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HRU International Journal of Dentistry and Oral Research (IJDOR)

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Type	Limit of Word	Limit of Abstract	Number of Table and Figure	Limit of References
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Articles in journals;

Doğan MS, Callea M, Kusdhany LS, Aras A, Maharani DA, Mandasari M, et al. The evaluation of root fracture with cone beam computed tomography (CBCT): an epidemiological study. J Clin Exp Dent 2018; 10(1):41-8.

Online articles not yet published;

Das RR, Singh M, Naik SS. Vitamin D as an adjunct to antibiotics for the treatment of acute childhood pneumonia. Cochrane Database System Rev. 2018 Jul 19;7:CD011597. doi: 10.1002/14651858.CD011597.pub2. [Epub ahead of print] Review.

Books;

1) Krogman WM, Iscan MY. The Human Skeleton in Forensic Medicine. Second ed. Springfield Illinois: Charles Thomas Publisher, 1986:189-243.

2) Beard SD. Gaines PA, eds. Vascular and Endovascular Surgery. London: WB Sounders, 1998:319-29.

Chapters from the book;

1) Soysal Z, Albek E, Eke M. Fetus rights. Soysal Z, Çakalır C, ed. Forensic Medicine, Volume III, Istanbul University Cerrahpasa Medical Faculty Publications, Istanbul, 1999: 1635-1650.

2) Dogan, M.S. 2018. Relation of trace elements on dental health. In Saleh, H.E.M. and El-Adham, E. (eds.) Human Health and Environment. United Kingdom: IntechOpen. 2018:856-910.

Web Articles;

Abood S. Quality improvement initiative in nursing homes: The ANA acts in an advisory role. Am J Nurs [serial on the Internet] 2002 [cited 12 Aug 2002]. Available from: www.nursingworld.org/AJN/2002/june/wawatch.htm

Website;

Cancer-pain.org [homepage on the Internet]. New York: Association of Cancer Online Resources [last reach 16 May 2002]. Available from:www.cancer-pain.org

Thesis;

Gezer R: Morphological Characteristics and Individual Differences of Rugae Palatines. Master Thesis, Şanlıurfa: Harran University Institute of Health Sciences, 2016.

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Financial resources, contributing institutions, organizations and individuals, if any, should be specified in this section.

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The editorial board can make any changes it deems necessary without changing the essence of the article.

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· On humans clinical studies,

· Animal studies,

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HRÜ Uluslararası Diş Hekimliği ve Oral Araştırmalar Dergisi

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Prognostic Risk Factors for the Development of Disorders of Occlusive Relationships in Patients with Temporomandibular Myofascial Pain Syndrome

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Abstract

Aim: Psychoemotional stress is currently recognized as one of the significant risk factors affecting human health. Recent studies have highlighted its role in the development of various dental pathologies, in particular disorders of occlusive relationships. The purpose of this study is to determine the frequency and severity of psychoemotional stress in patients with occlusion disorders, as well as to identify key symptoms of psychological stress that affect dental health.

Material and methods: The study was conducted at the Department of Dentistry of Volgograd State Medical University and included 120 patients aged 18 to 44 years with various disorders of occlusive relationships. The patients were divided into three groups depending on the degree of tooth abrasion. The PSM-25 questionnaire (Lemyr-Tessier-Fillion), adapted for the Russian-speaking audience, was used to assess the level of psychoemotional stress. The data were subjected to statistical analysis, including correlation analysis, to identify the relationship between stress levels and the severity of occlusive disorders.

Results: The results of the study showed that all patients included in the study experienced psychoemotional stress. The most common indicators of psychological stress have been identified: bruxism, clenching, physical malaise, fatigue and sleep disorders. Correlation analysis has demonstrated the presence of a direct relationship between the level of psychoemotional stress and the severity of occlusive disorders. Patients with more pronounced clinical manifestations of occlusal imbalance also had higher stress levels.

Conclusion: The study confirmed the significant influence of psychoemotional stress on the development and course of disorders of occlusive relationships. The identification of key symptoms of psychological stress in patients with occlusive disorders is important for practical dentistry, as it allows to improve the diagnosis and treatment of these conditions. However, for a more accurate and differentiated approach to diagnosis, it is necessary to take into account many risk factors and hidden relationships, which requires further research.

Research Article (HRU Int J Dent Oral Res 2025; 5(1):1-6)

Keywords: Disorders of occlusive relationships, psychoemotional stress, correlation relationship.

