three different compositions after exposure to coffee and a commonly used cleansing tablet. The null hypothesis of this study was that there would be no difference in color change and surface roughness regardless of artificial tooth type and immersion protocol.

MATERIALS AND METHODS

This study investigated the effect of Corega cleanser tablet application on the surface roughness and color stability of 3 different artificial teeth (conventional polymethylmethacrylate, cross-linked isosite, and double cross-linked acrylic) after exposure

to a coloring beverage. The minimum specimen size for this study was calculated as n = 8 per group (N = 128) with 81% power, 0.63 effect size, and error level α = 0.05. The materials used in the study and their contents are shown in Table 1, and the properties and preparation procedures of the solutions used are shown in Table 2.

Table 1: Content details of denture teeth evaluated

Artificial teeth material	Group abbreviations	Trade name	Manufacturer
Conventional polymethylmethacrylate	PMMA	Ivostar, Gnathostar	Ivoclar Vivodent AG, Italy
Cross-linked isosite	CLI	SR Orthosit PE	Ivoclar Vivodent AG, Italy
Double cross-linked acrylic	DCA	SR Vivodent DCL	Ivoclar Vivodent AG, Italy

Table 2: The properties of the materials used and preparation procedures of the solutions

Immersion solution	Manufacturer	Chemical composition	Preparation procedure	pH
Artificial saliva	Custom made	KCl (0.4 g L−1) NaCl (0.4gL−1) $CaCl_2(H_2O)$ (0.795 g L−1) $NaH_2PO_4(H_2O)$ (0.69 g L−1) Na_2S (0.005 g L−1) Urea (1 g L−1)	To create 1 L of artificial saliva, all of the ingredients were mixed. The desired pH of the saliva was then determined by adding 15 ml of 0.1 M NaOH.	6.5
Coffee (without sugar)	Nescafe Classic, Nestle, Bursa, Turkey	Grinded coffee Dipotasium phosphate Sodium poliphophate Trisodium sitrate, milk protein Diasetil tartaric acid Silicone dioxide, sucrose	2 g coffee granules were placed in 200 ml boiled distilled water for 7 min and allowed to cool at room temperature.	5
Corega Tablets	Corega Tablet Block Drug Company, Inc., NJ, USA	Sodium bicarbonate Potassium monopersulfate Sodium perborate monohydrate Sodium laurly sulfoacetate	The effervescent denture tablet was prepared by adding one tablet to 200 mL of 40°C warm water.	8.4

(NaCl: Sodium chloride, KCl: Potassium chloride, $CaCl_2(H_2O)$: Calcium chloride hydrate, $NaH_2PO_4(H_2O)$: Sodium dihydrogen phosphate monohydrate, Na_2S: Sodium sulfide, NaOH: Sodium hydroxide)

Thirty-two maxillary central artificial teeth (shade: A2) of each brand (PMMA, CLI, and DCA) were randomly allocated into four subgroups (n = 8) and immersed in 4 different solutions as follows: 1. Protocol AS: Specimens were kept in artificial saliva for 14 days 2. Protocol AS+C: Specimens were kept in artificial saliva for 14 days and then exposed to a Corega solution for 1 week, 8 hours a day 3. Protocol Co: Specimens were kept in coffee solution for 14 days 4. Protocol Co+C: Specimens were kept in a coffee solution for 14 days and then exposed to a Corega solution for 1 week, 8 hours a day.

Immersion in all solutions was monitored in an incubator (FN 500, Nüve, Turkey) by refreshing the solutions every 24 hours. After the soaking period, each specimen was cleaned with distilled water and dried with tissue paper before measurements. Surface roughness and color measurements were performed on all specimens at baseline and after immersion in the solutions.

Color measurements of the specimens were made from the middle third of the labial surface using a spectrophotometer (VITA Easyshade V; Vita Zahnfabrik, Germany) against a neutral grey background[15] in a light-controlled box[16] under standard D65 illumination.[17]

The color measurements of the specimens were calculated using the CIE2000 formula as

$$\Delta E_{00} = [\Delta L'/k_L \times S_L^2 + \Delta C'/k_C \times S_C^2 + \Delta H'/k_H \times S_H^2 + R_T \times \Delta C'/k_C \times S_C \times \Delta H'/k_H \times S_H]^{1/2}$$

The coefficient-K, also known as the parametric factor, expresses the effect of influencing the judgement of color difference. The S coefficient explains the visual homogeneity efficiency. In addition, a rotational factor (RT) was added to correct the deficiency in the blue-violet region in which L′, C′, and H′ are the transformed forms of LCH and KLSL is lighting weighting function, KCSC is chroma weighting function, KHSH is hue weighting function and RT is a rotational factor. In the present study, the parametric factors of the ΔE00 color difference formula were set to 1.[3]

The surface roughness of each specimen was measured from the labial surface using a contact profilometer (Perthometer; Mahr Gmbh, Ingolstadt, Germany). The measurement length was set to 1.75 mm, the cutoff 0.25 mm, and the instrument was calibrated before each group. Three distinct measurements in micrometers (μm) were taken for every specimen, and the average of these measurements was computed. Statistical analysis was conducted using the average Ra values.

Statistical Analysis

The data obtained in this study were analyzed using the SPSS 22 package program (IBM SPSS Inc., Chicago, USA). Compliance with normal distribution was evaluated by the Shapiro-Wilk test. ANOVA was utilized to compare three or more independent groups with normal distribution, and the Kruskal-Wallis test was employed when there was no normal distribution. The Wilcoxon and Bonferroni tests were used for comparisons (α=0.05).

RESULTS

Descriptive statistics for ΔE values of the test groups are given in Table 3. The lowest ΔE00 value was found in Group PMMA exposed to Corega suspension after immersion in artificial saliva [Group PMMA-AS+C: 2.33(1.72)]. The highest ΔE00 value was found in Group DCA immersed in coffee solution [Group DCA-Co: 9.55(4.46)]. According to the ΔE00 values, there was no statistically significant difference for comparisons between the groups according to both the type of immersion solution and the materials of the artificial teeth (p>0.05).

Table 3: Descriptive statistics and statistical significance evaluation for ΔE values obtained from the test groups

Test Group	Immersion protocol				
	AS	**AS+C**	**Co**	**Co+C**	***p***
PMMA	3.91(2.45)[a] 6.84 ± 3.28	2.33(1.72)[a] 5.26 ± 3.8	2.61(1.84)[a] 9.24 ± 3.19	2.67(2.03)[a] 7.52 ± 7.44	0.651†
CLI	4.31(3.59)[a] 3.77 ± 2.33	4.37(2.12)[a] 2.63 ± 1.39	5.52(4.7)[a] 5.07 ± 4.23	4.88(4.07)[a] 3.55 ± 2.29	0.646**
DCA	2.98(10.65)[a] 4.72 ± 2.41	4.5(5.79)[a] 4.59 ± 2.41	9.55(4.46)[a] 6.12 ± 3.68	7.67(4.03)[a] 6.0 ± 3.06	0.204†
p	0.092**	0.067**	0.080†	0.245†	

(PMMA: conventional polymetylmethacrylate, CLI: cross-linked isosite, DCa: double cross-linked acrylic, AS: artificial saliva, AS+C: artificial saliva + Corega, Co: coffee, Co+C: coffee + Corega)

** ANOVA test. † Kruskal-Wallis test. The data were presented as the median(IQR) and mean ± SD. The statistically significant p value is in bold. There is a statistically significant difference between groups with different superscripts (p<0,05).

Descriptive statistics of Ra values obtained from the test groups are shown in Table 4. At baseline, none of the test groups showed significant differences (p>0.05). Considering intragroup comparisons after immersion protocols, Group PMMA and DCA showed no significant difference in Ra values (p>0.05). However, Group CLI showed a higher Ra value after being immersed in Corega following coffee (p<0.05) compared to other immersion protocols for which similar results were obtained (p>0.05). Intergroup comparisons after immersion protocols showed similar results for Co and Co+C protocols irrespective of the test group (p>0.05). On the other hand, PMMA teeth showed significantly lower Ra values than other artificial teeth groups for immersion protocols AS and AS+C (p>0.05). The differences between other test groups were insignificant (p>0.05).

Table 4: Surface roughness (Ra) values of artificial teeth at baseline and after immersion protocols

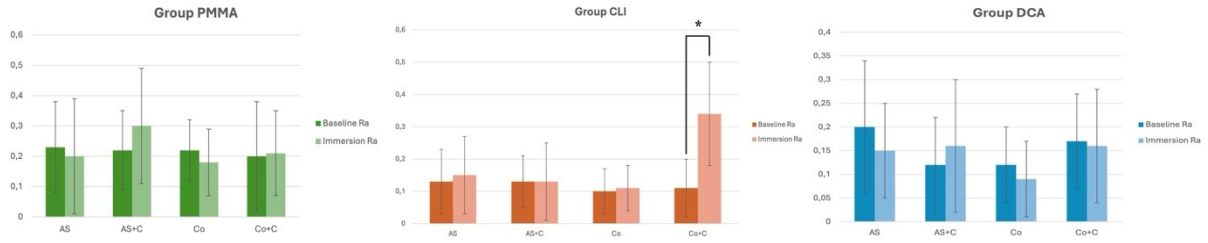
Surface roughness evaluation	Test groups			Median(IQR)		Total
Baseline	**PMMA**	0.23(0.15)	0.22(0.13)	0.22(0.1)	0.2(0.18)	0,14(0.12)^{A}
	CLI	0.13(0.1)	0.13(0.08)	0.1(0.07)	0.11(0.09)	0,14(0.10)^{A}
	DCA	0.20(0.14)	0.12(0.1)	0.12(0.08)	0.17(0.1)	0,22(0.17)^{A}
	p					0.050
		Immersion protocol				
		AS	**AS+C**	**Co**	**Co+C**	***p***
After immersion	**PMMA**	0.2(0.19)^{aA}	0.3(0.19)^{aA}	0.18(0.11)^{aA}	0.21(0.14)^{aA}	0.215
	CLI	0.15(0.12)^{aB}	0.13(0.12)^{aB}	0.11(0.07)^{aA}	0.34(0.16)^{bA}	**0.018**
	DCA	0.15(0.1)^{aB}	0.16(0.14)^{aB}	0.09(0.08)^{aA}	0.16(0.12)^{aA}	0.072
	p	**0.048**	**0.008**	0.344	0.131	

(PMMA: conventional polymetylmethacrylate, CLI: cross-linked isosite, DCa: double cross-linked acrylic, AS: artificial saliva, AS+C: artificial saliva + Corega, Co: coffee, Co+C: coffee + Corega)

The data were presented as the median(IQR). The statistically significant p value is in bold. A statistically significant difference exists between groups with different superscript lowercase letters within the same line ($p<0.05$). A statistically significant difference exists between groups with different superscript uppercase letters within the same column ($p<0.05$).

Comparisons of before and after surface roughness values for each group are shown in Figure 1. There was a significant difference in surface roughness values between baseline and after-immersion protocols only for Group CLI. The surface roughness of Group CLI increased after being subjected to Corega following immersion in coffee solution (Co+C) compared to baseline ($p<0.05$).

Fig. 1: Comparison of in-group surface roughness values of the test groups



(PMMA: conventional polymetylmethacrylate, CLI: cross-linked isosite, DCa: double cross-linked acrylic, AS: artificial saliva, AS+C: artificial saliva + Corega, Co: coffee, Co+C: coffee + Corega)
Median and The Interquartile Range of surface roughness values. (*$p<0.05$ indicate statistical differences between groups.)

DISCUSSION

This study investigated the effect of immersion in coffee and cleaning tablets on surface roughness and color stability of artificial teeth with different compositions. The null hypothesis of this study was partially rejected as no significant differences were found in the colour stability of different types of artificial teeth according to the immersion protocols, whereas significant differences were found in the surface roughness evaluations.

The color change of materials used in dentistry can be evaluated by visual observation or color measurement devices.[18] Color measurements performed by digital devices are much more reliable than visual evaluation since objective, rapid, and reproducible data can be obtained.[19,20] Digital color measurement devices include colorimeters, spectroradiometers, spectrophotometers, digital cameras, and image-analyzing systems.[21] In the dental field, color assessment by spectrophotometer was stated as the most preferred and reliable method.[18,20] Based on these considerations, color measurements were performed using a spectrophotometer device in the present study.

The Commission Internationale de l'Eclairage - CIE L* a* b* color system is used for the numerical expression of color change.[22,23] L* a* b* values are known as "chromaticity coordinates" in this three-dimensional color system. Evaluating the L*, a*, b* values individually is challenging and may be misleading. Therefore, the color change is evaluated by the mean color difference values (ΔE), which can detect even minor color differences.[24] ΔE is a numerical value indicating the amount of color difference perceived between two objects.[22,25,26]

ΔE can be calculated using CIELAB (ΔELab) or CIEDE2000 formulas (ΔE00). These two formulas can be used interchangeably when assessing the color differences of dental materials.[6] Recent studies have shown that the CIEDE2000 color difference formula can provide more accurate results in the assessment of color differences.[6,11] Since the parameters in this formula include weighing and scaling factors, color differences correlate better with the differences perceived by the human eye and are more clinically effective.[6]

Previous studies determined that the ΔE value for the CIEDE2000 system, the perceptibility threshold (PT) was accepted as 1.72 and the acceptability threshold (AT) as 4.08.[5,9] In our study, the lowest ΔE00 value was found in conventional PMMA artificial teeth subjected to cleaning tablet after immersion in artificial saliva [2.33(1.72)]. According to the CIEDE2000 system, there were no test groups that reached the perceptibility colour threshold, while all solution immersion groups of PMMA artificial teeth and artificial saliva immersion groups of double cross-linked acrylic artificial teeth remained below the acceptability colour threshold. The other ΔE00 values found in this study are above this AT values, meaning that they show a visible colour change when exposed to artificial saliva and coffee. These results may be due to the different chemical compositions of artificial teeth, degrees of polymerisation, crosslink density, molar mass distribution and oxidation properties of the polymer matrix structure.[27] Acrylic resins with linear structure or without sufficient crosslinking can absorb colourants when exposed to an aqueous environment. Due to the loosening of linkages along the polymeric network, this process causes plasticisation and subsurface modification of polymeric materials such as artificial teeth.[8]

Fraunhofer and Rogers[28] evaluated the erosive effects of different staining solutions on enamel specimens. They assumed an average of 700 g beverage intake with 20 seconds of intraoral duration daily, which equals the intraoral exposure time to these beverages as 25 hours per year. Based on this, they determined the 14-day test period would simulate approximately 13 years of beverage intake in a lifetime.[28] In previous studies, coffee was the standardized coloring solution with the determined immersion time.[9,29] Because of its yellow-brown color, tannic acid in coffee has been identified as the main staining agent.[30] In the present study, coffee and artificial saliva were used as the staining solutions with a predetermined immersion time of 14 days. Although insignificant, immersion in coffee solution increased ΔE values higher than other solutions in all artificial teeth groups. Also, using Corega cleaner tablets after immersion in coffee and artificial saliva solutions relatively reduced the staining caused by the solutions, yet this result was not statistically significant. Conversely, according to Peracini et al. [28] effervescent denture cleansers should be used with caution because they cause discolouration when submerged in Corega tablets. Sodium perborate or sodium bicarbonate are typically found in cleaning solutions in effervescent tablets.[31] The structure's sodium perborate decomposes to create an alkaline peroxide solution when these tablets dissolve in water,

releasing oxygen and micromechanically removing debris from the surface.[31,32] This effect may cause discoloration, especially in the polymer structure of resin-based materials. [9] Additionally, studies revealed that resin-based materials are damaged by high peroxide and oxygenation concentrations found in alkaline solutions.[9,28] Surface irregularities caused by these cleaners may enhance the discoloration effect. Manufacturers recommend leaving the prostheses in chemical cleaners for 15 minutes for routine cleaning. However, in extreme staining, it is recommended to keep the dentures in the solution overnight to clean them, corresponding to approximately 8 hours.[26] In this study, we used the maximum recommended time to evaluate the effect of chemical denture cleaners. However, the results did not show any effect of Corega solutions. As the material type used affects the impact of cleaning effect, these controversial results may have derived from the difference in the material used.[28]

Kurtulmus-Yilmaz and Deniz[33] evaluated the staining susceptibility of various types of resin artificial teeth and the stain removal efficiency of denture cleaners. They showed that cross-linked acrylic and nanocomposite resin teeth were more sensitive to staining. Similarly, Ansari et al[34] evaluated the color stability of composite resin and acrylic resin teeth in tea and coffee and found that acrylic teeth performed better. On the contrary, Kundu et al[35] found that hybrid and nanofilled composite prosthetic teeth were better than conventional composite and acrylic resin teeth in terms of surface smoothness and staining resistance. Koksal and Dikbas[36] examined the color change of acrylic and porcelain artificial teeth in staining solutions and reported superior results for porcelain teeth. In this study, no statistically significant difference was found between the groups compared, regardless of the type of artificial tooth and the type of solution immersed ($p>0.05$). The discrepancy in the results of all these studies can be explained by differences in prosthetic tooth brands and different types of media and immersion times.[3,5] When tooth types are compared, the different color changes of resin teeth can be attributed to the manufacturing processes and factors such as the degree of polymer conversion and the amount of unreacted monomer remaining and initiators such as dibenzoyl peroxide.[5,9]

Surface roughness is an essential property that affects a material's polishing capacity and wear rate, along with the optical properties and microbial adhesion, by facilitating the mechanical retention of pigments and biofilm by increasing surface area.[37-39] The critical surface roughness value for dental materials has been determined as Ra=0.2 μm in previous studies, above which a rapid increase in plaque accumulation occurs.[40,41] In our study, all Ra values except for conventional PMMA teeth subjected to Corega after artificial saliva and isosite teeth subjected to Corega after coffee immersion were below this threshold value. The increased surface roughness may be caused by the high peroxide content of the Corega cleaning solution and the damaging effect of the oxygenation level caused by the mechanical effect of free radicals released during the cleaning process in a strong alkaline solution.[42] Durkan et al.[42] and Ayaz et al.[40] reported an increase in the surface roughness of acrylic materials after cleaning solutions similar to the present results. The difference in color and surface roughness values differed according to artificial teeth type may be due to the different chemical compositions of artificial teeth and differences in polymer matrix structure.

This study's limitations include the lack of evaluation of different cleaning procedures and the re-polishing effect of colored artificial teeth. The impact of various polishing techniques on the surface roughness and color stability of artificial teeth should be an object of future research.

CONCLUSION

According to the results of this in vitro study, coloring solutions affected surface roughness to varying degrees. Patients should be informed about the long-term effects of denture cleaning tablets, which may increase the surface roughness of conventional PMMA and isosite teeth with prolonged use. Clinicians should consider cost-effective aspects for aesthetic expectations when choosing artificial teeth.

Ethical Approval

Since sources obtained from humans or animals were not used in this study, ethics committee approval was not obtained.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: NEO, EIO, Data collection and processing: NEO, Analysis and interpretation: NEO, EIO, Literature review: NEO, EIO, Writing: NEO, EIO.

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Evaluation of the Clinical Success of Fissure Sealants Applied to Young Permanent Teeth

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ABSTRACT

Aim: The success of a fissure sealant (FS) is usually measured with maintained retention, but it is reported that even if the FS is completely lost, the caries prevention effect may continue. The aim of the study was to evaluate clinical success of a fissure sealant according to the type, localization of applied teeth and the follow-up time and also determine the clinical success of the FS according to retention and caries prevalence.

Material and Methods: Children whose permanent premolar and/or molar teeth were treated with a fluoride-releasing resin-containing FS (Clinpro Sealant™, 3M ESPE, St. Paul, MN, USA) were invited for control. The clinical success of FS was evaluated by modified USPHS criteria and the data were analyzed by Chi-square test.

Results: In total, 1272 FS were examined for 2, 3 or 4 years. There was no significant relationship between the follow-up time and retention rates ($p=0.150$). Marginal discoloration, marginal adaptation and retention scores were significantly more successful in premolars ($p\leq0.05$). The rates of caries in premolars and molars were 0.5% and 0% in FS with full-retention, 14.2% and 25.7% in FS with partial-retention, and 6.2% and 11.2% in FS with total loss, respectively.

Conclusion: Full retention ensures the highest caries prevention. However, FS that have been completely lost are still effective in preventing caries and their success is higher than FS with partial retention. It is important to apply fissure sealants to permanent molars and premolars in every possible child to ensure their oral health in the future.

Genç Daimi Dişlere Uygulanan Fissür Örtücülerin Klinik Başarısının Değerlendirilmesi

Makale Bilgisi

Makale Geçmişi

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Anahtar Kelimeler:
Fissür Örtücü,
Retansiyon,
Çürük,
Çocuk diş hekimliği.

ÖZET

Amaç: Fissür örtücülerin (FÖ) başarısı genellikle retansiyonuyla ölçülmektedir ancak FÖ tamamen kaybolsa bile çürük önleyici etkisinin devam edebileceği bildirilmektedir. Bu çalışmanın amacı fissür örtücülerin klinik başarısını, uygulanan dişlerin tipine, lokalizasyonuna ve takip süresine göre değerlendirmek, ayrıca retansiyon ve çürük prevalansına göre fissür örtücünün klinik başarısını belirlemektir.

Gereç ve Yöntemler: Daimi küçük azı ve/veya büyük azı dişlerine, fluorid salgılayan rezin içerikli FÖ (Clinpro Sealant™, 3M ESPE, St. Paul, MN, ABD) uygulanmış olan çocuklar kontrol için kliniğe davet edilmiştir. FÖ'nün klinik başarısı, modifiye USPHS kriterleri ile değerlendirilmiştir ve veriler Ki-kare testi ile analiz edilmiştir.

Bulgular: Toplamda 1272 FÖ 2, 3 veya 4 yıl süreyle incelenmiştir. Takip süresi ile retansiyon oranları arasında anlamlı bir ilişki bulunamamıştır ($p=0,150$). Kenar renklenmesi, kenar adaptasyonu ve retansiyon skorlarının küçük azı dişlerinde anlamlı olarak daha başarılı olduğu tespit edilmiştir ($p\leq0,05$). Küçük azı ve büyük azı dişlerinde çürük oranları tam retansiyonlu FÖ'de %0,5 ve %0, kısmi retansiyonlu FÖ'de %14,2 ve %25,7 total kayıplı FÖ'de ise sırasıyla %6,2 ve %11,2 olarak belirlenmiştir.

Sonuç: Tam retansiyon en yüksek çürük önlemeyi sağlamaktadır. Ancak, tamamen kaybedilen FÖ'ler çürük önlemede hala etkilidir ve başarıları kısmi retansiyonlu FÖ'e göre daha yüksektir. Gelecekte ağız ve diş sağlığını sağlayabilmek için, mümkün olan her çocuğun daimi azı dişlerine fissür örtücü uygulanması önemlidir.

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INTRODUCTION

In recent years, thanks to fluoride, the incidence of tooth decay in the child and adolescent population has decreased compared to the past. However, the risk of caries formation on occlusal surfaces is still high in this age group. Covering the surface with various materials is one of the most effective methods known to protect the posterior teeth from pit and fissure caries where almost half of all caries occurs.[1-4] Fissure sealants are used to prevent the development of bacteria that cause caries in the fissures of posterior teeth. Resin-based sealants and glass ionomer based sealants are the two most common types.[5] Fissure sealants which were first developed in the 1960s, were produced in many different types with the changes made in the material content or the setting mechanism, and finally, materials releasing fluoride were produced.[6] It is known that regardless of its content and setting type, fissure sealants have achieved significant success in preventing bacterial retention in deep pits and fissures and mineral loss of tooth surfaces against acid attacks.[7] Therefore, fissure sealants are known as a valuable strategy to prevent the development of caries in permanent molars.[8]

Failure of fissure sealants is most common in the first year following the application, and failure rates increase when the follow-up period becomes longer.[9] Fissure sealants, in which the technique is applied meticulously, are desired to remain in fissures for a long time without deterioration or need to be repeated. There are studies reporting that there is a significant difference between the maxilla and mandible in the retention success of fissure sealants, and that there is a significant difference between the right and left sides of the jaws in terms of the success of fissure sealants.[10,11] To the contrary, a published review reported that the localization of fissure sealants had no effect on the success of fissure sealants.[12] According to some authors, a fissure sealant's clinical success is achieved by the continuation of full retention in fissures.[13,14] On the other hand, some authors reported that even if the fissure sealant has been clinically lost, the resin extensions placed on the roughened enamel surface, which can be observed microscopically, continue to protect the tooth tissues from demineralization.[15] In addition, Hevinga et al.[16] reported that tooth type and patient restoration profile are determinants of the long-term success of resin fissure sealants. These different opinions in the literature suggest the question of whether the determinant factor in the clinical success of fissure sealants is retention or the absence of caries.

The aim of the study was to evaluate the long-term clinical success of a fluoride-releasing resin-containing fissure sealant according to the type, localization of applied teeth and the follow-up time based on their caries prevention ability and retention. Secondly this study aimed to determine whether the main determinant in the clinical success of FS is the retention or caries prevention ability.

MATERIAL AND METHODS

This study has been reviewed and approved by the Ethical Committee of Pamukkale University, Faculty of Medicine and all the procedures performed in the study were performed in accordance with the ethical standards given in the Declaration of Helsinki.

Study Design

The records of all healthy children whose fully erupted permanent premolar and/or molar teeth were treated non-invasively with a fluoride-releasing resin-containing fissure sealant (Clinpro Sealant™, 3M ESPE, St. Paul, MN, USA) by the same physician (H.Ö.İ.) in a pediatric dentistry clinic between January 2015 and December 2018, were reviewed retrospectively. Patients were called by phone and invited to the clinic for a follow-up appointment. All patients who could be reached at the time of the study (from January 2019 to December 2020) and who could attend the

control appointment were included in the study. At the control visits, the children's demographic data, tooth brushing habits and clinical examination findings were recorded in the anamnesis forms. As a result of clinical and radiographical examinations, the number of teeth affected by dental caries was determined by using the DMFT/dmft index and the presence of microbial dental plaque was determined with the Simplified Oral Hygiene Index.[17,18]

Clinical Assessment

Clinical examination of all fissure sealants was performed by the same trained and calibrated dentist (F.S.) under reflector light. The examiner was calibrated with an experienced examiner. The teeth were dried and examined with a dental mirror and blunt probe The clinical success of fissure sealants were evaluated by modified United States Public Health Service (USPHS) clinical rating system.[19] Scoring was made according to marginal discoloration, marginal adaptation, retention, surface texture and caries criteria.

Statistical Analysis

The statistical analyses were performed by using IBM SPSS Software (SPSS v 23.0; SPSS Inc., Chicago, IL, USA). Descriptive analyses were used in the statistical analysis of the data and the Chi-square analysis were used to examine the differences between categorical variables at the significance level of $p \leq 0.05$.

RESULTS

In the study, 1272 fissure sealants in 208 (114 girls, 94 boys) children who could come for the control examination were evaluated. The intra-examiner reliability for retention and caries criteria were high, with kappa values of 0.95 and 0.93, respectively. The mean age of the children at the control visit was 13.42±2.61. In the fissure sealant groups followed for 2, 3 and 4 years, the mean ages of the children were 11.28, 12.75 and 13.92, respectively. It was learned that 80.7% of the children brush their teeth at least once a day and 94.7% of them use fluoride paste. The mean plaque index score of all children participating in the study was 0.69±0.47 and the mean DMFT/dmft index score was 3.38±3.01.

The mean number of fissure sealants applied to each patient was 6.40±4.00 and 659 of the examined fissure sealants were applied to premolar teeth and 613 to molar teeth (Table 1). Of the examined fissure sealants, 205 were followed for 2 years, 415 for 3 years, and 652 for 4 years (Table 1). The average follow-up period was 40.10±8.72 months (Table 1). The distribution of the FS according to the type and localization of the applied teeth and the follow-up time are given in Table 1.

Table 1. Distribution of the FS according to type and localization of applied teeth and the follow-up time

FS applied teeth	Follow-up time			
	2 years n	3 years n	4 years n	Total n
Upper right premolar	26	65	83	
Upper left premolar	27	62	75	
Lower left premolar	30	51	85	
Lower right premolar	31	51	73	
Total number of premolar	**114**	**229**	**316**	**659**
Upper right molar	21	58	83	
Upper left molar	20	53	81	
Lower left molar	24	36	88	
Lower right molar	26	39	84	
Total number of molar	**91**	**186**	**336**	**613**
Total number of teeth	**205**	**415**	**652**	**1272**

FS: fissure sealant. n: number of teeth.

The differences in the clinical success of the fissure sealants are shown in Tables 2, 3 and 4 according to the follow-up time. Marginal discoloration (p=0.005; p=0.000; p=0.000), marginal adaptation (p=0.000; p=0.000; p=0.000) and retention (p=0.000; p=0.000; p=0.000) scores were significantly more successful in premolars than in molars at all follow-up periods (Table 2, 3, 4). It was observed that the surface texture score did not differ significantly (p=0.855; 0.322) between the fissure sealants applied to the premolar and molar teeth during 3- and 4-year follow-up periods (Table 3, 4). Caries score was significantly more successful (p=0.031; p=0.002) in premolars than in molars at 2- and 3-year follow-up periods (Table 2, 3). In addition, there was no significant relationship between the follow-up time of the FS and clinical performance (marginal adaptation p=0.177; retention p=0150; surface texture p=0.382; caries p=0.759) either premolars or molars except marginal discoloration (2/3 year p=0.006; 2/4 year p=0.05; 3/4 year p=0.560).

Table 2. Differences in the clinical success of FS followed for 2 years according to the type and localization of the applied tooth

USPHS criteria	Comparison criteria	Statistical significant difference	p value
Marginal discoloration	Upper-lower jaw	No	p=0.252
	Right-Left jaw	No	p=0.340
	Premolar-molar	FS applied to premolars are more successful	p=0.005
Marginal adaptation	Upper-lower jaw	No	p=0.138
	Right-Left jaw	No	p=0.944
	Premolar-molar	FS applied to premolars are more successful	**p=0.000**
Retention	Upper-lower jaw	No	p=0.124
	Right-Left jaw	No	p=0.763
	Premolar-molar	FS applied to premolars are more successful	**p=0.000**
Surface texture	Upper-lower jaw	No	p=1.000
	Right-Left jaw	No	p=0.871
	Premolar-molar	FS applied to premolars are more successful	p=0.038
Caries	Upper-lower jaw	No	p=0.328
	Right-Left jaw	No	p=0.621
	Premolar-molar	FS applied to premolars are more successful	p=0.031

FS: fissure sealant. USPHS: United States Public Health Service clinical rating system. Those with p≤0.05 show statistically significant difference.

Table 3. Differences in the clinical success of FS followed for 3 years according to the type and localization of the applied tooth

USPHS criteria	Comparison criteria	Statistical significant difference	p value
Marginal discoloration	Upper-lower jaw	No	p=0.750
	Right-Left jaw	No	p=0.950
	Premolar-molar	FS applied to premolars are more successful	**p=0.000**
Marginal adaptation	Upper-lower jaw	No	p=0.861
	Right-Left jaw	No	p=0.466
	Premolar-molar	FS applied to premolars are more successful	**p=0.000**
Retention	Upper-lower jaw	No	p=0.905
	Right-Left jaw	No	p=0.649
	Premolar-molar	FS applied to premolars are more successful	**p=0.000**
Surface texture	Upper-lower jaw	No	p=0.920
	Right-Left jaw	No	p=0.062
	Premolar-molar	No	p=0.855
Caries	Upper-lower jaw	No	p=0.601
	Right-Left jaw	No	p=1.000
	Premolar-molar	No	p=0.002

FS: fissure sealant. USPHS: United States Public Health Service clinical rating system. Those with p≤0.05 show statistically significant difference.

Table 4. Differences in the clinical success of FS followed for 4 years according to the type and localization of the applied tooth

USPHS criteria	Comparison criteria	Statistical significant difference	p value
Marginal discoloration	Upper-lower jaw	Upper right molars more successful than lower right molars	**p=0.000**
	Right-Left jaw	No	p=0.358
	Premolar-molar	FS applied to premolars are more successful	**p=0.000**
Marginal adaptation	Upper-lower jaw	No	p=0.294
	Right-Left jaw	No	p=0.831
	Premolar-molar	FS applied to premolars are more successful	**p=0.000**
Retention	Upper-lower jaw	No	p=0.437
	Right-Left jaw	No	p=0.685
	Premolar-molar	FS applied to premolars are more successful	**p=0.000**
Surface texture	Upper-lower jaw	FS applied to lower jaw are more successful	p=0.045
	Right-Left jaw	No	p=0.750
	Premolar-molar	No	p=0.322
Caries	Upper-lower jaw	No	p=0.291
	Right-Left jaw	No	p=0.224
	Premolar-molar	No	p=0.072

FS: fissure sealant. USPHS: United States Public Health Service clinical rating system. Those with p≤0.05 show statistically significant difference.

The full retention rates in premolars and molars were 91.2% and 62.8% in cases with 2-year follow-up, 89.2% and 80.1% in cases with 3-year follow-up, and 92.2% and 72.6% in cases with 4-year follow-up, respectively (Table 5). The rates of caries in premolars and molars were 0.5% and 0% in FS with full retention, 14.2% and 25.7% in FS with partial retention, and 6.2% and 11.2% in those with total FS loss, respectively. (Table 6) The mean DMFT/dmft value of the cases with complete FS loss and caries was found to be 4, of the cases with partial FS loss and caries was 4.55, and of the cases with complete FS retention and caries was 7.

Table 5. Retention rates of fissure sealants

Follow up time	Premolar			Molar		
	Complete retention (Oscar*) n(%)	**Partial retention** (Bravo/ Charlie*) n(%)	**Complete loss** (Delta*) n(%)	**Complete retention** (Oscar*) n(%)	**Partial retention** (Bravo/Charlie*) n(%)	**Complete loss** (Delta*) n(%)
2 years	104 (91.2%)	5 (4.38%)	5 (4.38%)	57 (62.8%)	23 (25.2%)	11 (12%)
3 years	204 (89.2%)	12 (5.2%)	13 (5.6%)	149 (80.1%)	27 (14.5%)	10 (5.4%)
4 years	291 (92.2%)	11 (3.4%)	14 (4.4%)	244 (72.6%)	51 (15.2%)	41 (12.2%)

* Retention scores according to USPHS criteria[21] Oscar: Harmonious and continuous with occlusal form and structure. Bravo: Loss of sealant from one or two pits or accessory grooves (partial loss) but not requiring repair or replacement of the sealant. Charlie: Loss of sealant from pits or accessory grooves (partial loss), requiring a replacement or a repair of the sealant. Delta: Loss of sealant from all pits (total loss).

Table 6. The rates of caries based on retention scores of fissure sealants

Follow up time	**Complete retention** (Oscar*)		**Partial retention** (Bravo/ Charlie*)		**Complete loss** (Delta*)	
	Caries		**Caries**		**Caries**	
	Premolar n(%)	**Molar n(%)**	**Premolar n(%)**	**Molar n(%)**	**Premolar n(%)**	**Molar n(%)**
2 years	0(0%)	0 (0%)	0 (0%)	4 (17.3%)	0 (0%)	0 (0%)
3 years	1(0.4%)	0 (0%)	1(8.3%)	11 (40.7%)	1 (7.6%)	1 (10%)
4 years	2(0.6%)	0 (0%)	3 (27.2%)	11(21.5%)	1 (7.1%)	6 (14.6%)

* Retention scores according to USPHS criteria[21] Oscar: Harmonious and continuous with occlusal form and structure. Bravo: Loss of sealant from one or two pits or accessory grooves (partial loss) but not requiring repair or replacement of the sealant. Charlie: Loss of sealant from pits or accessory grooves (partial loss), requiring a replacement or a repair of the sealant. Delta: Loss of sealant from all pits (total loss).

DISCUSSION

Fissure sealants are known as a valuable strategy to prevent the development of caries in permanent molars and they have been the subject of many clinical studies in the field of pediatric dentistry.[8] Although fissure sealants are expected to fulfill their function by remaining in fissures for a long time without breaking or falling, losses may occur over time.[10,11] This study aimed to determine whether the main determinant in the clinical success of FS is the retention or caries prevention ability and to evaluate the long-term clinical success of a fluoride-releasing resin-containing fissure sealant.

Since the success of fissure sealants may not be standardized when applied by different operators, our study was carried out with fissure sealants performed by a single operator. Similarly, since differences may be observed when the clinical controls of fissure sealants are performed by different operators, in our study all fissure sealants were controlled by a single operator. There was no significant relationship between the follow-up time and retention rates of the fissure sealants, so it is inconsistent with the opinion that retention rates will decrease as the follow-up period increases.[12] The fact that, better retention scores were not obtained in FS followed for 2 years or worse scores were not obtained in FS followed for 4 years, supports the view that a meticulously performed FS can remain in fissures for many years.[16]

There was no significant difference between the fissure sealants on the right or left sides of the jaws in any evaluation criteria during all follow-up periods. Among the fissure sealants applied in the lower and upper jaws, it was observed that the marginal discoloration score showed better results in the upper molars than the lower molars in cases followed for 4 years. These results are compatible with the data in the literature.[12]

In the present study, in regard to marginal discoloration, marginal adaptation and retention, fissure sealants applied to premolar teeth were statistically significantly more successful than those applied to molar teeth in all follow-up periods. Similarly, it is stated in the studies conducted on this subject that the retention of fissure sealants applied to premolars is more successful.[12,20] It is stated that the reason for this result is not the differences in the anatomical structure of the teeth, but the doubling of the risk of failure due to the doubling of the total fissure sealant area and the amount of applied material in the molar teeth.[20,21]

In some studies, it is stated that the protective effect of the fissure sealant is provided by the continuation of the retention of the resin to the fissures.[5,22] It has been shown that even after the total loss of resin fissure sealants with or without fluoride release, residues of the resin remaining in the tags can continue to protect the enamel from decay.[15] In this study, caries rates in FS that were totally lost were 6.2% and 11.2% in premolars and molars, respectively. These rates are lower than the incidence of dental caries reported in posterior teeth that have never been treated with fissure sealant before.[23,24] It would be more accurate to compare the prevalence of caries in teeth with complete FS loss with teeth that have never had FS before in the same mouth. However, since it would not be ethical to consciously not apply FS to some teeth of children, a comparison was made with the data of caries prevalence studies conducted in the same age groups. Therefore, according to the results of this study, it is thought that even if the FS is visibly completely removed from the surface, its protective effect against dental caries may continue. This finding is parallel to the results of a similar study conducted previously.[25] It is stated that the reason for less decay formation in premolars, both at the margins of the FS and following total loss, is not due to the high protective ability of the material

in these teeth, but it is because the incidence of tooth decay in premolars is already lower than molars, although without FS.[23,26]

Some studies report that teeth with partially or completely lost fissure sealants do not have a higher risk of developing caries compared to unsealed teeth. It is concluded that fissure sealants are indicated even if regular follow-up is not possible.[25,27] On the other hand, some studies have reported that fissure sealants should be checked regularly and reapplied if found defective. They concluded that incompletely sealed fissures are at higher risk for caries development compared to fully sealed teeth.[12,28] Retention rate is considered to be an accurate determinant of the success of sealants in caries prevention.[29,30] Rock and Anderson[31] clearly emphasized that the effects of fissure sealants continue only while they are present on the teeth. Authors noted that fissure sealant retention must be completely intact if any prophylactic benefit is to be achieved.[30,32,33] However, Mickenautsch et al.[34,35] stated that the retention rate is not an accurate determinant for the success of sealants in caries prevention. They noted that after losing retention, fissures may still contain microseal residues. This may be because fissure sealants seal pits and fissures through micro-retention created via resin tags after enamel etching. It is reported that complete retention of fissure sealants has been established as a beneficial factor in preventing the teeth. However the retention of fissure sealants is not a valid predictor for clinical success.[34,35] Another problem with partially or completely lost fissure sealants is that they can leave sharp edges that cause food accumulation and ultimately lead to decay.[36] A systematic review assessed whether the risk of developing caries in teeth with partial or complete loss of sealant exceeded the risk in teeth that have never been sealed. It has been found that teeth that have partially or completely lost their sealant do not have a higher risk of developing caries than teeth that have never been sealed.[25,37] Ostrc et al.[38] reported similar findings which are parallel to present study. They indicated that incompletely sealed molars did not protect the teeth efficiently.

Compared to no sealant use, fissure sealant is an effective and valuable method against the caries.[24] American Academy of Pediatric Dentistry concluded that fissure sealants are effective in preventing and arresting pit-and-fissure occlusal carious lesions of primary and permanent molars in children and adolescents compared with the non-use of sealants.[39] It is reported that preventive effect of fissure sealants ranges from 87% at 12 months to 60% at 48-54 months.[40] However, the protective properties of fissure sealants are to some extent. [41] Regular check of sealed teeth is important, and if it is detected to be removed, reapplication of fissure sealant should be reapplied.[38] However, the fact that the child cannot attend the next appointments should not be the reason for the dentist not to apply fissure sealants.[25]

In the present study, teeth with FS were included in the study regardless of their occlusion type. The occlusion type of the teeth and whether they participate in chewing function may affect the retention of fissure sealants. In addition, the presence of a fissure sealant or restoration on the opposing tooth and the type of this restoration may also affect the retention of fissure sealants. This situation can be considered as a limitation of the study and new studies can be planned by taking it into consideration in future studies.