Introduction

Currently, scientists consider psychoemotional stress as one of the key risk factors for the development of various general somatic diseases [1, 2]. Its influence on the occurrence and course of dental diseases, where stress lability acts as an aggravating factor, has also been established [3]. The issue of the influence of psycho-emotional stress on the unity of the dental system remains relevant.

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Temporomandibular myofascial pain syndrome (TMMPS) is a common condition characterized by chronic pain in the temporomandibular joint (TMJ) and surrounding muscles, often accompanied by limited jaw mobility and occlusal dysfunction. The prevalence of TMMPS ranges from 31–76% in the general population, with a higher incidence among women [4]. In addition to psychoemotional stress, other risk factors for TMMPS include malocclusion, bruxism, trauma, and systemic diseases such as fibromyalgia.

Studies conducted by Zubareva A.S., Bragin A.V. et al. (2022), as well as Khan SIR, Aljammaz G. et al. (2023), showed that before a visit to the dentist, patients have a lower threshold of emotional stability and an increased stress level [5,6]. Modern research highlights the concept of stress-induced pathology, which implies pathological conditions caused by prolonged psychoemotional stress without proper correction. It has been proven that such pathologies negatively affect all body systems, including the oral cavity.

One of the key conditions that allow us to judge the possible long-term psychoemotional stress is a violation of occlusive relationships. Given the increasing prevalence of occlusion disorders and the exacerbation of pathologies of the stomatognathic system, it is important and relevant to investigate the frequency of psychoemotional stress in these patients in order to assess its impact on the development and course of occlusive disorders.

Current treatment approaches for TMMPS include occlusal splints, physical therapy, pharmacological management, and psychological interventions aimed at reducing stress and improving coping mechanisms [7, 9]. Recent studies have demonstrated a strong correlation between chronic stress and the severity of TMMPS symptoms, suggesting that stress management should be an integral part of the treatment protocol [10, 11].

The aim of the study is to determine the frequency and severity of psychoemotional stress in patients with disorders of occlusive relationships.

Materials and Methods

An observational, single-center, prospective, selective, controlled, non-randomized study was conducted. It includes 120 patients aged 18 to 44 years with disorders of occlusive relationships. All participants underwent a dental examination, including basic and additional techniques, according to the study design shown in Figure 1.

The study was conducted at the Department of Dentistry of the Institute of NMFO VolgSMU of the Ministry of Health of the Russian Federation in Volgograd. It was attended by patients who sought dental care.

The study consisted of a single visit to a dentist, which included planned manipulations: examination, palpation of the masticatory muscles and temporomandibular joint, and a questionnaire.

All patients underwent a dental examination, including a survey, examination of the face and oral cavity, palpation of soft tissues, chewing muscles and temporomandibular joint. The study complies with the standards of the Helsinki Declaration. All patients signed an informed consent, which is confirmed by Protocol No. 087 dated 04/15/2024 of the Local Ethics Committee of the Volga State Medical University of the Ministry of Health of the Russian Federation.

To determine the level of psychoemotional stress, the PSM-25 (Lemyr-Tessier-Fillion) psychological stress scale was used in adaptation according to N.E. Vodopyanova. The questionnaire included 25 questions with an 8-point scale, where 1 point indicates the absence of stress, and 8 indicates its high level. The calculated integral index of mental tension (PPN) was used to assess stress levels.

The survey of patients with occlusive disorders and the study of the correlation between the level of psychoemotional stress and the severity of clinical manifestations of occlusive imbalance. Patients were divided into three groups according to the degree of abrasion of hard dental tissues (according to the classification of M.G. Bushan, 1979) to assess the correlation between stress levels and the severity of occlusal imbalance.

Occlusive disorders were recorded on the basis of a clinical examination. The stress level was determined on the PSM-25 scale, and the correlation between stress symptoms and occlusive disorders was analyzed using the method of variance analysis.

Statistical analysis was carried out using Microsoft Excel 2016 and Statistica 13.0 programs. The method of multidimensional correlation analysis was used.

Results

The study included 120 patients aged 18 to 44 years with disorders of occlusive relationships. After a clinical dental examination, the patients were divided into three groups:

The first group included 42 people with tooth abrasion within the enamel. The second group included 49 patients with disorders of hard tissues within the enamel and partially dentin. The third group consisted of 29 people with tooth abrasion within the dentin.

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The study showed that all participants were exposed to psychoemotional stress in their daily lives to one degree or another (Fig. 2).

The frequency of occurrence of psychological tension of varying severity among the participants was 100%. Since the interpretation of the survey results turned out to be quite diverse, an analysis of individual criteria that are most significant for dental health was carried out. The data is presented in table 1.

These indicators indicate the presence of somatic manifestations of psychoemotional stress, which exacerbate the course of dental pathology. Moreover, the severity of these disorders increases with increased clinical manifestations of tooth hard tissue abrasion (Fig. 3).

Among the identified factors of the emotional sphere that indicate stress, there are: a feeling of tension and excitement, forgetfulness, impaired concentration, mood swings. All study participants reported rapid fatigue (Fig. 4).

To identify the relationship between stress symptoms and disorders of occlusive relationships, a correlation analysis was performed (Table 2). In all cases, a positive correlation was revealed, which increases with the transition from one group to another, indicating the influence of psycho-emotional stress on the severity of occlusive disorders. In addition, the most informative indicators in the analysis and diagnosis of stress-induced occlusion disorders are symptoms of bruxism and/or clenching, psychological tension, as well as fatigue.

Table 1. Study of symptoms of psycho-emotional stress in patients with disorders of occlusal relationships.

The symptom	Average level (points, M±m)		
	1 Group (N=42)	2 Group (N=49)	3 Group (N=29)
Feeling of tension and excitement	4,31±0,198 (N= 40)	5,83±0,111 (N=49)	6,68±0,12 (N=29)
Physical malaise	4,02±0,072 (N=34)	5,62±0,107 (N=45)	6,02±0,12 (N= 29)
Xerostomia	3,63±0,123 (N= 31)	4,31±0,159 (N= 43)	5,63±0,191 (N=28)
Forgetfulness	3,61±0,119 (N=30)	4,85±0,17 (N= 40)	5,77±0,19 (N= 26)
Fatigue	4,31±0,103 (N=42)	5,92±0,124 (N= 49)	7,31±0,263 (N=29)
Bruxism and/or clenching	3,08±0,099 (N=19)	4,87±0,185 (N= 44)	6,08±0,122 (N= 28)
Sleep disorders	5,28±0,121 (N= 33)	5,69±0,165 (N=38)	6,28±0,151 (N=24)
Impaired concentration	4,74±0,147 (N=39)	6,04±0,097 (N=48)	6,91±0,276 (N= 28)
Mood swings	3,13±0,063 (N=28)	4,26±0,085 (N= 34)	5,17±0,186 (N= 20)

Table 2. Results of correlation analysis of the considered symptoms of psycho-emotional stress by group.

The symptom	The level of correlation		
	1 group	2 group	3 group
Feeling of tension and excitement	0,47	0,51	0,63
Physical malaise	0,12	0,11	0,14
Xerostomia	0,19	0,19	0,21
Forgetfulness	0,12	0,15	0,13
Fatigue	0,54	0,52	0,51
Bruxism and/or clenching	0,69	0,77	0,75
Sleep disorders	0,3	0,36	0,41
Impaired concentration	0,24	0,18	0,22
Mood swings	0,1	0,11	0,08