In this study, an answer was sought to the question of whether ‘fissure sealant retention’ or ‘prevention of caries that cause the need for restoration’ is the main determinant in the clinical success of FS. According to the data obtained, the caries preventive effect of a fissure sealant, is highest in the case of complete retention. However, it was observed that the rate of caries observed in fissure sealants with partial loss was higher than that in teeth with

complete FS loss, and the DMFT/dmft scores of the patients in these two groups were similar. This result may be attributed to two reasons. The first is that the FS remaining partially on the fissures creates a suitable ground for caries by creating a retention area for bacteria and food residues, and the second is that the FS that is completely loss may continue to protect the tooth surface against demineralization.

CONCLUSION

In this study, it was determined that tooth type, localization and follow-up period do not have a significant effect on the clinical success of fissure sealants. The clinical success of fissure sealants should be measured by the continuation of caries prevention efficacy. It has been found that complete retention provides the highest success for caries prevention efficacy; however, fissure sealants with complete loss also continue to have this effect and are more successful than fissure sealants with partial retention. This article clarified the effect of the retention status of resin fissure sealants on their preventive efficacy and showed that the anti-caries effect of resin fissure sealants may continue even if they are completely lost.

Ethical Committee Approval

The required ethical approval for this study was received from Pamukkale University Faculty of Medicine Non-Drug and Medical Device ethics committee (2020/01).

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: CÇE, HÖİ. Fissure sealant applications: HÖİ. Fissure sealant controls: FS. Literature review: CÇE, HÖİ. Analysis and writing: CÇE.

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Evaluation of the Awareness of Patients Applying to the Periodontology Clinic on Oral Hygiene Habits According to Periodontal Status

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ABSTRACT

Aim: The aim of this study is to examine the awareness of patients applying to the periodontology clinic about oral hygiene habits (OHH) according to their periodontal status through a survey.

Material and Methods: 400 volunteer patients who applied to the periodontology clinic and were diagnosed with periodontitis (n=200) and gingivitis (n=200)) after clinical and radiographic examination were included in the study. Questionnaires including demographic data and oral hygiene habits were directed to the patients in the form of mutual question-answer.

Results: In the gingivitis group, the incidence rate in female individuals between the ages of 18-39, university graduates, non-smokers were found to be statistically higher than in the periodontitis group ($p<0.05$). In the gingivitis group, the rate of knowing what the bleeding in the gingiva is a symptom of, the rate of brushing teeth twice or more a day, the rate of using electric toothbrushes were found to be statistically higher than the periodontitis group ($p<0.05$). The rate of using toothpicks in the periodontitis group was statistically significantly higher than the gingivitis group ($p<0.05$). No statistical difference was found between the two groups in terms of other findings ($p>0.05$).

Conclusion: In line with the results of this study, it has been shown that patients have insufficient knowledge about the use of auxiliary oral hygiene tools other than toothbrushes. It was determined that oral hygiene education and motivation of patients should be provided.

Periodontoloji Kliniğine Başvuran Hastaların Periodontal Duruma Göre Ağız Hijyeni Alışkanlıkları Konusundaki Farkındalıklarının Değerlendirilmesi

Makale Bilgisi

Makale Geçmişi

Geliş Tarihi: 22.02.2024
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Anahtar Kelimeler:
Gingivitis,
Periodontitis,
Oral hijyen,
Ağız sağlığı.

ÖZET

Amaç: Bu çalışmanın amacı, periodontoloji kliniğine başvuran hastaların periodontal durumlarına göre oral hijyen alışkanlıkları (OHH) konusundaki farkındalıklarını bir anket aracılığıyla incelemektir.

Gereç ve Yöntem: Çalışmaya, periodontoloji kliniğine başvuran, klinik ve radyografik muayene sonucu periodontitis (n=200) ve gingivitis (n=200) teşhisi konulan 400 gönüllü hasta dahil edildi. Hastalara demografik veriler ve oral hijyen alışkanlıklarını içeren anket soruları karşılıklı soru-cevap şeklinde yönlendirildi.

Bulgular: Gingivitis grubunda kadın olgu oranı, 18-39 yaş arası olgu oranı, üniversite mezunu olgu oranı ve sigara kullanmama oranı periodontitis grubuna göre istatistiksel olarak yüksek bulundu ($p<0.05$). Gingivitis grubunda diş etindeki kanamanın neyin belirtisi olduğunu bilme oranları, günde iki veya daha fazla diş fırçalama oranı, elektrikli fırça kullanma oranı periodontitis grubuna göre istatistiksel olarak yüksek bulundu ($p<0.05$). Periodontitis grubunda kürdan kullanma oranı gingivitis grubuna göre istatistiksel olarak anlamlı düzeyde yüksek bulundu ($p<0.05$). Her iki grup arasında diğer bulgular açısından istatistiksel olarak anlamlı bir farklılık bulunamadı ($p>0.05$).

Sonuç: Bu çalışmanın sonuçları doğrultusunda, hastaların diş fırçası dışındaki yardımcı ağız hijyeni araçlarının kullanımı konusunda yeterli bilgiye sahip olmadığı gösterilmiştir. Hastaların oral hijyen eğitimi ve motivasyonunun sağlanması gerektiği belirlendi.

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INTRODUCTION

Periodontal disease is a pathological inflammatory condition that starts with the bacterial infection of the gingival and supporting tissues surrounding the teeth and can progress to the destruction of the tissues. The major factor effective in the formation of periodontal diseases is microbial dental plaque. Microbial dental plaque, which is attached to the surface of teeth and dentures, is an organized structure consisting of salivary glycoproteins and extracellular microbial products. They are adherent, soft consistency, yellow-white colored matrix structures that cannot be removed by rinsing the mouth with water.[1] The regular removal of dental plaque accumulated on the tooth and denture surface is called plaque control and is of great importance in terms of maintaining the health of periodontal tissues. In addition, applications for the removal of dental plaque appear as one of the most effective methods for the protection of tooth and gingival health, as well as the treatment of existing periodontal disease and the maintenance of the obtained health.[2]

Plaque control is achieved in two ways using mechanical and chemical applications. The toothbrush is the most common mechanical cleaning tool that individuals use in their daily routine in order to control plaque. The adequacy of oral hygiene provided by tooth brushing varies depending on the design of the brush, the degree of softness, brushing technique, brushing frequency and duration. Careful use of manual or electric toothbrushes, which are preferred with medium hardness, helps to remove plaque without causing any trauma to the mucosa.[3] In order to mechanically remove plaque, other auxiliary oral hygiene tools such as dental floss, interdental brush, mouthwash, toothpick, waterjet and tongue brush are also used. Toothpastes and mouthwashes, on the other hand, are materials that prevent plaque formation, remove or neutralize plaque, and provide chemical plaque control, aiding mechanical cleaning.[4-6]

In addition to the microbial dental plaque being the main etiological factor in periodontal diseases, in epidemiological studies on this subject; It has been concluded that periodontal health levels can change according to the OHH, systemic diseases, socio-economic and demographic conditions of individuals.[7,8] Smoking is also an important risk factor for periodontal health. It has been determined that smokers give less importance to oral care than non-smokers, have more plaque accumulation, and are more prone to periodontal disease due to these reasons.[9]

Patient education and motivation are essential to achieving good plaque control and OHH. The biggest task in this regard falls on dentists and especially periodontologists. Dentists need to choose the appropriate oral hygiene tools for the patient and explain the way of use to the patient in an appropriate language. This situation constitutes the most critical step to achieve success in the patient's education on oral hygiene. It is also of great importance to examine the awareness of the society to use oral hygiene tools to protect gingival health and the awareness of gingival disease in order for dentists to inform their patients about this issue.[10]

In this study, our aim is to examine the demographic data, OHH and periodontal status of the patients with the questionnaire questions directed to the patients who applied to the periodontology clinic. In the light of these data, it is to measure the awareness of patients about oral hygiene and to consider the points that the dentist should pay attention to in patient education. The null hypothesis of this study is that gingivitis patients are more conscious about the use of oral hygiene tools than periodontitis patients.

MATERIAL AND METHODS

This study involved 400 systemically healthy volunteers who applied to the Department of Periodontology at Alanya Alaaddin Keykubat University Faculty of Dentistry. After undergoing a clinical and radiographic examination by a skilled periodontologist (K.S.), 200 of the volunteers were diagnosed with gingivitis and 200 with periodontitis. The Alanya Alaaddin Keykubat University Clinical Research Ethics Committee approved the research protocol with the number 14-02 on 14.12.2022 and the individuals who agreed to participate in the study signed an informed consent form. The study was performed in accordance with the guidelines of the 1964 Helsinki Declaration. The questionnaire questions of the study were prepared similarly to previous studies.[11,12] Questionnaires were asked to the patients included in the study in the form of questions and answers, and the answers were recorded in the questionnaire form. In the first step of the questionnaire, the demographic data of the patient (gender, age, education level and financial income level) and smoking status of the patient was recorded, and in the last step, OHH (last dentist check, gum disease awareness, frequency of brushing, type of brush used, degree of softness, brush replacement frequency), other oral hygiene tools (dental floss, interdental brush, mouthwash, toothpick, waterjet and tongue brush) used other than toothbrushes, and questions to measure the awareness of the time left between brushing and mouthwash use were recorded. Only one of the questions (auxiliary oral hygiene tools other than toothbrushes) had more than one choice, while the other questions had only one answer.

Exclusion criteria in the study were determined as follows;

- Patients under the age of 18 and over the age of 70
- Edentulous patients
- Patients with a systemic disease
- Patients unable to use oral hygiene tools
- Disabled patients who cannot allow hand manipulation
- Patients who did not accept the informed consent form

Statistical Analysis

The IBM SPSS Statistics 22 application was utilized for statistical analysis in assessing the study's findings. The Chi-Square test, Continuity (Yates) Correction and Fisher Freeman Halton Exact Chi-square test were utilized to evaluate qualitative data between groups when analyzing the study data. Significance was evaluated at the $p<0.05$ level.

RESULTS

Demographic Data

Table 1 displays the distribution of the study participants by gender, age, education level, and monthly income.

There was a statistically significant variation in the distribution of genders among the groups (p:0.004; $p<0.05$). While the rate of female cases (55%) is higher in the gingivitis group, the rate of male cases (59.5%) is higher in the periodontitis group. There was a statistically significant variation in age distribution among the groups (p:0.001; $p<0.05$). While the rate of cases between the ages of 18-39 were higher in the gingivitis group (73%), the rate of cases between the ages of 40-59 were higher in the periodontitis group (60%) (Table 1).

There was a statistically significant variation in the distribution of educational attainment among the groups (p:0.001; $p<0.05$). While the rate of university graduates was higher in the gingivitis group (48%), the rate of primary school graduates in the periodontitis group was higher (46.5%). There was no statistically significant variation in the distribution of monthly income levels among the groups (p:0.490; $p>0.05$) (Table 1).

Table 1: Comparison of demographic data of patients according to groups

		Gingivitis (n=200)	Periodontitis (n=200)	Total (n=400)	
		n (%)	n (%)	n (%)	p-Value
Gender	Female	110 (55%)	81 (40.5%)	191 (47.8%)	**0.004***
	Male	90 (45%)	119 (59.5%)	209 (52.3%)	
Age	18-39	146 (73%)	50 (25%)	196 (49%)	**0.001***
	40-59	46 (23%)	120 (60%)	166 (41.5%)	
	60 and over	8 (4%)	30 (15%)	38 (9.5%)	
Education Level	Primary	47 (23.5%)	93 (46.5%)	140 (35%)	**0.001***
	High school	51 (25.5%)	66 (33%)	117 (29.3%)	
	University	96 (48%)	37 (18.5%)	133 (33.3%)	
	Graduate Education	6 (3%)	4 (2%)	10 (2.5%)	
Monthly Income	0-10.000TL	152 (76%)	160 (80%)	312 (78%)	0.49
	10.000-20.000TL	38 (19%)	34 (17%)	72 (18%)	
	Over 20.000TL	10 (5%)	6 (3%)	16 (4%)	
Smoking Habit	Smoker	62 (31%)	85 (42.5%)	147 (36.8%)	**0.019***
	Non-smoker	123 (61.5%)	95 (47.5%)	218 (54.5%)	
	Quitter	15 (7.5%)	20 (10%)	35 (8.8%)	

Chi-square test | *The significance level was set as $p < 0.05$.

There was a statistically significant variation in the distribution of smoking habits among the groups (p:0.019; p<0.05). While the rate of non-smokers was higher in the gingivitis group (61.5%), the rate of smokers was higher in the periodontitis group (42.5%) (Table 1).

Oral Hygeine Habits and Gum Disease Awareness

In the questionnaire, the patients included in the study were asked questions about their OHH and gum disease awareness. Table 2 displays data on OHH and awareness of gum disease among the study participants.

There was no statistically significant variation among the groups on the frequency of going to the dentist in the last year (p:0.597; p>0.05) (Table 2).

There was a statistically significant variation in terms of knowing what the bleeding in the gums is a symptom of across the groups (p:0.001; p<0.05). The rate of saying gum disease in the gingivitis group (70%) was significantly higher than in the periodontitis group (52.5%) (Table 2).

There was a statistically significant variation in tooth brushing frequency among the groups (p:0.002; p<0.05). The rate of brushing twice or more times a day in the gingivitis group (47.5%) was significantly higher than in the periodontitis group (33.5%) (Table 2).

There was a statistically significant variation in the brush types used among the groups (p:0.003; p<0.05). The rate of using electric toothbrushes in the gingivitis group (13%) was significantly higher than in the periodontitis group (4.5%) (Table 2).

There was no statistically significant variation in the hardness of the bristles among the groups (p:0.337; p>0.05) (Table 2).

There was no statistically significant variation in brush change frequencies among the groups (p:0.107; p>0.05) (Table 2).

There was no statistically significant variation in using anything other than a toothbrush, such as dental floss, interdental brushes, gargles and mouthwash, water jets, and tongue brushing, among the groups (p>0.05). The rate of using toothpicks (33.5%) excluding toothbrushes in the periodontitis group was statistically significantly higher than the gingivitis group (19%) (p:0.001; p<0.05) (Table 2).

Table 2: Evaluation of questions about oral hygiene habits according to groups

		Gingivitis (n=200)	Periodontitis (n=200)	Total (n=400)	
		n (%)	n (%)	n (%)	p-Value
Visited a dentist in the last year	Yes	135 (67.5%)	130 (65%)	265 (66.3%)	0.597
	No	65 (32.5%)	70 (35%)	135 (33.8%)	
Signs of bleeding in gums	Tooth decay	13 (6.5%)	10 (5%)	23 (5.8%)	**0.001***
	Gum disease	140 (70%)	105 (52.5%)	245 (61.3%)	
	Unknown	47 (23.5%)	85 (42.5%)	132 (33%)	
Tooth brushing frequency	Does not brush	1 (0.5%)	9 (4.5%)	10 (2.5%)	**0.002***
	A few times a week	21 (10.5%)	36 (18%)	57 (14.2%)	
	Once a day	83 (41.5%)	88 (44%)	171 (42.8%)	
	Twice or more in a day	95 (47.5%)	67 (33.5%)	162 (40.5%)	
Brush type	Manuel toothbrush	174 (87%)	191 (95.5%)	365 (91.3%)	**0.003***
	Electric toothbrush	26 (13%)	9 (4.5%)	35 (8.8%)	
Hardness of brush bristles	Hard	14 (7%)	21 (10.5%)	35 (8.8%)	$^{+}$0.337
	Medium	129 (64.5%)	135 (67.5%)	264 (66%)	
	Soft	55 (27.5%)	43 (21.5%)	98 (24.5%)	
	Extra soft	2 (1%)	1 (0.5%)	3 (0.8%)	
Brush change frequency	2-3 months	103 (51.5%)	96 (48%)	199 (49.8%)	0.107
	6 months	80 (40%)	76 (38%)	156 (39%)	
	1 year	9 (4.5%)	22 (11%)	31 (7.8%)	
	More than a year	8 (4%)	6 (3%)	14 (3.5%)	
Tools used for oral hygiene, excluding toothbrushes	Floss	47 (23.5%)	39 (19.5%)	86 (21.5%)	0.330
	Interdental brush	6 (3%)	5 (2.5%)	11 (2.8%)	$^{++}$1.000
	Toothpick	38 (19%)	67 (33.5%)	105 (26.3%)	**0.001***
	Gargles and mouthwashes	57 (28.5%)	42 (21%)	99 (24.8%)	0.082
	Waterjet	10 (5%)	5 (2.5%)	15 (3.8%)	$^{++}$0.292
	Tongue brush	15 (7.5%)	7 (3.5%)	22 (5.5%)	$^{++}$0.125
	Doesn't use any	75 (37.5%)	77 (38.5%)	152 (38%)	0.837
Time between tooth brushing and mouthwash	Should be brushed right away	118 (59%)	127 (63.5%)	245 (61.3%)	0.356
	Should be brushed after half an hour	82 (41%)	73 (36.5%)	155 (38.8%)	

Chi-Square Test | $^{+}$Fisher Freeman Halton Exact Test | $^{++}$Continuity (yates) corrections | *The significance level was set as $p < 0.05$.

There was no statistically significant variation in the time between tooth brushing and mouthwash among the groups (p:0.356; p>0.05) (Table 2).

DISCUSSION

In order to protect and maintain periodontal health, patients should consult a dentist regularly. Dentists have the greatest responsibility in providing oral hygiene training to their patients and supervising their correct and effective use during these control sessions. Predicting OHH and public awareness according to the periodontal status of the patients during the oral hygiene education of the physicians will enable them to focus on the missing or insufficient points in the education. Therefore, in this study, it was aimed to examine the demographic data and OHH of the patients who applied to Alanya Alaaddin Keykubat University, Faculty of Dentistry, Department of Periodontology, according to their periodontal status, through a questionnaire.

Su et al. [13] showed in their study that the prevalence and severity of periodontal disease is higher in male individuals, and they reported that this situation is proportional to the fact that male individuals visit the dentist less, pay less

attention to dental and gingival health, and inability to use auxiliary oral hygiene tools. In the present study, the statistically high rate of female individuals in the gingivitis group and male individuals in the periodontitis group is similar to this study.

In a study evaluating the prevalence of periodontal disease in young, middle-aged and elderly individuals by Nazir et al. [14], it was reported that the incidence and severity of periodontitis increased with age. Curtis et al. [15] showed that age is the most important factor affecting attachment loss in cases where patients' demographic data, oral hygiene and health are similar. In the present study, gingivitis in the young patient (18-39 years old) population and the high incidence of periodontitis in the middle-aged population (40-59 years old) supports these studies. The low number of participants in the elderly population may have caused the rate of periodontitis to be higher in the middle-aged population.

Baskaradoss et al. [16] reported in their study that education level and literacy level are very important due to factors such as understanding the information that physicians give to their patients, applying them correctly, and easily accessing information about oral health. Walther et al. [17] argued that individuals with low education levels have a three times higher risk of periodontitis than individuals with higher education. Bui et al. [18] reported that individuals with low education levels do not pay enough attention to their oral health, which may cause exacerbation of periodontitis by risking their general health status. The high rate of university graduate cases in the gingivitis group and the high rate of primary school graduates in the periodontitis group in the present study supports these studies.

Celeste et al. [19] reported in their study that the socio-economic status of patients affects the frequency of visiting the dentist, since dentistry service is paid for in many countries. On the other hand, Hussein et al. [20] stated that the number of physicians is insufficient in regions with low socio-economic status, and all these conditions carry a risk for the protection of oral health due to low socio-economic income. In contrast, Walther et al. [17] argued that the monthly income of individuals is not a risk factor for periodontal disease. The fact that there was no statistically significant difference between the groups in terms of monthly income levels in the present study supports the study of Walther et al. We think that this is due to the fact that patients in our country can receive free service in the state institution.

Smoking is an important risk factor that increases the tendency to periodontal disease in proportion to the amount of daily use, accelerates the course of the disease and negatively affects the success of the treatment.[21] As a result of their study, Tomar et al. [22] stated that individuals who smoke and have used before are more likely to develop periodontitis than individuals who have never smoked. More et al. [23] argued that smokers do not pay enough attention to their oral hygiene and this situation increases the susceptibility to periodontal disease. The statistically high rate of smokers in the periodontitis group in the present study supports these literatures.

In their study, Dannewitz et al. [24] reported that periodontitis patients should go to the dentist 1-4 times a year, taking into account the individual risks. They stated that these control sessions are important in terms of evaluating the need for periodontal phase I treatment, the early treatment of pathological pockets affected by the disease, and the repetition of oral hygiene motivation. As a result of their study, Samorodnitzky et al. [25] reported that tooth loss would be higher in individuals who had irregular check-ups with the dentist. It was observed that approximately 65% of the patients participating in the present study had applied to the dentist in the last 1 year. We think that this is due to the fact that individuals living in Alanya are conscious about going to the dentist for regular check-ups.

In their study, Deng et al. [26] stated that it is important for the society to be aware of gingival bleeding, because periodontal disease is diagnosed early and its progression is stopped with treatment. In their survey study, Eren et al. [11] showed that 66.3% of the individuals participating in the study did not have knowledge about gingival disease. In a study by Beşiroğlu et al. [27], while the number of those who gave the answer 'gum disease' to the question "What is the sign of gingival bleeding when brushing?" was similar in the gingivitis and periodontitis groups they found that the number of those who could not give the correct answer was statistically high in the periodontitis group. The higher rate (66.3%) of those who gave the answer to the question "What is the symptom of gingival disease?" in the present study contradicts the study of Eren et al. We think that this situation is due to the information given by the departments that referred to the periodontology clinic. The gingival disease response rate (70%) in the gingivitis group was found to be significantly higher than the Periodontitis group (52.5%), which is similar to the study of Beşiroğlu et al.

As a result of their study, Chapple et al. [28] reported that regardless of the toothbrush bristle design, daily routine brushing reduces gingivitis by removing plaque. Joshi et al. [29] showed that brushing twice or more times per day significantly reduces the prevalence of periodontitis and the risk of periodontal pathological pocket formation. It has been shown that the vast majority of individuals participating in the present study brush their teeth daily. The fact that the frequency of brushing twice or more times a day was statistically higher in the gingivitis group than in the periodontitis group in the present study supports this literature.

In their study in which they compared electric and manual toothbrushes, Petker-Jung et al. [30] reported that both methods did not differ in terms of oral hygiene if the patients showed appropriate time and care. A Ramseier et al. [31] reported that the use of electric toothbrushes showed a significant decrease in plaque index and gingival index levels compared to the use of manual toothbrushes. Al-Omiri et al. [32] argued that the reason for these conflicting results is that the use of electric toothbrushes is not as common as manual toothbrushes in some societies or that the difference in toothbrushes used in the research. The fact that 91.3% of the individuals participating in the present study were using a manual toothbrush supports the study by Al-Omiri et al. The fact that the rate of using electric toothbrushes in the present study was significantly higher in the gingivitis group than in the periodontitis group suggests that the electric toothbrush may be more effective in removing plaque than a manual toothbrush.

As a result of their study, Ranzan et al. [33] reported that toothbrushes with a hard bristle structure, although they are more effective in removing plaque compared to toothbrushes with medium and soft hardness, cause gingival abrasions, traumatic lesions in the gingiva and gingival recession. Langa et al. [34] showed in their study that medium-hard toothbrushes removed plaque more effectively than soft brushes, resulting in more positive results in periodontal parameters. Extra soft brushes are mostly recommended after periodontal soft tissue surgeries to remove plaque without trauma to the surgical area.[35] In this study, no difference was found between the gingivitis and periodontitis groups in terms of the hardness of the bristles. It was observed that the individuals who participated in the study preferred the medium hard (66%) and soft hardness (24.5%) toothbrushes, which remove plaque most effectively without causing trauma to the gums.

This may be due to the fact that the individuals participating in the study were conscious and aware of oral hygiene.

As a result of their systematic review, Silva et al. [36] reported that no difference was observed in plaque removal between the new

toothbrush and the 3-month-old toothbrush, although the vast majority of dentists recommend their patients to change their toothbrushes at 3-4 monthly intervals. As a result of their study, Schmickler et al. [37] reported that the plaque removal efficiency of the toothbrush decreased after 6 months of use and the incidence of gingivitis increased. Romesa et al. [38] on the other hand, associated the change time of the toothbrush with the deterioration of the structure of the bristles rather than the duration of use. In this study, the majority of the individuals participating in the study answered the question of brush change frequency as 2-3 months (49.8%) and 6 months (39%). There is no statistically significant difference between the groups in terms of brush change frequencies. This suggests that patients who applied to the Department of Periodontology were informed during their previous dental check-ups.

Insufficient use of the toothbrush alone in removing the plaque accumulated on the interproximal tooth surface poses a risk in terms of periodontal disease. For this reason, the American dental association recommends the use of auxiliary oral hygiene tools such as dental floss, interdental brushes, toothpicks, antiseptic agents, and waterjet in addition to toothbrushes.[39] In a study in which they compared dental floss, interdental brush and waterjet, Worthington et al. [40] reported that after 1 month of use, interdental brushes and waterjet had better results in plaque and bleeding scores compared to dental floss. In this study, it was determined that 38% of the participants did not use any oral hygiene tool in addition to the toothbrush in providing oral hygiene. In addition, it was found that the use of dental floss (21.5%) in interproximal surface cleaning was higher than the use of interdental brushes (2.8%) and waterjet (3.8%). This situation suggests that physicians are incomplete in recommending the use of auxiliary oral hygiene tools such as interdental brushes and waterjetes, especially to their patients with periodontitis who have open interdental contact. In their study, Sun et al. [41] showed that the use of toothpicks in interproximal surface cleaning is quite common and argued that toothpicks cause periodontal damage due to their pointed ends and pose a risk for periodontal disease. The fact that the toothpick (26.3%) was the most commonly used auxillary hygiene tool, other than the toothbrush, in the present study supports this literature. The rate of using toothpicks (33.5%) excluding toothbrushes in the periodontitis group was statistically significantly higher than the gingivitis group (19%) ($p<0.05$). This may be due to the accumulation of food in the areas of attachment loss after meals in individuals with periodontitis and the need to remove it. It also suggests that the use of toothpicks causes trauma to the periodontal tissues. In their study, Rickenbacher et al. [42] recommended the use of a tongue brush by stating that microorganisms on the tongue surface cause periodontitis, periimplantitis, tooth decay and bad breath. On the other hand, in their study on patients with periodontitis, Laleman et al. [43] reported that tongue cleaning did not cause a decrease in the number of microorganisms in the saliva and oral cavity. There is no consensus in the literature on tongue cleaning. In this study, only 5.5% of the participants use a tongue brush. The necessity of informing the patients about the tongue cleaning practice was shown.

In their study, Rajendiran et al. [44] showed the effectiveness of mouthwash and gargles in antiplaque, antigingivitis and antiperiodontitis. On the other hand, in their survey study, Górska et al. [45] showed that 33% of the participants do not use mouthwash, 25% of them use it regularly every day, and the rest use it weekly. The fact that only 24.8% of the participants in the present study used mouthwash and mouthwash contradicts this literature. This situation is actually due to the lack of information about individuals that mouthwash and gargles reduce plaque formation when used

in addition to tooth brushing. Mouthwashes and gargles are recommended in addition to tooth brushing as they provide plaque control in places where the toothbrush and other auxiliary oral hygiene tools cannot reach. When mouthwashes and gargles are used immediately after brushing, they cause the fluoride taken with toothpaste to be absorbed and removed from the mouth.[46] Additionally, sodium lauryl sulfate or anionic fluorides contained in toothpaste inactivate cationic chlorhexidine. Therefore, it is appropriate to use mouthwash approximately half an hour after brushing your teeth.[47] In this study, to the question "How long do you think you should leave between brushing and mouthwash?", 245 participants answered that it should be used immediately after brushing, and 155 participants answered it half an hour later. This shows that physicians are insufficient not only to recommend mouthwashes, but also to inform their patients about the use of mouthwashes.

As a result of their study, Fatima et al. [48] reported that most of the physicians did not perform periodontal examination and they were insufficient to diagnose periodontal disease. In addition, they emphasized that many physicians do not even pay enough attention to their own oral health and reported that they lacked oral hygiene education and motivation to their patients. In this survey study, it was shown that most of the patients neglected their dental check-ups, did not know about periodontal disease, and did not use or misused oral hygiene tools other than toothbrushes. It is thought that our physicians are also insufficient in informing their patients about oral health and care.

This study has several limitations. Firstly, the questionnaire study included patients from a single institution, potentially limiting the generalizability of the findings to a broader population. Secondly, patients can be informed about oral hygiene in other clinic departments before visiting the periodontology clinic. These limitations should be acknowledged and taken into account in future studies.

CONCLUSION

Based on the limited results of this study, it was concluded that gingivitis patients are more conscious about periodontal disease and pay more attention to tooth brushing. Despite this, it has been shown that both gingivitis and periodontitis patients are deficient in the use of auxiliary oral hygiene tools for interdental spaces cleaning. It has been revealed that dental check-ups should become more frequent and that physicians should provide motivation and education for their patients in these sessions. In order for the oral and dental health of the society to reach the desired level, it is necessary to increase the frequency of oral screenings and to provide education on oral hygiene from an early age. Dentists have the greatest responsibility for supervising patients' correct use of oral hygiene products and providing motivation for oral health. This study is limited to survey questions. There is a need for more comprehensive studies that will investigate the contribution of education to the oral hygiene status of patients and their reflection on clinical outcomes.

Ethical Approval

The necessary ethical approval for this study was received by Alanya Alaaddin Keykubat University Clinical Research Ethics Committee (2022/14-02).

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: KS, Data collection and processing: KS, Analysis and interpretation: KS, Literature review: KS, Writing: KS.

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Effect of Whitening Mouthwashes on Color Change of Colored One Shade Composite Resins

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ABSTRACT

Aim: The aim of this study was to evaluate the effects of different whitening mouthwashes on the color change of stained four different one-shade composite resins and to compare them with a multi-shade composite.
Materials and Methods: A multi-shade (Filtek Ultimate) and four one-shade (Omnichroma, Charisma Diamond One, Essentia Universal, Vittra Unique) composite resins were used. A total of 160 samples, 32 of each composite were prepared and the initial color parameters of the composite samples were measured with a spectrophotometer and the composite samples in each group were divided into four groups (n=8). Then, the samples were kept in coffee and second color measurements were made. After the samples were kept in four whitening mouthwashes (Colgate Optic White, Listerin Advanced White, Pasta del Capitano Whitening, SPLAT® Professional Bio-Active), third color measurements were made and color changes were calculated with the CIEDE2000 formula. Statistical analyzes were performed using one-way ANOVA and post-hoc Tukey's test.
Results: The color changes observed in the stained composite resins after immersion in mouthwash were statistically significant, varying by mouthwashes and composites ($p \leq 0.05$). Average color change values ($\Delta E00$) were between 0.85 and 4.87. While the highest color change was observed in the Charisma Diamond One group using Pasta del Capitano Whitening ($\Delta E00=4.87$), the lowest color change in all groups was observed in the use of SPLAT® Professional Bio-Active.
Conclusion: One-shade composites showed more color change than the multi-shade composite, with variations depending on the mouthwash used. Almost all groups, whitening mouthwashes caused a color change above the perceptibility threshold level.

Beyazlatıcı Etkili Gargaraların Renklendirilmiş Tek Renk Kompozit Rezinlerin Renk Değişimi Üzerine Etkisi

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ÖZET

Amaç: Bu çalışmanın amacı farklı beyazlatıcı ağız gargaralarının renklendirilmiş dört farklı tek renk kompozit rezinin renk değişimi üzerine olan etkilerini değerlendirmek ve çoklu renk sistemine sahip bir kompozitle karşılaştırmaktır.
Gereç ve Yöntemler: Çalışmada bir çoklu renk sistemine sahip estetik kompozit (Filtek Ultimate) ile dört tek renk kompozit (Omnichroma, Charisma Diamond One, Essentia Universal, Vittra Unique) olmak üzere beş farklı kompozit rezin kullanıldı. Her kompozitten 32 toplamda 160 örnek hazırlandı. Kompozit örneklerin ilk renk parametreleri bir spektrofotometre ile ölçüldü ve her gruptaki kompozit örnekler rastgele dört gruba ayrıldı ve örnekler numaralandırıldı (n=8). Daha sonra kahvede bekletilen örnekler yıkandıktan sonra ikinci renk ölçümleri yapıldı. Örnekler dört beyazlatıcı etkili ağız gargarasında (Colgate Optic White, Listerin Advanced White, Pasta del Capitano Whitening, SPLAT® Professional Bıo-Active) bekletildikten sonra üçüncü renk ölçümleri yapıldı ve renk değişimleri CIEDE2000 formülüyle hesaplandı. İstatistiksel analizler one way ANOVA ve post-hoc Tukey's testi kullanılarak yapıldı.
Bulgular: Renklendirilen kompozit rezinlerin gargarada bekletilme sonunda görülen renk değişimleri kullanılan gargaraya ve kompozitlere göre istatistiksel olarak farklı bulundu ($p \leq 0,05$). Ortalama renk değişim değerlerinin ($\Delta E00$) 0,85 ile 4,87 aralığında olduğu tespit edildi. Kompozitler içinde en çok renk değişimi Charisma Diamond One grubunda Pasta del Capitano Whitening gargara kullanımında gözlemlenirken ($\Delta E00=4,87$), grupların tamamında en düşük renk değişimi SPLAT® Professional Bio-Active kullanımında gözlendi.
Sonuç: Tek renk kompozitler çoklu renk sistemine sahip kompozitten daha fazla renk değişimi göstermiştir ve kullanılan gargaralara göre değişim miktarı farklılık göstermiştir. Grupların genelinde beyazlatıcı ağız gargaraları algılanabilirlik eşik düzeyinin üzerinde bir renk değişimine neden olmuştur.

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INTRODUCTION

Since whiter teeth are considered more aesthetically acceptable by individuals, whitening discolored teeth is one of the most commonly performed procedures in clinical practice.[1, 2] The natural color of the crown part of a human tooth is predominantly white, with slight yellow tones that reflect the color of the dentin beneath the translucent enamel, along with minimal amounts of red tones.[3] Tooth discolorations are classified into two main groups: intrinsic and extrinsic discolorations. Whitening procedures are typically used for external discolorations. In external discoloration, changes in tooth color typically result from pigments that come into significant contact with teeth, such as cigarettes, beverages, and foods, as well as antibiotics, and metals like iron or copper and environmental factors and these colored compounds obtained from these sources can be absorbed into the tooth surface, causing staining to occur.[4, 5]

Teeth whitening is a process performed to lighten and whiten the teeth. Whitening can be achieved through physically removing discoloration or staining, or by chemically whitening or lightening the tooth color through a chemical reaction. The active ingredient in most whitening products is hydrogen peroxide or carbamide peroxide, which breaks down to release hydrogen peroxide. Additionally, various chemicals and natural agents are often added to whitening agents for their whitening purposes. There are various types of products used for teeth whitening purposes. There are many products marketed for teeth whitening purposes, including toothpastes and mouthwashes with higher amounts of detergents and abrasive substances to help remove chromogens from tooth surfaces; whitening agents that react with chromogens to lighten color; products that enhance both cleaning and whitening effects; and whitening strips designed to whiten teeth gradually.[5] More severe or complex discolorations are best treated with professional whitening, whereas for milder cases and daily use, over-the-counter products that are more easily accessible may be preferred. One of the most commonly used materials among these are mouthwashes (mouthrinses). Some of these moutwashes are combined with whitening agents to create whitening mouthwashes, which are marketed for their whitening effects.

Today, with the rapid developments in aesthetic composite resins, one shade composite resins have been introduced to the market, which are color compatible with all 16 colors in the VITA scale and providing comprehensive color matching capabilities thanks to the advanced chameleon and blending effect, and to eliminate the treatment complexity arising from the layering technique.[6, 7] Most studies on tooth color change focus on dental enamel, highlighting the importance of color stability in the success of aesthetic dental restorations. As a result, there is increasing interest in the ability of restorative materials to resist color changes over time. Many studies have shown that factors influencing tooth color can similarly affect aesthetic restorative materials, especially composite resins.[8, 9] Composite resins differ significantly from dental enamel in terms of composition and chemical as well as physical properties. Therefore, when exposed to the same color change factors, they are likely to be affected to varying degrees. This variability can lead to color mismatch, treatment failures, and patient dissatisfaction.[10]

The clinical success of composite resin restorations depends on achieving perfect color matching with natural teeth. Therefore, it is crucial to fully understand the effects of whitening agents on resin composites as well. The literature currently has limited studies on the color change (or color recovery) of one shade composite resins, a popular product today, especially after staining and the use of

whitening products. The aim of this study was to evaluate the effects of different whitening mouthwashes on the color change (color recovery) of stained four different one-shade composite resins and to compare them with a multi-shade composite resin. The null hypothesis of the study was that whitening mouthwashes applied to composites colored with coffee would not significantly change the color of the composites and that the color changes would not be affected by the type of mouthwash and composite.

MATERIALS AND METHODS

In the present study, five different composite resins were used, including one aesthetic composite resin with a multi-shade color system (Filtek Ultimate, A2 Body, 3M ESPE, USA) as a control group and four one shade composite resins [(Omnichroma, Tokuyama, Japan), (Charisma Diamond One, Kulzer, Germany), (Essentia Universal, GC Corp., Japan), (Vittra Unique, FGM Dental, Brazil)]. Detailed information about the composite resins used is presented in Table 1.

Table1: The composite resins used in the study

Composite Resins	Filler Type	Composition	Manufacturer
Filtek Ultimate, A2 Body (control) (multi-shade)	Nanofilled	Bis-GMA, UDMA, Bis-EMA, PEGDMA, TEGDMA, Zirconia, Silica	3M ESPE, St. Paul, MN, ABD
Omnichroma (one-shade)	Spherical Nanofilled	UDMA, TEGDMA, uniform sized supra-nano spherical filler (260 nm spherical SiO_2-ZrO_2) and composite fillers	Tokuyama Dental, Tokyo, Japan
Charisma Diamond One (one-shade)	Nanohybrid	advanced TCD matrix, BPA-free, and BrF B_2O_3-F-Al_2O_3-SiO_2, silica, TiO_2, fluorescent pigments, metallic oxide pigments, organic pigments,	Kulzer, Hanau, Germany
Essentia Universal (one-shade)	Microhybrid	UDMA, Bis-MEPP, Bis-EMA, Bis-GMA, TEGDMA, Prepolymerized fillers, Barium glass, Silica	GC Corp., Tokyo, Japan
Vittra APS UNIQUE (one-shade)	Nanohybrid	UDMA, TEGDMA, advanced polymerization system(APS) composition, co-initiators, silane, boron-aluminum-silicate glass	FGM Dental, Joinville, Brazil

Abbreviations: Bis-GMA: Bisphenol A-diglycidyl methacrylate; UDMA: Urethane dimethacrylate; Bis-EMA: Ethoxylated bisphenol A glycol dimethacrylate; PEGDMA: Polyethylene glycol dimethacrylate; TEGDMA: Triethylene glycol dimethacrylate; TCD: Tricyclodecane; BPA: Bisphenol A; Bis-MEPP: bisphenol-A ethoxylate dimethacrylate.

In this study, each group being divided into four subgroups based on the moutwashes used with α set at 0.05, β set at 0.10, (1-β) set at 0.80 and effect size set at 0.278; it was determined that n=8 samples would be taken from each subgroup, yielding a total sample size of N = 160. The power of the test p=0.80424 was found. Samples were prepared by using plastic molds measuring 8 mm in width and 2 mm in depth, resulting in a total of 160 samples with 32 samples from each composite resin. After placing the composite resins into the plastic molds, polyester strips were placed over them. Subsequently, the samples were positioned between two microscope slides and a slight pressure was applied to create a flat surface. Following this, the samples were light-cured using an LED light device (Valo Cordless, Ultradent Products Inc., South Jordan, UT, USA) with a light intensity of 1000 mw/cm² for 20 seconds on their upper surfaces. After the polymerization process, the samples were removed from the molds and subjected to surface treatments using a disc polishing system (Sof-Lex, 3M ESPE, USA).

Afterward, the samples were immersed in

distilled water at 37°C for 24 hours. The initial color parameters of the composite samples were measured using a clinical type spectrophotometer (Vita Easyshade Compact, Vita Zahnfabrik, Germany) based on the CIE L*a*b* color scale. Following color measurement, the L_1, C_1, H_1, a_1 and b_1 values were recorded, and the composite samples in each group were randomly divided into four groups and numbered (n=8).