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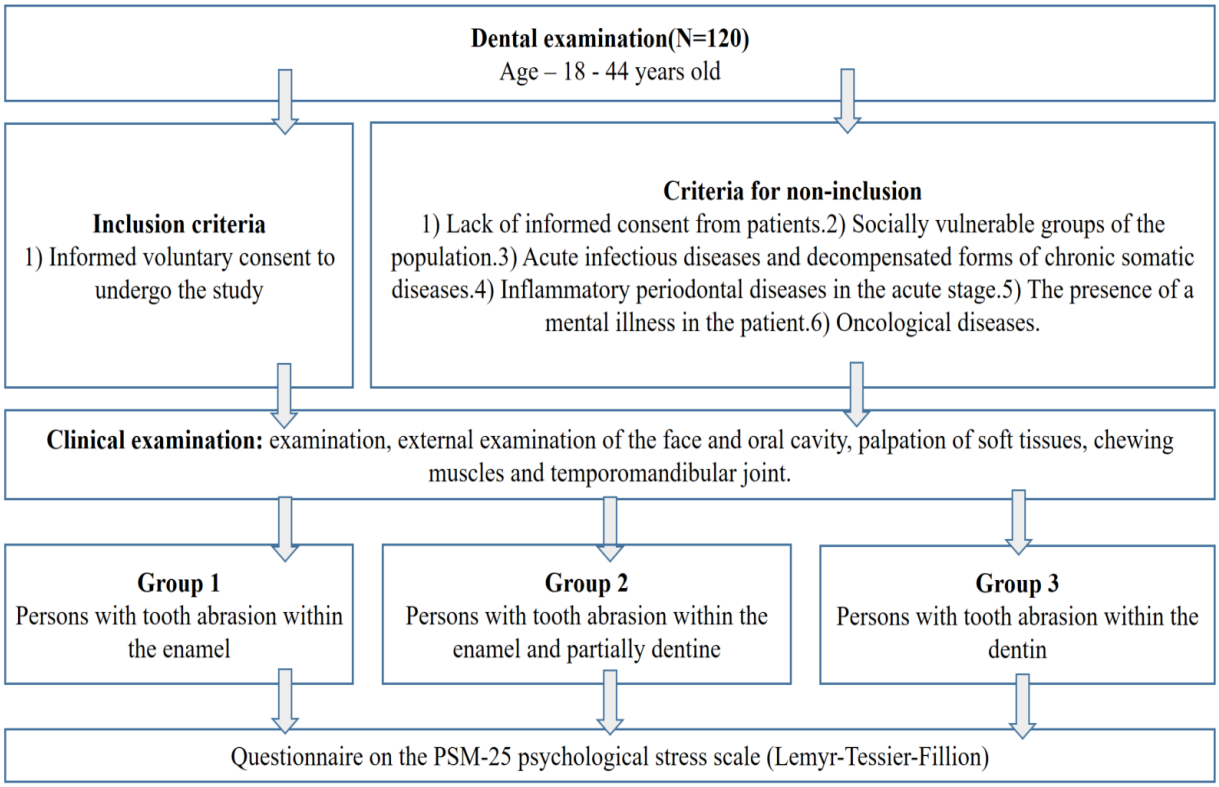

Figure 1. Study design.

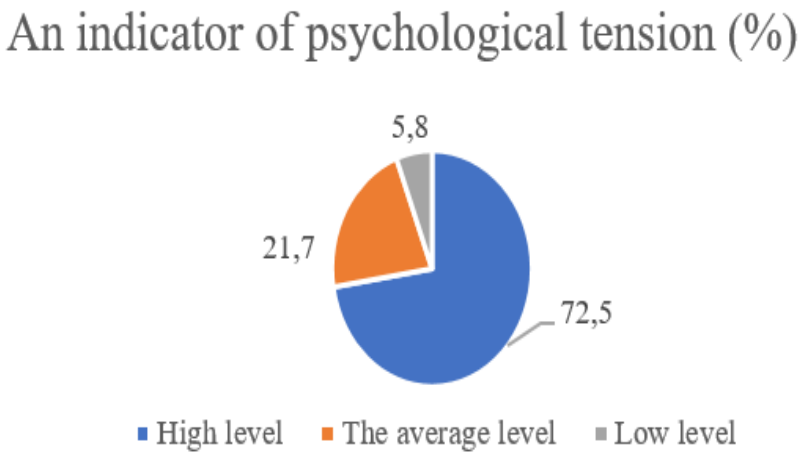

Figure 2. Level of psychological tension in patients with disorders of occlusal relationships.