Then, the samples were immersed in filter coffee prepared with 4g coffee / 200 ml boiling water (Tchibo Gold Selection, Tchibo GmbH, Hamburg, Germany) at 37°C for 24 hours (equivalent to 1 month of use).[11] After washing and drying the samples using absorbent paper, second color measurements were taken, and L_2, C_2, H_2, a_2 and b_2 values were recorded. The color change ($\Delta E_{00\ 2\text{-}1}$) that occurred after waiting in the coffee was analyzed with the CIEDE2000 formula shown in Figure 1. The analysis was performed using the Excel spreadsheet application of the CIEDE2000 color difference formula.[12]

Figure 1: CIEDE2000 color difference formula

$$\Delta E_{00} = \left(\left(\frac{\Delta L^*}{k_L S_L} \right)^2 + \left(\frac{\Delta C'}{k_C S_C} \right)^2 + \left(\frac{\Delta H'}{k_H S_H} \right)^2 + R_T \left(\frac{\Delta C' \Delta H'}{S_C S_H} \right) \right)^{1/2}$$

Afterwards, the samples were immersed in four different whitening mouthwashes at 37°C for 24 hours (equivalent to daily use of 2 minutes for 2 years).[13, 14] In the study, the following 4 mouthwashes were used: Colgate Optic White (GABA International AG, Therwil, Switzerland), Listerine Advanced White (Johnson & Johnson, Skillman, NJ, USA), Pasta del Capitano Whitening (Farmaceutici Dott. Ciccarelli S.P.A., Milano, Italy), and Splat Professional Bio-Active (Splat-Global, Novgorod, Russia). Detailed information about these mouthwashes is presented in Table 2. After immersing the samples in the four whitening mouthwashes for 24 hours, third color measurements were taken. L_3, C_3, H_3, a_3 and b_3 values were obtained, and the color changes ($\Delta E_{00\ 3\text{-}2}$) induced by immersion in the mouthwashes after staining were analyzed using the CIEDE2000 formula.

Table 2: The moutwashes used in the study

Mouthwash	Composition	Manufacturer
Colgate Optic White (COW)	Aqua, Glycerin, Sorbitol, Propylene Glycol, PVM/MA Copolymer, Tetrapotassium Pyrophosphate, Polysorbate 20, Sodium Fluoride, Sodium Saccharine, CI 42051	GABA International AG, Therwil, Switzerland
Listerine Advanced White (LAW)	Water, Alcohol, Sorbitol, Tetra Potassium Pyrophosphate, Penta Sodium Triphosphate, Citric Acid, Poloxamer 407, Flavors, Sodium Saccharin, Sucralose, Sodium Fluoride, SodiumBenzoate, Tetra SodiumPyrophosphate, Menthol, Eucalyptol, Thymol, Aroma, Propylene Glycol, Disodium Phosphate.	Johnson & Johnson, Skillman, NJ, USA
Pasta del Capitano Whitening (PDC)	Aqua, Glycerin, Alcohol, Potassium Citrate, Polisorbate 20, PVP, PEG-40, Sodium Benzoate, Aroma, Betaine, Lactic Acid, Sodium Lactate, Sodium Bicarbonate, Sodium Fluorit, Sodium Monoflorophasphate, SodiumSaccarin, Eugenol, Limonen, CI47005, CI 42051.	Farmaceutici Dott. Ciccarelli S.P.A., Milano, Italy
Splat Professional Bio-Active (SPL)	Water, Hydrogenated Starch Hydrolysine, PVP, Polyglyceryl-4 Lourate/Sebacate, Polyglyceryl-6 Caprylate/Caprate, Sodium Coco-Sulphate, Aroma, Cyclodextrin, Zinc Gluconate, Citrus Lemon Peel Oil, Pineapple Fruit Extract, Maltodextrin, Thyme Oil, Licorice Root Extract , Stevia Leaf Extract, Glycerin, Pentylene Glycol, ida Ferment Lysate, Phthalimido-peroxy-caproic acid, Potassium Thiocyanate, Lacoein, Lactoperoxidase, Glucose Ondase, Glucose Pentaacetate, Sodium Benzodl, Potassium Sorbate, Benzyl Alcohol, Limonene, Citral, Linalool	Splat-Global, Novgorod, Russia

Abbreviations: PVM/MA: Polyvinyl methyl ether/Maleic anhydride; PVP. Poly- Vinyl Pyrrolidone; PEG: Polyethylene glycol.

Statistical Analysis

Based on the data obtained in the study, statistical evaluations were performed using IBM SPSS version 22.0 for Windows (SPSS, Chicago, IL, USA). Firstly, the normality and homogeneity of the data were assessed using the Kolmogorov-Smirnov and Levene tests, respectively. Subsequently, the data were analyzed using one-way ANOVA (analysis of variance). Post hoc pairwise comparisons were conducted using the Tukey test with a significance level (α) set at 0.05.

RESULTS

As a result of statistical evaluation of color change values, the color change ($\Delta E_{00\ 2\text{-}1}$) seen in composite resins colored with coffee were found to be statistically different compared to the composites used ($p \leq 0.05$). The average $\Delta E_{00\ 2\text{-}1}$ values observed after immersion in coffee are presented in Table 3. After immersion in coffee, the greatest color change was observed in the Charisma Diamond Diamond One group, while the least color change was observed in the Essentia Universal group. Essentia Universal showed color change similar to the multi-shade composite resin Filtek Ultimate as control group.

The color changes (color recovery) ($\Delta E_{00\ 3\text{-}2}$) observed in composite resins stained with coffee after immersion in mouthwashes were found to be statistically different based on the mouthwash used and the composites ($p \leq 0.05$). It was determined that the average color change values ($\Delta E_{00\ 3\text{-}2}$) of composite resins stained with coffee and subsequently immersed in mouthwashes ranged from 0.85 to 4.87 (Table 4). After immersion in mouthwashes, the highest color change was observed in the Charisma Diamond One group when using PDC mouthwash (ΔE_{00}=4.87), while the lowest color change was observed in the Filtek Ultimate group when using SPL (ΔE_{00}=0.85).

Table 3: Average color change ($\Delta E_{00\ 2\text{-}1}$) and standard deviation values of composites after immersion in coffee

	$\Delta E_{2\text{-}1}$
Filtek Ultimate (control)	3.49* (0.39)
Omnichroma	3.89 (0.43)
Charisma Diamond One	5.46 (0.64)
Vittra APS Unique	4.72 (0.54)
Essentia Universal	3.24* (0.33)
p value	<0.01

* indicates statistically similar groups. $p<0.05$ indicates statistical differences between groups.

Table 4: Average color change ($\Delta E_{00\ 3\text{-}2}$) and standard deviation values of stained composite resins after immersion in mouthwashes

	COW	LAW	PDC	SPL	p values
Filtek Ultimate (control)	1.74 (0.18) ^{A}	1.91 (0.22) ^{A}	1.87 (0.23)^{A}	0.85 (0.13) ^{B}	0.03
Omnichroma	2.62 (0.32) ^{CK}	2.44 (0.30) ^{CJ}	3.08 (0.29) ^{D}	1.91 (0.20) ^{A}	<0.001
Charisma Diamond One	4.04 (0.53) ^{E}	4.41 (0.49) ^{F}	4.87 (0.54) ^{G}	3.43 (0.36) ^{H}	<0.001
Vittra APS Unique	3.23 (0.29) ^{DH}	3.41 (0.31) ^{H}	4.00 (0.47) ^{E}	2.40 (0.28) ^{CJ}	<0.001
Essentia Universal	2.35 (0.29) ^{J}	2.80 (0.34) ^{K}	3.34 (0.33) ^{H}	1.71 (0.15) ^{A}	<0.001

* Same uppercase superscripts indicate groups showing statistically similar color change

The least color change was observed in all composite resins when using SPL. The highest color change values were observed when using PDC, excluding the Filtek Ultimate group. After immersion in mouthwashes, the least color change was observed in the Filtek Ultimate group as control group across all mouthwash groups, while the highest color change was observed in the Charisma Diamond One group across all mouthwash groups.

When examining color parameters separately, after immersion in coffee, a decrease in L* values was observed (Table 5), whereas an increase was observed after immersion in mouthwashes. For a*, and b* values, an increase was observed after immersion in coffee, while a decrease was observed after immersion in mouthwashes (Table 5).

Table 5: Average L* (Lightness), a* and b* values of samples before coloring with coffee (L_1, a_1, b_1); after coloring (L_2, a_2, b_2) and after waiting in mouthwash (L_3, a_3, b_3).

	L_1	L_2	L_3		a_1 / b_1	a_2 / b_2	a_3 / b_3	
Filtek Ultimate (control)	83.9	78.8	***COW***	81.2	1.1 / 28.0	1.5 / 28.8	***COW***	1 / 28.0
			LAW	80.9			***LAW***	0.5 / 26.7
			PDC	81.0			***PDC***	0.6 / 27.0
			SPL	80.0			***SPL***	1.3 / 28.7
Omnichroma	82.0	78.9	***COW***	80.9	-3.7 / 9.8	-2.9 / 14.0	***COW***	-3.5 / 11.0
			LAW	81.5			***LAW***	-3.4 / 11.8
			PDC	81.9			***PDC***	-3.6 / 11.0
			SPL	79.1			***SPL***	-3.4 / 11.4
Charisma Diamond One	79.4	74.9	***COW***	78.4	-1.7 / 9.0	-0.7 / 15.3	***COW***	-1.8 / 11.0
			LAW	79.0			***LAW***	-1.8 / 10.8
			PDC	79.3			***PDC***	-1.8 /10.1
			SPL	77			***SPL***	-1.2 / 10.6
Vittra APS Unique	82.8	79.8	***COW***	81.6	-2.3 / 6.0	-2.1 / 11.8	***COW***	-2.2 / 7.6
			LAW	82			***LAW***	-2.6 / 7.7
			PDC	82.7			***PDC***	-2.3 / 7.0
			SPL	80.4			***SPL***	-2.5 / 8.6
Essentia Universal	80.2	76.2	***COW***	78.3	1.5 / 21.7	2.0 / 24.9	***COW***	1.1 / 21.5
			LAW	79			***LAW***	1.2 / 21.1
			PDC	79.6			***PDC***	1.0 / 20.5
			SPL	77.3			***SPL***	1.4 / 22

DISCUSSION

There are numerous studies focusing on the changes that mouthwashes cause in the color parameters of composite resins; however, studies specifically related to color change of stained composite resins (especially one-shade composites) are limited.[13, 15-19] In the present study evaluating the color change (color recovery) of one-shade composites stained with coffee using whitening mouthwashes, significant color changes were observed in all groups. It was observed that this change varied statistically depending on the type of composite and mouthwash used. Therefore, the null hypothesis was rejected.

Due to dissatisfaction with tooth color among patients and their desire for whitening, the use of over-the-counter whitening products has increased in recent years. Products claiming to provide whitening effects have also gained popularity. Among these products, mouthwashes are prominent due to their ease of use, low cost, and ready availability. In recent years, mouthwashes containing whitening agents have become popular due to their perceived whitening effects. Therefore, our

study evaluated the impact of these whitening mouthwashes on the color change (whitening effect) of stained composites.

In dentistry, color selection or determination of restoration color compatibility can be achieved through visual inspection or with the assistance of various devices. In the study, to obtain objective results and eliminate human errors, [4] a clinical type of spectrophotometer was used. Although different color systems such as CIELAB (ΔE_{ab}) and CIEDE2000 (ΔE_{00}) are used in the analysis of color changes, it has been stated in studies that the CIEDE2000 color system is superior to the CIELAB color system in determining perceptibility and acceptability.[20, 21] Therefore, in our study, we used the CIEDE2000 (ΔE_{00}) color system and formula for analyzing color changes.

When reviewing the literature, there are various opinions regarding the perceptibility and acceptability of color changes in restorations[22]. Recently, Paravina et al.[21] indicated threshold values where they defined the perceptibility threshold as ΔE_{00}=0.8 and the acceptability threshold as ΔE_{00}=1.8. They also reported in their study that the ΔE_{00} value should be greater than 1.8 in order for whitening to be interpreted as effective.[21] When the ΔE_{00} values obtained as a result of the present study were examined, it was found that all of the obtained values were higher than the perceptibility threshold value (ΔE_{00}>0.8) and effective whitening was achieved in almost all of the groups (ΔE_{00}>1.8), except for a few groups.

Whitening agent application can cause changes in the color of existing restorative materials due to the breakdown of large pigment molecules.[23] Changes in the color of restorative materials are attributed to the oxidation of surface pigments and amine compounds.[15, 24] The amount of resin matrix and the degree of polymerization of the resin matrix can lead to differences in color changes among different restorative materials.[25, 26] The chemical agents used during whitening not only affect teeth but can also impact existing restorations due to their organic matrix content, potentially causing color changes. Variations in the composition of composites used in this study, including differences in resin matrix formulations, may have led to varying degrees of color change in composite resins.[27] One shade composite resins are composites that do not contain color pigments and have color matching ability. Changes made to the composition of one shade composites [28] and color matching abilities of them may explain more color variation compared to multi-shade composite. In this study, similar to the study of Fidan and Yağcı [29], the most coloration and the most color change after waiting in mouthwash were found in the Charisma Diamond One group. The significant color variation observed in Charisma Diamond One compared to the other materials may be due to the presence of filler particles, which can result in inadequate cross-linking between the polymer matrix and the fillers.[30] The tricyclododecane monomer found in Charisma Diamond One exhibits a considerable affinity for coffee, a low-polarity beverage. This characteristic may explain the monomer's contribution to the material's decreased color stability.[29,31] The high color change observed in Charisma Diamond One after soaking in mouthwash can also be attributed to its higher translucency.[32] However, studies on the color change of this material as a result of the application of whitening agents are limited.[29]

Studies investigating color changes after whitening procedures have reported that the results are influenced by the concentrations of whitening agents, exposure durations, and particularly the composition of the test materials.[24, 33] Whitening effective mouthwashes contain various ingredients aimed at whitening and preventing discoloration, such as peroxide derivatives, sodium hexametaphosphate, pyrophosphate, sodium citrate, plasdone (polyvinylpyrrolidone or PVP), phthalimido-peroxy-caproic acid, detergent derivatives, and some enzymes.[34-37] Hydrogen peroxide (HP) is a common bleaching agent used both in professional clinical settings and in products for at-home use.[38, 39] HP is a potent oxidizing agent that breaks down long-chain organic pigment

molecules into shorter-chain compounds, thereby facilitating bleaching.[40] However, due to its short shelf life and safety restrictions, its use in mouthwashes is problematic, and typically, mouthwashes contain low concentrations of HP, around 1%-2%.[35, 41] The mouthwashes used in this study do not contain HP.

Various phosphate derivatives such as pyrophosphates and hexametaphosphates have strong binding affinities and can desorb stain components from the tooth surface.[35] The presence of sodium hexametaphosphate and pyrophosphate in whitening agents prevents to being adsorbed onto the tooth surface.[35, 36] Plasdone (PVP), is a water-soluble polymer with high solubility and can form complexes with catechins and other coloring agents, that removes them from the surface of teeth and reduces discoloration.[42] Phthalimido-peroxy-caproic acid is a synthetic organic peroxy acid derived from caproic acid and phthalimide and has high oxidation potential with active oxygen release.[37] In this study, when reviewing the whitening materials in mouthwashes, COW and LAW contain pyrophosphate derivatives, PDC contains Plasdone (PVP), and SPL contains both PVP and phthalimido-peroxy-caproic acid. Among these mouthwashes, excluding the Filtek Ultimate group, PDC was found to be the most effective mouthwash for color recovery of composite resins. Interestingly, SPL, despite containing PVP like PDC, resulted in the lowest color recovery. This could be due to SPL's composition using organic components instead of chemical ones found in other mouthwashes, and its lack of alcohol content, which may not effectively interact with the resin matrix. When examining the color change (recovery) values among groups, although statistically different, some groups showed similar values between LAW and COW.

In the study, when examining the L* values obtained and showed Table 5, after immersion in coffee, the L_2 values showed a decrease compared to the initial values L_1. However, after immersion in mouthwash, the L_3 values showed an increase. This indicates that the mouthwashes shifted the lightness values of the composites from darker to lighter shades, demonstrating a whitening effect. Looking at the a* and b* values obtained, after immersion in coffee, the a_2 and b_2 values showed an increase compared to the initial values a_1 and b_1. On the other hand, after immersion in mouthwash, the a_3 and b_3 values showed a decrease. This situation indicates that after immersion in coffee, the color of composite resins shifts towards the yellowness and redness axes (increased a* and b* values), whereas after using mouthwash, it shifts back towards the blueness and greenness axes (decreased a* and b* values). Additionally, Patent Blue V (Color Index 420151), found in COW and PDC, may contribute to the increased a* value.[35] Similar to this study, Harorli and Barutcugil[35], Bilgili Can and Özarslan[40] have reported that samples immersed in mouthwash after staining recovered their color in their respective studies.

As every in vitro study, this study has some limitations. The present study has limitations such as not being able to imitate the real oral environment exactly, not having a cleaning effect of saliva, not forming a pellicle structure, and the absence of brushing. Furthermore, in vivo studies are needed to better analyze the effects of whitening mouthwashes.

CONCLUSION

Within the limitations of the study; stained one-shade composite resins showed more color change (color recovery) than the multi shade composite, and the amount of change varied depending on the mouthwash used. Almost all groups, whitening mouthwashes caused a color change above the perceptibility threshold level.

Ethical Approval

Since this study did not involve any human or animal subjects, ethical committee approval was not required.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: NŞ, EB, Data collection and processing: NŞ, EBG, VK, Analysis and interpretation: VK, Literature review: VK, NŞ, Writing: NŞ, EBG, VK.

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Effect of Different Composite Resin Types on the Repair Strength of Resin Matrix Ceramics: An in Vitro Study

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ABSTRACT

Aim: The aim of this study is to investigate the effect of different composite resins and surface treatments on the repair strength of a resin matrix ceramic.
Material and Methods: Sixty resin matrix ceramic samples were divided into three main groups based on the surface treatments (Diamond bur roughening, hydrofluoric acid roughening, no surface treatment). Each main group was further divided into two subgroups depending on the type of composite resin (Nanoceramic and nanohybrid composite resins) bonded. Shear bond strength testing was performed for all groups at a 0.5 mm/min approach speed after thermal ageing. For all statistical comparisons in the study, $p<0.05$ was the level of statistical significance.
Results: The results showed that the highest shear bond strength was obtained in the group that underwent hydrofluoric acid surface treatment and was bonded with nanoceramic composite (18.17±4.48 MPa). On the other hand, the lowest shear bond strength was observed in the nanohybrid group (3.64±0.9 MPa), which did not undergo any surface treatment. The group that underwent hydrofluoric acid roughening showed significantly higher shear bond strength than those without surface treatment and those roughened with a diamond bur. Additionally, the nanoceramic-bonded groups had significantly higher shear bond strength than the nanohybrid-bonded groups.
Conclusions: Based on these findings, it can be concluded that resin matrix ceramics that are treated with hydrofluoric acid and bonded with nanoceramic provide better repair strength.

Farklı Kompozit Rezin Türlerinin Rezin Matriks Seramiklerin Tamir Dayanımı Üzerine Etkisinin Değerlendirilmesi

Makale Bilgisi

Makale Geçmişi

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Anahtar Kelimeler:
Seramikler,
Kompozit rezinler,
Makaslama dayanımı.

ÖZET

Amaç: Bu çalışmanın amacı, farklı kompozit rezinlerin ve yüzey işlemlerinin rezin matriks seramiğin tamir dayanımı üzerindeki etkisini araştırmaktadır.
Gereç ve Yöntemler: Altmış rezin matriks seramik örneği yüzey işlemlerine göre üç ana gruba ayrıldı (Elmas frezle pürüzlendirme, hidroflorik asitle pürüzlendirme, yüzey işlemi yok). Her ana grup ise bağlanan kompozit rezin tipine (Nanoseramik ve nanohibrit kompozit rezinler) bağlı olarak iki alt gruba ayrılmıştır. Termal yaşlandırma sonrasında tüm gruplara için 0,5 mm/dk yaklaşım hızında makaslama bağlanma dayanımı testi gerçekleştirilmiştir. Çalışmadaki tüm istatistiksel karşılaştırmalar için anlamlılık düzeyi $p<0.05$ olarak belirlenmiştir.
Bulgular: En yüksek makaslama bağlanma dayanımının hidroflorik asit yüzey işlemi uygulanan ve nanoseramik kompozit ile bağlanan grupta elde edilmiştir (18,17±4,48 MPa). Öte yandan, en düşük makaslama bağlanma dayanımı ise herhangi bir yüzey işlemi uygulanmayan nanohibrit grubunda (3,64±0,9 MPa) gözlenmiştir. Hidroflorik asitle pürüzlendirme yapılan grup, yüzey işlemi yapılmayanlara ve elmas frezle pürüzlendirilenlere göre istatistiksel olarak anlamlı dercede daha yüksek makaslama bağlanma mukavemeti göstermiştir. Ek olarak, nanoseramik bağlı gruplar nanohibrit bağlı gruplara göre istatistiksel olarak anlamlı ölçüde daha yüksek makaslama bağlanma dayanımına sahiptir.
Sonuçlar: Bu bulgulara dayanarak, hidroflorik asit ile yüzey işlemi uygulanan ve nanoseramik kompozit rezin bağlanan rezin matriks seramiklerin daha iyi onarım gücü sağladığı sonucuna varılabilir.

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INTRODUCTION

Dental ceramics are frequently employed in dentistry for their mechanical and aesthetic aspects.[1] According to the current classification, ceramic restorative materials can be categorized into glass matrix, polycrystalline, and resin matrix ceramics, depending on their chemical structure.[2,3]

Combining the advantages of ceramics and composites, resin matrix ceramics are easier to machine due to their soft matrix structure and have better physical and mechanical properties than direct composites. They can also successfully mimic the physical properties of natural teeth and can be repaired intraorally. Dental materials experience continuous stress in the oral environment due to masticatory forces, temperature changes, and variations in saliva pH. Ceramic restorative materials are particularly vulnerable to fatigue and fracture due to their low tensile strength and high modulus of elasticity. Although dental materials with high stiffness exhibit durable mechanical properties, they are more prone to fracturing under masticatory forces. Intraoral repairs of defective restorations with composite resins are widely used in clinical practice because this method is more advantageous in terms of time, cost, and preservation of dental tissue.[4-6] Dental composites have come a long way over the last five decades with significant developments. They are classified under several headings, such as filler size distribution, filler content, or composition.[7,8] As a result of nanotechnological developments in dentistry, nanohybrid composite resins containing nanoscale fillers are being produced.[9,10] The nano-sized clustered agglomerate fillers of nanohybrid composite resins give them superior mechanical and optical characteristics.[11] Nanoceramic composites are another type of composite resin produced thanks to nanotechnology developments. This resin contains methacrylate-modified, silicon dioxide–containing nanofiller, chemically similar to glass or ceramics.[12-14] While the literature assessing the repair strength of resin matrix ceramics often concentrates on surface preparation and the ceramic material type, there is limited research on the consequences of differing composite resin types. This research analysed the shear bond strength (SBS) of nanohybrid composite resins compared to resin matrix ceramics after undergoing different surface treatments. The null hypotheses were that the surface treatments could not affect the SBS between nanohybrid composite resins and resin matrix ceramics and that the type of composite resins could not vary the SBS.

MATERIAL and METHODS

All materials used in this study are given in Table 1, and the schematic diagram of the study is given in Figure 1.

Preparation of specimens

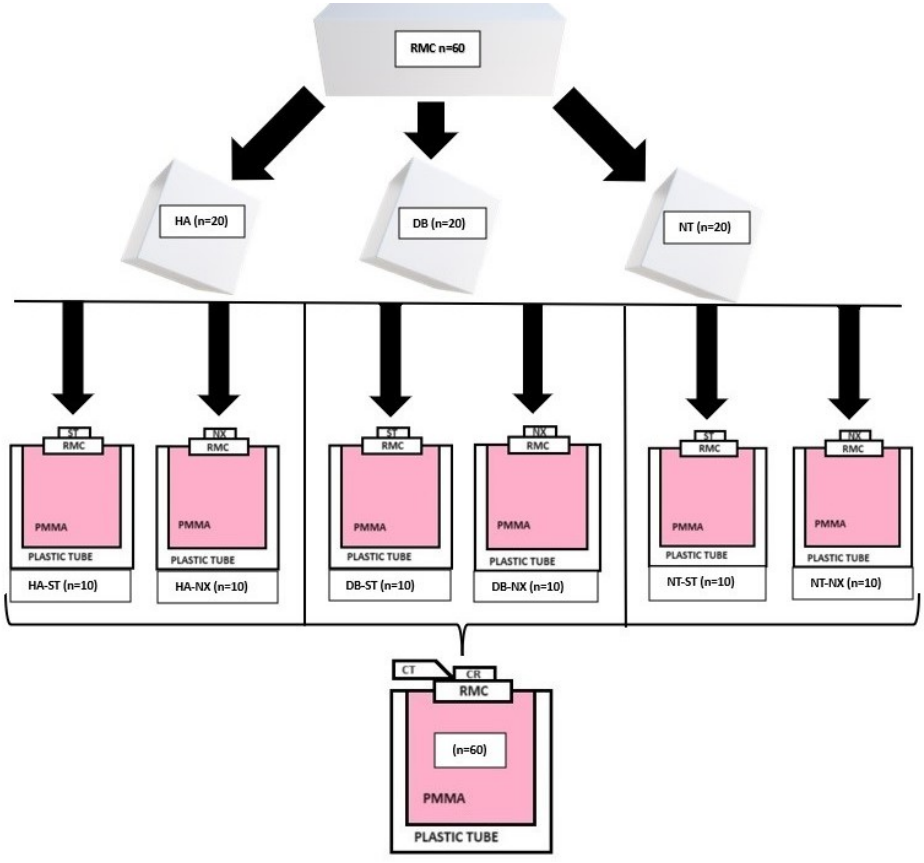
A total of 60 specimens with a size of 10x10x2 mm were obtained from a resin matrix ceramic block (VITA ENAMIC; VITA Zahnfabrik) with a size of 12x14x18 mm using a water-cooled diamond blade (Diamond Cutting Disc; Dimos-M) and a low-speed saw (Micro Cut 125; Metkon). The specimens' surfaces were standardized using silicon carbide papers (Wurth Industry Products) with grids of 80, 180, 600, 800, and 1200. The prepared samples were kept in an ultrasonic cleaner (VEVOR) at 25°C for 10 min and dried with air. The specimens were divided into three groups (n=20 per group): roughened with 9% hydrofloric acid, Porcelain etch; Ultradent Products), roughened with a diamond bur (MDT; Micro Diamond Technologies) and no treatment control group. Each group was then divided into two subgroups (n=10 per group), bonded with nanoceramic (Spektra ST HV; Dentsply Sirona) and bonded with nanohybrid composite resins (Nexcomp; META-BİOMED).

Table 1: Materials used in the study

Material	Chemical Content	Brand-Manufacturer, Country
RMC Blocks	Feldspar ceramic network: 86 wt% (58–63% SiO_2, 20–23% Al_2O_3, 6–11% Na_2O, 4–6% K_2O, 0.5–2% B_2O_3, < 1% CaO, < 1%TiO_2) Polymer network: Methacrylate polymer (14wt%)	VITA ENAMIC- VITA Zahnfabrik, Germany
Nanoceramic composite resin	Matrix: Methacrylic modified polysiloxane nanoparticles, dimethacrylate resin, ethyl-4-(dimethylamino)benzoat Filler: Spherical, pre-polymerized SphereTEC fillers (particle size ≈ 15 µm), non-agglomerated barium glass, CQ 1 , ytterbium fluoride (78–80 wt%)	SpektraST HV- Dentsply Sirona, Germany
Nanohybrid composite resin	Matrix: Bis-GMA(bisphenol A-glycidyl methacrylate), UDMA(urethane di-methacrylate), Bis-EMA (ethoxylated bisphenol A glycol dimethacrylate), TEGDMA (Triethyleneglycol dimethacrylate) borosilicate. Fillers: Barium aluminum boro silicate (75% wt)	Nexcomp- META-BİOMED, Germany
HA	9% Hydrofluoric acid	Porcelain Etch- Ultradent Products, USA
DB	Diamond particles	MDT- Micro Diamond Technologies, Israel
Silane coupling agent	Isopropyl alcohol, silane	Porcelain silane- Ultradent Products, USA
Adhesive agent	Oligomeric methacrylates, HEMA, camphorquinone	C-Bond WP Dental, Germany

RMC: Resin Matrix Ceramic, HA: Hydrofluoric Acid, DB: Diamond Bur

Figure 1: The schematic diagram of the study. RMC: Resin Matrix Ceramic, HA: Hydrofluoric Acid, DB: Diamond Bur, NT: No Treatment, ST: Nanoceramic composite resin, NX: Nanohybrid composite resin, PMMA: Polymethylmethacrylate, CT: Chisel Tangent. NT-ST(No treatment applied and nanoceramic composite resin bonded), NT-NX(No treatment applied and nanohybrid resin bonded), DB-ST(Roughened with diamond bur and nanoceramic composite resin bonded), DB-NX(Roughened with diamond bur and nanohybrid composite resin bonded), HA-ST(Roughened with hydrofluoric acid and nanoceramic composite resin bonded), HA-NX(Roughened with hydrofluoric acid and nanohybrid composite resin bonded)



Roughening of surfaces and repairing with composite resins

Diamond bur roughening was performed by contacting the entire surface of the blue belt diamond bur with the specimens for 10 seconds under water cooling. Once the surface roughening was complete, a silane coupling agent (porcelain silane; Ultradent Products) was applied to the surface of the specimens for 60 seconds. An adhesive agent (C-Bond; WP Dental) was applied to the samples for 10 seconds, followed by light polymerization for 20 seconds. Half of the samples (n=10) were bonded with nanoceramic, and the other half (n=10) with nanohybrid composite resin using a 4mm diameter x 2mm height mould made of plastic pipe and polymerised with light for 20 seconds. The hydrofluoric acid roughening process was carried out by the application of 9% hydrofluoric acid for 60 seconds, followed by the air-water spray washing and drying process; the silane bonding agent, adhesive agent, and composite resin bonding applications were carried out using the same protocol as the diamond bur roughened group. Similar silane, adhesive, and composite resin applications in the control group were carried out with other groups without any surface roughening process.

Surface roughness measurements

For the surface roughness measurement, the profilometer was calibrated with a reference calibration block with a Ra value of 6.0 μm and adjusted to 0.1 mm/s with a diamond tip with a radius of 10 μm. Measurements were then taken in the exact directions at three different points on three samples from each group. The three different measurements of each sample were averaged, and the Ra values were recorded by calculating the average of three samples from each group.

Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) investigation

SEM and EDS investigated the microstructures of the hydrofluoric acid and diamond bur etched ceramic surfaces and the composite resin-ceramic interface with 500 and 3000X magnification.

Thermal ageing and shear bond strength test

The bonded specimens were then subjected to thermocycling (5500 cycles, between 5 and 55ºC, 20s dwell time). Samples were fixed to the autopolymerising acrylic resin in plastic tubes and placed in the universal tester (Mod-dental, Ankara). Then, the ceramic and composite resin interface was loaded in shear using a knife-edged chisel tangent to the tooth surface at a cross-head speed of 0.5 mm/min. The test was stopped automatically when the separation occurred, and the computer calculated the results in MPa. The failures were examined with a camera (Canon EOS 1000D) connected to a stereomicroscope (Stemi 305; Carl Zeiss Microscopy GmbH) at X15 magnification.

Evaluation of the failures

Failures in which the composite resin separated from the RMC were considered an adhesive failure, ruptures of the composite resin or resin matrix ceramic were considered a cohesive failure, and these two conditions were seen together as a mixed failure.

Statistical analyses

Statistical analyses were performed using SPSS version 22.0 for Windows (IBM Corp). Descriptive statistics of the continuous variables included in the study were presented as means and standard deviations. Two-way ANOVA was used to show the effect of different surface treatments and composite resin types. Bonferroni's post hoc test was used for pairwise comparisons when the ANOVA test was significant. The Kruskal-Wallis test compared SBS between surface treatment groups within a composite resin type. Independent samples t-test and Mann-Whitney U test were used to compare SBS between composite resin groups within a surface

treatment type. For all statistical comparisons in the study, $p<0.05$ was the level of statistical significance.

RESULTS

Shear bond strength results

The mean and standard deviation of SBS (MPa) for each group and statistical analyses are shown in Table 2. To evaluate the effect of the composite resin type on the bond strength in the groups where the same kind of surface treatment was applied, the bond strengths of the specimens belonging to the no-treatment and diamond bur groups were examined by the Mann-Whitney U-test. Independent samples t-test was used to investigate the hydrofluoric acid roughened groups. The SBS of the nanoceramic composite resin bonded group (6.95±2.15 MPa) was significantly higher than that of the nanohybrid composite resin (3.64±0.90 MPa) in the no surface treatment group ($p<0.05$). The bond strength of the nanoceramic composites bonded group in the diamond bur roughened group (9.43±3.74 Mpa) was also significantly higher ($p<0.05$) than that of nanohybrids (5.40±1.30 Mpa). In contrast, in the hydrofluoric acid roughened group, the bond strength of the nanoceramic composite bonded group (18.17±4.48 Mpa) was higher than that of nanohybrid composite resins (815.94±4.78 Mpa). However, the difference was not statistically significant ($p>0.05$). The Kruskall-Wallis test was used to evaluate the effect of surface treatments on bond strength in groups bonded with the same type of composite resin. In both composite resin groups, the SBS after hydrofluoric acid roughening was statistically significantly higher than the diamond bur and no treatment groups ($p<0.05$). In both composite resin groups, the SBS of the diamond bur group was higher than that of the none-treatment group, but the difference was not statistically significant. ($p>0.05$).

Two-way ANOVA showed no statistically significant interaction between surface treatment and resin type ($p = 0.683$). However, each surface treatment ($p<0.001$) and resin type ($p<0.001$) had a statistically significant effect on SBS. When comparing the surface treatments, according to the Benforroni test, the SBS of the hydrofluoric acid roughened group (17.05±4.65 MPa) was significantly higher than that of the no treatment (5.29±2.34 MPa) and the diamond bur roughened group (7.41±3.42 MPa) ($p<0.05$). The difference between the none treatment and the diamond burr group was not significant ($p>0.05$). In addition, the surface preparation parameter had a large effect size ($\eta p2=0.73$). When comparing the composite resin types, the nanoceramic composite resin bonded group (11.52±5.99 MPa) showed statistically significantly higher SBS values than the nanohybrid composite resin (8.32±6.19 MPa) bonded group ($p<0.05$) according to the Benforroni test. The composite resin type parameter had a moderate effect size ($\eta p^2=0.20$) (Table 3).

Table 2: Mean±SD of the SBS (MPa) for each group and statistical analyses

Composite resin	Surface treatment		
	NT	DB	HA
ST	$6.95±2.15^{A\,a\,*}$	$9.43±3.74^{A\,a\,*}$	$18.17±4.48^{B\,a\,**}$
NX	$3.64±0.90^{A\,b\,*}$	$5.40±1.30^{A\,a\,*}$	$15.94±4.78^{B\,a\,**}$

Mean values represented with same superscript lowercase letter (column) are not significantly different according to independent samples t-test and Mann Whitney U-test($p>0,05$). Mean values represented with different superscript uppercase letter (row) are significantly different according to Kruskal-Wallis test ($p<0,05$). HA:Hydrofluoric Acid, DB:Diamond Bur, NT: No Treatment, ST:Nanoceramic composite resin, NX:Nanohybrid composite resin. * Mann Whitney U-test, ** Independent samples t-test.

Table 3: Bonferroni's post hoc tests for pairwise comparisons after Two-Way Anova

	Mean±SD (MPa)	n
Surface Treatment		
NT	5.29[a]±2.34	20
DB	7.41[a]±3.42	20
HA	17.05[b]±4.65	20
Composite resin		
ST	11.52[c]±5.99	30
NX	8.32[d]±6.19	30

Different letters indicate significant differences (p<0,05). HA:Hydrofluoric Acid, DB:Diamond Bur, NT: No Treatment, ST:Nanoceramic composite resin, NX:Nanohybrid composite resin. SD: Standard Deviation

Surface roughness results

The Ra values of three samples from each group were averaged, and the surface roughness values were found to be 0.74±0.11µm for the no treatment group, 4.82±0.62µm for the diamond bur roughened group, and 1.22±0.21µm for the hydrofluoric acid roughened group. According to the Kruskal-Wallis test, there was a statistically significant difference between the NT and DB groups (p=0.02).

SEM and EDS results

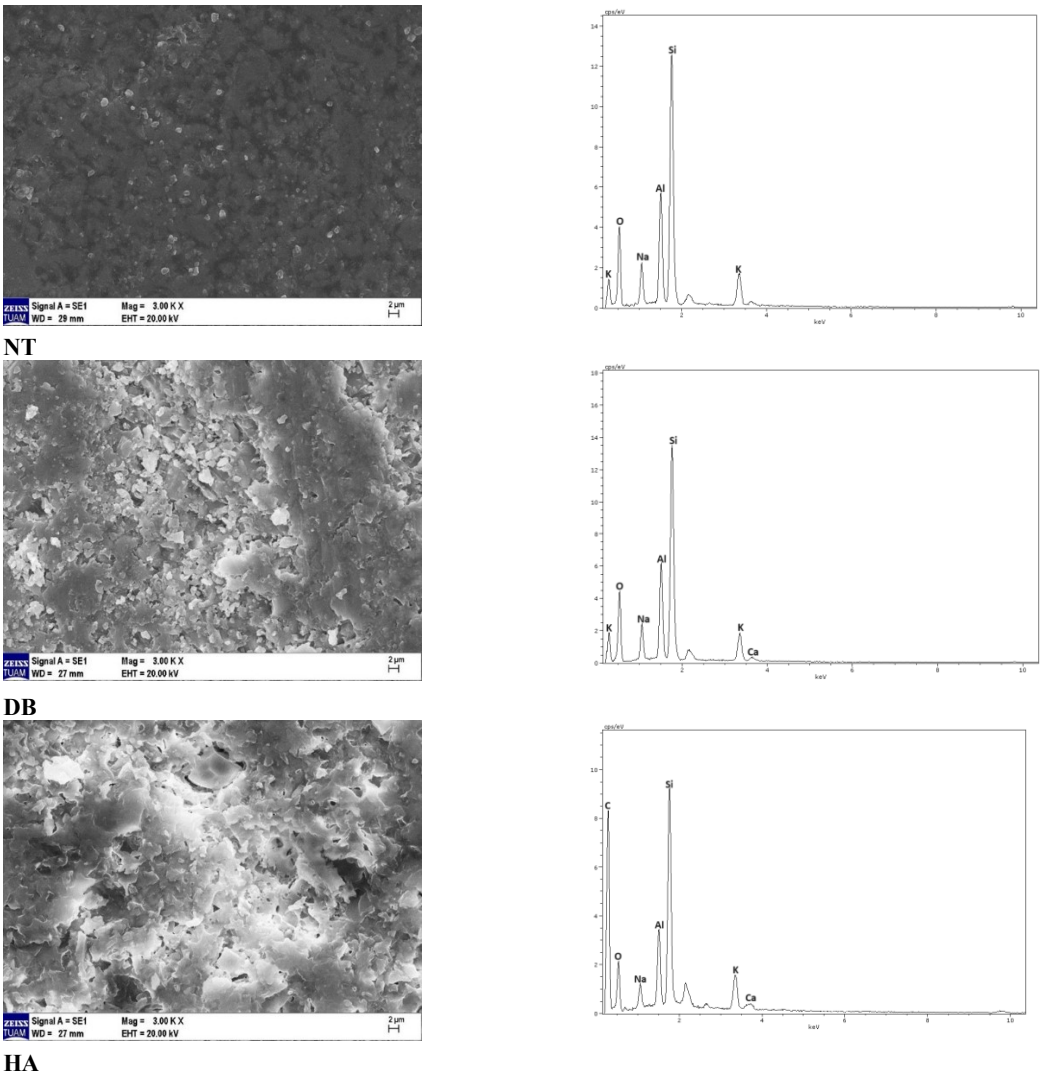
The SEM images of the samples with different surface treatments are shown in Figure 2. It was found that both hydrofluoric acid and diamond bur roughening significantly altered the ceramic surface topography compared to the control group, and it was also observed that hydrofluoric acid produced more microporosity on the ceramic surface compared to diamond bur. The results of an EDS analysis showed that the distribution of elements was similar in the samples belonging to diamond bur and none treatment groups. However, in the sample belonging to the hydrofluoric acid group, it was found that the signals related to the elements O, Al, K, Si, and Na decreased compared to the samples belonging to the other groups. In addition, element C was not found in the samples of the diamond bur group and no treatment but was detected in the sample of the hydrofluoric acid group at a level of about 38% by weight (Table 4).

Table 4: Elemental distribution on RMC surfaces after different surface treatments

	Surface treatments		
Elements	**NT**	**DB**	**HA**
Oxygen	51.16	51.74	40.09
Potassium	4.80	4.97	2.62
Aluminium	10.99	10.71	4.25
Silicon	26.94	26.08	12.09
Sodium	6.11	6.11	2.36
Carbon	-	-	38.01
Calcium	-	0.39	0.58

HA:Hydrofluoric Acid, DB:Diamond Bur, NT: No Treatment

Figure 2: SEM images and EDS analysis of RMC samples after different surface treatments. HA: Hydrofluoric Acid, DB: Diamond Bur, NT: No Treatment



The scanning electron microscopy images and energy dispersive spectroscopy analyses of the ceramic and composite resin interface are shown in Figures 3 and 4. The interfacial layers of the samples belonging to all groups were around 10±2 µm. The scanning electron microscopy images and energy dispersive spectroscopy analyses showed that the signals due to the elements Si, Al, K, and Na decreased through the ceramic towards the composite resin side, and the signals due to the element Ti increased. At the same time, O and Ca remained at similar intensities on both the composite resin and resin matrix ceramic sides. While a decrease in the density of the elements Si, Al, O, Na, and K was observed in the interface regions, it was found that the element K reached its highest density at the interface in the sample belonging to the hydrofluoric acid roughened and nanoceramic composite resin bonded group. In addition, element F was not found in the samples belonging to the other groups. In contrast, the low density of element F was detected in the sample belonging to the hydrofluoric acid roughened and nanoceramic composite resin bonded group throughout the entire cross-section.

Failure types

When the types of failure were evaluated, adhesive failure was the most common type of failure, while cohesive failure was not observed. The rate of mixed failure was higher in the hydrofluoric acid roughened specimens (Table 5).

Figure 3: SEM images of RMC to CR interfaces sectioned at 90° across to the plane of the interface with 3000X magnification. The direction of the yellow arrow is from the RMC side to the CR side. NT-ST (No treatment applied and nanoceramic composite resin bonded), NT-NX(No treatment applied and nanohybrid resin bonded), DB-ST(Roughened with diamond bur and nanoceramic composite resin bonded), DB-NX(Roughened with diamond bur and nanohybrid composite resin bonded), HA-ST(Roughened with hydrofluoric acid and nanoceramic composite resin bonded), HA-NX(Roughened with hydrofluoric acid and nanohybrid composite resin bonded)

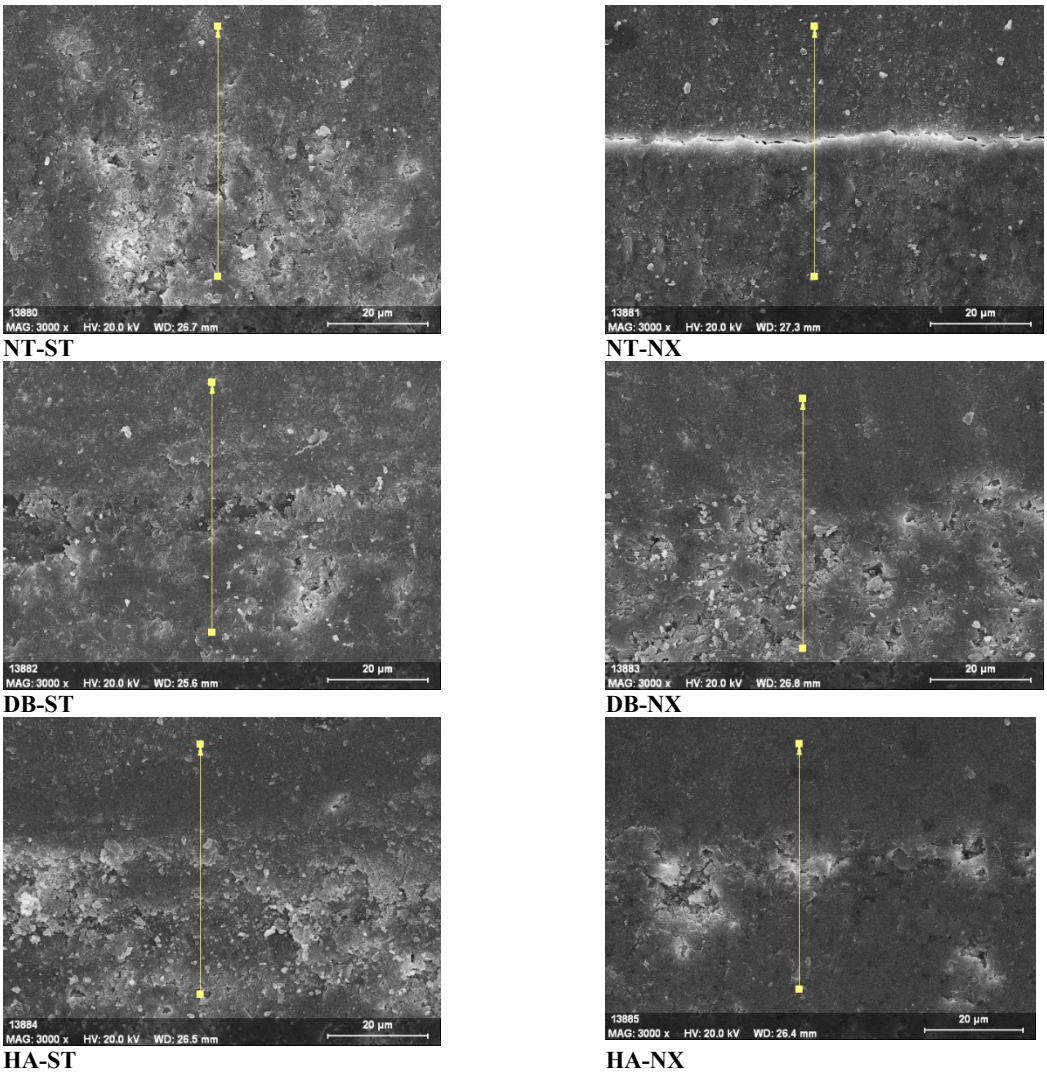


Table 5: Distribution of failure types among groups

	Types of failure %		
Groups	**Adhesive**	**Cohesive**	**Mixed**
NT-ST	100	-	-
NT-NX	100	-	-
DB-ST	100	-	-
DB-DX	90	-	10
HA-ST	30	-	70
HA-NX	40	-	60

NT-ST(No treatment applied and nanoceramic composite resin bonded),NT-NX(No treatment applied and nanohybrid composite resin bonded), DB-ST(Roughened with diamond bur and nanoceramic composite resin bonded), DB-NX (Roughened with diamond bur and nanohybrid composite resin bonded), HA-ST(Roughened with hydrofluoric acid and nanoceramic composite resin bonded), HA-NX(Roughened with hydrofluoric acid and nanohybrid composite resin bonded).

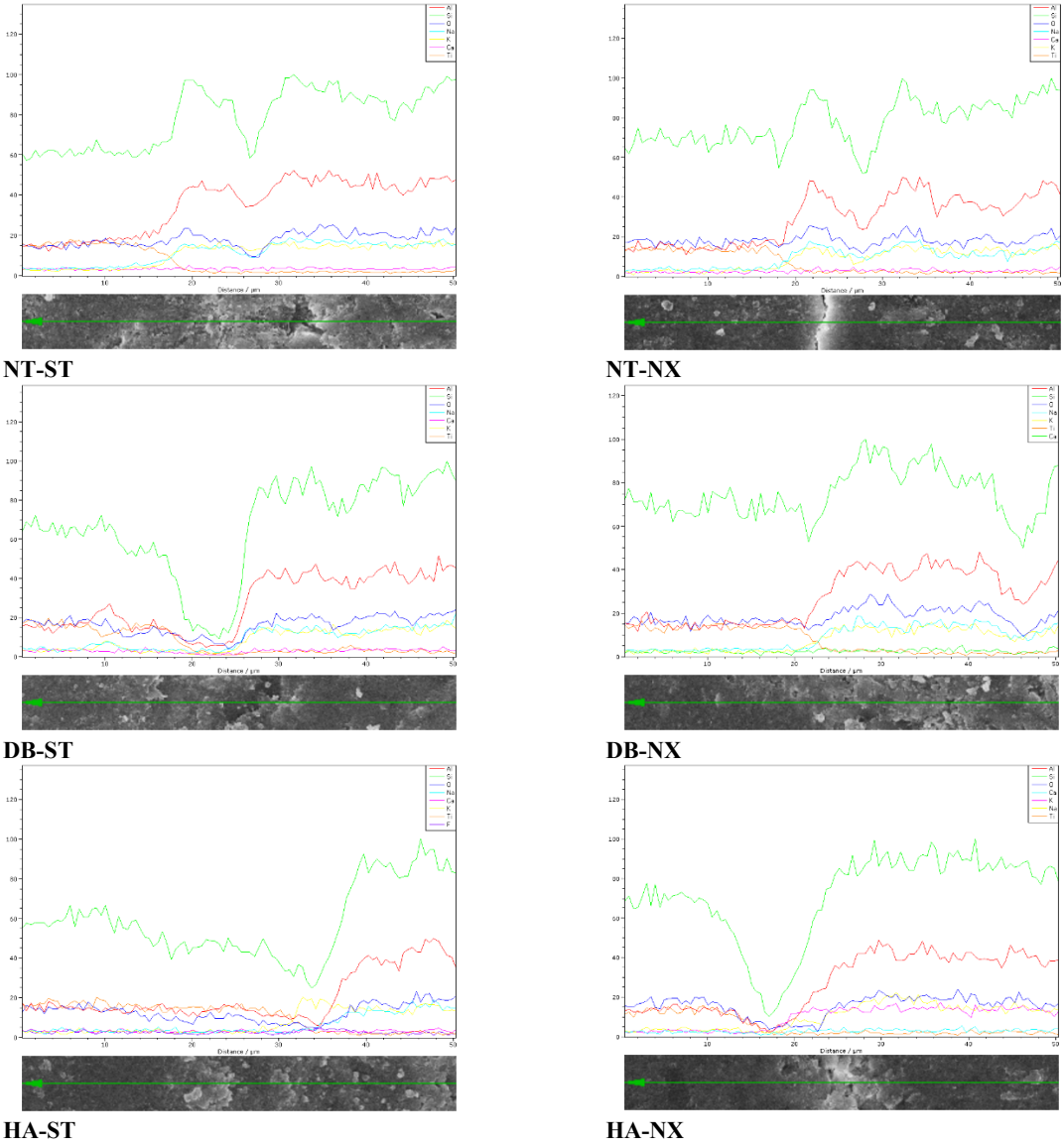


Figure 4: The concentration (wt.%) profiles of major elements of RMC to CR interfaces sectioned at 90° across the plane of the interface with 3000X magnification. The direction of the green arrow is from the RMC side to the CR side. NT-ST(No treatment applied and nanoceramic composite resin bonded), NT-NX(No treatment applied and nanohybrid resin bonded), DB-ST(Roughened with diamond bur and nanoceramic composite resin bonded), DB-NX(Roughened with diamond bur and nanohybrid composite resin bonded), HA-ST(Roughened with hydrofluoric acid and nanoceramic composite resin bonded), HA-NX(Roughened with hydrofluoric acid and nanohybrid composite resin bonded).

DISCUSSION

This study evaluated the SBS of resin matrix ceramics with different types of nanohybrid composite resin after different surface treatments. It was concluded that the SBS showed significant differences in the groups with different types of surface treatments or nanoceramic composite resin. Therefore, the null hypothesis were rejected.

Many reports in the literature show that resin matrix ceramics can be repaired with composite resins after various surface treatments. As a result of these surface preparation processes, chemical retention, micromechanical retention, or a combination of both can be used to achieve long-term adhesion.[15-19] Micromechanical adhesion is achieved by roughening the surface with aluminium oxide particles and etching or

grinding with hydrofluoric acid or other acidic compounds. At the same time, silane provides chemical adhesion by forming a siloxane bond with the ceramic surface.[20] This study used diamond bur roughening and hydrofluoric acid etching with silane coupling and bonding agents to provide micromechanical and chemical bonding.

One of the methods used to create retention on the repaired ceramic surface is diamond bur roughening, which has the advantages of simplicity and low cost; another method is hydrofluoric acid etching.[21] Bello et al. concluded that resin matrix ceramics could be repaired with composite resins by sandblasting or acid roughening followed by silane application.[22] Compos et al. reported that the bond strength between resin cement and resin matrix ceramics increased with the application of hydrofluoric acid.[23] Wolf et al. reported that Al_2O_3 sandblasting or diamond bur roughening provides a satisfactory bond strength between ceramic and composite resins, but in cases where a higher bond strength is desired, surface roughening with hydrofluoric acid is a more effective step in achieving composite resin-ceramic bonding due to the deeper penetration of the acid.[24] Chen et al. concluded that air abrasion of the porcelain surface is not necessary when acid etching is used as the surface preparation process, as a result of their study on the bond strength between composite resin and ceramics.[25] Schmage et al. reported that the bond strength of samples prepared with hydrofluoric acid was higher than those prepared with a diamond bur.[26] As a result of their study, Neis et al. concluded that the surface preparation process of lithium disilicate-reinforced ceramics and feldspathic ceramics with hydrofluoric acid provides higher bond strength than surface treatment with a diamond bur.[27] This study showed that the hydrofluoric acid-treated groups had significantly higher bond strength values than the diamond bur-treated groups. In addition, the diamond bur-roughened specimens had a higher SBS than the none-treatment group, but this difference was not statistically significant. Hydrofluoric acid removes some of the glass matrices and dissolves the polymer, creating micropores and microchannels.[28] The ceramics used in this study consist of a feldspar ceramic network (86 wt%) fully integrated with a polymeric network (14 wt%), and hydrofluoric acid interacts with this polymeric matrix, disrupting the organic matrix and exposing the carbon chain.[29,30] The EDX results confirm this situation; approximately 38% of carbon elements were found on the resin matrix ceramic surface roughened with hydrofluoric acid, while no carbon atoms were found in the samples belonging to other groups. The high bond strength between ceramic and composite resin in the hydrofluoric acid roughened group may be due to the micropores and microchannels created by the hydrofluoric acid dissolving the polymer matrix in the resin matrix ceramic. In the SEM image of the hydrofluoric acid roughened group sample, it can be seen that more microporous structures are formed compared to the samples in the other groups. This high bond strength may be due to the carbon chain-containing polymer structure of the resin matrix ceramic. Furthermore, although the surface roughness of the hydrofluoric acid roughened group was considerably lower than that of the diamond bur roughened group, the high bond strength of the hydrofluoric acid roughened specimens suggests that a more potent chemical bond rather than a physical bond between the composite resin and the ceramic is responsible for the high bond strength.

The restorative component is also crucial in ceramic and metal repair.[31] Although many studies in the literature evaluating bond strength between ceramics and composite resin focus on different surface treatments or ceramic types, studies evaluating the effect of composite resin

type are limited. This study investigated the bond strength of two composite resins with resin matrix ceramics and concluded that nanoceramic composite resin exhibited significantly higher bond strength. The matrix part of the nanohybrid composite resin used in this study consists of ethoxylated BISGMA, BISGMA, and UDMA, while the filler part consists of barium aluminium borosilicate.[32] On the other hand, nanoceramic composite contains methacrylate-modified, silicon dioxide–containing nanofiller and resin matrix that is replaced by a matrix full of highly dispersed methacrylate-modified polysiloxane particles, which are chemically similar to ceramics.[13,14] The high bond strength in the nanoceramic composite bonded group may be due to the similar content with dental ceramics.

The nanoceramic composite resin used in this investigation is a high-viscosity dental composite resin with SphereTEC filler technology consisting of spherical pre-polymerized particles of sub-micron glass particles ranging in size from 0.1 to 3.0 μm.[14] Due to their specific morphology, SphereTEC fillers give composite resin unique properties and reduce internal friction under shear stress. This is achieved by the blocked interlocking of the filler particles, and therefore, composite resin has excellent sculptability with hand tools. At the same time, the combination of SphereTEC® fillers with irregularly shaped submicron particles gives the composite resin a slump resistance property when left unagitated.[14]Another reason for the high SBS of the nanoceramic bonded group may be that SphereTEC fillers impart excellent sculptability to composite resin, resulting in better adaptation to the resin matrix ceramic surface. Ozdemir and Yanikoglu investigated the bond strength between different composite resins and feldspathic ceramics after different surface treatments. In contrast to this present study, they obtained lower bond strength in samples bonded with nanoceramic composite. This may be because the ceramics tested for repair strength have different chemical content.[33]

Ageing methods such as thermal cycling and water immersion often predict the long-term clinical behaviour of materials bonded together under in vitro conditions.[34] The ISO TR 11450 (1994) standard states that thermal cycling at 5-55°C for 500 cycles is appropriate. The shear bond test, frequently used to measure bond strength, is an in-vitro test method in which a force is applied to the joint area at a specific rate until separation occurs between two bonded materials. SBS is calculated by dividing the maximum force applied by the connection area.[35,36] In this present study, bonded specimens were thermocycled (5500, 5–55ºC, dwell time: 20s) and SBS test was applied to them (approach speed of 0.5 mm/min.) to predict long-term clinical behaviour. The mean SBS for the nanoceramic composite bonded group was 11.52 MPa, which was 8.32 MPa for the nanohybrid. Also, hydrofluoric acid roughened groups were shown at 17.05 MPa SBS value and 7.41 MPa for diamond bur roughened groups. As a minimum value for acceptable clinical bonding, a limit of 10-13 MPa is suggested.[35] The nano ceramic bonded and hydrofluoric acid roughened groups exhibited clinically acceptable bond strengths in this context.

CONCLUSION

This study aimed to investigate the impact of various composite resins on the strength of repairing resin matrix ceramics under two different surface treatments. The results show that in clinical applications, nanoceramic-based composites, after surface treatment with hydrofluoric acid, can produce acceptable clinical results when used to repair resin matrix-based ceramics. Further research can be conducted using different surface treatments, composite resins, and test methods to expand upon these findings.

Ethical Approval

Since this study did not involve the use of human or animal subjects, ethical committee approval was not required.

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Conflict of Interest

This research was funded by the Scientific Research Projects Unit of Afyonkarahisar Health Sciences University under the project number 21.KARİYER.006.

Author Contributions

Design: Öİ, ÖK, Data collection and processing: Öİ, Analysis and interpretation: Öİ, Literature review: Öİ, ÖK, Writing: Öİ.

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Caries Prevalence of the First Permanent Molars and Treatment Needs in Children Aged 7-13 Years in the Western Mediterranean Region of Turkey

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ABSTRACT

Aim: This study aimed to determine the caries prevalence of the first permanent molars and treatment needs in children aged 7-13 years living in the Western Mediterranean Region of Turkey.
Material and Methods: The study included 1912 patients aged between 7 and 13 years who attended to the Pedodontics Clinic for dental reasons and required panoramic radiographs. The number of sound, decayed (D), missing (M), and filled (F) teeth (T) in the first permanent molars of the patients were evaluated. The relationships of these values with gender, age, age groups, and location were analyzed. First permanent molars needing treatment were grouped according to the treatments needed.
Results: The mean age of 1912 patients (977 females, 935 males) was 9.60±1.93 years. The caries prevalence in the first permanent molars was 26.8% and the mean DMFT6 value was 1.53±1.54. There was no difference between mean DMFT6 values and gender ($p>0.05$), but mean DMFT6 values increased statistically significantly with increasing age ($p<0.001$). While the mean D, M, F, and DMF values of the first permanent molars were higher in the mandibular teeth ($p<0.001$), there was no statistically significant difference between the right and left jaws ($p>0.05$). Of the first permanent molars, 19.6% needed single-surface restoration, 2.2% needed two-surface restoration, 0.2% needed ≥three-surface restoration, 4.5% needed endodontic treatment, and 0.4% needed extraction treatment.
Conclusion: To protect first permanent molars from caries, families and children should be made aware of oral care, and preventive practices should be carried out by determining the caries risk status of individuals.

Türkiye'nin Batı Akdeniz Bölgesi'nde 7-13 Yaş Arası Çocukların Daimi Birinci Azı Dişlerinde Çürük Prevalansı ve Tedavi İhtiyaçları

Makale Bilgisi

Makale Geçmişi

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Anahtar Kelimeler:
Çocuk,
Diş çürüğü,
Birinci büyük azı dişi,
Prevalans.

ÖZET

Amaç: Bu çalışma, Türkiye'nin Batı Akdeniz Bölgesi'nde yaşayan 7-13 yaş arası çocukların daimi birinci büyük azı dişlerinde çürük prevalansını ve tedavi ihtiyaçlarını belirlemeyi amaçlamıştır.
Gereç ve Yöntemler: Çalışmamıza, Pedodonti Kliniği'ne dişsel sebeplerden dolayı başvuran ve panoramik radyograf gereksinimi olan yaşları 7-13 arasında değişen 1912 hasta dahil edildi. Hastaların daimi birinci büyük azı dişlerindeki sağlıklı, çürük, çürük nedeniyle çekilmiş, dolgulu diş sayıları değerlendirmeye alındı. Bu değerlerin; cinsiyet, yaş, yaş grupları, lokasyon ile olan ilişkileri incelendi. Tedavi ihtiyacı olan birinci büyük azı dişleri ihtiyaç duyulan tedavilere göre gruplandırıldı.
Bulgular: Çalışma grubunu oluşturan 1912 hastanın (977 kız, 935 erkek) ortalama yaşları 9,60±1,93'dü. Daimi birinci büyük azı dişlerinde çürük prevalansı %26,8, ortalama DMFT6 değeri 1,53±1,54 olarak kaydedildi. Ortalama DMFT6 değerleri ile cinsiyet arasında herhangi bir farklılık bulunmadı ($p>0,05$), ancak artan yaşla birlikte ortalama DMFT6 değerlerinin istatistiksel olarak anlamlı şekilde arttığı belirlendi ($p<0,001$). Daimi birinci büyük azı dişlerinin ortalama D, M, F ve DMF değerleri alt çene dişlerinde daha fazla iken ($p<0,001$), çenelerin sağ ve sol bölgesine göre istatistiksel olarak anlamlı farklılık oluşmadı ($p>0,05$). Daimi birinci büyük azı dişlerinin %19,6'sının tek yüzlü restorasyona, %2,2'sinin iki ve %0,2'sinin ≥üç yüzlü restorasyona, %4,5'inin endodontik tedaviye ve %0,4'ünün çekim tedavisine ihtiyacı vardı.
Sonuç: Daimi birinci büyük azı dişlerini çürüklerden korumak için aileler ve çocuklar ağız bakımı konusunda bilinçlendirilmeli, bireylerin çürük risk durumları belirlenerek koruyucu uygulamalar yapılmalıdır.

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INTRODUCTION

Although dental caries, which affects 60-90% of school-age children, can be prevented, it is a chronic disease with a high prevalence in countries where preventive programs are not widely implemented.[1]

First permanent molars (FPMs) are the first permanent teeth to erupt in the oral cavity, reflecting the beginning of the mixed dentition period at the end of early childhood. They are also the teeth most affected by caries.[2] The susceptibility of FPMs to carious attacks is due to the occlusal surface anatomy (deep and narrow pit-fissure structure), parents' lack of knowledge of the eruption time (mistaking these teeth with deciduous teeth), and children's inability to brush their teeth effectively.[3,4] The period between FPM eruption and the completion of occlusion is the most critical in maintaining dental health.[2]

Although FPMs are the key to occlusion and their early loss due to caries has significant effects on a child's dental health, the importance of these teeth has not been sufficiently emphasized. However, FPMs have important roles in chewing, maintaining vertical facial height, and ensuring the function and balance of occlusion. Early loss due to caries can cause premature contact of teeth and occlusal and functional disorders due to tooth displacement.[5]

Thus, it is important to determine the prevalence of caries in FPMs to establish preventive programs. Previous epidemiological studies on the prevalence of caries in the FPMs of children in different geographical regions of Turkey revealed that the prevalence was quite high.[6-10]

The Western Mediterranean Region of Turkey is one of the regions with the highest population growth rate which constitutes 4% of Turkey's population.[11] In reviewing the literature, there is a lack of information regarding the prevalence of caries in the FPMs and treatment needs among the pediatric population in this region. Knowing sufficient data is useful for planning preventive measures earlier and emphasizing the importance of caries prevention. The data obtained will assist in future program and policy planning for community oral health as well as current public health initiatives in the Western Mediterranean region of Turkey.

This study aimed to determine the prevalence of caries in the FPMs and treatment needs among 7-13-year-old children in the Western Mediterranean Region of Turkey and to evaluate their relationship with various factors.

MATERIAL AND METHODS

Ethical aspects

Ethical approval was obtained from the Research Ethics Committee at Suleyman Demirel University, Faculty of Medicine (13.12.2018/233). The written informed consent was obtained from the parents. The study was conducted by the Helsinki Declaration.

Sample size

The required sample size was estimated using G*Power V. 3.1.9.6 (Franz Faul Universitat, Kiel, Germany). Based on the "DMFT" values in a previous study,[12] the total number of people who should be included was determined as 1794, including 598 people in each age group, with 95% confidence (1-α), 95% test power (1-β), and f=0.093 effect size.

Study samples

For this cross-sectional epidemiological study, the intraoral examination of 2050 children, aged between 7 and 13 years who visited the Department of Pediatric Dentistry for dental treatments from January 2019 to January 2021 was performed. Among these patients, 1912 systemically healthy patients who had to take a panoramic film for any reason and had good quality radiographs, all FPMs fully

erupted, no developmental enamel defects, and no history of orthodontic treatment or dental trauma were included in the study.

Panoramic radiographs were taken with the Planmeca ProMax® panoramic radiography device (Planmeca, Helsinki, Finland), and the exposure time was 14 s. No other panoramic radiograph was obtained from any patient.

The participants were classified into three groups (7-8 years, 9-10 years, and 11-13 years). Sociodemographic details including age, gender, toothbrushing frequency, and parental education, were recorded on each participant's form.

Clinical examinations

The clinical oral examinations were carried out by a pediatric dentist (E.O) under reflector light using a dental explorer and a mouth mirror. The caries status was recorded using the decayed, missing, and filled teeth (DMFT) and decayed, missing, and filled surface (DMFS) index based on the World Health Organisation (WHO) criteria.[13] In the evaluation, teeth with pit and fissure lesions, temporary fillings, restored teeth with seconder caries, and broken teeth were recorded as having caries. The number of sound, decayed, missing (according to caries), and filled (included root canal treated) FPMs were assessed. Mean D, M, F, DF, DMFT values, and percentages of FPMs were calculated according to gender, age, age groups, and localization (jaw and side). The dental status of FPMs was recorded as decayed [occlusal, mesial-occlusal/ distal-occlusal (MO/DO) and mesial-occlusal-distal (MOD)], filled (occlusal, OM/OD, MOD), root canal treated, missing and sound. An individual with no decayed, missing or filled first permanent molars (DMFT6 index score of 0) was recognized as Caries Free (CF). If "decayed'', "missing'', and "filled'' features were observed in any of the first four permanent molars, they were assigned a score of 1. FPMs in need of treatment were grouped according to the treatments needed.

The calibration was evaluated in a pilot study involving randomly selected 30 children who had not participated in the main study. Intra-examiner reliability was assessed by the same examiner using Cohen's kappa statistic (κ). After 2 weeks, the same patients were re-examined to calculate dental caries (κ= 0.93).

Statistical analysis

The collected data were entered into SPSS 23 (Chicago, IL, USA) software. Descriptive statistics were calculated for categorical variables. The normality assumption was verified using the Shapiro-Wilk test. As the variables were not normally distributed, the Mann–Whitney U and Kruskal–Wallis tests were used to compare groups. The chi-square test was applied to assess the difference between the categorical variables. Intraobserver agreement was evaluated with Cohen's kappa statistic. The significance level was considered as $p < 0.05$.

RESULTS

A total of 1912 patients, 977 females (51.1%) and 935 males (48.9%), with a mean age of 9.60 ± 1.93 years between the ages of 7 and 13, were included in the study. After clinical and radiographic examinations, the distributions of mean D, M, F, DFT, DMFT, and DMFS values of patients according to gender, age, and age groups were shown in Table 1.

In the study, of 1912 patients evaluated, 906 patients (47.4%) were determined to have decayed, 34 (1.8%) have missing, and 411 (21.5%) have filled FPMs. The overall mean DMFT6 index was 1.53 ± 1.54. There was no significant difference between females and males in the mean of DMFT6 (p>0.05). The lowest and highest mean values of DMFT6 were 0.83 ± 1.23 in the 7-8 age group and 2.19 ± 1.51 in the 11-13 age group (p<0.001). The mean DMFT6 values were increased statistically significantly with increasing age (p<0.001) (Table 2).

Table 1. Distrubition of mean D, M, F, DFT, DMFT, and DMFS values of patients as per age, age groups, and gender

Gender	N (%)	Decayed Mean (SD)	Missing Mean (SD)	Filled Mean (SD)	DFT Mean (SD)	DMFT Mean (SD)	DMFS Mean (SD)
Female	977 (51.1)	1.37 (0.85)	0.03 (0.20)	0.52 (1.21)	1.88 (2.14)	1.90 (2.17)	2.44 (3.14)
Male	935 (48.9)	1.21 (1.72)	0.04 (0.30)	0.46 (1.06)	1.66 (2.02)	1.69 (2.06)	2.22 (3.18)
p		0.213	0.533	0.721	**0.044***	0.058	0.086
Ages							
7	344 (18.0)	0.66 (1.17)	0	0.08 (0.39)	0.73 (1.21)	0.72 (1.20)	0.80 (1.40)
8	316 (16.5)	0.78 (1.17)	0	0.18 (0.63)	0.95 (1.30)	0.95 (1.30)	1.05 (1.54)
9	324 (17.0)	1.09 (1.42)	0.02 (0.18)	0.28 (0.75)	1.37 (1.50)	1.39 (1.52)	1.66 (2.07)
10	284 (14.9)	1.52 (1.91)	0.04 (0.30)	0.49 (1.03)	2.00 (2.02)	2.03 (2.02)	2.58 (3.00)
11	259 (13.6)	1.61 (1.83)	0.04 (0.22)	0.75 (1.36)	2.37 (2.06)	2.39 (2.07)	3.19 (3.13)
12	198 (10.4)	1.84 (2.28)	0.10 (0.57)	0.99 (1.61)	2.83 (2.73)	2.90 (2.83)	4.06 (4.35)
13	187 (9.8)	2.32 (2.45)	0.06 (0.24)	1.21 (1.74)	3.53 (2.63)	3.57 (2.66)	5.10 (4.52)
p		**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***
Age groups							
7-8	660 (34.5)	0.71 (1.17)	0	0.13 (0.52)	0.84 (1.25)	0.83 (1.25)	0.92 (1.47)
9-10	608 (31.8)	1.29 (1.68)	0.03 (0.24)	0.38 (0.89)	1.67 (1.79)	1.69 (1.80)	2.09 (2.59)
11-13	644 (33.7)	1.89 (2.18)	0.06 (0.37)	0.96 (1.56)	2.85 (2.49)	2.89 (2.54)	4.01 (4.03)
p		**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***
Total	1912 (100)	1.29 (1.79)	0.03 (0.25)	0.49 (1.14)	1.78 (2.09)	1.80 (2.11)	2.33 (3.16)

N: number of patients examined, DFT: Decayed Filled Teeth, DMFT: Decayed, Missing or Filled Teeth,
DMFS: Decayed, Missing or Filled Surface, SD: Standard Deviation, Kruskal-Wallis test, Mann Whitney U tests
p^*<0.05 statistically significant

Table 2. Distrubition of the number of patients of mean D, M, F, DMFT values and percentages of first permanent molars as per age, age groups, and gender

Age groups	N (%)	Decayed N (%)	Decayed Mean (SD)	Missing N (%)	Missing Mean (SD)	Filled N (%)	Filled Mean (SD)	DMFT6 Mean (SD)
7-8	660 (34.5)	225 (34.1)	0.70 (1.15)	-	0 (0)	48 (7.3)	0.12 (0.52)	0.83 (1.23)
9-10	608 (31.8)	306 (50.3)	1.21 (1.43)	9 (1.5)	0.02 (0.16)	121 (19.9)	0.38 (0.90)	1.61 (1.55)
11-13	644 (33.7)	375 (58.2)	1.32 (1.39)	25 (3.9)	0.05 (0.24)	242 (37.6)	0.83 (1.26)	2.19 (1.51)
p		**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***
Ages								
7	344 (18.0)	107 (31.1)	0.65 (1.13)	-	0 (0)	15 (4.4)	0.08 (0.39)	0.72 (1.18)
8	316 (16.5)	118 (37.3)	0.76 (1.16)	-	0 (0)	33 (10.4)	0.18 (0.62)	0.94 (1.28)
9	324 (17.0)	150 (46.3)	1.07 (1.37)	2 (0.6)	0.01 (0.12)	53 (16.4)	0.29 (0.75)	1.37 (1.47)
10	284 (14.9)	156 (54.9)	1.36 (1.48)	7 (2.5)	0.03 (0.19)	68 (23.9)	0.49 (1.03)	1.88 (1.49)
11	259 (13.6)	151 (58.3)	1.29 (1.35)	6 (2.3)	0.03 (0.21)	83 (32.1)	0.67 (1.16)	2.00 (1.49)
12	198 (10.4)	117 (59.1)	1.31 (1.40)	10 (5.1)	0.06 (0.28)	75 (37.9)	0.84 (1.26)	2.21 (1.58)
13	187 (9.8)	107 (57.2)	1.36 (1.43)	9 (4.8)	0.05 (0.22)	84 (44.9)	1.02 (1.36)	2.43 (1.41)
p		**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***
Gender								
Female	977 (51.1)	460 (47.1)	1.11 (1.40)	17 (1.7)	0.02 (0.15)	208 (21.3)	0.46 (1.02)	1.59 (1.56)
Male	935 (48.9)	446 (47.7)	1.03 (1.29)	17 (1.8)	0.02 (0.18)	203(21.7)	0.43 (0.94)	1.48 (1.51)
p		0.787	0.504	0.897	0.892	0.823	0.992	0.128
Total	1912 (100.0)	906 (47.4)	1.07 (1.35)	34 (1.8)	0.02 (0.98)	411 (21.5)	0.44 (0.98)	1.53 (1.54)

N: number of patients examined, DMFT: Decayed, Missing or Filled Teeth SD: Standart Deviation
Chi-square test, Kruskal-Wallis test, Mann Whitney U tests p^*<0.05 statistically significant

Totally 7648 FPMs were examined. The prevalence of DT in FPMs was 26.8%, MT was 0.5%, and FT was 11.1%. No statistically significant differences were observed between the right and the left FPMs regarding D, M, and F prevalences by age group, age, and gender (p>0.05) (Table 3, 4). Mean DMFT6 for maxillary FPMs were 1.12 ± 0.84 as compared to 1.54 ± 0.66 for mandibular FPMs. The differences according to mean D, M, F ve DMF values in FPMs were statistically significant according to the jaw (p<0.001) but not statistically significant according to side (p>0.05) (Table 5).

The total rate of CF6 of the participants was 41%. The highest and lowest prevalences of CF6 were observed respectively in 7 and 13 years old for females and males. Children in the 7-8 age group were more caries-free than the other age groups (p<0.001). For all ages except 9,10 and 12, males demonstrated a higher percentage of CF6 than females. The education

level of most participants' parents was at a primary school level for mothers (39.1%) and at a high school level for fathers (33.3%). Furthermore, as the parent's education level increased, the number of children being CF6 increased (p<0.05). The CF6 percentage of children who brushed their teeth twice a day or more was significantly higher than those who brushed their teeth once a day or less (p<0.05) (Table 6).

Table 3. Distrubition of D, M, and F percentages of first permanent teeth in relation to ages, age groups, and gender

Age groups	N (%)	Maxillary First Permanent Molars N (%)					
		Right D	Left D	Right M	Left M	Right F	Left F
7-8	2640 (34.5)	88(13.3)	91(13.8)	-	-	16(2.4)	11(1.7)
9-10	2432 (31.8)	164(27.0)	157(25.8)	1(0.2)	-	39(6.4)	35(5.8)
11-13	2576 (33.7)	189(29.3)	207(32.1)	2(0.3)	3(0.5)	116(18.0)	102(15.8)
p		0.669		0.273		0.825	
Ages							
7	1376 (18.0)	35 (10.2)	42(12.2)	-	-	7(2.0)	1(0.3)
8	1264 (16.5)	53 (16.8)	49(15.5)	-	-	9(2.8)	10(3.2)
9	1296 (19.5)	74 (22.8)	68(21.0)	-	-	16(4.9)	14(4.3)
10	1136 (14.8)	90 (31.7)	89 (31.3)	1 (0.4)	-	23(8.1)	21(7.4)
11	1036 (13.5)	73 (28.2)	79 (30.5)	-	1(0.4)	35(13.5)	32(12.4)
12	792 (10.3)	56 (28.3)	67 (33.8)	1 (0.5)	-	40(20.2)	29(14.6)
13	748 (9.8)	60 (32.1)	61 (32.6)	1 (0.5)	2(1.1)	41(21.9)	41(21.9)
p		0.914		0.343		0.540	
Gender							
Female	3908 (51.1)	222(22.7)	241(24.7)	2(0.2)	2(0.2)	91(9.3)	82(8.4)
Male	3740 (48.9)	219(23.4)	214(22.9)	1(0.1)	1(0.1)	80(8.6)	66(7.1)
p		0.431		1.000		0.696	
Total	7648 (100)	441(23.1)	455(23.8)	3(0.2)	3(0.2)	171(8.9)	148(7.7)

N: number of teeth examined, D: Decayed, M: Missing, F: Filled chi-square, p*<0.05 statistically significant

Table 4. Distrubition of D, M, and F percentages of first permanent teeth in relation to ages, age groups, and gender

Age groups	N (%)	Mandibular First Permanent Molars N (%)						Total N (%)		
		Right D	Left D	Right M	Left M	Right F	Left F	D	M	F
7-8	2640 (34.5)	146(22.1)	139(21.1)	-	-	28(4.2)	27(4.1)	464 (17.6)	0 (0)	82 (9.7)
9-10	2432 (31.8)	205(33.7)	207(34.0)	5(0.8)	5(0.8)	77(12.7)	81(13.3)	733 (30.1)	11 (27.5)	232 (27.4)
11-13	2576 (33.7)	224(34.8)	229(35.6)	10(1.6)	14(2.2)	156(24.2)	158(24.5)	849 (33.0)	29 (72.5)	532 (62.9)
p		0.888		0.656		0.959				
Ages										
7	1376 (18.0)	71(20.6)	75(21.8)	-	-	9(2.6)	9(2.6)	223 (10.9)	-	26 (3.1)
8	1264 (16.5)	75(23.7)	64(20.3)	-	-	19(6.0)	18(5.7)	241 (11.8)	-	56 (6.6)
9	1296 (19.5)	101(31.2)	103(31.8)	1(0.3)	2(0.6)	32(9.9)	32(9.9)	346 (16.9)	3 (7.5)	94 (11.1)
10	1136 (14.8)	104(36.6)	104(36.6)	4(1.4)	3(1.1)	45(15.8)	49(17.3)	387 (18.9)	8 (20)	138 (16.3)
11	1036 (13.5)	88(34.0)	95(36.7)	3(1.2)	4(1.5)	49(18.9)	58(22.4)	335 (16.4)	8 (20)	174 (20.6)
12	792 (10.3)	70(35.4)	66(33.3)	5(2.5)	6(3.0)	53(26.8)	45(22.7)	259 (12.7)	12 (30)	167 (19.7)
13	748 (9.8)	66(35.3)	68(36.4)	2(1.1)	4(2.1)	54(28.9)	55(29.4)	255 (12.5)	9 (22.5)	191 (22.6)
p		0.965		0.922		0.955				
Gender										
Female	3908 (51.1)	314(32.1)	308(31.5)	7(0.7)	8(0.8)	135(13.8)	141(14.4)	1085 (53.0)	19 (47.5)	449 (53.1)
Male	3740 (48.9)	261(27.9)	267(28.6)	8(0.9)	11(1.2)	126(13.5)	125(13.4)	961 (47.0)	21 (52.5)	397 (46.9)
p		0.723		0.790		0.768				
Total	7648 (100)	575(30.1)	575(30.1)	15(0.8)	19(1.0)	261(13.7)	266(13.9)	2046 (26.8)	40 (0.5)	846 (11.1)

N: number of teeth examined, D: Decayed, M: Missing, F: Filled chi-square, p*<0.05 statistically significant

Table 5. Distrubition of mean D, M, F, DMFT values and percentages of first permanent molars as location (jaw and side)

Jaw	N (%)	Decayed N (%)	Decayed Mean (SD)	Missing N (%)	Missing Mean (SD)	Filled N (%)	Filled Mean (SD)	DMFT6 Mean (SD)
Maxillar	3824 (50.0)	896 (23.4)	1.03 (0.82)	6 (0.2)	0.00 (0.06)	319 (8.3)	0.08 (0.31)	1.12 (0.84)
Mandibular	3824 (50.0)	1150 (30.1)	1.34 (0.73)	34 (0.9)	0.02 (0.15)	527 (13.8)	0.18 (0.48)	1.54 (0.66)
p		**<0.001***	**<0.001***	**<0.001***	**0.010***	**<0.001***	**<0.001***	**<0.001***
Side								
Right	3824 (50.0)	1016 (26.6)	1.18 (0.68)	18 (0.5)	0.01 (0.10)	432 (11.3)	0.14 (0.40)	1.34 (0.66)
Left	3824 (50.0)	1030 (26.9)	1.19 (0.69)	22 (0.6)	0.01 (0.11)	414 (10.8)	0.12 (0.37)	1.33 (0.68)
p		0.718	0.737	0.526	0.636	0.512	0.237	0.760
Total	7648 (100.0)	2046 (26.8)	1.07 (1.35)	40 (0.5)	0.02 (0.98)	846 (11.1)	0.44 (0.98)	1.53 (1.54)

DMFT: Decayed, Missing or Filled Teeth, SD: Standart Deviation, *p**<0.05 statistically significant

Table 6. Distrubition of percentage of the caries-free criterion in the first permanent molars of patients by ages, age groups, parental education and tooth brushing frequency

Variables	Caries Free Index N (%)				
Age groups	**N (%)**	**Female N (%)**	**Male N (%)**	**Total N (%)**	***p***
7-8	660 (34.5)	195 (29.6)	211 (32.0)	406 (61.5)	**<0.001***
9-10	608 (31.8)	125 (20.6)	107 (17.6)	232 (38.2)	
11-13	644 (33.7)	70 (10.9)	75 (11.7)	145 (22.5)	
p		0.335			
Ages					
7	344 (18.0)	109 (31.7)	117 (34.0)	226 (65.7)	**<0.001***
8	316 (16.5)	86 (27.2)	94 (29.7)	180 (57.0)	
9	324 (17.0)	73 (22.5)	68 (21.0)	141 (43.5)	
10	284 (14.8)	52 (18.3)	39 (13.7)	91 (32.0)	
11	259 (13.5)	30 (11.6)	34 (13.1)	61 (23.6)	
12	198 (10.4)	28 (14.1)	23 (11.6)	51 (25.8)	
13	187 (9.8)	12 (6.4)	18 (9.62)	30 (16.0)	
p		0.596			
Mother education					
Primary	748 (39.1)	115 (15.4)	131 (17.5)	246 (32.9)	**<0.001***
Secondary	322 (16.8)	62 (19.2)	63 (19.6)	125 (38.8)	
High	532 (27.8)	124 (23.3)	115 (21.6)	239 (45.0)	
University	310 (16.2)	89 (28.7)	84 (27.1)	173 (55.8)	
p		0.678			
Father education					
Primary	521 (27.2)	81 (15.5)	93 (17.8)	174 (33.4)	**<0.001***
Secondary	278 (14.5)	55 (19.8)	54 (19.4)	109 (39.2)	
High	637 (33.3)	123 (19.3)	130 (20.4)	253 (39.7)	
University	476 (24.9)	131 (27.5)	116 (24.4)	247 (51.9)	
p		0.587			
Tooth brushing frequency					
None	184 (9.6)	21 (11.4)	39 (21.2)	60 (32.6)	**0.039***
Sometimes	1360 (71.1)	269 (19.8)	289 (21.3)	558 (41.0)	
Once a day	335 (17.5)	89 (26.6)	59 (17.6)	148 (44.2)	
≥2 daily	33 (1.7)	11 (33.3)	6 (18.2)	17 (51.5)	
p		**0.003***			
Total	1912 (100.0)	390 (20.4)	393 (20.6)	783 (41.0)	

N: number of patients examined, Chi-square, *p**<0.05 statistically significant

The surface most affected by caries was the occlusal surface in both the upper and lower FPMs. Teeth with caries on two and ≥three surfaces followed, respectively, which was valid for all FPMs. Statistically significant differences were found between FPMs 16, 26,

36, and 46 regarding the number of decayed and filled FPMs (p<0.05). Of the teeth evaluated, 1% had been treated with root canals, and 61.3% of these teeth were in the lower jaw (Table 7).

Regarding the types of treatment needed, 19.6% of the FPMs needed one surface restoration, 2.2% needed two and 0.2% needed ≥three restorations, 4.5% needed endodontic therapy, and 0.4% required extraction treatment. Lower FPMs needed more one- and two-surface restorations, endodontic therapy, and extraction treatment than upper FPMs (p<0.05). The need for treatment varied significantly by age and age groups (p<0.05) (Table 8).

Table 7. Distribution of dental status (decayed, missing, filled, root canal treated, sound) of first permanent molars

Status		16 N (%)	26 N (%)	36 N (%)	46 N (%)	Total N (%)	*p*
Decayed	**Occlusal**	361 (18.9)	371 (19.4)	438 (22.9)	435 (22.8)	1605 (21.0)	**0.015***
	OM/OD	68 (3.6)	73 (3.8)	106 (5.5)	107 (5.6)	354 (4.6)	
	MOD	12 (0.6)	11 (0.6)	31 (1.6)	33 (1.7)	87 (1.1)	
	Total	441 (23.1)	455 (23.8)	575 (30.1)	575 (30.1)	2046 (26.8)	
Filled	**Occlusal**	140 (7.3)	127 (6.6)	236 (12.3)	226 (11.8)	729 (9.5)	**0.007***
	OM/OD	28 (1.5)	21 (1.1)	20 (1.1)	29 (1.5)	98 (1.3)	
	MOD	3 (0.2)	-	10 (0.5)	6 (0.3)	19 (0.3)	
	Total	171 (8.9)	148 (7.7)	266 (13.9)	261 (13.7)	846 (11.1)	
Root canal treated		17 (0.9)	12 (0.6)	24 (1.3)	22 (1.15)	75 (1.0)	
Missing		3 (0.2)	3 (0.2)	19 (1.0)	15 (0.8)	40 (0.5)	
Sound		1297 (67.8)	1306 (68.3)	1052 (55.0)	1061 (55.5)	4716 (61.7)	

OM: Occlusal-Mesial, OD: Occlusal-Distal, MOD: Mesial Occlusal Distal, N: Number of patients examined, Chi-square p*<0.05 statistically significant

Table 8. Distribution of first permanent molars requiring treatments according to gender, age, age groups, jaw and side

Gender	N (%)	One surface filling N (%)	Two surface filling N (%)	≥Three surface filling N (%)	Endodontic therapy N (%)	Extraction N (%)	Total N (%)	*p*
Female	3908 (51.1)	798 (53.3)	78 (47.3)	6 (50.0)	191 (56.2)	12 (36.4)	1085 (53.0)	
Male	3740 (48.9)	698 (46.7)	87 (52.7)	6 (50.0)	149 (43.8)	21 (63.6)	961 (47.0)	0.119
p		0.053	0.321	0.939	0.055	0.092	**0.041***	
Age groups								
7-8	2640 (34.5)	384 (25.7)	24 (14.5)	2 (16.7)	54 (15.9)	0	464 (22.7)	**<0.001***
9-10	2432 (31.8)	547 (36.6)	55 (33.3)	7 (58.3)	118 (34.7)	6 (18.2)	733 (35.8)	
11-13	2576 (33.7)	565 (37.8)	86 (52.1)	3 (25.0)	168 (49.4)	27 (81.8)	849 (41.5)	
Ages								
7	1376 (18.0)	187 (12.5)	9 (5.5)	1 (8.3)	26 (7.7)	0	223 (10.9)	**<0.001***
8	1264 (16.5)	197 (13.2)	15 (9.1)	1 (8.3)	28 (8.2)	0	241 (11.8)	
9	1296 (19.5)	263 (17.6)	29 (17.6)	4 (33.3)	50 (14.7)	0	346 (16.9)	
10	1136 (11.36)	284 (19.0)	26 (15.8)	3 (25.0)	68 (20.0)	6 (18.2)	387 (18.9)	
11	1036 (13.5)	217 (14.5	36 (21.8)	2 (16.7)	71 (20.9)	9 (27.3)	335 (16.4)	
12	792 (10.3)	172 (11.5)	26 (15.8)	0	57 (16.8)	4 (12.1)	259 (12.7)	
13	748 (9.8)	176 (11.8)	24 (14.5)	1 (8.3)	40 (11.8)	14 (42.4)	255 (12.5)	
Jaw								
Maxilla	3824 (50.0)	698 (46.7)	63 (38.2)	5 (41.7)	117 (34.4)	13 (39.4)	896 (43.8)	**<0.001***
Mandibula	3824 (50.0)	798 (53.3)	102 (61.8)	7 (58.3)	223 (65.6)	20 (60.6)	1150 (56.2)	
p		**0.004***	**0.002***	0.563	**<0.001***	**0.222***	**<0.001***	
Side								0.922
Right	3824 (50.0)	743 (49.7)	87 (52.7)	6 (50.0)	164 (48.2)	16 (48.5)	1016 (49.7)	
Left	3824 (50.0)	753 (50.3)	78 (47.3)	6 (50.0)	176 (51.8)	17 (51.5)	1030 (50.3)	

p		0.773	0.479	1.000	0.506	0.862	0.718
Total	7648 (100.0)	1496 (19.6)	165 (2.2)	12 (0.2)	340 (4.5)	33 (0.4)	2046 (26.8)

N: Number of patients examined, Chi-square, $p^*<0.05$ statistically significant

DISCUSSION

The active population of a country consists of children aged 6-7 years, the age at which FPMs begin to erupt, and children aged 7-12 ages, in the mixed dentition period. The fact that preventive programs are not applied to children in these age groups and that the problem-oriented treatment approach is dominant in children results in a high risk of caries.

Although there are differences in cultural habits, socioeconomic status, diet, and oral care habits in populations, the most affected teeth by caries are FPMs. The caries prevalence of FPMs in children of different age ranges in different populations has been recorded as 21.7% in North America,[14] 24.6%-66.4% in Asia,[5,15-21], and 14.0%-68% [6-10] in Turkey. In this study, the caries prevalence of FPMs in children aged 9-10 and 11-13 was more than 50%. Today, the high caries prevalence among FPMs in children may be related to the inadequate implementation of dental health promotion activities and preventive measures, inadequate oral hygiene habits, and increased cariogenic food consumption. In addition, the fact that our study group consisted of patients who visited the clinic due to problems in their teeth may be another reason for the high caries prevalence observed.

Caries activity continues throughout life, and the incidence of caries increases with age.[8,9,15,16,22-25] In the present study, the caries prevalence of FPMs was 34.1% in children aged 7-8 years, while this rate was observed to be more than 50% after 9 years of age. Bulucu et al.[6] reported the caries prevalence of FPMs as 9% in 6-year-olds, 51% in 9-year-olds, and 61% in 12-year-olds, respectively. In the studies conducted in our country within the last five years, the caries prevalence of FPMs for children in the 7-9 age group; 51.2%,[8] in the 7-12 age group; 41%,[9] in the 8-12 age group; 58.6%[25] were reported. These data showed that FPMs are at risk of caries at an early age and that the rate of caries increases at later ages primarily because preventive treatments are not applied promptly and on time.

Failure to perform timely preventive treatments for FPMs may result in tooth extraction due to the increased risk of caries. While there was no extraction of FPMs in children aged 7-8 years in the study group, similar findings were reported in previous studies.[23,26] In the present study, patients who had their FPM/s extracted by the age of 9 were observed, and the highest number of tooth extractions occurred in children aged 11-13. Bulucu et al.[6] reported that tooth extraction or extraction indication begins after the age of 9 and reaches 7% at the age of 12, whereas the age of 11-12 represents the period when the teeth are most exposed to extraction. In previous studies, the percentage of FPM loss for children at 12 ages, 1.5%,[18] at 6-12 age groups, 0.6%[27] and 1%[28] were reported, and tooth loss was stated to increase with increasing age. In this study, statistically significant relationships were found between age, age group, and the number of extracted teeth ($p<0.05$), but not with gender as in other studies ($p>0.05$).[9,28] However, Kılınc et al.[7] reported that there was more tooth loss in males.

The DMF index and each of its components are well established as the key measures of caries and the most common epidemiological scale used in studies.[29] In this study, the mean DMF6 index was 1.53 (1.54). The results of this study showed that the mean DMFT6 index in children aged 7-13 years was high compared to WHO standards in 2010 (≥1).[30] The caries experience of FPMs in our

study was lower than other similar studies,[4,12,22] but higher than those reported in others.[8,10,19,20,31] The different results may be related to the children's age and the designs of the studies. Mean DMFT6 index values may increase with increasing age.[26] This finding was consistent with our study due to the increased number of decayed and restored teeth with age. In the study, the mean DMFT6 index was 1.48 (1.51) for males and 1.59 (1.56) for females; gender does not have an effect on mean DMF6 values. While similar results have been observed by other authors,[10,12,18,32] gender has also been reported to be an important factor.[8,18,24,31] This can be explained through long-term exposure to caries risk factors due to premature teeth eruption in girls, anatomical differences in teeth, differences in dietary and oral hygiene habits, early puberty in girls, and possible quantitative and qualitative changes in the saliva.

When the relationship between the dental status of the FPMs and the jaws is examined, the number of DMFTs was determined to be higher in the lower jaw than in the upper jaw.[5,7,9,15,17,22,25,33,34] The results obtained from the present study also support these findings. Certain factors cause lower FPMs to be more affected by caries and subsequently extracted; pit-fissure caries, which facilitate food accumulation, are more common in these teeth, cleaning is more difficult in the lower region, and the palatal salivary gland duct opening to the buccal surface of the upper FPMs has a cleansing effect.[7,9] On the contrary, Mimoza et al.[24] reported that the upper left FPMs were the most affected by caries in children with mixed dentition, followed by the upper right, lower left, and right FPMs, respectively.

When the caries and missing status of the FPMs are evaluated according to the right and left regions of the jaws, no difference was found,[7,9,27,34] while Khodadadi et al.[33] reported that the number of DT was higher on the right side. In the present study, significant results of evaluating DMFT6 according to side were not found. This may be caused by the mechanical cleaning effects of foods when chewing and the handedness, which affects the brushing ability.[27]

The surface most affected by caries in FPMs is the occlusal surface,[7,9,17,34] followed by the proximal surfaces.[5,17] Since the increased incidence of caries on the occlusal and proximal surfaces is related to the morphology of these regions, this result of the present study is expected. In addition, while the number of teeth with occlusal fillings was determined to be higher among FPMs than in other treatments, a study by Kılınc et al.[7] presented similar findings.

In children, endodontic therapy for severely decayed teeth may be required. In the study, 1% of the FPMs evaluated were root canal treated and 82.7% of them were in children aged 11-13 years. In previous studies conducted in Turkey, the percentage of FPMs with endodontic treatment for children in the 6-12 age groups was 0.47%[27] and 1%,[28] in the 7-12 age group; 0.6%,[9] in the 10-12 age group; 1%[34] were reported. As in a previous study, no differences were observed in the present study regarding the presence of root canal-treated teeth in the right and left jaws, while root canal treatment was applied mostly to the mandibular FPMs.[27] This result is expected due to the differences in the anatomical structures and eruption times.

Determining the treatments needed by FPMs is important to shed light on the severity of caries and intervene early to prevent tooth loss. In the present study, 19.6% of the evaluated teeth needed one surface filling, 4.5% needed endodontic treatment and 0.4% needed extraction. Studies conducted on children aged 6-12 years in Turkey reported that 21% of FPMs needed one surface filling, 3-4% needed endodontic treatment, and 0.2-0.47% needed extraction.[23,27] The results of the present study were similar to those of the previous studies.

Demirbuga et al.[27] reported that the number of teeth that need root canal treatment is higher than those with root canal treatment in children aged 6-12 years. The observation of this situation in the present study may be because the patients neglected routine dental checkups and went to the dentist only when they experienced tooth pain.

In the present study, the total rate of CF6 of the participants was 41% and the percentage of the CF criteria decreased with increased age. In the previous studies, the percentage of CF6 values in the 7-9 age group; 48.8%,[8] in the 7-10 age group; 33.7%,[5] in the 6-12 age group; 72%,[28] in the 7-12 age group; 34.7%,[12] in the 12 ages; 33.9%[35] and 51.5%[31] were reported**.** The reason for CF6 as age increases can be attributed to the fact that caries, being a continuous process, has increased.[5]

Parental education level and children's tooth brushing frequency positively affect children's mean DMF6 values.[4,31] Children who brush their teeth twice or more a day have lower caries incidence than children who brush once or not.[22] In the present study, the percentages of CF6 were increased with increasing parental education and the participants' brushing frequency but decreased with increasing participants' age (p<0.05). However, Sadat-Sajadi et al.[32] reported that the parents' education level may not have any effect on the mean DMF6 values of the children. To prevent caries in FPMs, it is important to provide children with good oral hygiene habits and regular dental controls before the FPMs erupt to ensure the effective implementation of preventive programs and inform parents accordingly.

The limitations of the study were that the psychosocial, behavioral, and clinical factors, such as dietary habits and socioeconomic status of the subjects, could not be taken into consideration. Inferences made without considering these factors need to be confirmed. Future studies are recommended to collect data on the relationships between dental caries and these factors such as dietary practices and socioeconomic status. Also, this study relied on records of 7-13-year-olds from a single pediatric dental clinic of a university, so the results can not be generalized to the Turkish population. Future research should consider large multicenter studies encompassing many age groups and FPM caries-related variables.

Despite the limitations of this study, its strengths of performing both radiographic and clinical evaluations when determining the dental status and treatment needs of FPMs, as well as being the first large-scale study on this subject in children living in the Western Mediterranean Region of Turkey, are worth noting.

CONCLUSION

The present study showed that the prevalence of dental caries in FPMs and the mean DMFT6 of children aged 7-13 years in a Turkish pediatric population were relatively high. The tooth brushing frequency of children and the level of parental education have important effects on caries prevalence. To protect FPMs from caries, families and children should be aware of oral care at early ages, and protective practices should be applied by determining the caries risk status of individuals. For clinical implications, oral and dental health policies can be developed to encourage regular dental check-ups and tooth brushing, so that the implementation of preventive programs can effectively support the management of caries risk.

Ethical Approval

Ethical approval was obtained from the Research Ethics Committee at Suleyman Demirel University, Faculty of Medicine (13.12.2018/233).

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Conflict of Interest

The author denies any conflicts of interest related to this study.

Author Contributions

Design: EÖ, Data collection and processing: EÖ, Analysis and interpretation: EÖ, Literature review: EÖ, Writing: EÖ.

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Evaluation of Knowledge Levels and Awareness of Dentists Working in Sivas Province about Ergonomics

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ABSTRACT

Aim: Dentists are among the occupational workers at ergonomic risk. Musculoskeletal system diseases constitute the largest class of occupational injuries that occur when ergonomic rules are not followed and the prevalence is high in dentists. Appropriate working posture is the starting point in the prevention of damages. If dentists are aware of this issue, the profession can be continued in a healthy way for many years.

Materials and Methods: The aim of this structured questionnaire study was to determine the awareness of ergonomics in 103 dentists working in the centre of Sivas province and to determine their level of knowledge about occupational diseases that may occur when ergonomic conditions are not complied with and to raise awareness. The questionnaire consists of demographic information, awareness, risk factors and Nordic musculoskeletal questionnaire (NMQ). IBM SPSS 23® programme was used for statistical analysis.

Results: 96.1% of dentists stated that they knew occupational ergonomics and 94.2% knew the correct working position. However, 68.9% reported that they worked in the same position for a long time and 52.4% reported that they did not do stretching or breathing exercises. NMQ results were found to be statistically significantly different according to gender and place of work ($p<0.05$).A statistically significant positive correlation was found between NMQ and awareness section ($p<0.05$). Age and body mass index values were found to have no statistically significant effect on NMQ ($p>0.05$).

Conclusion: Our study revealed that dentists working in Sivas province have insufficient awareness of ergonomic working conditions and occupational musculoskeletal disorders.

Sivas İlinde Görev Yapan Diş Hekimlerinin Ergonomi Hakkında Bilgi Düzeylerinin ve Farkındalıklarının Değerlendirilmesi

Makale Bilgisi

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İskandinav kas-iskelet sistemi anketi.

ÖZET

Amaç: Diş hekimleri ergonomik olarak risk altındaki meslek çalışanları arasındadır. Ergonomik kurallara uygun olmayan çalışmalar sonucunda oluşan mesleki hasarların en büyük sınıfını kas ve iskelet sistemi hastalıkları oluşturmaktadır ve bu hastalıkların diş hekimlerinde prevalansı oldukça yüksektir. Uygun çalışma duruşu, hasarların önlenmesinde başlangıç noktasıdır. Bu konuda diş hekimlerinin kişisel farkındalığı oluştuğu takdirde meslek uzun yıllar sağlıklı bir şekilde sürdürülebilmektedir.

Gereç ve Yöntemler: Bu yapılandırılmış anket çalışmasının amacı; Sivas ili merkezinde çalışan 103 diş hekiminde ergonomi bilincini ve ergonomik koşullara uyulmadığında oluşabilecek mesleki hastalıklara ilişkin bilgi düzeylerini belirlemek ve farkındalık oluşturmaktır. Anket formu demografik bilgiler, farkındalık bölümü, risk faktörleri bölümü ve İskandinav kas-iskelet sistemi anketi (İKİSA) bölümünden oluşmaktadır. Verilerin istatistiksel analizinde IBM SPSS 23® programı kullanılmıştır.

Bulgular: Diş hekimlerinin %96,1'i mesleki ergonomi hakkında bilgisi olduğunu, % 94,2'si doğru çalışma pozisyonunu bildiğini belirtmiştir. Ancak %68,9'u uzun süre aynı pozisyonda çalıştığını ve %52,4'ü hastalar arasındaki zamanlarında esneme veya nefes egzersizi yapmadıklarını bildirmiştir. İKİSA sonuçları, cinsiyete ve görev yapılan yere göre istatistiksel olarak anlamlı farklı bulunmuştur ($p<0,05$). İKİSA ile farkındalık bölümü arasında istatistiksel olarak anlamlı pozitif korelasyon belirlenmiştir ($r=0,201$, $p=0,042$). Yaş ve vücut kitle indeksi değerlerinin İKİSA üzerine istatistiksel olarak anlamlı bir etkisi olmadığı bulunmuştur ($p>0,05$).

Sonuç: Çalışmamız Sivas ilinde görev yapan diş hekimlerinin ergonomik çalışma koşulları ve mesleki kas ve iskelet sistemi hastalıklarına karşı farkındalıklarının yetersiz olduğunu ortaya koymuştur.

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INTRODUCTION

With the realisation of the link between safety at work and productivity, the search began for a discipline to study the relationship between man and his working environment. This is how the science of ergonomics, which studies the relationship between man, work and the environment, came into being. Ergonomics is the discipline of designing the working and living environment in accordance with human characteristics, or "the scientific study of the relationship between man and his workplace and environment".[1] The science of ergonomics, which is at the heart of occupational health and safety, is related to various branches of science and covers a wide range of applications.

Rehabilitation specialists state that the profession of dentistry necessarily requires frequent and prolonged mechanical stress.[2] Dentists have many risks that may cause occupational diseases because they perform repetitive and forceful movements in a narrow and localised working area, use high-precision technical instruments that cause mechanical stress in the musculoskeletal system, and stand in a certain position continuously.[3] Furthermore, the profession of dentistry is inherently stressful, requiring the practitioner to pay close attention to detail and maintain concentration throughout the course of their duties. This can result in dentists neglecting their own health and well-being, leading to a tendency to prioritise the maintenance of their patients' dental health.

The provision of ergonomic working conditions serves to establish a harmonious relationship between the employee and their work, protects the physical and psychological health of the employee, reduces work-related stress, and reduces the risk of occupational accidents and occupational diseases. The implementation of ergonomic working conditions enhances the quality of work, ensures the safety and health of employees, and creates a comfortable and productive work environment. These factors collectively contribute to enhanced work efficiency and performance.[4] In the field of dentistry, ergonomics is the science of designing devices, machines, equipment and environments in a way that optimises the efficiency and safety of the physician. The key principle is to ensure that the physician can adopt the correct working posture. In addition, ergonomic measures are employed to enhance the effectiveness of the physician in their use of devices, machines, equipment and environments, thereby improving the standard of treatment and protecting the health of both the physician and the patient.

The musculoskeletal system constitutes the largest class of occupational injuries resulting from the disregard of ergonomic rules and non-ergonomic work.[5] Dental practices may result in muscular imbalances, neuromuscular limitations, pain and dysfunction due to cumulative microtrauma and non-ergonomic work.[6] Even in the most optimal work positions, dentists are required to maintain a posture in which over 50% of their muscles are engaged to resist gravity, which may result in prolonged, repetitive muscle contractions.[7] The prevalence of musculoskeletal disorders (MSDs) in oral health workers is estimated to range from 62% to 93%.[8] Although there is a wide variety of CMDs defined in the literature, the most commonly observed in dentists are carpal tunnel syndrome, shoulder and low back pain.[9] The most common symptoms of MSDs include painful joints, pain in the wrists, shoulders, elbows and knees, pain, tingling and numbness in the hands or feet, neck and back pain, swelling or inflammation, and weakness in the hands.

These occupational illnesses are regarded as a significant public health concern in numerous developed nations, accounting for one-third of the reasons for leaving work due to health issues.[10] Musculoskeletal system disorders represent the primary cause of both temporary and permanent work incapacity, resulting in human resource shortages and financial expenditures. They are also a significant factor contributing to the early retirement of dentists.[11,12] When the general and occupational health of dentists is analysed, musculoskeletal system diseases are an important health problem, with a significant number of cases leading to medical reports and retirement from the profession.[13] A study conducted in our country revealed that health problems arising over time were the most unfavourable aspect of the profession, with a rate of 43%.[14] The economic impact of musculoskeletal system diseases caused by ergonomic risks is significant, with high treatment costs and loss of work resulting in considerable financial strain.

In light of the aforementioned information, a study was conducted among 103 dentists working in the centre of Sivas province. This was due to the fact that their knowledge and awareness levels regarding ergonomics and occupational diseases that may occur in the event of non-compliance with ergonomic conditions were deemed to be insufficiently developed.

MATERIALS AND METHODS

The sample size was calculated with a 95% confidence level in accordance with the methodology summarised in 2001. It was determined that data should be collected from at least 101 individuals.[15] This structured questionnaire study was conducted in 103 dentists working in the centre of Sivas province to ascertain their awareness of ergonomics and the extent of their knowledge about occupational diseases that may result from non-compliance with ergonomic conditions. Furthermore, the study aimed to raise awareness about the importance of ergonomics in dentistry. The study was conducted in accordance with the ethical principles set forth in the Declaration of Helsinki and was approved by the Sivas Cumhuriyet University Clinical Research Ethics Committee (21.12.2023; 2023-12/48). All physicians were provided with comprehensive information regarding the objectives and methodology of the study. Prior to the commencement of the study, each participant was provided with an informed consent form, which was accepted by the ethics committee.

The study included all dentists aged 24 to 64 years who were actively engaged in their profession. Individuals who had undergone musculoskeletal surgery, were pregnant or lactating, had rheumatic, neuromuscular or genetic muscle and bone diseases, or who did not wish to participate in the study were excluded from the study.

A structured questionnaire was administered to the participants by a dentist, who has five years of dental expertise, through a face-to-face interview. The questionnaire comprised four sections: demographic information, awareness section, risk factors section, and a section on the Nordic musculoskeletal system (Figure 1, 2 and 3). The first three sections were derived from a comprehensive literature review. In the demographic information section, data on age, gender, place of work, years of active work, daily working hours, educational status, height, weight, chronic disease status, smoking and alcohol use status were recorded. In the awareness section, data on ergonomics, occupational diseases, correct working position and environment were recorded. In the risk factors section, data pertaining to physical working conditions, psychosocial factors and exercise were

recorded.

Figure 1: The structured questionnaire form for the awareness section

1- Do you have information on ergonomics in the dental profession?	Yes ☐		No ☐	
2- Do you know the working position according to the watch dial?	Yes ☐		No ☐	
3- Are you aware of the occupational diseases specific to the dental profession?	Yes ☐		No ☐	
4- Do you have information on the most common musculoskeletal disorders in dentistry?	Yes ☐		No ☐	
5- Are you familiar with four-handed dentistry?	Yes ☐		No ☐	
6- Do you know the correct physician working posture?	Yes ☐		No ☐	
	Never	Rarely	Mostly	Always
7- Does ergonomic work affect fatigue and work stress?				
8- Does ergonomic work affect accidents at work and occupational diseases?				
9- Does ergonomics affect work efficiency and performance?				
10- Are ergonomic conditions influenced by the anthropometric characteristics of the individual?				

Figure 2: The structured questionnaire from for the risk factors section

	Never	Rarely	Mostly	Always
1- I treat patients while standing.				
2- I work under intense stress				
3- I work in the same position for a long time				
4- I exercise regularly.				
5- My rest time between patients is sufficient.				
6- I do stretches/breathing exercises between patients.				
7- Noise and vibration of the equipment used affect my comfort at work.				
8- Psychosocial factors affect my working conditions.				
9- The time allocated to a patient is appropriate for my treatment.				
10-I work with auxiliary staff.				

Figure 3: Nordic Musculoskeletal Questionnaire (NMQ)*

Have you at any time during **the last 12 months** had trouble (ache, pain, discomfort, numbness) in:	Have you at any time during the **last 12 months been prevented from doing your normal work** (at home or away from home) because of the trouble?	Have you had trouble at any time during **the last 7 days?**
Neck ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
Shoulders ☐ No ☐ Yes, right shoulder ☐ Yes, left shoulder ☐ Yes, both shoulders	☐ No ☐ Yes	☐ No ☐ Yes
Elbows ☐ No ☐ Yes, right elbow ☐ Yes, left elbow ☐ Yes, both elbows	☐ No ☐ Yes	☐ No ☐ Yes
Wrists/Hands ☐ No ☐ Yes, right wrist/hand ☐ Yes, left wrist/hand ☐ Yes, both wrists/hands	☐ No ☐ Yes	☐ No ☐ Yes
Upper Back ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
Lower Back (small of back) ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
One or Both Hips/Thighs ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
One or Both Knees ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
One or Both Ankles/Feet ☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes

In the Nordic musculoskeletal section, data were collected on musculoskeletal complaints in the previous seven days and the previous 12 months. This section constitutes a component of the Standardised Nordic Musculoskeletal Questionnaire (NMQ), which was first introduced to the literature in 1987.[16] The NMQ assesses general musculoskeletal complaints over the past 12 months and seven days in nine specific symptom areas using standardised questions. The NMQ is completed by self-administration or personal interview, which provides reliable information.

Statistical Analysis

The IBM SPSS 23® (IBM Corp., 2012) computer programme was employed for the purposes of this study. Descriptive statistical methods were used to calculate mean, percentage distribution and standard deviation values. The normality of distribution was tested by means of the Kolmogorov-Smirnov test. Given that the data did not exhibit a normal distribution, Mann-Whitney U and Kruskal-Wallis tests were employed to ascertain the significance of the values obtained, with a p-value of less than 0.05 considered to be statistically significant. Logistic regression analyses were conducted to identify potential NMQ risk factors.

RESULTS

In the general reliability analysis of the study, the Cronbach alpha coefficient was determined to be 0.775, thereby establishing the reliability of the study's results. In our study, 65 (63.1%) of 103 participants were female, 38 (36.9%) were male, and the mean age was 31.3 ± 5.16 years. The mean BMI of the participants was 24 ± 3.88. The majority

of dentists who participated in our study (85.4%) were employed in the public sector, while 30% were specialists. The majority of dentists (65%) work between six and eight hours per day, while 93.2% do not suffer from any chronic diseases. The data on the demographic characteristics of the participants are presented in Table 1. The data on the daily working hours and years of active work are presented in Table 2.

Table 1: Demographic information of participants

Demographic Information	
Average Age	**31.3**
BMI Mean	**24**
Percentage of Female Participants	**% 63.1**
Participant Working In The Public Sector	**% 85.4**
Participants Who Do Not Smoke And/Or Drink Alcohol	**% 78.6**
Specialist dentist	**% 30**

Table 2: Participants' active working years and daily working hours

Active Working Year	
1-3 Years	**%29,1**
3-6 Years	**% 22,3**
6-9 Years	**% 13,6**
9 Years And Over	**% 35**
Daily Working Hours	
2-4 Hours	**% 1**
4-6 Hours	**% 5.8**
6-8 Hours	**% 65**
8 Hours And Over	**% 28.2**

A total of 96.1% of dentists indicated that they possessed knowledge about occupational ergonomics, while 94.2% stated that they were aware of the correct working position (Table 3). Despite these data, 21.4% of the participants indicated that they mostly saw patients standing, and 68.9% of them reported working in the same position for extended periods. Similarly, 52.4% of dentists reported that they did not perform stretching movements or breathing exercises during the time between patients. A total of 86.4% of the participants reported that they were aware of occupational diseases, 87.4% were aware of working according to the clock dial, 82.5% were aware of the most common musculoskeletal diseases in dentistry, and 85.4% were aware of four-handed dentistry. Furthermore, 43.7% of the participants indicated that ergonomic working conditions are always associated with fatigue and stress, while 30.1% asserted that ergonomics is always linked to occupational accidents and occupational diseases. A total of 35% of the participants indicated that ergonomics is always associated with enhanced work efficiency and performance, while 24.3% reported that anthropometry is always affected by ergonomics.

The Nordic musculoskeletal questionnaire was found to be statistically significantly different according to the place of employment and gender. Those employed in the public sector ($p=0.030$) and women reported a higher prevalence of musculoskeletal system-related complaints ($p=0.031$). It was observed that there was no significant correlation between the active working years of dentists and their awareness of ergonomic work, risk factors and Nordic musculoskeletal questionnaire results ($p>0.05$).

When compared according to educational status, specialised dentists reported that psychosocial factors among the risk factors affected their working status more ($p=0.009$).

As physicians aged, they reported greater familiarity with occupational health and specific diseases associated with particular work schedules ($p=0.046$, 0.016, 0.019). Furthermore, as the age of the physicians increased, they employed a greater number of auxiliary personnel ($p=0.000$).

Table 3: Participants' answers to the awareness section

	Yes	No		
1- Do you have information on ergonomics in the dental profession?	96.1% (n=99)	3.9% (n=4)		
2- Do you know the working position according to the watch dial?	87.4% (n=90)	12.6% (n=13)		
3- Are you aware of the occupational diseases specific to the dental profession?	86.4% (n=89)	13.6% (n=14)		
4- Do you have information on the most common musculoskeletal disorders in dentistry?	82.5% (n=85)	17.5% (n=18)		
5- Are you familiar with four-handed dentistry?	85.4% (n=88)	14.6% (n=15)		
6- Do you know the correct physician working posture?	94.2% (n=97)	5.8% (n=6)		
	Never	**Rarely**	**Mostly**	**Always**
7- Does ergonomic work affect fatigue and work stress?	0% (n=0)	6.8% (n=7)	49.5% (n=51)	43.7% (n=45)
8- Does ergonomic work affect accidents at work and occupational diseases?	0% (n=0)	9.7% (n=10)	60.2% (n=62)	30.1% (n=31)
9- Does ergonomics affect work efficiency and performance?	1% (n=1)	4.9% (n=5)	59.2% (n=61)	35.0% (n=36)
10- Are ergonomic conditions influenced by the anthropometric characteristics of the individual?	0% (n=0)	12.6% (n=13)	63.1% (n=65)	24.3% (n=25)

As the duration of active work increased, physicians indicated that they possessed greater knowledge of occupation-specific diseases and collaborated more frequently with auxiliary personnel (p=0.010, p=0.001).

Individuals with a BMI below 18.5 indicated that psychosocial factors had a greater impact on their working status. Physicians who reported an increase in their daily working hours indicated that the noise and vibrations associated with the instruments they used had a negative impact on their working comfort (p=0.045).

The results of the NMQ indicated that the majority of physicians reported experiencing neck (85.4%), shoulder (74.8%), back (87.4%), wrist (59.2%) and low back pain (80.6%) in the previous 12 months. Similarly, in the previous seven days, 59.2% of physicians reported experiencing pain in the neck, 50.5% in the shoulder, 57.3% in the back, and 50.5% in the lower back. Nevertheless, the proportion of respondents who reported negative effects on their ability to perform ordinary work was lower.

A statistically significant positive correlation was observed between age and BMI, as well as between the NMQ and the awareness section ($p < 0.05$).

The results of the linear regression analysis indicated that age and BMI values did not have a statistically significant effect on the NMQ.

DISCUSSION

Ergonomics is a discipline that aims to create a suitable work environment for employees. In the context of dentistry, ergonomics seeks to ensure that dentists adopt the correct working posture and that the equipment and environment are designed in a way that allows dentists to use them most effectively. In the field of dentistry, the successful implementation of ergonomic principles ensures that physicians and their employees perform their duties in a manner that does not compromise their health and physical well-being.[3] Moreover, by enhancing treatment standards, productivity and efficiency can be

optimised. The human body is not designed to maintain the same body position for an extended period of time. However, in instances where the working order is not aligned with ergonomic principles, dentists are compelled to adapt to a role that exceeds their physical capabilities. This usually occurs as a result of performing their profession with high concentration, long-term repetitive movements, and uncomfortable posture, and this causes occupational injuries.[17]

The NMQ was first introduced to the literature in 1987 and has since been employed in numerous national and international studies. The NMQ assesses musculoskeletal complaints in the back, neck, shoulders, and general areas with standardised questions. The NMQ is a self-administered or self-interviewed questionnaire that provides reliable information about discomforts in the last 12 months and seven days in nine specific symptom areas (feet-ankles, knees, thighs-hip, wrists-hands, waist, elbows, back, shoulders, neck).[16] It has been demonstrated to be a reproducible, sensitive, valid and reliable screening test in studies.[18]

The results of the NMQ in our study indicate that the majority of physicians reported experiencing neck, shoulder, back and low back pain in the short and long term. These results are consistent with those of previous studies indicating that dentists are exposed to mechanical stresses in their professional lives and are affected by musculoskeletal system problems due to a lack of application of ergonomic principles.[2,5] Furthermore, in our study, the complaints of dentists working in the public sector and women were found to be more pronounced according to the NMQ. These results can be explained by the fact that public sector employees have more intensive patient intake than private sector employees, they do not have enough time between patients, the psychosocial risk factors scores of public sector employees are 97% and there are physiological differences between men and women in terms of muscle strength, cardiovascular function, aerobic work capacity.[19,20]

The results of our study indicate that dentists possess sufficient knowledge about occupational ergonomics and the correct working position. However, approximately one-quarter of them treated patients while standing, 68.9% of them remained in the same position for extended periods, and 52.4% of them did not perform stretching movements or breathing exercises between patients. These results demonstrate that dentists possess knowledge regarding the subject matter. However, difficulties in implementing this knowledge may be attributed to a number of factors, including insufficient time allocated to dental treatments due to patient density, inadequate intervals between patients to facilitate stretching or breathing exercises for physicians, and clinical infrastructures that are not optimally designed from an ergonomic perspective.

Musculoskeletal disorders represent the primary cause of both short-term and permanent work disabilities, resulting in significant financial expenses due to human shortages and high treatment costs.[11] Although there are a number of recommendations for the treatment of musculoskeletal disorders, including exercise, heat application, drug treatments, massage and weight loss, the most important point is that the most ideal treatment is to take precautions before the disease occurs.[21]

The prevention of these damages begins with the adoption of an ergonomically appropriate working posture. During normal conditions, damaged tissues are repaired during rest. However, due to insufficient rest periods, the repairable stage is often passed. It is therefore evident that the personal awareness of dentists is of great importance in this regard. If a balance between work and rest can be established through awareness, ergonomic arrangements can be made in the clinics, regular exercise programmes can be implemented, correct posture and position strategies can be

applied, and appropriate working strategies can be developed. This will result in the prevention of damage, a reduction in cognitive and physical stress, an increase in productivity, quality and comfort, and the continuation of the dentist's profession successfully and healthily for many years.[3]

In our study, dentists stated that they knew more about occupation-specific diseases and worked with more auxiliary personnel as age and active working time increased. These results can be interpreted as the awareness of dentists about occupation-specific diseases increases with increasing age and active working time and they pay more attention to continue their professional life in this direction.

In our results specialised dentists reported that psychosocial factors affected their working status more. These results are consistent with the fact that a high percentage of specialised dentists are women and with the study which found that women have a higher score of psychosocial risk factors in their working environment than men.[19]

In our study, a statistically significant positive correlation was found between the NMQ and the awareness section ($p<0.05$). These results can be explained as the presence of a musculoskeletal disorder in dentists increases their awareness.

According to the results of regression analysis, it was found that age and BMI values had no statistically significant effect on the NMQ questionnaire. These results can be explained by the fact that the average age and BMI of the dentists participating in the study were not high.

Consequently, dentists must be cognizant of the ergonomic risk factors present in their work areas and implement ergonomic principles accordingly. This entails providing a suitable working environment, equipping the workplace with appropriate equipment, and formulating a rational work plan and time adjustment. In light of the aforementioned information, the present study sought to ascertain the knowledge and awareness levels of dentists working in the Sivas province regarding ergonomics awareness and occupational diseases that may result from work that is not aligned with ergonomic standards. The findings of this study indicate that dentists residing in Sivas province exhibit a lack of awareness regarding ergonomic work conditions and occupational musculoskeletal diseases. Furthermore, they demonstrate a limited ability to translate this knowledge into practice.

CONCLUSION

It has been established that there is a lack of awareness among dentists with regard to ergonomic working conditions and occupational musculoskeletal disorders. The enhancement of knowledge in this field will facilitate the formulation of recommendations that can be readily implemented in professional practice. Furthermore, it will provide a foundation for future studies on the design and production of ergonomically appropriate materials and equipment.

Ethical Approval

This study has been approved by the Non-Interventional Clinical Research Ethics Committee of Sivas Cumhuriyet University. (Decision No: 2023-12/48 Date: 21.12.2023)

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: ŞA, AK, Data collection and processing: ŞA, AK Analysis and interpretation: ŞA, Literature review: ŞA, Writing: ŞA.

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Changes in the Condyle After Orthognathic Surgery in Class II and Class III Patients: A Retrospective Three-Dimensional Study

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Orthognatic surgery, Temporomandibular joint, Cone-beam computed tomograpy

ABSTRACT

Aim: Orthognathic surgery (OGS) may cause or exacerbate temporomandibular joint (TMJ) disorders and affect mandibular stability. The aim of this retrospective study is to evaluate the changes in the mandibular condyle and ramal angles as a result of mandibular and/or maxiller advancement/set back surgeries in patients with Class ll and Class lll malocclusions after OGS.

Material and Methods: Cone Beam Computed Tomography (CBCT) records which obtained 25 skeletal Class ll (6 males and 19 females mean ages=26.28 ± 5.89 y) and 25 skeletal Class lll (10 males and 15 females mean ages=23.32 ± 3.89 y) who had undergone OGS was selected. CBCT images were evaluated before surgery (T0) and 6 months after surgery (T1) using ITK Snap software to evaluate the measurement of the ramus. Changes of the condylar head were measured in axial, sagittal, and coronal sections.

Results: After OGS the axial ramal angle decreased significantly in both Class ll (4.24°±4.68) and Class III (1.52°±3.1) groups (p<.05). Condylar length in the sagittal dimension decreased significantly (p<.05) also in both groups (Cl II= 0.68 mm, Cl III= 0.13 mm). As a result of our study, it was found that resorption occurred in the condylar length and mandibular the proximal segment rotated laterally after OGS.

Conclusion: It would be appropriate to evaluate Class II and Class III patients who are planned to undergo OGS in terms of TMJ dysfunction before and after surgery.

Sınıf II ve Sınıf III Hastalarda Ortognatik Cerrahi Sonrası Kondil Değişiklikleri: Retrospektif Üç Boyutlu Çalışma

Makale Bilgisi

Makale Geçmişi

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Anahtar Kelimeler:
Ortognatik cerrahi, Temporomandibular eklem, Cone-beam bilgisayarlı tomografi

ÖZET

Amaç: Ortognatik cerrahi (OGC) temporomandibular eklem (TME) bozukluklarına neden olabilir veya şiddetlendirebilir ve mandibular stabiliteyi etkileyebilir. Bu retrospektif çalışmanın amacı, Sınıf II ve Sınıf III maloklüzyonlu hastalarda OGC sonrası mandibular ve/veya maksiller ilerletme/geri alma ameliyatları sonucu mandibular kondil ve ramal açılarda meydana gelen değişiklikleri değerlendirmektir.

Gereç ve Yöntemler: OGC geçirmiş olan 25 iskeletsel Sınıf II (6 erkek ve 19 kadın ortalama yaş=26,28 ± 5,89 y) ve 25 iskeletsel Sınıf III (10 erkek ve 15 kadın ortalama yaş=23,32 ± 3,89 y) hastaya ait Konik Işınlı Bilgisayarlı Tomografi (KIBT) kayıtları seçildi. Ramus yüksekliği, uzunluğu, genişliği ve açısını ölçmek için KIBT görüntüleri ameliyattan önce (T0) ve ameliyattan 6 ay sonra (T1) ITK Snap yazılımı kullanılarak değerlendirildi. Kondil başındaki değişiklikler aksiyal, sagittal ve koronal kesitlerde ölçüldü. Gruplar arasındaki verilerin karşılaştırılmasında bağımsız t testi, grup içi korelasyonun değerlendirilmesinde Pearson korelasyon testi kullanıldı.

Bulgular: OGC sonrası aksiyel ramal açı hem Sınıf II (4,24°±4,68) hem de Sınıf III (1,52°±3,1) gruplarında anlamlı derecede azaldı (p<,05). Sagital düzlemdeki kondiler uzunluk her iki grupta da anlamlı derecede azaldı (p<,05) (Cl II= 0,68 mm, Cl III= 0,13 mm). Bu çalışma sonucunda OGC sonrasında kondil uzunluğunda rezorpsiyon meydana geldiği ve mandibular proksimal segmentin laterale rotasyon yaptığı tespit edildi.

Sonuçlar: OGC yapılması planlanan Sınıf II ve Sınıf III hastaların cerrahi öncesi ve sonrasında TME disfonksiyon açısından değerlendirilmesi uygun olacaktır.

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INTRODUCTION

Over /Under-developed jaw growth may cause dentofacial deformities. It is necessary to undergo combined surgical and orthodontic treatment when the disagreement is beyond the range of orthodontic camouflage due to patient's requests for aesthetics and achieving an ideal occlusion with superordinate treatment outcomes and stability. [1] Orthognathic surgery (OGS) is a method of maxillomandibular deformity correction related to dental occlusion by osteotomy or replacing of the mandible and maxilla, in order to achieve optimal dental occlusion and facial aesthetic. These surgical procedures have an impact on the condylar region, which includes the temporomandibular joints (TMJ) and mandibular condyles. Evaluating craniofacial structures is a crucial part of orthognathic diagnosis. OGS is commonly used to treat individuals with Class II (Cl II) or Class III (Cl III) malocclusion and skeletal abnormalities.[2]

3D images have progressively utilized in clinical settings for the demonstration of hard and soft tissues.[3] Measuring 3D models of pre-operative and post-operative in Cone beam computed tomography (CBCT) has been used for 30 years to evaluate post-operative stability and morphological changes of TMJ.[1] Particularly, CBCT monitors both soft and hard tissues; for this reason, it is becoming more frequently used in the evaluation of operative consequences and the facial aesthetic changes generated by OGS.[4,5] By controlling the condyle position, the surgical procedure can be planned more accurately with Computer-aided design and computer-aided manufacturing (CAD/CAM) technologies.[6] In additional, various 3D imaging programs facilitate clinical experts in predicting post-surgical skeletal, dental and condylar outcomes. 3D based volumetric methods have been latterly used to measure post-operative outcomes to cope with the limitations of linear evaluation.[3]

Changed jaw position can cause or aggravate TMJ disorders and mandibular stability can affected have been found by many scientist.[7-9] The condylar repositioning during fixation is one of the challenges of OGS.[1] The post-surgical changes in the condyle morphologically and also stability of operation are thought to result from the post-operative condylar position.[1] Despite the fact that the reason for post-operative resorption of condyle remains unknown, most effective way for reducing post-operative TMJ symptoms is retaining the condylar head position physiologically and minimizing intra-operative movement of condyle.[10,11] One of the effective factors to relapse is the used fixation method for bone fragments, and the positioning of the proximal segment, including the mandibular condyle, is the most substantial factor affecting skeletal stability and relapse after OGS.[12] However, dissimilar recording algorithms and segmentation methods have been adopted by previous studies; therefore, a consensus on this matter is hard to achieve regarding post-operative changes in position of TMJ and morphology of condyle.[8,13-16] Furthermore, the nature of the tendency to resorption of condyle after OGS can be varied between skeletal Cl II and Cl III patients markedly, and these differences have been mentioned by very few studies.[10,11,13]

The aim of this retrospective study is assessment of the changes in the mandibular condyle region as a result of mandibular movement differences in patients with different malocclusions after OGS.

MATERIALS AND METHODS

This retrospective study was conducted and received approval from the Research Ethics Committee of Nevşehir Hacı Bektaş Veli Üniversitesi University with decision number 2023.07.05. Written informed consent documents were obtained from the all patients.

G Power 3.1.9.2 (Heinrich-Heine-Universidad Düsseldorf, Düsseldorf, Germany) with an alpha significance level of 95% to detect a minimum between-group difference of 0.94 mm with a standard deviation of 1.40 was used to figure out the effective sample size was determined through a power analysis conducted for linear regression and sample size. The analysis showed that minimum 50 samples would be necessary for an α of 0.05 and a power of 0.95. However, in order to ensure that the results of the study are more reliable, it is planned to include data from at 50 patients in total.

Patient selection criteria

This study was based on CBCT records of 50 adult patients (34 females, 16 males) with skeletal Cl II (6 males and 19 females; mean age during the surgery: 26.28 ± 5.89 years) and Cl III (10 males and 15 females; mean age during the surgery: 23.32 ± 3.89 years) malocclusions selected from the archives of İstanbul Medipol Univercity, Faculty of Dentistry and who had undergone OGS from 2018 to 2023. The patient age ranged from 17-44 years, with a mean age of 24.8 ± 5.16 years at the time of operation.

The inclusion criteria were as follows:

- Group 1: Adult Skeletal Cl III patients (SNB > 80°, Wits < -1 mm),
- Group 2: Adult Skeletal Cl II patients (SNA>84°, Wits > 2 mm),
- Normal vertical growth pattern (total angle: 396 ± 3°(gonial, saddle, and articular angle)),
- For group 1, bilateral sagittal split ramus osteotomy mandibular setback and/or Le Fort I maxillary advancement surgery,
- For group 2, bilateral sagittal split ramus osteotomy mandibular advancement and/or Le Fort I maxillary impaction setback surgery,
- The availability of pre (T0: just before surgery) and post (T1: approximately 6 months after surgery) operative CBCT images.

The exclusion criteria were; pregnancy, severe mandibular asymmetry, congenital anomalies or genetic syndrome, severe maxillofacial trauma history and TMJ dysfunction.

The surgical plans encompassed both single jaw and bimaxillary surgeries. Within both the Cl III and Cl II groups, 23 patients underwent bimaxillary surgery, while 2 patients in each group underwent mandibular sagittal split osteotomy exclusively (Table 1).

Table 1 Age, sex, type of malocclusion, and surgical method for all included patients.

	Cl II (C2) group, n=25	**Cl III (C3) group, n=25**
Average age	26.28 ± 5.89 y	23.32 ± 3.89 y
Male	6	10
Female	19	15
One-jaw approach	2	2
Two-jaw approach	23	23
Surgery with genioplasty	14	9

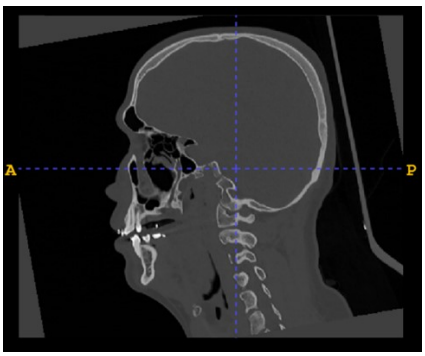
Image Acquisition and Measurements

All CBCT images were assessed at two time points: before surgery (T0) and 6 months after surgery (T1). The CBCT images were acquired using the MSCT, Philips Brilliance ICT 256 (Philips Medical Systems, Eindhoven, the Netherlands), with scan settings of 120 kV and 150 mAs. Subsequently, the images were transferred to ITK-SNAP software (version 4.0.1; open-source software available at http://www.itksnap.org/pmwiki/pmwiki.php) for analysis.

To ensure consistency in image orientation, the Frankfort horizontal plane was positioned parallel to the floor on sagittal images, while the midline was arranged to pass between the anterior nasal spine and posterior nasal spine on axial images (Figure 1). Initially, a head mask with a threshold value for bone structures (minimum 226, maximum 3071 Hounsfield units) was generated. Subsequently, the mandibular condylar region was delineated from the cranial base in three sections (axial,

sagittal, and coronal) using a manual editing tool.

Fig 1: Head position orientation during measurements of CBCT images



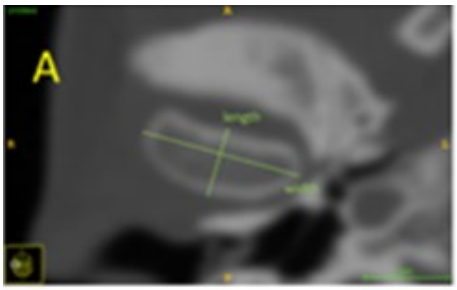
The 3D reconstruction of the condyle was assessed as the area between the line (C plane) passing parallel to the Frankfort horizontal plane from the sigmoid line and the perpendicular passing through the lowest endpoint of the tuberculum articulare. To minimize the influence of potential position changes post-operative, linear measurements were conducted by measuring direct distances.

Measurements, including height, length, width (Figure 2), ramal angular changes (Figure 3), and volume of the condylar head (Figure 4), were obtained in axial, sagittal, and coronal sections. Individual evaluations were performed separately for the right and left condyle in the images captured at T0 and T1 for each patient. Subsequently, the average of these measurements was calculated. The discrepancies between the obtained values at T0 and T1 were then compared for analysis. Additionally, the maxillary advancement, mandibular setback/advancement amounts were evaluated as the horizontal displacement of point A and B relative to the true vertical line passing through the Sella point.

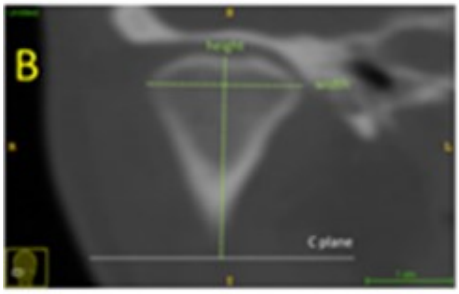
Statistical Analysis

The average rates of movement for soft and hard tissues were measured across the 10 facial regions of each patient. For reliability testing, all measurements were repeated twice with an interval of 15 days for 10 randomly selected patients. An investigation was conducted to explore the relationship between changes in soft tissue and movements in the underlying hard tissue using Scatter plots. For each corresponding pair, the Pearson correlation parameter was calculated.

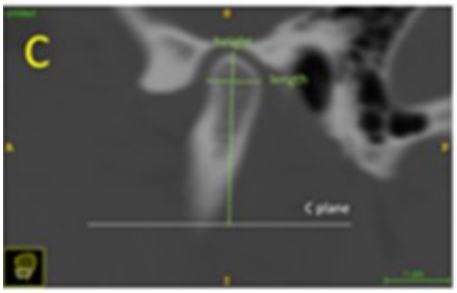
Fig 2: Measurement of condylar linear changes



A, width and length on the axial section; The width between the medial pole and the lateral pole at the axial section at the level of its greatest geometric dimension, the length between the anterior pole and the posterior pole at the axial section at the level of its greatest geometric dimension.



B, width and height on the coronal section; The width between the medial pole and the lateral pole at the coronal section at the level of its greatest geometric dimension, the distance between the highest point of the condylar head to the C plane at the coronal section at the level of its greatest geometric dimension.

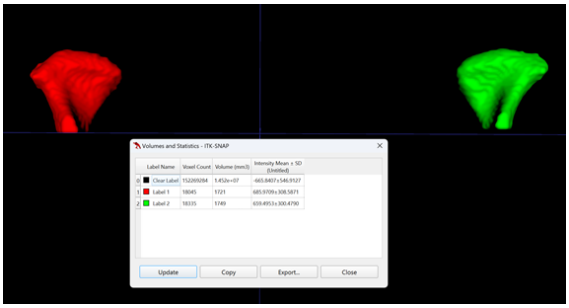


C, length and height on the sagittal section; The length between the most forward and backward points of the condylar head at the sagittal section at the level of its greatest geometric dimension, the distance from the highest point of the condylar head to the C plane at the sagittal section at the level of its greatest geometric dimension.

Fig 3: Measurements of angular changes from CBCT.

A, axial ramal angle; Angular changes from the ascending ramus to the midsagittal plane at the axial section at the level of its greatest M-D dimension
B, sagittal condylar angle; Angular changes from the condylar axis (the line connecting the center of the condylar head and the center of the condylar neck) to the Frankfort horizontal plane at the sagittal section at the level of its greatest length
C, coronal ramal angle; Angular changes from the ascending ramus to the Frankfort horizontal plane at the coronal section at the level of its greatest vertical ramus height.

Fig 4: Volumetric evaluation of the condylar head



The data were analyzed using IBM SPSS V23. The Shapiro-Wilk Test was used to evaluate the normality of distribution. Independent Sample t-test was used to compare normally distributed parameters between groups, whereas the Mann-Whitney U Test was utilized for those not conforming to normal distribution. The relationship between parameters that showed normal distribution was examined using Pearson's Correlation Coefficient, while Spearman's rho Correlation Coefficient was used for parameters that did not distribute normally. The significance level was determined as $p<0.05$.

RESULTS

Angular and volumetric changes in Cl II and Cl III groups are shown in Table 2. While the axial ramal angle decreased in both groups, the coronal ramal and sagittal condylar angles increased. The amount of axial ramal angle decrease and coronal ramal increase were found to be statistically significant in the Cl III group (p: 0.020, p: 0.020 sequentially). The changes in both groups for axial width and coronal width increased, while decreases were observed in other morphological measurements. Coronal width increase amount was significant in the Cl II group (p: 0.034). In both groups, condylar volume decreased after OGS, however, the difference between the groups was not found significantly.

Table 2 Comparison of angular and volumetric changes between Cl II and Cl II group from T0 to T1

	Cl II Mean (SD)	Cl III Mean (SD)	p
Axial Ramal Angle	4.24 (4.68)	1.52 (3.1)	**0.020***
Coronal Ramal Angle	-0.26 (3.53)	-0.35 (2.98)	**0.020***
Sagittal Condylar Angle	-0.3 (4.83)	-0.29 (4.48)	0.996
Axial Width	-0.18 (0.81)	-0.26 (0.46)	0.654
Axial Length	0.21 (0.63)	0.14 (0.43)	0.628
Coronal Width	-0.53 (1.16)	-0.1 (0.87)	**0.034****
Coronal Height	0.16 (1.52)	0.57 (1.15)	0.116
Sagittal Length	0.68 (1.23)	0.14 (0.41)	0.103
Sagittal Height	0 (1.8)	0.71 (1.44)	0.107
Condylar Volume	90.65 (176.02)	97.92 (176.24)	0.594

SD standard deviation, Statistically significant at $p < 0.05$, *Independent t test, **Mann Whitney U test

Table 3 shows that there was a statistically insignificant correlation between condylar volume and angular changes in Cl II and Cl III groups. There is a moderate positive significant correlation between the change in sagittal condylar angle and the displacement of point A in both Cl II and Cl III groups. There is a strong positive significant correlation between

the change in sagittal condylar angle and the displacement of point B in the Cl III group. Additionally, there is a moderate positive significant correlation between sagittal height and the displacement of points A and B in the Cl II group (Table 4).

Table 3 Comparison of angular changes between Cl III and Cl II group from T0 to T1 in Condylar volume

	Condylar Volume			
	Class II		Class III	
	r*	p	r**	p
Axial Ramal Angle	-0.149*	0.476	0.110**	0.601
Coronal Ramal Angle	0.040*	0.851	-0.180**	0.388
Sagittal Condylar Angle	0.092*	0.661	-0.136**	0.517

Statistically significant at $p < 0.05$, *Spearman's rho correlation coefficient; **Pearson correlation coefficient

DISCUSSION

The common effects of OGS on the mandibular condyles are remodeling and displacement. Due to a physiological adaptation period of the TMJ, it can cause significant major results related to occlusion.[8] The resorption process, which causes volumetric change in the condyle, begins with the exceeding of TMJ adaptation capacity.[8,17] OGS may be one of the triggering factors for condylar resorption[8], particularly in Cl II patients, if rigid fixation is applied.[18]

The application of different recording protocols in CBCT studies may affect the observed morphological changes.[1] Registration, segmentation, and analysis were identified as essential steps in the analysis of condyle by a recent literature review.[15] In order to designate volume of condyle in CBCT evaluations, different methods have been suggested antecedently.[8] Bayram et al. used a planimetry method in CBCT examinations to test the accuracy of volume analysis of the mandibular condyle.[19] Dolphin 3D Imaging software (Dolphin Imaging and Management Solutions) was used by Goulart et al.[20] and V-Works 4.0 imaging software (Cybermed Inc., Seoul, Korea) was used by Schlueter et al.[21] using various Hounsfield unit window widths. All these methods have been shown to be dependable for assessing condylar volume[8], and could have been used in this study with some minor revisions. ITK-SNAP software was used to evaluate tomography images. The images were oriented so that the Frankfort horizontal plane was parallel to the ground in sagittal sections. DICOM datasets were investigated in sagittal, coronal, axial slices, and 3D reconstruction. Right and left condyle CBCT images of each patient taken at T0 and T1 measurements were made separately and then the average of these measurements was used for evaluation. The right and left condyle TMJs are structures connected by a single bone that work simultaneously. Nevertheless, there may be differences in a particular bone resorption or remodeling period for each condyle because of the variational amounts of stress. In this bilateral difference, chewing habits may be a key point, because the used side of the condyle is subjected to lower loads than the opposite side condyle.[8,22] Consistent with previous studies, it was determined that 19 of the patients had resorption in one of the condyles and apposition in the other according to volumetric evaluation. No correlation has been found between the right and left sides in terms of volume changes previously. [8,23] Associated with these results, right and left condyle were measured separately but were not evaluated in relation to each other's.

Da Silva et al.[8] employed a combination of Dolphin 3D Imaging and ITK-SNAP to integrate functionalities from two software applications. The segmentation tool in Dolphin 3D heavily relies on the thresholding of bone voxel values and the suppression of surrounding tissues.[20] The ITK-SNAP software segmentation tool was better than Dolphin 3D to enhance the precision of volume measurements.[8] ITK SNAP software made it

possible to segment condyles using the "zone competition" approach, which achieves a more precise measurement by demarcating the volume within the condyle and minimizing the effect of the threshold and surrounding tissues.[8] Due to the evaluation and standardization advantages, in this study measurements were completed with The ITK-SNAP software instead of Dolphin 3D.

Previous examinations have shown the reduction of the mandibular condyles in mean volume was statistically significant.[8] Similar volumetric reductions were found in our study, however, this finding was statistically insignificant (p=0.59). Even though it has been found that the resorption period is more remarkable in Cl II group performed bimaxillary surgery previously,[8,24] the amount of resorption is higher in Cl III patients (97.92±176.24mm³) in the present study. While 25 of the patients had a volume decrease in both condyles, 6 patients had a volume increase in both condyles. Even though the basic expectation in adult subjects is to result in endochondral growth, these findings may indicate that the condyle can form new bone after repositioning through an adaptive biomechanical process.[25] Further investigations with extended follow-up periods following OGS are necessary to substantiate this hypothesis.

The axial and coronal width for both Cl II and Cl III groups increased in our study and was supported by Me´ndez-Manjo´n et al.[26] who showed the supreme changes in the lateral and posterior side of the condyle in the right after OSG. While the coronal width increase was statistically significant, the axial width increase was not statistically significant in this study. Kim et al. [27] also found similar findings that the condyles are directed more posteriorly in the post-surgical period, but in the following periods return to position originally. However, Li-Fang Hsu et al.[1] found axial condylar length and width both reduction were statistically significant, which was similar to our study in axial length evaluation. But also this result was statistically insignificant for each group. Post-operative localized resorption or bone remodeling at the condyle was indicated by previous researchers. In the condylar height Li-Fang Hsu et al.[1] observed similar non-significant reduction. It has been shown that in most cases there may be little or no change, or even an increase in volume.[8] In accordance with previous studies[28], no significant correlation was found between the distance of jaw movement and condylar changes.

Despite the comprehensive analysis conducted in this study, several limitations should be acknowledged. The relatively small sample size in this retrospective study might limit the generalizability of the findings. Further studies with larger cohorts could provide more robust conclusions. The follow-up period of approximately 6 months after surgery might not capture long-term changes in condylar morphology and volume. Longer follow-up durations are essential to assess the stability of surgical outcomes over time. The fact that this study was performed in a single institution may limit the diversity of patient characteristics and surgical techniques. Polycentric studies involving diverse patient populations could enhance the external validity of the results. Although cone beam computed tomography (CBCT) imaging was utilized for analysis, variations in imaging protocols and segmentation techniques could introduce variability in the measurements. Standardization of imaging protocols and analysis methods could mitigate these limitations. The lack of a control group, such as patients undergoing orthodontic treatment without OGS, limits the ability to directly compare the effects of surgery versus non-surgical interventions on condylar morphology.

While various statistical analyses were employed, other advanced techniques, such as finite element analysis or machine learning algorithms, could provide deeper insights into the complex relationships between surgical interventions and condylar changes. This study relied on retrospective analysis of patient data, and ethical considerations regarding patient privacy and consent were addressed. However, retrospective studies inherently carry limitations in data availability and quality compared to prospective studies. Further research that takes these limitations into account will contribute to a more detailed determination of the impact of OGS on condyle morphology and patient outcomes.

CONCLUSION

In conclusion, although in this study an insignificant reduction in mean condyle volume was found after OGS in both Cl II and Cl III groups, the changes in the dimensional measurement of condyle may be different from each other. Further research seems necessary to compare patients with surgery first and after orthodontic treatment surgery to evaluate whether condylar resorption is due to orthodontics or surgery.

Ethical Approval

This study has been approved by the Non-Pharmaceutical and Medical Device Ethics Committee of Nevşehir Hacı Bektaş Veli University with decision number 2023.07.05.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: KKD, Data collection and processing: HY Analysis and interpretation: ÖB, Literature review: SB, Writing: SB.

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Effects of Whitening Mouthrinses on the Color Recovery of One-shade and Multi-shade Stained Composite Resins

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ABSTRACT

Aim: The aim of the present study was to evaluate the efficacy of mouthrinses on the color recovery of stained one-shade (Charisma Topaz One [CTO]) and multi-shade (Estelite Sigma Quick [ESQ]) composite resins.

Methodology: Sixty disc-shaped specimens (8-mm diameterx2-mm thickness) were prepared (n=30 for each composit resin). After polishing (Sof-Lex), the specimens were stored in 37°C for 24h. The specimens were stained by coffee immersion for 168h at 37°C, and then randomized into three subgroups based on the type of mouthrinse (n=10): LAW: Listerine Advanced White; CPWC: Colgate Plax White+Charcoal Capitano Whitening; LTC: Listerine Total Care. Colorimetric measurements were performed at baseline (T0), after staining (T1) and after mouthrinse immersion for 12h at 37°C (T2) with a spectrophotometer (VITA Easy shade). CIELab parameters were used for the analysis. Color change expressed by ΔE and ΔL, Δa, Δb were calculated. The data were subjected to two-way ANOVA, post hoc Tukey, Student t tests ($p<0.05$).

Results: All samples demonstrated clinically unacceptable color change after coffee-discoloration (ΔE>3.3). CTO showed significantly higher ΔE (12.16±1.37) than ESQ (7.48±0.95) ($p=0.001$). The mouthrinses led to a distinct increase in the L and decrease in the a and b after staining. LAW and CPWC resulted in significant differences in ΔL ($p=0.001$), Δb ($p=0.031$) and ΔE ($p=0.002$) of ESQ, while causing significant difference in Δb of CTO ($p=0.037$) at T2-T0.

Conclusion: Whitening mouthrinse may reduce the discoloration of coffee-stained composite resins, but not match the initial colour. It provides a better whitening effect in multi-shade composite resin than one-shade composite resins.

Ağartma Etkili Ağız Gargaralarının Renklendirilmiş Tek-renk ve Çoklu-renk Sistemli Kompozit Rezinlerin Renk Geri Kazanımı Üzerine Etkileri

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ÖZET

Amaç: Bu çalışmanın amacı, ağartma etkili ağız gargaralarının renklendirilmiş tek-renk (Charisma Topaz One [CTO]) ve çoklu-renk sistemli (Estelite Sigma Quick [ESQ]) kompozit rezinlerin renk geri kazanımı üzerine etkilerini değerlendirmektir.

Gereç ve Yöntemler: 60 adet disk şeklinde (8 mm çap x 2 mm kalınlık) örnekler hazırlandı (her bir kompozit reçine için n=30). Örnekler, cilalandıktan (Sof-Lex) sonra 24 saat 37°C'de saklandı. Sonrasında 37°C'de 168 saat kahve solüsyonunda renklendirildi ve ardından ağız gargaralarına göre rastgele üç alt gruba ayrıldı (n=10): LAW: Listerine Advanced White; CPWC: Colgate Plax White+Charcoal Capitano Whitening; LTC: Listerine Total Care. Renk ölçümleri başlangıçta (T0), kahvede reklendirme sonrası (T1) ve 37°C'de 12 saat ağız gargarasında bekletildikten sonra (T2) spektrofotometre cihazı (VITA Easy shade) ile gerçekleştirildi. Analizler için CIELab parametreleri kullanıldı. Renk değişimlerini belirlemek için ΔE ve ΔL, Δa, Δb hesaplandı. Veriler two-way ANOVA, post hoc Tukey, Student t testleri ile analiz edildi ($p<0,05$).

Bulgular: Kahve ile renklendirme sonrası tüm örneklerde klinik olarak kabul edilemez (ΔE>3,3) renk değişiklikleri saptanmış olup CTO kompozit rezinin ΔE değeri (12,16±1,37) ESQ' den (7,48±0,95) anlamlı düzeyde yüksektir ($p=0,001$). Renklendirme sonrasında ağız gargaraları, L'de belirgin bir artışa, a ve b parametrelerinde azalmaya neden olmuştur. LAW ve CPWC, ESQ kompozit rezinin ΔL ($p=0,001$), Δb($p=0,031$) ve ΔE ($p=0,002$) değerlerinde anlamlı farklılığa neden olurken CTO kompozit rezinin Δb ($p=0,037$) değerinde anlamlı farklılık göstermiştir.

Sonuç: Ağartma etkili ağız gargaraları, kompozit rezinlerin kahve renklenmelerini azaltsa da başlangıç renk değerlerine ulaştıramamaktadır. Çoklu-renk kompozitlerin rengini geri kazandırmada tek-renk kompozitlere göre daha iyi bir beyazlatma sağlamaktadır

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INTRODUCTION

The structural and optical matching of the restorative material with the tooth structure and adjacent teeth plays a critical role in achieving an esthetically result. Multi-shade layering techniques using composite resins (CRs) of various opacities as well as colors have been demonstrated to imitate the natural tooth appearance. Restorative dentistry requires a high level of technical skill and accurate shade matching, frequently increasing the time spent in the chair and the cost of treatment.[1-2] A new concept of 'monochromatic' or 'one-shade' CRs has recently been developed to describe resin-based composites formulated to esthetically simulate all shades with a single nominal shade by a color adjustment potential or blending effect (BE).[3-4] The BE is believed to be caused by the change in shade due to the reflection from the surrounding dentition and is influenced by the translucency parameter and the size of the cavity.[5] One-shade CRs based on this principle aim to simplify shade selection, minimize technical sensitivity, and reduce treatment time.[6] Despite these advantages, studies have addressed concerns about color stability and vulnerability to staining from beverages.[7-12]

Discoloration of CRs is an undesirable, although unavoidable, effect in the oral environment. Several factors can affect the color match, including the composition and size of the filler and the matrix structure, the size of the restoration, the placement of the CR, and the color and brand of the CR.[13] Additionally, discoloration can be attributed by external factors, such as plaque accumulation, tobacco, diet, oral care and internal factors related to the characteristics of the teeth, and resin.[14]

Tooth whitening is a cosmetic, safe and effective dental treatment. Non-professional bleaching products such as over-the-counter strips, pens, mouthrinses and toothpastes are available for use.[15] Mouthrinses have gained popularity for both plaque removal and teeth whitening due to their price, accessibility and simplicity. They contain a whitening agent that creates an optical illusion of whiter teeth.[16] However, the efficacy of whitening mouthrinses is often debated due to insufficient evidence on the effect of CRs. Therefore, this in vitro study aims to evaluate the effects of whitening mouthrinses on the color recovery of stained one-shade and multi-shade CRs. The hypotheses tested were that: (1) There would be no significant difference in the discoloration of between the CRs after immersion in the coffee solution. (2) There would be an efficacy of whitening mouthrinses in terms of color recovery of CRs.

MATERIAL AND METHODS:

One-shade (Charisma Topaz One [CTO], Heraus Kulzer) and multi-shade (Estelite Sigma Quick [ESQ], Tokuyama) CRs were used in this *in vitro* study (Table 1). Thirty disc-shaped specimens from each CR were prepared using teflon molds of 8-mm diameter x 2-mm thickness (N = 30 for each composite type). Moulds were placed on a microscopic slide, filled with CR, covered with a mylar strip and compressed with a second slide. After light-curing (Elipar S10; 3M ESPE), top surfaces of the samples were polished with Sof-Lex disc (3M ESPE), rinsed with distilled water for 30 s, blot-dried with paper towels and stored in distilled water at 37°C for 24 h. Color measurement of the all specimens was then performed at baseline (T0).

The samples were stained with coffee solution by 3.6 g of powder (Nescafe Classic, Nestl´e) in 300 ml of boiling distilled water. After being filtered, the specimens were incubated in coffee solution, which was refreshed daily, for 168 h at 37°C, equivalent to six months of clinical ageing in vivo. Then, gently rinsed and air-dried before a second color measurement (T1). After, randomized into three subgroups based on the type of mouthrinse used

(n=10): Two of them have a whitening effect- Listerine Advanced White (LAW) and Colgate Plax White+Charcoal (CPWC)- and the other has most complete effect- Listerine Total Care (LTC) (Table 2). The samples were immersed in 20 mL of the relevant mouthrinses for 12 hours in an incubator set at 37°C, and then rinsed with distilled water for 10 sec. and dried with towel paper. Then a third color measurement was done (T2). A spectrophotometer (VITA Easy shade, Vita Zahnfabrik, Germany) was used to record the CIE L*a*b* parameters on a gray ceramic background. The colorimetry procedures were carried out at baseline (T0), after staining (T1), and after using the mouthrinse (T2).

Table 1. The composition and manufacturer of the composite resins

Material	Type	Content	Filler load	Batch number
Charisma Topaz One- [CTO] Heraeus Kulzer, Hanau, Germany.	Nanohybrid	Matrix: TCD-DI-HEA UDMA, TEGDMA Filler: Silica -Barium aluminium fluoride glass filler (5 nm-5 µm) - Titanium dioksit	Wt.74% Vol 59%	E8743
Estelite Σ Sigma Quick [ESQ] Tokuyama Dental, Tokyo, Japan	Supra-nanohybrid	Matrix: BIS-GMA, TEGDMA, photoinitiators Filler: Silica-zirconia, silica-titania	Wt. 82% Vol 71%	K010201

Table 2. Details of Tested Whitening Mouthrinses

Mouthrinse	**Composition**
Listerine Advanced White [LAW] Johnson&Johnson SPA Pomezia, Italy	Aqua, Sorbitol, Propylene Glycol, Tetrapotassium Pyrophosphate, Pentasodium Triphosphate, Citric Acid, Poloxamer 407, Aroma, Sodium Methyl Cocoyl Taurate, Caprylyl Glycol, Eucalyptol, Thymol, Sodium Saccharin, Menthol, Sodium Fluoride, Sucralose.
Colgate Plax White+ Charcoal [CPWC] Colgate Palmolive, İstanbul, Türkiye	Aqua, Glycerin, Propylene Glycol, Sorbitol, Tetrapotassium Pyrophosphate, Polysorbate 20, Tetrasodium Pyrophosphate, Zinc Citrate, PVM/MA Copolymer, Aroma, Benzyl Alcohol, Sodium Fluoride, Sodium Saccharin, Bambusa Vulgaris Shoot Extract, Charcoal Powder
Listerine Total Care [LTC] Johnson&Johnson SPA Pomezia, Italy	Water (Aqua), Sorbitol, Propylene glycol, Poloxamer 407, Sodium sulfate, Phosphoric acid, Eucalyptol, Methyl salicylate, Thymol, Sodium benzoate, Sodium saccharin, Menthol, Sucralose, Disodium phosphate, Hydrogen peroxide

The CIELab system is composed of three axes: L* is the lightness from 0 (black) to 100 (white), a* is the red (+a) and green (−a), and b* is the blue (−b) and yellow (+b). The color change (ΔE*) was calculated using the equation:

$$\Delta E^*_{ab} = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

$\Delta L^* = L$ (after) – L (before);

$\Delta a^* = a$ (after) – a (before);

$\Delta b^* = b$ (after) – b (before)

Statistical Analysis: IBM SPSS Statistics 22 was used for statistical analysis of the results obtained in the study. After the determination that the parameters had a normal distribution, the Student t test was used between the parameters of the composite groups. Two-way ANOVA test and post hoc Tukey test were used for composites and mouthrinses. Significance was assessed at $p<0.05$ level.

RESULTS:

The mean color changes in ΔE and standart deviation (SD) of the color parameters ΔL*, Δa* and Δb* at all time periods are shown in Tables 3, 4, 5.

In the current research, the immersion in coffee solution resulted in a decrease of L and an increase of a and b values. Statistical analysis showed significant differences between the composite resins. The statistically highest color changes ΔE01, ΔL, Δa, Δb were obtained in the CTO group ($p<0.05$). (Table 3).

Table 3. Means and standard deviations of color changes after immersion in the coffee solution

	ESQ	CTO	
Baseline-Staining T1-T0	Mean ± SD	Mean ± SD	**p**
ΔL	-6.45±0.75	-9.61±1.21	0.001*
Δa	1.74±0.28	2.96±0.37	0.001*
Δb	3.29±0.92	6.78±1.03	0.001*
ΔE	7.48±0.95	12.16±1.37	0.001*

Student t test *p<0.05

In the T2-T1 period; there was a statistically significant difference between composites and among mouthrinses in terms of mean ΔL (p:0.012; p:0.048); Δa (p:0.001; p:0.024); Δb (p:0.003; p:0.003) at T2-T1 period. There was a statistically significant difference between composites in terms of mean ΔE in T2-T1 period (p:0.001) (Table 4). The interaction effect of CR and mouthrinses on the average ΔL, Δa, Δb was not statistically significant (p:0.206; p>0.05).

For the T2-T0 period; Two-way ANOVA tests, revealed significant differences between the composite resins for ΔL, Δa, Δb parameters (p=0.001), and among the mouthrinses for ΔL and Δb parameters (p:0.038 and p:0.002). Based on the ΔE; no differences were found among the mouthrinses (p=0.110) and no significant composite-mouthrinses interactions (p=0.114). However, statistically difference was found between the composite resins (p =0.001) (Table 5).

Table 4. Means and standard deviations of color changes at T2-T1

Mouthrinse-Staining		**ESQ**	**CTO**	
(T2-T1)		**Mean±SD**	**Mean±SD**	**p**
ΔL	LAW	3.73±0.64	3.99±3.22	0.840
	CPWC	3.11±0.75	4.36±1.76	0.111
	LTC	1.21±0.60	3.69±0.90	0.001*
	p	0.001*	0.848	
Δa	LAW	-1.13±0.24	-1.56±0.28	0.010*
	CPWC	-0.90±0.28	-1.69±0.42	0.001*
	LTC	-0.77±0.26	-1.29±0.34	0.008*
	p	0.058	0.126	
Δb	LAW	-2.51±0.67	-3.04±0.41	0.100
	CPWC	-1.54±0.61	-2.19±1.12	0.205
	LTC	-2.29±0.91	-3.47±0.93	0.033*
	p	0.060	0.038*	
ΔE	LAW	4.65±0.87	5.71±2.17	0.253
	CPWC	3.61±0.91	5.22±1.95	0.072
	LTC	2.72±1.06	5.30±0.95	0.001*
	p	0.005*	0.854	

Two-way ANOVA Test *p<0.05

Table 5. Means and standard deviations of color changes at T2-T0

Mouthrinse-Baseline		**ESQ**	**CTO**	
(T2-T0)		**Mean±SD**	**Mean±SD**	**p**
ΔL	LAW	-3.06±0.32	-5.16±2.53	0.045*
	CPWC	-3.19±0.23	-5.80±1.03	0.001*
	LTC	-5.06±1.26	-5.86±1.47	0.296
	p	0.001*	0.723	
Δa	LAW	0.73±0.15	1.26±0.24	0.001*
	CPWC	0.80±0.13	1.46±0.41	0.005*
	LTC	0.89±0.50	1.64±0.33	0.006*
	p	0.646	0.121	
Δb	LAW	1.29±0.64	3.67±0.92	0.001*
	CPWC	1.60±0.39	4.63±0.37	0.001*
	LTC	0.63±0.81	3.34±1.17	0.001*
	p	0.031*	0.037*	
ΔE	LAW	3.43±0.54	6.63±2.15	0.002*
	CPWC	3.67±0.31	7.58±1.06	0.001*
	LTC	5.22±1.39	7.01±1.59	0.045*
	p	0.002*	0.573	

Two-way ANOVA Test *p<0.05

DISCUSSION

The present study evaluated the efficacy of whitening mouthrinses on the color recovery of stained one-shade CRs. The first null hypothesis stating that there would be no significant difference in the discoloration between the CRs after immersion in the coffee solution was rejected.

Nanohybrid composite resins have gained popularity because of their superior mechanical, physical, and esthetic qualities. However, the accuracy of the color match to the surrounding dental tissues is a challenge due to various factors influencing tooth color.[17] In recent years, composite resins labeled as "universal-shade or one-shade" have been developed to address this issue.[4] However, the role of one-shade CR on color stability has been the subject of research in the literature. A clinical study conducted by Anwar et al. [7] revealed a statistically significant change in one-shade CR color match scores over time. Furthermore, Abreu et al. [8] demonstrated that multishade CR surpassed one-shade CR regarding color matching. In addition, in vitro studies have noted that one-shade CRs are prone to staining from typical intakes.[9-12]

In the present study, the samples exposed to coffee exhibited a decrease in the L parameter and an increase in the a and b parameters. It was shown that the lightness of the samples decreased and the color saturation increased. One-shade CR (ΔE=12,16±1,37) showed significantly more color change than multi-color CR (ΔE=7,48±0,95) in this study. The research by Fidan et al.[11] revealed that coffee immersion causes the most significant color change in one-shade CR, which supports our results. Moreover, this finding is aligned with the studies by Khayat et al.[9], and Aydın et al.[10], considered that one shade CRs exhibited more color changes than multi-color CRs. The color stability varies depending on the properties of the CRs; inorganic content, resin matrix volume and the monomer they contain.[6,13] In the current research, this difference may be due to CTO containing different resin monomers (bis-acryloyloxymethyl-tricyclododecane; TCD-DI-HEA) and a lower filler load. A previous study by Korkut et al. [12] reported that, due to its significant affinity for the low-polarity colorants in coffee, the TCD-DI-HEA monomer might be responsible for the lower color stability.

In the current study, a spectrophotometer and CIELAB color system were utilized. The color change value represents with E, only

demonstrates changes in the esthetic properties, but does not specify the type of changes.[18] Therefore, to calculate whether the material is lighter or darker, yellowed or green, ΔE*ab was used in this study. ΔE > 3.3 was considered clinically unacceptable.[19]

Extrinsic staining can be caused by adsorption and absorption of colorants. Surface quality is dependent on the finishing and polishing of the CR, which has an effect on its optical properties and durability. It was reported that untreated composite surfaces are more susceptible to staining.[6,20] A multi-stage Sof-Lex disc (3M ESPE) was therefore used in this study after composite discs were prepared.

According to the results of the study, a clinically unacceptable discoloration of the CRs was observed after immersion in coffee (ΔE > 3.3). This result is consistent with previous studies reporting that coffee causes significant discoloration of CRs.[21-23] Surface or subsurface color change may occur due to staining agents, pigments through absorption and/or adsorption mechanism.

Immersion period was a significant factor for color recovery. Mouthrinsing is recommended twice a day for 2 minutes. In view of this situation, the samples were kept in the solutions for 12 hours to obtain an effect that was equivalent to daily use of mouthrinse for one year.[24]

Whitening mouthrinses contain various bleaching agents such as peroxides, sodium citrate, sodium hexametaphosphate, pyrophosphates and activated charcoal.[25] These agents have either a bleaching or a stain removal effect. The effectiveness of hydrogen peroxide as a bleaching agent is supported in the literature. However, there are some risks associated with its uncontrolled use at home.[26] Thus, none of the mouthrinses tested in this study contain hydrogen peroxide.

In the present study, the mouthrinses led to increase in the L parameter and decrease in the a and b parameters for stained CR (T2-T1). Lima et al. [27] stated that increasing lightness (positive ΔL) and decreasing yellowness (negative Δb) are the main factors in tooth whitening, while decreasing redness (negative Δa) plays a minor role. This may explain the results of our study on the efficacy parameters of whitening. Whitening mouthrinses caused a significant difference in the ΔL (p=0.001), Δb (p=0.031) and ΔE (p=0.002) values for ESQ, while the Δb (p=0.037) value for CTO showed a significant difference. In this respect, the whitening mouthrinses reduced the discoloration of the CRs, but it was not a clinical acceptance level. Thus, the second null hypothesis was rejected. For the ESQ, LAW (ΔE=3,43±0,54) and CPWC (ΔE=3,67±0,31) improved the color compared more than the others. Similar to our findings, studies investigating the color changes of CRs did not find any significant difference between CRs and mouthrinses.[28-30]

The brand of mouthrinse and its ingredients may affect the color recovery of the CR. In the present study, LAW contains Tetrasodium pyrophosphates, and CPCW has pyrophosphates and charcoal whereas LTC has total effect without bleaching.[31] However, LTC had similar results in color recovery of CTO when compared LAV and CPCW, but no such effect was seen with ESQ. Differences are thought to be caused by material properties exposed to mouthrinses. In addition, mouthrinses are marketed in two forms of alcohol content which functions as solvent. Low pH and alcohol have been reported to affect the surface integrity and make it susceptible to coloration. Several studies have reported no clinically detectable discoloration of composite resins with alcohol-containing mouthrinses, while other studies have reported similar effects to alcohol-free mouthrinses.[31] Similarly, when reviewing studies on charcoal, the component of CPCW, one *in vitro* study [32] found no effect on discoloration, while one clinical study [33] reported dissatisfaction and minor effect.

The main limitations of this study were the *in vitro* setting and the use of only one type of one-shade CR. Further, *in vivo* studies are

required to assess the whitening effects of mouthrinses on different restorative materials.

CONCLUSION

All samples showed clinically unacceptable color change values after immersion in coffee solution but significantly higher in one-shade CR. None of the whitening mouthrinses was able to reduce coffee staining to a clinically acceptable level. However, the whitening mouthinses improved the color of multi-shade CR compared to one-shade.

Ethical Approval

Since sources obtained from humans or animals were not used in this study, ethics *committee* approval was not obtained.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: GYY, Data collection and processing: GYY, Analysis and interpretation: GYY, Literature review: GYY, Writing: GYY.

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Conditions that May Require Molar Distalization in Children and Treatment Approaches

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ABSTRACT

It is of great importance that deciduous teeth remain in the mouth until the physiological age of eruption. One of the most important reasons for this is that they serve as placeholders for the permanent teeth that will come from emerge below, among their functions in chewing, speaking, and aesthetics. Therefore, significant problems arise with the early loss of these teeth. Teeth tend to fill the gaps in the arch and become mesialized. The length of the arch is shortened as a result of the mesialization of the teeth at the end of the arch when a placeholder is not utilized after the early loss of deciduous teeth. When the permanent teeth coming from below cannot find a place to erupt, various anomalies occur in the arch. These anomalies include impacted permanent teeth, ectopic eruptions, or crowding. The distalization method was developed to correct these anomalies. In this method, the mesialized teeth are pushed distally with various forces to regain the lost arch length. Patients who will undergo distalization procedures should meet certain criteria and be indicated accordingly. Many intraoral and extraoral methods are used in the process of gaining space by distalizing the teeth. Careful consideration should be given when choosing these methods, and monthly follow-ups should be performed.

Çocuklarda Molar Distalizasyonu Gerekebilecek Durumlar ve Tedavi Yaklaşımları

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ÖZET

Süt dişlerinin fizyolojik sürme yaşına kadar ağızda kalması büyük önem taşımaktadır. Bunun en önemli nedenlerinden biri çiğneme, konuşma ve estetikteki işlevlerinin yanı sıra alttan gelecek olan daimi dişler için yer tutucu görevi görmeleridir. Bu nedenle bu dişlerin erken kaybı ile önemli sorunlar ortaya çıkmaktadır. Dişler arktaki boşlukları doldurma ve mezialize olma eğilimindedir. Süt dişlerinin erken kaybından sonra herhangi bir yer tutucu kullanılmadığında ark dizisinin sonundaki dişlerin mezializasyonu sonucu ark boyu kısalmaktadır. Alttan gelen daimi dişler sürebilecek yer bulamadığında arkta çeşitli anomaliler meydana gelmektedir. Bu anomaliler arasında daimi dişlerin gömülü kalması, ektopik sürmesi veya çapraşıklık sayılabilir. Distalizasyon yöntemi bu anomalileri düzeltmek için geliştirilmiştir. Bu yöntemde mezialize olan dişler çeşitli kuvvetlerle distale doğru itilerek kaybedilen ark uzunluğu yeniden kazandırılmaktadır. Distalizasyon işlemi uygulanacak hastaların belirli kriterleri karşılaması ve buna göre endikasyon konulması gerekmektedir. Dişlerin distalize edilerek yer kazanılması işleminde intraoral ve ekstraoral birçok yöntem kullanılmaktadır. Bu yöntemler seçilirken dikkatli olunmalı ve aylık takipler yapılmalıdır.

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INTRODUCTION

Pediatric dentistry emphasizes the importance of keeping deciduous teeth healthy and functional in the mouth until they fall out physiologically.[1] In this way, chewing and speech disorders are prevented, the midline is preserved, abnormal tongue habits are prevented and the normal development processes of the jaw can continue while maintaining the length of the dental arch.[2-4]

In the "Managing Dental Occlusion in Pediatric Dentistry" guideline of the American Association of Pdiatric Dentists, it is accepted that it is an important task of the pedodontic specialty to guide the eruption and thus to ensure the correct formation of the development of deciduous and permanent dentition, and it has been reported that thanks to this guidance, it should have the knowledge and skills to identify, distinguish, and intervene at the right time with a functionally and aesthetically acceptable occlusion development and abnormal conditions and problems that may occur with it.[1,5]

Although the number of patients visiting pediatric clinics has increased due to modern advances in preventing tooth decay and growing dental care, the premature loss of deciduous teeth to decay remains a very common problem.[6, 7] As a result, it is very likely to cause loss of space in the dental arches and cause malocclusions in the future.[8,9] Advances in mechanical treatments and changes in treatment concepts have significantly reduced the necessity for extractions in severe dental discrepancies. Nowadays, various techniques are employed to treat numerous malocclusions without resorting to extraction. Additionally, molar distalization has emerged as an alternative method of gaining space in the arch.[10] Distalization is the process of gaining space by moving the terminal molar distally in arch.[11]

LOSS OF SPACE

The most common causes of space loss during deciduous and permanent dentition;

1. Untreated interfacial caries
2. Early loss of deciduous teeth
3. Loss of deciduous or permanent incisiors as a result of trauma
4. Congenital deficiency of teeth
5. Ectopic eruptions of permanent teeth
6. Ankylosis of deciduous molars
7. Delayed eruption of permanent teeth
8. Dental size anomalies such as macrodontia or microdontia.[12-16]

As a result of deciduous tooth decay, material loss may occur in the mesio-distal direction. As much as this amount is lost, the teeth physiologically move in this direction and narrow the space for permanent teeth to replace the deciduous teeth.[15,16]

Problems as a result of dental caries occur as a result of these physiological tooth movements. The movement of the teeth in the mesial direction is greater than in the distal direction.[12, 15] In neighboring teeth and further teeth, these movements take place towards the gaps to a decreasing extent.[15] These physiological movements are usually caused by tipping and tilting (tipping).[12,15] The physiologic movements of the teeth are greater in the upper jaw than in the lower jaw. This is because the upper jaw bone is more spongy while the lower jaw bone is more compact.[15,17]

Factors that cause early loss of deciduous teeth:

1. Caries with excessive loss of material
2. Trauma
3. Untreatable pulpal and dento-alveolar abscesses

4. Internal or external resorptions
5. Extraction of some deciduous teeth for interceptive orthodontic treatment to prevent ectopic eruption of permanent tooth germs
6. Orthodontic causes such as arch size mismatch and crowding
7. Infraocclusion.[7,9,12,14]

In a study conducted by Alsheneifi and Hughes in 2001, the reasons for the extraction of deciduous teeth in children aged 3-13 years and the frequency of extraction were investigated. According to the results, it was found that extractions were most frequently performed in the 6-9 age range 56%, the reason for these extractions was caries 53% and the second most common reason was orthodontic reasons. In addition, the question of which teeth were extracted the most was also asked. In the age range of 3-5 years, anterior incisors were extracted mostly due to early childhood caries, while in the 6-9 age range, first deciduous molars were extracted, and in the 10-13 age range, deciduous molars were extracted mostly due to the replacement of anterior incisor.[18]

In another study conducted in 2009, the age range of 3-13 years was taken into consideration and the most commonly extracted deciduous teeth and the reasons for extraction of these teeth were investigated. According to the results, the most common reason for extraction in the 3-5 age group was caries with 86.3% and in the 6-9 age group with 52.8%, while the most common reason for extraction in the 10-13 age group was the physiologic falling age of these teeth with 86.6%. When asked about the most frequently extracted tooth types, the respondents cited deciduous first molars, followed by deciduous second molars and deciduous incisors, respectively.[19]

When deciduous teeth are lost early, the consequences that may occur if a placeholder is not made on time are as follows:

1. A reduction in arch size is available for permanent dentition
2. Impacted permanent tooth germs due to loss of space
3. Crowding in permanent dentition
4. Deviation to the midline
5. Ectopic eruption
6. Closing problems
7. Degeneration and inflammation of tooth support tissues as a result of teeth falling into extraction cavities.[9,14,17]

MOLAR DISTALIZATION

Malocclusions can often develop as a result of the loss of deciduous teeth the physiologic age of falling. Two concepts early orthodontic and interceptive orthodontics, are prominent. While interventions are made at the very beginning of the early orthodontic dentition period, treatment starts as a result of eny suspicious situation seen after start of the dentition period in interceptive orthodontics.[20, 21] In 1998, Hoffding and Kisling noted that premature separation of deciduous teeth from their position in the dental arch results in a subsequent loss of space for permanent teeth within arch.[22] As a consequence of space loss, the permanent tooth may become impacted or may erupt buccally or lingually.[22] When second deciduous molars are lost early, the rate of space closure is notably higher compared to the early loss of first molars. Consequently, a space regainer system in often necessary when space is lost. Various appliances are utilized during the eruption of the permanent tooth to both to regain the lost space and to preserve the lost space. At the first appointment and at follow-up appointments, the appliances are activated to distalize the terminal teeth in the arch. After gaining space for the teeth that cannot erupt, these appliances remain in the mouth as a placeholder until the teeth erupt.[23]

Diagnosis

Molars shifting mesially, crowding and space loss in both the upper and lower jaws often result often the mismatch between tooth and jaw size. When devising a treatment, clinicians should account for growth patterns, spacing, and factors such as facial profile and the size of the apical base.[24-26]

Radiographs and working models are utilized to assess the space required and the alignment within the arch. The forces necessary to straighten an overturned tooth are greater than the forces required to restore a body-moved tooth to its proper position. Therefore, it is crucial to determine whether the teeth that causing the loss of space moved to the edentulous area bodily or axially. Another aspect to consider in the diagnosis is the position of the permanent second molar. Since these teeth will be distalized during the distalization process, the condition of the tooth should be evaluated with periapical radiographs.[20,21]

The space regaining procedure necessitates careful consideration of tooth alignment factors, including tooth rotation, improper contacts and transverse relationship of the tooth. Working models serve as the most reliable source of data for assessing these aspects. They enable visualization of vertical, transverse and sagittal tooth relationships, which are crucial for ensuring the stability of Moyer's mixed dentition analysis. Furthermore, working models are invaluable in determining the extent of space loss and estimating of the space required by the unerupted permanent tooth.[27]

Space recovery procedures present various challenges. Generally, recovering minimal space loss is preferable. When considering the distalization process, it is crucial to recognize that it is may be suitable for every patient. Factors that positively affect this procedure include: Class 1 occlusion, sufficient anchorage, absence of the second permanent molar and, if present, a positive relationship with the first molar.[27]

Extraoral Molar Distalization Methods

Headgear

This appliance offers both orthodontic and orthopedic effects. The headgear can be used to direct or brake the growth of the upper jaw in the forward and downward directions. It is also commonly used to give distal movement to the teeth or to provide anchorage in fixed orthodontic treatments.[20,28]

The headgear is designed in three different configurations depending on the direction of force application: high pull (occipital), straight pull (occipital) or low pull (cervical). Occipital and cervical headgear define the point and direction of force application in relation to the center of resistance of the molar teeth or maxilla.[28,29] Among these configurations, cervical headgear is the most commonly utilized. It is effective in restraining maxillary growth and in distalizalizing maxillary molars. However, molar extrusion and distal crown tipping are recognized as potential side effects of this appliance.[26, 30] On the other hand, occipital headgear is effective in controlling vertical dimension of occlusion.[31,32]

Although the headgear can fulfill its purpose to a great extent, since the target patient group is adolescents, cooperation problems may arise due to aesthetic concerns. Additionally, because of the disadvantages of this appliance, such difficulty in use and prolonged duration of wear, patient compliance issues are experienced, leading to a decrease in the likelihood of success.[33]

Intraoral Molar Distalization Methods

Repulsor Magnets

In 1978, Blechman and Smiley conducted animal experiments, which led to its application in humans in 1985.[34] The samarium-cobalt alloy is utilized to render it biologically compatible. Since it is activated and managed by physicians, there is no need for patient compliance. Bondemark and Kurol achieved simultaneous distalization of the upper first and second molars using magnetic forces and employed a modified Nance appliance for anchorage. However, the limited understanding of the effects of magnetic fields generated by magnets on human oral cavity and dental tissues hinders the widespread adoption of these systems.[35]

Molar distalization with magnetic forces has reduced the risk of tooth decalcification, caries and gingival problems due to minimized patient compliance, easy activation, physiological forces, and short treatment time.[36] Disadvantages include their potential toxicity when isolation is not ensured, fragility, occupying significant space in mouth, lack of hygiene, and causing irritation of the cheek mucosa.[33]

Open Coil Springs

Open coil springs are very commonly used in clinics and are compression-activated systems that apply force from the center in two directions.[33]

Pieringer et al. achieved 5-10 mm molar distalization using open coiled springs placed on segmental archwires in 8 individuals who were anchored using the Nance appliance over a period ranging from 3 months to 18 months.[37]

Erverdi et al. compared magnets and open coil springs and found that molar distalization was achieved in both groups, but open coil springs were more effective.[38]

Superelastic Nitinol Wires

Nickel titanium was first introduced into orthodontic clinics by Andreasen and Johnson in 1971.[39] Miura et al. were the first to use them for alignment in dental arches.[40] Superelastic nickel-titanium braces are widely used in clinical orthodontic treatment.[40,41] These wires have many special properties such as shape memory effect and super elasticity.[42]

Gianelly compared nitinol open coil springs and superelastic wires, and reported that 1 mm distalization was achieved within a month with both methods, albeits with some loss of anchorage.The study found that the optimal time for molar distalization is during the mixed dentition period, as 1st molars can be distalized more rapidly and easily before the 2nd molars, and continuous forces result in faster movement compared to intermittent forces.[43]

Jones Jig Appliance

In the system developed by Jones and White, which includes a thick segmental arch and a nitinol open-coiled spring attached to it, a class 2 molar relationship was converted into a class 1 molar relationship by applying 70-75 grams of force with 1-5 mm activation of the spring. The open coiled spring was activated every 4-5 weeks.[44]

Haydar and Üner conducted a comparison study the Jones-Jig appliance and cervical headgear, finding that molar distalization averaged 2.5 mm per month with Jones-Jig and 10.7 mm per month with cervical headgear. The main disadvantage during molar distalization with the Jones-Jig appliance is the risk of anchorage loss; however, advantages include shorter treatment times and similar treatment effects as cervical headgears.[45]

Distal Jet Appliances

Carano and Testa stated that they achieved significant molar distalization with the

distal jet appliance they developed, which offered a considerable advantage when used in conjunction with fixed treatments.[46] In this appliance, 2 tubular bands are positioned on the right and left sides, intended for connected to the nance button on the palate. Open-coiled springs are connected to the tubes of these bands with a screw system extending from the nance appliance. One end of this open coiled spring is on the 1st premolars and the other end is on the 1st molars.[11,47]

In their study comparing the effects of orthodontic treatment and distal jet appliance, Ngantung et al. observed that distalization with distal jet resulted in 2.1 mm and 3.3 degrees of distal tilting in the upper 1st molars, 2.6 mm mesial movement and 4.3 degrees of distal tilting in the 2nd premolars used as anchorage. After orthodontic treatment, 3.9 mm mesial movement and 6.1 degrees mesial tipping of the upper 1st molar, 0.9 mm distal movement and 2.1 degrees mesial tipping of the 2nd premolar were measured.[48]

Bolla et al. compared the distal jet appliance with other distalization systems and found 71% distalization and 29% loss of anchorage in molars, less loss of anchorage in patients with partially or fully erupted 2nd molars, and less distal deviation of the 1st molar.[49]

First-Class Appliance

Fortini et al. developed this appliance to reduce the anchorage loss of the distal jet and used it for distalization of maxillary molars. In their study, they obtained an average molar distalization of 4.8 mm in 42 days in 62 individuals with class 2 malocclusion with an average age of 8.7-14.5 years.[50]

This appliance can be utilized in both permanent and mixed dentition, and distalization can be achieved even in the presence of 2nd molars. Fortini stated that this appliance is suitable for dental and skeletal class 2 cases with maxillary protrusion near the end of growth, deep bites, cases where patient compliance, such as with bionators and twin-blocks cannot be achieved, individuals with maxillary arch insufficiency, and extreme crowding requiring space gain.[33]

IBMD (Intraoral Bodily Molar Distalizer) Appliance

Keleş and Sayınsu introduced an intraoral molar distalizer featuring a stem, which successfully completed the distalization of upper molars within an average period of 7.5 months.[51] For molar distalization, 0.032x0.032 inch TMA springs are manipulated and directed through acrylic. The springs consist of 2 components: the distalizing segment applies a tilting force to the crowns of the 1st molars, while the uprighting segment exert a force to align the roots. The IBMD appliance is cemented to the first premolars, with left unattached to the each other. Post-cementation, the hinge covers on the molar bands are opened. The springs are activated by pulling them distally to mesially using Weingart pliers, and then inserted into the sockets of the palatal hinge cap attachments. It has been reported that, due to the combined force application, an average distalization of 5.23 was achieved without distal tipping or extrusion of the upper molars. Furthermore, the upper first molars did not exhibit distopalatal rotation, and there was no increase inter-molar distance.[51]

The primary challenge in molar distalization is the risk of distal tipping of the molars. The only method to counteract this is by ensuring that the applied force passes close to the center of resistance of the tooth. Forces applied at the level of the trifurcation zone level move the crown and roots of the tooth distally or mesially without inducing any tipping. Therefore, molar tubes should be positioned as gingivally as possible.[33]

Bimetric Molar Distalization System

In the 3D bimetric distalization system introduced by Wilson, which necessitates patient compliance despite being an intraoral method, the arch can be utilized either alone in the mouth or with a bracketing system.[52,53] In this system, support is provided with a class 2 elastic extending from the lower 1st molar to the upper canine. In the study, it was observed that there was parallel distal movement in the upper 1st molars but there was no change in the lower incisors.[54]

In a study by Küçükkeleş and Doğanay, 1 boy and 3 girls with an average age of 13.5 years were treated in accordance with Wilson's principles and 3 mm distalization was achieved at the end of 3 months.[55] As a result of distalization, it was determined that the upper molars were crossbite, slightly intruded and tipped distally, while the lower molars were extruded and tipped mesially with the effect of intermaxillary class 2 elastics.[38,54]

In their study, Muse et al. found 2.16 mm distal movement of the upper 1st molars at an average of 14.9 weeks. No correlation was found between the presence of the upper 2nd molars and the amount of movement of the upper 1st molars or the resulting distal tilting movement.[56]

K-Springs

Kalra, with the assistance of the Nance appliance, fabricated a double-armed segmental arch in the shape of the letter "K" from the TMA wire, opened the arms of this letter “K”, and positioned the activated arch between the upper 1st molar and upper 1st premolar teeth. By activating the arch twice, each time by 2 mm, a total of 4 mm of upper molar distalization was achieved, while preventing distal and mesial tipping by anglulating the arms of arch at a 20 degrees.[57]

Pendulum Appliance

In this appliance developed by Hilgers, a modified Nance appliance was utilized, and TMA springs were incorpotaed into the acrylic component, transmiting a gentle and continuous force in the distal direction to the upper 1st molars. Activation was conducted every 3 weeks, and 5 mm of distalization was achieved within 3-4 months.[47]

The Pendulum appliance, one of the most commonly employed intraoral distalization methods, has been modified and employed by numerous researchers to eliminate the loss of anchorage induce by mesialization in the upper 1st and 2nd premolars, which serve anchoring teeth, and to prevent distal tipping in the upper 1st molars.[58,59]

Distalization Screw Removable Appliance

This orthodontic appliance, constucted on a working model, consists of Hawley ring (vestibular arch), three or four retaining clasps, a distalization screw located adjacent to the space loss, and an acrylic lingual plate. Patients and their families receive instructions on proper usage, insertion and removal of the appliance, as well as guidance on maintaining oral hygiene.[60] To optimize its effectiveness, patients are advised to wear the appliance full time, except during meals, brushing, and oral cleaning routines. The appliance should remain passive in the oral cavity for one week to allow children to acclimate to it. Subsequently, patients and their parents are instructed to activate the distalization screw by a quarter turn (0.25mm) twice a week. Monthly follow-up appointments are scheduled to monitor progress, during which the retaining clasps are adjusted until the necessary space for the eruption of the second premolar is achived.[61]

Lip Bumper Appliance

The equivalent of the lip bumper appliance used to gain space in the mandibular arch or to distalize the molars is the Denholtz appliance in the maxillary arch.[62] Molar bands are fabricated for the permanent first molars and welded to the buccal side of each molar band. Subsequently, the labial arch wire is attached to the buccal tube, and an acrylic button is prepared for the labial vestibule. To distalize the molar, the forces exerted by the lips are directly transferred to the buccal aspect of the first molar. This appliance is employed for minimal molar distalization in early deciduous dentition and is also beneficial for uprighting mesially tipped teeth to preserve arch space.[21]

Space Regainer and Space-Holder Appliance

The construction of the appliance is as follows: First, a band is custom-made fort he tooth to be supported, or a band of suitable dimensions is selected from ready-made sets. The band is then adapted to the mouth, and an impressions is taken using alginate impression material. To prevent overheating during the soldering process, the wire component to be placed in the edentulous area gap is positioned slightly away from the band on both sides of the tooth, with attention to the direction of tooth eruption. This "U" ring or the canine retractor is activated during the follow-up sessions to gain space. This appliance is indicated in cases where there is minimal space loss due to early loss of deciduous teeth. If there is loss of more than one deciduous tooth, the use of this appliance is not recommended.[63]

Orthodontic Implants and Mini Screws

Orthodontic implants utilized for anchorage are positioned in the palatal region for maxillary molar distalization. These implants can be utilized individually or in conjuction with other intraoral distalization appliances.[64-66]

Mini screws employed for distalization of the maxillary posterior segment are inserted between the 1st and 2nd molars in the palatinal region or between the 2nd premolar and 1st molar in the buccal alveolar bone. These screws facilitate distalization by exerting force on the 1st premolar or canine.[67,68] Mini screws are more commonly utilized due to their ease of insertion and removal, immediate loading capability, and affordable cost compared to mini-plates and palatal implants.[69,70] Mini screws can serve as anchors for maxillary molar distalization, either directly or indirectly. In direct anchorage, the forces involved in distalizing the upper molars act directly on the mini screw, potentially compromising anchorage. Conversely, indirect anchorage involves the mini screw supporting the teeth that receive the reactive forces, rather than traditional devices like the Nance button. However, this method may result to mesial tilting of the anchorage teeth and proclination of the anterior teeth, heightening the risk of anchorage loss.[71,72]

CONCLUSION

Early loss of deciduous teeth in children due to various reasons can lead to several significant issues in the future. If not identified and addressed early, this can result in mild to severe space loss.

There are various distalization systems that can be used for molar distalization, depending on the location, degree, and patient cooperation. However, it is important that each case be evaluated individually, providers make accurate indications, and that they regularly perform follow-up.

Ethical Approval

Since sources obtained from humans or animals were not used in this study, ethics *committee* approval was not obtained.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: MK, MM, Data collection and processing: MM, MK Analysis and interpretation: MM, MK Literatüre review: MM. Writng: MM, MK

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Single Tooth Implant-Supported Crowns in The Maxillary Anterior Region: Treatment Planning and Prosthetic Options

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ABSTRACT

With the advancement of technology and prosthetic materials, treating one or more missing teeth with implant-supported crowns and fixed partial dentures has become preferable. This choice is driven by factors such as the preservation of neighboring teeth, which do not require preparation, and the ease of maintaining gingival health. Success in treating single missing teeth in the anterior region must consider esthetics and function. Thus, all details should be carefully considered for ideal treatment from the surgical process of implant placement to the prosthetic process, including the material selection and the type of retention for the prosthesis on the implant. This review discusses implant planning based on the clinical and radiologic evaluation of tooth loss in the maxillary anterior region, emphasizing its impact on the prosthesis. It also covers factors to consider implant prosthetic options, such as the osseointegration of the implant.

Maksiller Ön Bölgede Tek Diş İmplant Destekli Kronlar: Tedavi Planlaması ve Protetik Seçenekler

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ÖZET

Tek veya daha fazla diş eksikliğinin tedavisinde diş destekli yapılan kron ve köprüler, günümüzde teknolojinin ve materyallerin gelişmesi ile birlikte yerini implant destekli sabit restorasyonlara bırakmaktadır. İmplant destekli yapılan tedaviler ile komşu dişlerde madde kaybı olmaması ve dişeti sağlığının korunması gibi avantajlar sağlanmaktadır. Anterior tek diş eksikliğinde sıklıkla tercih edilen implant destekli kronların başarısının değerlendirilmesinde fonksiyon ile birlikte estetik de etkilidir. Klinik başarıyı sağlayabilmek için implant yerleştirmenin cerrahi sürecinden, implant üzerindeki protezin materyal seçimi ve tutuculuk şekline kadar tüm detayların dikkatle düşünülmesi gerekir. Bu literatür derlemesinde maksiller anterior bölgedeki diş kaybının klinik ve radyolojik değerlendirmesine dayalı olarak implant planlaması ele alınmakta ve protetik seçenekler hakkında bilgi verilmektedir.

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INTRODUCTION

Implant-supported fixed prostheses have become effective alternatives for the treatment of missing teeth. With the recent technological improvements, these prostheses not only provide function but also give satisfactory esthetic appearance.[1] For this reason, implant placements and implant-supported prostheses must be planned together and conducted with precision, particularly in the maxillary anterior region.[2]

Clinical and radiographic evaluation of the maxillary anterior region

Tooth loss in the maxillary anterior region is observed due to trauma in approximately 6 to 38% of young patients, while it is observed in adults due to caries, periodontal disease, oral habits, and familial reasons such as hypodontia.[3-5] The choice of treatment for a patient with a single missing tooth in the maxillary anterior region depends on several factors, including clinical and radiological assessments, the patient's conditions, access to technology, the experiences of clinicians and dental technicians, and economic factors. Treatment options for single-tooth loss in this region include fixed prostheses, removable partial dentures, orthodontic closure, and dental implants.[6,7] The final decision, reached by considering the advantages and disadvantages of each method, depends on the case.[6] In addition, orthodontic treatment requires multidisciplinary planning and can be used in limited clinical situations and conjunction with implant placement.[7] Fixed prosthetic options can be listed as three-unit tooth-supported or cantilever-fixed prostheses. However, these options have some disadvantages. Tooth preparation is necessary for the application of these treatments. Dental caries formation depending on the patient's oral hygiene habits, or chronic gingivitis and periodontal diseases especially on the subgingival margins of the abutment may be observed.[3,8] According to a systematic literature review conducted at the 3rd European Society for Osseointegration Consensus Conference in 2012, the 5-year estimated survival rate for a single implant is approximately 98%; the 10-year estimated survival rate is approximately 95%; the 5-year estimated survival rate for implant-supported single crowns is approximately 96%; and the 10-year estimated survival rate is approximately 90%.[9] Survival rates of tooth-supported fixed partial dentures were significantly lower than implant-supported prostheses.[10] In case of tooth loss in the maxillary anterior region, clinical evaluation is critical in implant planning. The main factors are summarized in the Table 1.[11-13]

Table 1: Factors to be considered in implant planning[11-13]

Adjacent teeth	• Caries • Endodontic treatment • Periodontal health • Trauma • Amount of tooth structure available for retention
Occlusion	• Intermaxillary distance and occlusal relationship • Bruxism or parafunctional activity
Width and volume of the edentulous area	• Mesio-distal and labio-lingual width • Amount of available bone and soft tissues
Patient condition	• Complete skeletal growth • Patient age and systemic condition • Patient's habits (use of medicine, alcohol, cigarette)
Restoration design and material	• Metal or ceramic • Cemented or screw-retained implant prostheses • Cantilever or resin bonding systems

Clinical examination should be made together with a radiographic examination in implant planning. Periapical, panoramic, cephalometric, and occlusal radiographs are used for radiographic examination. Panoramic radiography, one of the most widely used imaging techniques, has the advantage of comprehensive visualization of facial bones and teeth, but the disadvantages, such as two-dimensional imaging, distortion, and magnification cause this technique to be inadequate during planning. Thus, Cone Beam Computed Tomography (CBCT) is preferred by developing technology. CBCT offers high-resolution and three-dimensional imaging.[14]

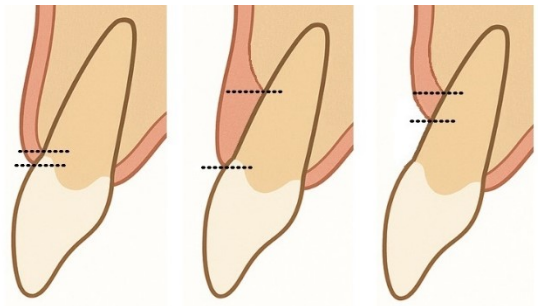
Implant planning in the maxillary anterior region

The position of the dental implants should ideally be planned according to the final prosthetic outcome to achieve the desired esthetic and physiological loading position. The maxillary anterior region has great importance for the esthetic appearance; therefore, positioning the implants according to the prosthesis becomes even more essential in this region.[12] Considering the history of implant applications, in addition to bone augmentation methods, soft tissue regenerative surgery has gained importance due to esthetic concerns. As a result, recently successful treatment includes not only the osseointegration of the implant but also the optimization of the soft and hard tissues around the implant.[15] From this point of view, pre-implant augmentation procedures, precision in implant placement, optimal implant position and angulation, management of peri-implant soft tissue, and the quality of the prosthetic restoration should be considered for successful implant-supported prostheses.[16] Furthermore, the quantity and quality of bone in the edentulous area after tooth extraction, the surgical planning including three-dimensional analysis, the management of soft tissue, the relationship of the implant site with adjacent teeth, the implant placement protocols, the requirement for hard and soft tissue augmentation, smile line, patient expectation, the factors such as pre-existing pathology, and the position of the implant and the neck design of the implant should be evaluated.[13,17-20]

The quantity and quality of the bone in the edentulous area or after tooth extraction:

When evaluating the quantity and quality of bone in the maxilla, its anatomical relationship with the nasal cavity, maxillary sinus floor, and incisive canal should also be evaluated. The vertical height and sagittal width of the alveolar bone are vital factors for implant planning. Since the bone on the labial surface of the roots is usually thin, fracture during extraction or collapse after extraction may occur.[19] The bone structure in the anterior and premolar regions of the maxilla, characterized by fine porous bone on the labial side, very fine porous-dense compact bone on the nasal side, and thick cortical bone on the palatal side, is classified as Type III bone.[21] There are three different types of sockets after tooth extraction (Figure 1):

Figure 1: Different types of sockets after tooth extraction[13]



a) Type 1 socket: The most favorable clinical situation for implant treatment is the presence of adequate amounts of bone and healthy soft tissues.
b) Type 2 socket: There is inadequate labial bone thickness, and implant placement can result in gingival recession.
c) Type 3 socket: There is a loss in both hard and soft tissues.
Type 2 sockets can be clinically misleading because they appear similar to Type 1 sockets before extraction. However, in Type 2 sockets, this soft tissue is supported by the underlying tooth root, not the labial bone. If the labial bone is partially missing in Type 2 sockets, gum recession is likely to happen. [13]

Surgical planning, including three-dimensional analysis of hard and soft tissues:

When placing implants in the esthetic zone (such as the anterior region of the maxilla), CBCT is important to determine the quantity of existing buccal bone, need for bone grafting, estimation for width and length of the implant to be placed, and the sagittal position of the root in the presence of teeth. Determination of the buccal bone thickness influences the decision of immediate loading.[18]

Management of the soft tissue according to biotype:

Tooth morphology is associated with the characteristics of the gingiva. It should be considered that generally, square-shaped teeth are associated with thick, and triangular-shaped teeth are associated with a thin gingival form. Gingival form influences implant planning by affecting bone thickness. In a patient with a thin gingival phenotype, the labial bone thickness is approximately 0.6 mm, while in a patient with a thick phenotype, the labial bone is 1.2 mm thick, which also affects the positioning of the implant.[22] Soft tissue phenotype is one of the factors that influence the contour of the restoration. If the existing soft tissue is thin and less keratinized, it is more prone to recession. Therefore, in the presence of a gingiva with a thin phenotype, a flatter or concave contour should be created to prevent gingival recession related to the restoration contour.[12,13] The height of the papilla is crucial for creating a natural-looking smile, particularly in the esthetic zone. An adequate amount of attached gingiva is also important for the health and stability of the gingival tissues around the implant.[19]

The relationship of the implant site with adjacent teeth:

Maintaining a horizontal distance of 1.0 to 1.5 mm between a natural tooth and an implant is generally recommended. This recommendation is based on the typical vertical and horizontal bone loss around implants, which is approximately 1.5 to 2.0 mm vertically and 1.0 to 1.5 mm horizontally. By maintaining this distance, the risk of bone resorption and potential damage to the adjacent tooth or implant is minimized.[23] Limitations in bone quantity in the mesiodistal dimension may be caused by the root position of adjacent teeth. The roots of the adjacent teeth may encroach into the space where an implant is to be placed and reduce the width of the bone available.[24] Clinical studies indicate that 60 to 70% of cases with a horizontal distance of less than 2.5 to 3 mm between the implant and the adjacent tooth do not have an interproximal papilla. However, cases with a horizontal distance of 2.5 to 4 mm between the implant and the adjacent tooth tend to have an interproximal papilla.[25,26]

Implant placement protocols:

Implant treatment can be performed with the healing of the alveolar bone after tooth extraction, or today, especially for esthetic reasons, it can be performed immediately after extraction following various protocols.[1] Immediate implant placement reduces the number of surgical operations and treatment time; however, it is essential to evaluate the hard tissue required for the ideal positioning of the implant and keratinized gingival tissue, which is important for prosthetic treatment.[27,28]

A classification for the timing of implant placement after tooth extraction has been established based on the evaluation of hard and soft tissues:[1]

a) Implant placement after extraction, immediate placement (Type 1):

It has been suggested that immediate placement of implants reduces alveolar bone resorption, a key factor in enhancing treatment outcomes in the anterior maxillary esthetic region. This reduction in bone resorption can decrease the need for additional bone augmentation procedures, making the immediate placement protocol preferable. However, questions have been raised regarding

the advantages of immediate placement, as factors such as inadequate primary stability and improper implant positioning may impair the outcome of subsequent prosthetic restoration.[17] The amount of available bone, the presence of acute infection, and the need for atraumatic extraction affect the preference for immediate implant placement.[12] Implants placed immediately after extraction can be restored immediately. Correctly shaped morphology of the abutment allows repositioning of the peri-implant soft tissue. Esthetic results depend mainly on the stability or remodeling of the soft and hard peri-implant tissues.[29]

b) Early placement with soft tissue healing (Type 2) and partial bone healing (Type 3):

In the late 1990s, early implant placement with partial soft/hard tissue healing was developed. This method involves a healing period of 4 to 8 weeks after extraction before placing the implants. During this time, soft tissue healing occurs, utilizing the keratinized mucosa covering the socket. This helps implant placement by reducing postoperative complications. Nonetheless, delaying implant placement by 3 to 4 weeks after extraction may lead to loss of the papilla. Therefore, supporting the papilla after extraction is critical.[12]

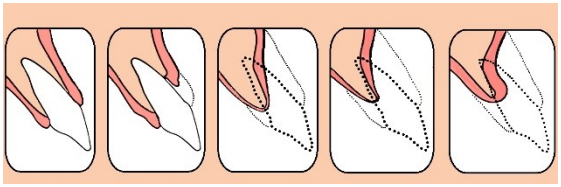
c) Late placement (Type 4):

Late implant placement is influenced by site- and patient-related factors. Site-related factors include the presence of an infected tooth requiring healing, extraction of a hopeless tooth in a growing patient, and trauma-related tooth loss which need time for healing. Patient-related factors include comorbidities influencing implant success. If a late implant placement protocol is decided, the possibility of bone resorption during the healing process should be considered. Graft materials can be placed into the socket after extraction to prevent resorption and deformity later. However, the choice of graft materials for this procedure remains controversial.[17]

Hard and soft tissue status and the need for augmentation:

The thickness, height, and contour of the labial alveolar bone can significantly affect a patient's facial expression and smile line and the transmission of functional forces.[24] The amount of vertical and horizontal bone loss and the presence of the buccal bone determine the quantity and the type of graft material needed (Figure 2).[12] To place a standard implant in 3.75 to 4 mm diameter, the required bone thickness is 6 mm in the bucco-lingual direction and 5 to 6 mm in the mesio-distal direction.[30]

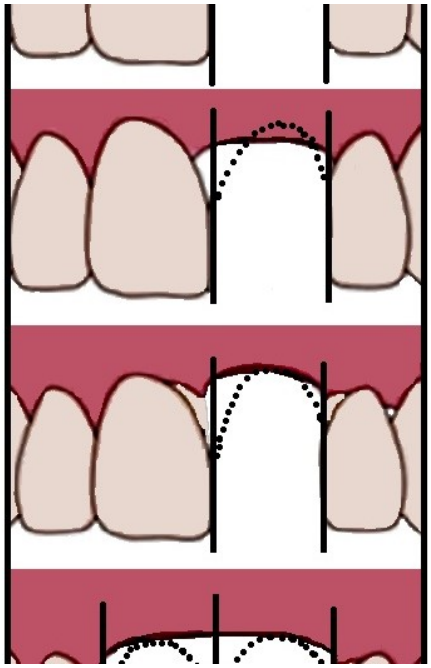
Figure 2: Vertical and horizontal alveolar bone loss[24]



Peri-implant mucosa height follows the alveolar bone; however, providing an interproximal papilla around an implant is complex and may not be fully controlled by the design of implant components or surgical interventions. While bone height and thickness play crucial roles in determining soft tissue level around implants, other factors, including tooth morphology, the position of the interdental contact point, and the arrangement and quality of soft tissue fibers, also influence soft tissue. The absence of various types of fibers around implants poses a significant challenge in managing the soft tissue around implants. The lack of papilla causing a black triangle between the implants is a major problem in the esthetics of implant-supported fixed prostheses. The type of temporary prosthesis used during the healing period plays a critical role in achieving the desired healing of the soft tissue.[24] Palacci and Ericsson[31] introduced a classification system in 2001 to aid clinicians in visualizing the outcomes and limitations of implant treatment. This system

categorizes implant sites into four classes based on the extent of vertical and horizontal tissue loss (Figure 3).[24,32] The clinician should not expect to go directly from class IV to class II or from class III to class I with a single surgical procedure. However, class IV cases can be converted into Class II cases through a series of procedures. A total gain of 4 to 5 mm in soft tissue height can be achieved with surgical interventions. Bone augmentation procedures can provide a height gain of 2 to 3 mm. Soft tissue augmentation can provide an additional 2 mm, while surgical crown lengthening can add 1 to 2 mm more, potentially gaining a total of 3 to 4 mm. A staged surgical approach can further increase soft tissue height by 5 to 6 mm. These combined attempts can significantly enhance the success of implant treatment. Therefore, hard and soft tissue augmentation affects implant placement and subsequent prosthetic restoration.[24]

Figure 3: Palacci-Ericson classification[24]



Vertical loss: Class I, intact or slightly reduced papilla; class II, limited papilla loss (less than 50%); class III, severe papilla loss; class IV, absence of papilla (edentulous ridge).
Horizontal loss: Class A, intact or slightly reduced buccal tissues; Class B, limited loss of buccal tissue; Class C, severe loss of buccal tissue; Class D, excessive loss of buccal tissue, often with a limited amount of adherent mucosa.

Smile line:

In an ideal smile line, the lip displays 75 to 100% of the maxillary central incisors and the interproximal gingiva. A high smile line exposes the full length of the maxillary anterior teeth and the surrounding gingiva. A low smile line shows less than 75% of the anterior teeth.[19] Since the mean lip lines of females are 1.5 mm higher that of males, 1 to 2 mm of gingival exposure during a maximum smile can be considered normal in women. It has been reported that an average of 0.7 mm of gingiva is visible during the smile in women, while in men, an average of 0.8 mm of the clinical crown is covered by the upper lip.[33] The support and visibility of the vermillion line during a smile are greatly affected by the anatomy of the upper alveolar bone, the placement of implants, the surrounding tissue around the implants, and the shape of the teeth.[24,33] Low smile provides advantages for esthetical results of implant treatment.

Patient expectation:

Implant prostheses are intended to provide function and esthetics to patients, but it is difficult to meet these expectations in some cases. The patient should be informed about the final results of the prosthesis to avoid the disappointment.[24]

Position of the implant:

The optimal implant position is achieved by positioning the implant shoulder approximately 1 mm palatal from the origin of the adjacent teeth. Placing the implant too labially, also called entering the dangerous zone, can cause buccal bone resorption and subsequent gingival recession.[23] In such cases, if the implant is deeply embedded in the bone to correct this malposition, the gingival level of prosthetic restoration would be higher than the other teeth. Furthermore, in some of these cases, removal of the implant, hard tissue augmentation, and a new implant placement are required.[13] A risk with implant placement is

inserting the implant too palatally, which may require an over-contoured implant-supported crown.[23] In natural teeth, the presence of periodontal ligaments with adequate blood supply allows the tooth to remain stable even if the width of the labial alveolar bone supporting the tooth is less than 1 mm.[34] However, bone support around the implant is important for an implant without periodontal tissue support. According to the study by Miyamoto et al.,[26] vertical bone resorption and the resulting gingival recession could be prevented if 2 mm or higher labial bone thickness was maintained.

The optimal depth for implant placement is typically around 1 mm below the enamel-cement junction of the neighboring teeth.[23] Deep implant placement may result in deep periodontal pockets around the implants. However, bone resorption of coronally placed implants is similar to that of apically placed implants.[35] The depth of implant placement is vital for the contour of the restoration and long-term prognosis of the implant.[13]

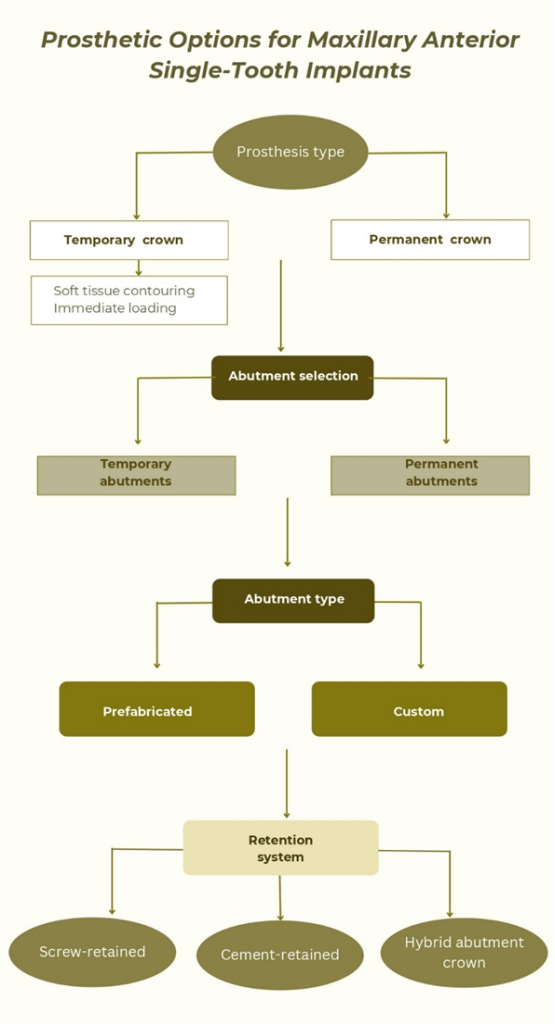
Implant neck design:

The implant neck design affects the relationship between the implant, the prosthesis, and the surrounding soft tissue, thereby affecting marginal bone, the level of the implant, and the long-term health of these tissues.[20,36] Hartog et al.[20] compared the effect of three different implant neck designs on the preservation of marginal bone. They found no significant difference in rough or smooth necks, but the neck design with micro-grooves resulted in higher bone loss and deeper pockets. On the contrary, Nickenig et al.[37] reported that marginal bone loss was higher in smooth-neck implants compared with rough-neck implants and that the micro-grooved design might reduce the marginal bone loss.

Prosthetic Options

Function and esthetics play an important role in implant-supported treatments for the rehabilitation of tooth loss in the maxillary anterior region. The prosthetic options are summarized in Figure 4. The factors affecting these prosthetic outcomes are abutment selection, prosthesis type, soft tissue repositioning with temporary crowns, and occlusion.

Figure 4: Prosthetic options for maxillary anterior single-tooth implants



Abutment selection:

Abutment selection includes factors such as screw- or cement-retention, abutment material, implant-abutment connection type, abutment selection time, and production method of the abutment.

Screw/cement-retained abutments: The fixation of an implant-supported prosthesis on the implant is achieved by screws or by types of luting cement to the abutment, which is screwed onto the implant.[38] Cement-retained prostheses

are preferred in single-unit restorations, although favorable long-term clinical results have been reported for cemented and screwed prosthetic restorations.[38,39] However, both cement and screw-retained prostheses have advantages and disadvantages.[38,40] In cement-retained prostheses, prefabricated or customized abutments are needed, and the restoration is cemented onto the abutment. Residual cement around the peri-implant tissue after cementation can cause peri-implantitis.[41,42] Furthermore, in case of a complication, removing a cement-retained prosthesis can be more challenging without damaging the prosthesis.[38] This system is preferred because it is easy to provide passive fit and tolerate improper implant angle.[40,43] The most crucial benefit of screw-retained restoration is the ease of removal of the prosthesis for different purposes such as hygiene protocols, repair, and surgical intervention requirements.[43] In addition, when the interocclusal distance is limited to 4 mm, good retention can be achieved with screw-retained restorations.[40] The ideal screw hole should be placed in the palatal or oral surface of the restoration, which is not visible. However, the horizontal and angular position of the implant may cause the position of the screw hole at the labial site, which may adversely affect the esthetics of the prosthesis.[43,44] For these reasons, implant positioning is critical in screw-retained restorations. Also, the production technique is more complex, and complications such as screw loosening and porcelain fracture may be observed during intra-oral use.[45] Screw-retained restorations are preferred in the anterior regions because it is difficult to remove the cement when the implant is placed deeply in the posterior regions.[46] Freitas et al.[47] reported that there is more stress concentration in screw-retained restorations than in cement-retained restorations, resulting in more screw/implant fractures. Edmondson et al.[48] reported that the need for an angled abutment is common in the anterior region, and screw-retained abutments can tolerate angles up to 15 degrees. According to Chee et al.[40], screw-retained restorations can be preferred for the anterior implants since screw hole access has no role in occlusion.

Abutment material: Titanium, stainless steel, gold, zirconia, alumina ceramic, and Polyetheretherketone (PEEK) can be used as abutment materials.[49,50] Good long-term results have been documented for single crowns using titanium and gold abutments. However, these materials have esthetic drawbacks in the anterior region in thin soft tissues or peri-implant mucosal recession.[44,51,52] Prestipino et al.[53] reported that densely sintered alumina ceramics had low corrosion, high biocompatibility, and low thermal conductivity; however, their mechanical durability was less than metal abutments.[44] Glauser et al.[55] first described densely sintered yttrium-stabilized zirconia as an alternative ceramic abutment. As zirconia abutments have good mechanical properties and peri-implant tissue response similar to titanium abutments, they have emerged as an alternative material. The grayish-bluish appearance caused by titanium abutments can be overcome with zirconia material.[56,57] In addition to esthetic advantages, ceramic abutments have high corrosion resistance, biocompatibility, and less bacterial adhesion.[58] Foong et al.[59] compared the fracture resistance of titanium and zirconia abutments in their study. As a result, fracture localization was observed at the abutment in zirconia abutments, while screw fracture was observed in titanium abutments. Bidra et al.[60] reported that fractures were reported in 1.15% of the abutments examined used in the anterior region. All fractured abutments were made of alumina or zirconia while no fractures were observed in titanium abutments. In a systematic review and meta-analysis, Laleman et al.[61] investigated the biological, technical, and esthetic outcomes of zirconia, alumina, and titanium abutments on peri-implant tissues after a minimum of one year of use. The study found that all three

materials—zirconia, alumina, and titanium—performed similarly in terms of biological effects on peri-implant tissues, with no significant differences in marginal bone loss, probing depth, or abutment survival. However, ceramic abutments, such as zirconia and alumina, were more prone to fractures, whereas titanium abutments presented minor esthetic limitations. Despite these differences, both materials delivered satisfactory esthetic results. In a systematic review, Davoudi et al.[62] investigated the effects of CAD-CAM zirconia abutments on peri-implant health and compared the esthetic outcomes to other abutment types, such as stock abutments and titanium abutments. While pink esthetic and white esthetic scores were similar between CAD-CAM zirconia and other abutments, zirconia showed better soft tissue color, contour, and gingival recession outcomes, especially in thin soft tissue areas. Zirconia abutments also had lower bacterial colonization and improved soft tissue stability compared to titanium, reducing inflammation and peri-implantitis risk. Customizable CAD-CAM zirconia abutments offered better adaptation to patient anatomy, enhancing soft tissue stability and aesthetic outcomes. Long-term studies suggested stable soft tissue and bone levels over time, with minimal gingival recession. Despite promising results, the review calls for more high-quality, long-term studies to confirm these findings.[62] There is difficulty in soft tissue attachment to the surface of zirconia abutments, which are prominent for esthetic purposes. To solve this problem, micro and macro processes affecting soft tissue integration on the zirconia abutment surface have been developed. These processes include polishing, sandblasting, acid etching, plasma treatment, biomimetic coating, and UV treatment.[63] It was stated that soft tissue cells attach better to smooth polished surfaces.[64] Valantijiene et al.[65] also reported that periodontal cells showed better results around ultra-polished zirconia abutments than conventionally polished zirconia abutments.

Abutment-implant connection type: The type of abutment-implant connection imposes mechanical and functional limitations. Different types of interface designs have been developed, each having inherent advantages and disadvantages.[66] The external hexagonal connection type facilitates prosthesis placement and provides an anti-rotation mechanism. However, it can cause complications under high occlusal loads because a micro-gap has arisen with this connection.[67,68] In contrast, internal hexagonal connections facilitate load distribution and provide an antibacterial sealing because the implant-abutment connection interface area is increased, and the micro-gap with the morse taper is reduced. It has been reported that internal connections provide a more stable abutment-implant connection and reduce bone loss.[67,69] According to Misch,[15] implant and abutment designs with internal hexagonal connections remain the most widely used method. The study by Vetromilla et al.[67] showed that the morse-taper connection reduced bone loss and revealed successful results.

Abutment selection time: In the standard prosthetic protocol applied after implant application, the separation and reconnection of prosthetic components are involved. The replacement of these prosthetic components can disrupt the mucosal barrier due to the mobility of the peri-implant tissue they contact, potentially leading to bone loss.[70-72] In today's practice, where the goal is to minimize soft and hard tissue loss, the "one abutment at one time" concept has been developed. This concept aims to place the permanent abutment during the implant application instead of attaching a healing abutment.[73] To evaluate this concept, Canullo et al.[73] conducted an implant treatment with immediate loading in place of extracted premolar teeth in 32 patients. Half of the patients received temporary abutments, while the other half were treated with the "one abutment at one time" concept, where

permanent abutments were placed during the implant procedure. Follow-up results indicated that patients with permanent abutments experienced a bone gain of approximately 0.2 mm. In the study conducted by Grandi et al.[74], it was observed that 0.5 mm of bone was preserved when abutments placed during surgery were not removed, compared to the use of temporary abutments and abutment replacement. However, this amount is considered clinically insignificant.

Abutment production method: Abutments are categorized as either prefabricated or custom-designed. Prefabricated abutments offer advantages such as low cost, availability, and reduced chairside time for patients. However, they have disadvantages including inadequate gingival emergence profile and lack of retention-contributing surfaces due to their cylindrical structure. Creating additional grooves on the abutment surface may be necessary to prevent rotation. Prefabricated abutments can be made of titanium or ceramic materials. Customized abutments are usually designed like a prepared tooth. This provides the desired result in terms of both retention and esthetics. They also facilitate correcting the implant angle. However, relatively higher cost and dependence on the experience of the technician limit their use.[43,75] Lops et al.[76] compared the sealing of prefabricated or custom-made abutments after screw tightening. It was found that the prefabricated ones had a higher sealing volume. In another study by Lops et al.[77], the effect of the type of abutment used on the gingiva was examined, and it was reported that prefabricated abutments positively affected the papillary gingival level. It is thought that custom-made abutments are more effective in obtaining the appropriate emergence profile of the restoration.[78]

Types of Prostheses:

Today, a variety of prosthetic materials are available for implant-retained fixed prostheses. These materials include metal-supported ceramics, zirconia-based ceramics, lithium disilicate ceramics, hybrid ceramics, and high-performance polymers.[79,80] The choice of prosthetic material is crucial and involves considering several factors to ensure the long-term success, stability, functionality, and esthetics of the restoration.[81] These factors include the individual design of the implant-supported prosthesis, number of implants, implant location, type of implant-abutment connection, esthetic requirements, masticatory forces, and occlusion.[79] Metal-ceramic restorations have been commonly used for their strength, durability, and satisfactory esthetics.[81] With advancements in materials science, zirconia ceramics have become more popular due to their enhanced mechanical properties, high biocompatibility, and esthetics.[82,83] However, high fracture rates of veneer porcelain have also been observed in the veneered zirconia-supported prostheses. Monolithic zirconia without veneer porcelain has been reported to be more fracture-resistant, which is expected to reduce fracture incidence.[84] According to Rammelsberg et al.[85] restorations with substructures made of chromium cobalt alloys showed lower failure rates than noble metal alloys such as gold. For zirconia and lithium disilicate ceramics, monolithic restorations are found to have significantly lower fracture risks than veneered restorations. Zembic et al.[86] evaluated 54 all-ceramic crowns cemented to zirconia abutments in the anterior and premolar regions, demonstrating a 90.7% success rate after 11 years with minor fractures and screw loosening as complications. Despite being made of leucite-reinforced ceramic, which has lower strength than zirconia and lithium disilicate, no ceramic fractures were observed.

Metal-free restorations are becoming increasingly important in dental practice, primarily due to the growing emphasis on esthetics. PEEK, a high-performance polymer,

has shown excellent mechanical properties for various dental applications. PEEK frameworks can be coated with composite resin, a suitable option for implant-supported fixed prostheses for patients with metal allergies. Additionally, PEEK material can be seen as an alternative to titanium or zirconia due to its high-quality mechanical properties. However, PEEK is used for both long-term temporary and permanent prosthetic treatments.[84] In addition to these types of prostheses, with the development of CAD-CAM systems, manufacturers have produced hybrid abutments by combining the durability of titanium with the esthetics of ceramics.[58] Customized CAD-CAM abutments and titanium base abutments have gained significant popularity because they integrate seamlessly into digital workflows, which enhances cost-efficiency.[87] Prostheses with hybrid abutments are produced in two ways: hybrid abutment crown and hybrid abutment and separated crown.[88] Instead of one-piece zirconia abutments, zirconia abutments or abutment-crowns cemented on a titanium spacer increase success. In addition to zirconia ceramics, lithium disilicate, hybrid, and zirconia-reinforced lithium silicate ceramics can be used to produce abutment crowns on titanium inserts.[58,89] Strasding et al.[87] stated that titanium base abutments are favored for their mechanical strength and compatibility with ceramic superstructures, making them ideal for both single and multiple-unit restorations. Zirconia and lithium disilicate ceramics are suggested for final restorations, with zirconia suited for posterior regions and lithium disilicate for the anterior, depending on esthetic considerations. While titanium abutments excel in durability, zirconia offers better esthetics but carries a greater risk of fracture. They highlighted the importance of selecting abutments and materials carefully, considering mechanical properties, aesthetic needs, and factors such as implant location and patient preferences.

Temporary crowns and soft tissue contouring:

Esthetically pleasing implant prostheses require a temporary restoration to contouring peri-implant soft tissue. The advantage of provisional prostheses is the ability to transfer the final prosthesis emergence profile to permanent restorations. The choice between temporary prostheses depends on timing, interocclusal space, longevity, ease of fabrication and modification, ease of removal, esthetic demands, and economic considerations.[90] Before implant placement, the provisional restoration is often a removable prosthesis with an oval body placed immediately in the post-extraction site or an adhesive fixed restoration, such as in Maryland, to preserve the natural appearance.[91] Following implant placement, the most straightforward approach is to utilize a screw-retained provisional restoration. Healing caps are inadequate to establish the contours and emergence profile of a crown because they are narrower than the tooth's emergence profile. Screw-retained provisional restorations enable easy placement and removal; thereby, the restoration and shape of the peri-implant mucosa can be modified. However, the torquing value of the provisional abutment is essential. Nedir et al.[92] recommended 30 Ncm for an instantaneously loaded single implant insertion torque. However, in cement-retained provisional restorations, it is more difficult to manage bleeding and ensure ideal tissue health due to the cement.[40] According to Castellon et al.[93] provisional restorations had advantages such as preservation of the interdental space, gingival remodeling, and improvement of patient comfort. Chee et al.[91] reported that removable or fixed provisional restorations made in the provisional stage could improve soft tissue esthetics. According to a review by Lewis et al.[94] there was no evidence that any provisional restoration showed superior clinical results; however, provisional restoration construction was effective in conditioning the gingiva and providing patient satisfaction.

Emergence profile management can be accomplished through either a customized anatomical screw-retained provisional restoration or a customizable PEEK support with a straight or slightly contoured customized anatomical screw retainer. These approaches help to contour the soft tissues around the implant and provide a natural and healthy appearance. The recommendation for a screw-retained restoration is partly based on the risk of excess cement causing complications in nearby tissues. Using a screw-retained approach reduces the likelihood of leaving residual cement, which can lead to issues such as inflammation, tissue damage, and implant failure. A screw-retained provisional restoration offers the advantage of applying pressure to the soft tissue, which can help to improve the transition zone during tissue healing. When applied correctly, this pressure can positively influence soft tissue thickness, which is crucial for achieving long-term esthetic outcomes around implants. However, excessive or inappropriate pressure from the provisional can lead to mucosal thinning and potential gingival recession. To avoid these issues, the provisional restoration should be adjusted gradually over time (usually about 5 minutes) to reach the correct height of the proposed mucosal border. It is important to note that excessive pressure during adjustment can cause whitening of the tissue, indicating that the pressure is too high. Initially, the provisional restoration may have a poor contour, but through tissue maturation and several adjustments, the contouring can be corrected to achieve the desired esthetic outcome.[18]

In immediate implant treatment following tooth extraction, standard temporary crown applications often struggle to provide the desired aesthetics due to the materials used. Instead, to quickly create a temporary crown, facilitate the shaping of soft tissue, and achieve better aesthetics, a temporary crown can be made using the crown of the extracted tooth.[95] In the clinical report published by Deliberador et al.[95], they placed implants in place of extracted maxillary anterior teeth. For the temporary crown, they separated the crown from the root of the extracted tooth, prepared the crown to fit the abutment, and cemented it with resin cement. After a 12-month follow-up, they found the clinical results to be good in terms of preserving the natural shape and function of the tissues. In the case conducted by Giacomo et al.[96], they separated the buccal surface of the extracted tooth and fixed it to the abutment with resin cement, shaping and polishing it appropriately. As a result, they achieved a simple, quick, low-cost, and aesthetic outcome. In the clinical study conducted by Passos et al.[97], they used a polyvinyl siloxane index, referencing the patient's tooth before extraction, for the temporary crown in a patient who had undergone extraction and implant planning for central incisor tooth due to trauma. This allowed them to create a temporary crown that closely resembled the extracted tooth and facilitated the formation of papillae, enabling immediate loading. When the patient returned six months later, they removed the temporary crown, placed a scan body, and took an intraoral scan to design and mill the permanent restoration using a CAD-CAM system.

Occlusion:

The direction, intensity, and duration of chewing forces on implants influence the surrounding bone density and thickness. Forces that are not aligned with the implant's long axis can stress the bone and lead to bone loss. Angular forces on implants correlate with reduced alveolar bone thickness and height. Occlusal adjustment is crucial to align chewing forces with the implant's long axis for a better prognosis. Prosthetic treatment planning and follow-ups are necessary to ensure implant restorations meet requirements for proper occlusion and phonetics.[24,98]

CONCLUSION

The main purpose of implant-supported prostheses is to fabricate restorations with long-

term success. However, restoring a single tooth loss with an implant-supported prosthesis can be challenging, especially in the maxillary anterior region. This region has functional and esthetic importance. Therefore, to meet the expectations of both the clinician and the patient, detailed planning for the implant and prosthetic treatment, selection of the appropriate abutment and prosthetic materials, and soft tissue recontouring should be performed.

Ethical Approval

Since sources obtained from humans or animals were not used in this study, ethics *committee* approval was not obtained.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: ÖMY, MBG, ALiterature review: ÖMY, BTB, SKN, MBG, Writing: ÖMY, BTB, SKN, MBG.

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Supernumerary Mandibular Premolar Developing In Late Stages During Orthodontic Treatment: A Case Report

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ABSTRACT

Supernumerary teeth represent one of the developmental anomalies observed in the jaws. While the precise etiology of supernumerary teeth remains incompletely understood, it is believed to arise from a combination of genetic and environmental factors. These additional teeth, which may appear singly or in multiples within both the maxilla and mandible, typically manifest without symptoms. Notably, supernumerary premolar teeth exhibit a greater prevalence in the mandible compared to other supernumerary types. Supernumerary premolar teeth, which are similar to premolar teeth in terms of morphology, tend to form at a later stage than the normal development period. Supernumerary teeth emerging during or subsequent to orthodontic treatment may occasionally be encountered. It is crucial to diagnose these teeth, typically detected incidentally during radiographic examinations, owing to the potential complications they may entail. In instances where these supernumerary teeth remain undiagnosed, complications such as cyst formation, root resorption, and dental crowding may arise, potentially compromising the stability of orthodontic treatment. Therefore, the decision regarding whether to extract or monitor the supernumerary tooth should be approached with caution, considering the balance between potential benefits and risks, in addition to a thorough evaluation through detailed radiographic examination. This case report presents an instance of a supernumerary tooth developing belatedly during orthodontic treatment in the mandibular right premolar region of a 15-year and 11-month-old female patient.

Ortodontik Tedavi Sırasında Geç Dönemde Gelişen Süpernumere Mandibular Premolar: Vaka Raporu

Makale Bilgisi

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ÖZET

Süpernumere dişler çenelerde görülen gelişimsel anomalilerden biridir. Süpernumere dişlerin etyolojisi tam olarak bilinmemekle beraber genetik ve çevresel faktörlerin birleşiminden kaynaklandığı düşünülmektedir. Hem maksilla hem de mandibulada tekli veya çoklu olarak görülebilen süpernumere dişler genellikle asemptomatiktir. Süpernumere premolar dişlere ise diğer süpernumere dişlerden farklı olarak daha çok mandibulada rastlanmaktadır. Morfoloji bakımından premolar dişlere benzerlik gösteren süpernumere premolar dişler normal gelişim döneminden daha geç bir dönemde oluşmaya eğilim göstermektedirler. Ortodontik tedavi esnasında veya sonrasında da geç dönemde gelişim gösteren süpernumere dişlere rastlanılabilmektedir. Genellikle radyografik muayene sırasında tesadüfen tespit edilen bu dişlerin neden olabileceği komplikasyonlar sebebiyle teşhisi önemlidir. Teşhis edilemediği durumlarda kist oluşumu, kök rezorpsiyonu, çapraşıklık gibi komplikasyonlar görülebilirken aynı zamanda ortodontik tedavinin stabilitesini de tehlikeye atabilir. Detaylı radyografik inceleme ile birlikte fayda/zarar ilişkisi göz önüne alınarak süpernumere dişin çekim veya takip kararı dikkatle verilmelidir. Bu vaka raporunda, 15 yıl 11 aylık kadın hastanın mandibular sağ premolar bölgesinde ortodontik tedavi sırasında geç dönemde gelişim gösteren süpernumere diş olgusu sunulmaktadır.

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INTRODUCTION

Supernumerary teeth, also known as hyperdontia or extra teeth, are additional teeth that develop in the jaws. The etiology of supernumerary teeth, considered a developmental anomaly, remains incompletely understood. While various theories have been proposed to elucidate this condition, it is generally assumed that both genetic and environmental factors contribute to its manifestation.[1–4]

Ethnicity is an important factor in the prevalence of supernumerary teeth. Various studies in the literature have reported that the prevalence of supernumerary teeth varies between 0.05% and 3.5% in different populations.[5] According to the results of a study conducted by Esenlik et al. [6] on 2599 patients with a mean age of 8.6 ± 0.23 years, the prevalence of supernumerary teeth in the Turkish population is 2.7%. In a study conducted by Çelikoğlu et al. [7] on 3491 patients aged between 12 and 25 years, the prevalence of supernumerary teeth in the Turkish population was found to be 1.2%.

The most prevalent type of supernumerary teeth is mesiodens, which is localized between the upper central incisors. In second place are distomolar teeth located distally to the third molar teeth. Less commonly, 'paramolar' and 'supernumerary premolars' located between two molar teeth can be seen.[2,8,9]

Supernumerary premolar teeth constitute 8% to 9.1% of all supernumerary teeth.[3,10–13] Found in higher rates in the mandible compared to the maxilla, these teeth bear resemblance to permanent premolars in terms of shape and morphology.[1,10]

Supernumerary teeth, typically asymptomatic, are usually detected incidentally during radiographic examinations. The treatment of diagnosed supernumerary teeth may vary depending on their position, number, and the risk of complications that may arise from surgical extraction.[14] In the presence of supernumerary teeth, complications such as the formation of dentigerous cysts, anomalies in the eruption of permanent teeth, crowding, and resorption of adjacent tooth roots may arise.[1–4,10,12,15,16] Furthermore, if not considered, supernumerary teeth could hinder the application of dental implants in dental treatments or the placement of mini implants during orthodontic treatment. They can also interfere with orthodontic space closure mechanics or root movements.[1,3,10] Additionally, ensuring stability in the outcomes is a crucial objective of orthodontic treatment, and a supernumerary tooth can significantly impede this stability.[3] Considering all these factors, supernumerary teeth should be approached as part of a comprehensive treatment plan. The ideal treatment option may not always be the extraction of the supernumerary tooth. In cases where an asymptomatic and unerupted supernumerary tooth has no adverse impact on dentition, monitoring rather than extraction may be preferred. In a study conducted by Ezirganlı et al. [5] it was determined that 39.32% of supernumerary teeth were extracted, while 60.68% were kept under observation.

In the literature, supernumerary premolar teeth that develop after the permanent dentition are termed 'late-developing supernumerary premolar teeth'. They typically emerge in the premolar region of both the upper and lower jaws. The decision regarding extraction or follow-up of late-developing supernumerary premolar teeth depends on numerous factors and should be carefully planned due to potential risks. Extraction of the tooth may be necessary due to potential complications it may cause,

while regular radiographic monitoring could be considered in cases where surgical intervention might jeopardize surrounding anatomical structures. Radiographic examination holds significant importance in both diagnosing and treating supernumerary teeth. Upon diagnosis, it is advisable to utilize advanced imaging techniques such as cone beam computed tomography (CBCT) or three-dimensional computed tomography (3D CT).[1,3,10,17,18]

CASE REPORT

A 15-year-11-month-old female patient, without any systemic disease, sought treatment at the Orthodontics Department of Usak University Faculty of Dentistry. In the cephalometric radiograph taken from the patient, the cervical vertebral maturation was examined, and the patient's growth development stage was determined to be CS5. The cephalometric measurements indicated that the patient had a skeletal Class I relationship (SNA: 80.5, SNB: 78, ANB: +2.5), with vertical dimension measurements within normal limits (GoGn-SN: 33.4). The inclinations of the upper and lower incisors were also found to be in a normal position relative to the cranial base (U1-NA: 22.3, L1-NB: 24.3). Following the radiographic assessment and intraoral examination, the patient was diagnosed with skeletal and dental Class I malocclusion (Figure 1). Both radiographic and clinical assessments revealed no missing or supernumerary teeth in the patient. The panoramic radiograph showed that all teeth, except the third molars, had erupted and no caries were present. It was observed that the third molars were developing in all four quadrants but had not yet erupted (Figure 2). A non-extraction treatment plan was devised for the patient, who exhibited dental crowding in both the upper and lower jaws. Orthodontic treatment using fixed appliances commenced, aiming to alleviate the crowding. During the treatment, a 0.22 inch slot MBT bracket system was used. The fixed orthodontic treatment, which began with levelling using a 0.014 inch NiTi wire, was completed with the use of a 0.019 x 0.025 inch SS wire, achieving the ideal torque and angulation values for the teeth. After 18 months of treatment, the crowding was successfully resolved, and the patient achieved an ideal occlusion with normal overbite and overjet (Figure 3). Subsequently, the fixed appliances were removed, and a retention protocol was initiated. Fixed retainers were applied to the canine-to-canine regions in both the upper and lower jaws. Additionally, the patient was provided with a removable retention appliance, specifically Essix retainers, and advised to use them full-time for the first 6 months and then only at night for the subsequent 6 months. However, in the panoramic radiograph taken at the treatment's conclusion, the presence of a supernumerary premolar between the lower right first and second premolars was noted (Figure 4). Since the orthodontic treatment had been completed, and all teeth were appropriately aligned, it was decided to surgically remove this supernumerary tooth. Then, the patient and her family were informed and informed consent was obtained. Localization of the supernumerary premolar was determined in three dimensions using cone beam computed tomography (CBCT) before the surgical intervention. The surgical procedure was carried out under local anaesthesia. Due to its position, the approach was made through a flap raised from the vestibule to access the impacted tooth. The supernumerary tooth germ was extracted without damaging the adjacent tooth roots, and the flap was then closed. (Figures 5, 6, and 7).

Figure1: Intraoral initial photographs.

Figure 2: Panoramic radiograph of a 15 -year-11-month-old patient before orthodontic treatment

Figure 3: Post-treatment intraoral photographs.

Figure 4: Panoramic radiograph taken after 18 months of treatment. Supernumerary tooth formation is observed in the lower right mandibular premolar region.

Figure 5: 3D view of the supernumerary premolar tooth with CBCT.

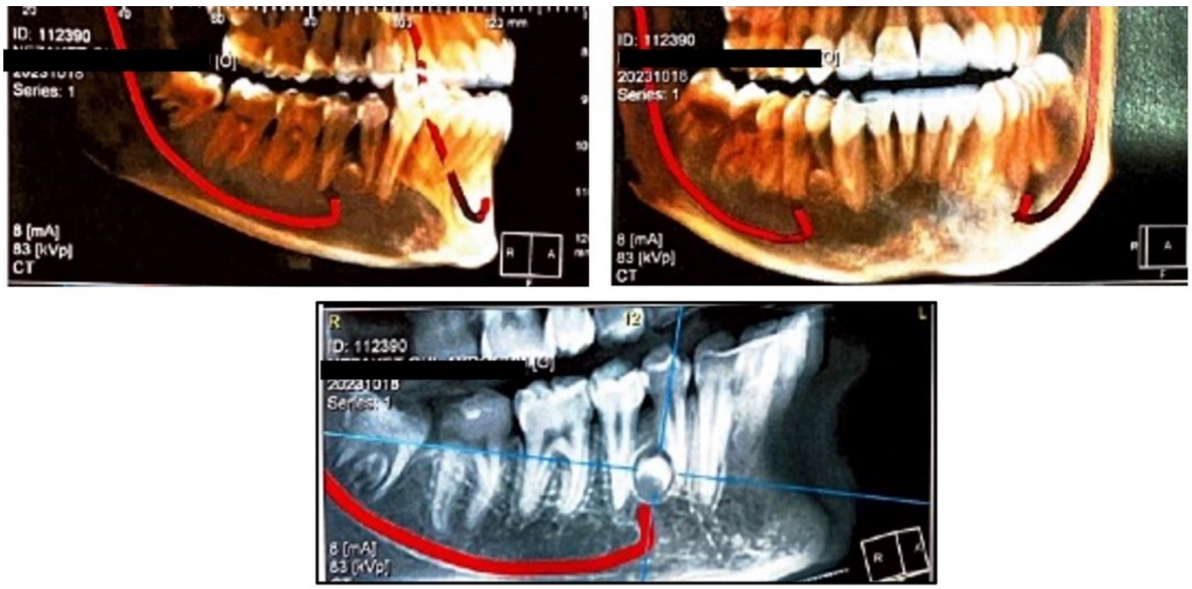

Figure 6: Surgical removal of supernumerary mandibular premolar.

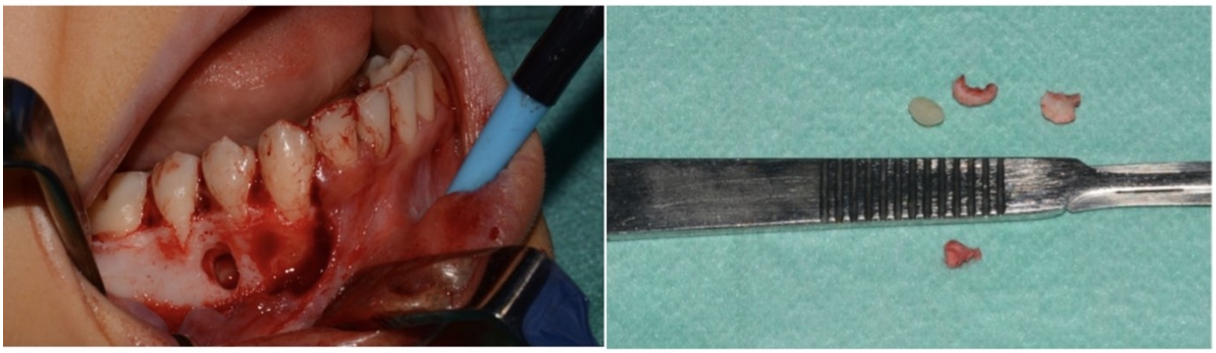

Figure 7: Panoramic radiograph taken after tooth extraction.

DISCUSSION

Supernumerary teeth can be seen singly or in multiples. While the likelihood of multiple supernumerary teeth being associated with various syndromes such as Gardner syndrome, Cleidocranial dysplasia, and Crouzon disease is higher, they can also occur non-syndromically.[1–4,9,10,13,16] It has been reported that supernumerary premolar teeth, unlike other supernumerary teeth, predominantly occur in the mandible and exhibit premolar tooth morphology. Additionally, these supernumerary teeth tend to develop later than the normal teeth in the area. It has been reported that premolar teeth typically begin to calcify around the age of 1,5 to 2,5 years but may not be detectable on radiographs until the age of 3 or 4. Late-developing supernumerary premolar teeth are reported to form around the age of 10 to 15.[1,3,10,13] Since this age range generally coincides with the young adult period, during which orthodontic treatments are frequently performed, it is important for orthodontists to conduct regular radiographic follow-ups.

Other instances of late-developing supernumerary premolar teeth have also been documented in the literature.[1,3,10–13,15,19] In the study by Suga et al. [13], the presence of multiple supernumerary premolar teeth, including those in the lower and upper jaw, has been detected at the age of 16 in a patient who underwent early orthodontic treatment and received orthognathic surgical planning after permanent dentition. Subsequently, the teeth have been removed. When the patient reached the age of 20, a panoramic radiograph taken before orthognathic surgery has revealed the presence of another late-developing supernumerary premolar in the mandibular premolar region. The authors have been emphasized that periodic radiographic follow-up is crucial for patients with a history of supernumerary teeth. In the another study of Paduano et al. [3], late-developed supernumerary premolar teeth have been found in 4 cases over the age of 14, and extraction or periodic follow-up has been performed, taking into account the benefit/harm relationship along with detailed radiographic examination. In the study by Öztürk et al. [1], a panoramic radiograph taken from an 11-year-8-month-old female patient prior to orthodontic treatment revealed no supernumerary tooth. However, a radiograph taken 10 months after the commencement of treatment incidentally showed the formation of a new tooth. As the patient was in the final stages of orthodontic treatment, and the supernumerary tooth was deemed to offer no aesthetic or functional benefit, the decision was made to extract the supernumerary tooth.

In our case, since orthodontic treatment was completed, the supernumerary tooth that appeared later had a recurrence effect on the treatment results. In addition, it was thought that if the extraction was postponed, its proximity to the mental nerve, as seen from the three-dimensional images, could cause greater complications in the future. The three-dimensional images obtained allowed the removal of this tooth without damaging both the teeth and the mental nerve.

CONCLUSION

Orthodontists should consider the possibility of late-developing supernumerary teeth after the completion of permanent dentition. If there is a delay or failure in the expected tooth movement during orthodontic treatment, or if placed mini implants fail, the presence of late-developing supernumerary teeth should be considered. In addition to optimum occlusion criteria, orthopantomographic examinations will be useful in annual routine controls after orthodontic treatment.

Ethical Approval

Since sources obtained from humans or animals were not used in this study, ethics *committee* approval was not obtained.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: ZB, Data collection and processing: ZB, Analysis and interpretation: ZB, İEG, Literature review: ZB, Writing: ZB.

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