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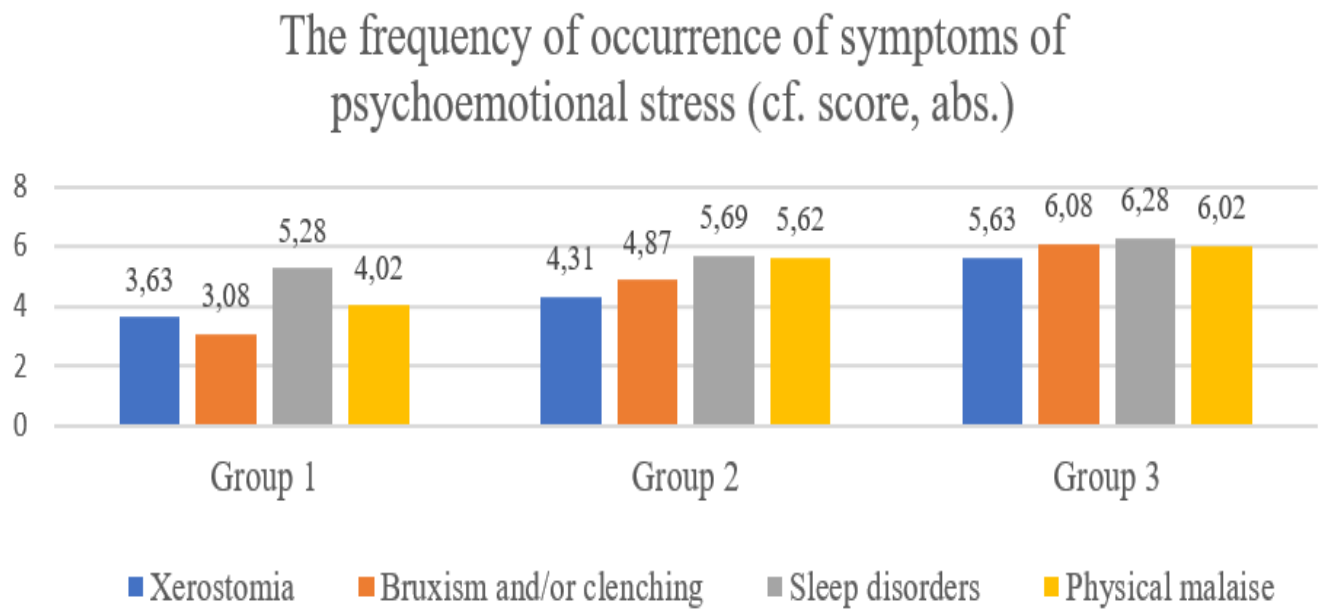

Figure 3. Frequency of occurrence of somatic symptoms of psychoemotional stress.

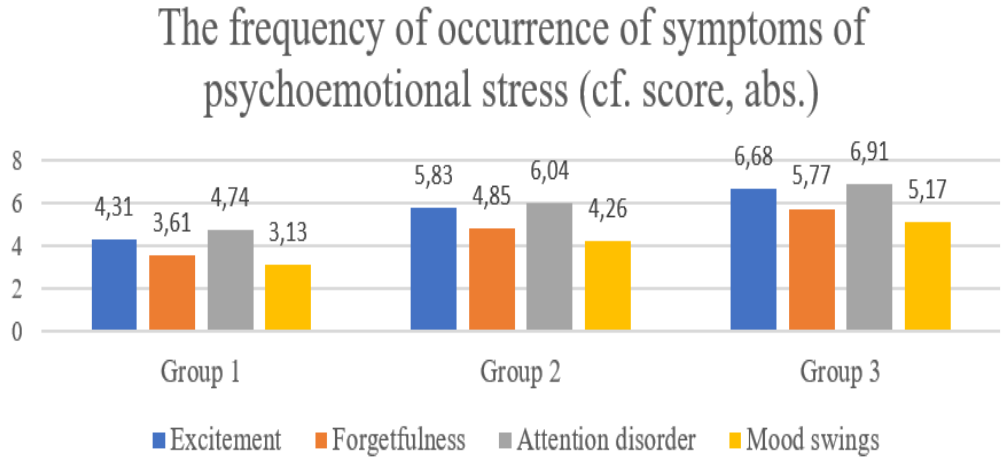

Figure 4. Frequency of occurrence of symptoms of psychoemotional stress.

Discussion

The results of the study confirm the significant influence of psychoemotional stress on the development of disorders of occlusive relationships.

In recent years, there has been an increase in the number of patients with disorders of occlusive relationships, one of the key risk factors for which is a high level of psychoemotional stress. In this regard, it becomes especially important to identify symptoms of psychological tension that have a negative impact on the stomatognathic system. This is of great importance for practical dentistry.

With an increase in the frequency of symptoms of occlusive imbalance, the need for a predictive approach to correct them increases. According to one theory, psychogenic factors play a significant role in the occurrence of occlusive disorders, while the level of

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psychological tension is critically important. Since stress-induced symptoms can manifest not only emotionally (agitation, mood swings), but also somatically (sleep disorders, physical malaise), a comprehensive approach to the management of such patients is required.

The study revealed that the most significant symptoms of psychological tension in patients with occlusive disorders are: a feeling of tension and agitation, physical malaise, xerostomia, forgetfulness, fatigue, bruxism and/or clenching, sleep disorders, impaired concentration, mood swings. In all cases, a positive correlation was established between the symptoms of stress and the severity of occlusive disorders, which confirms the influence of psychological tension on dental disharmony.

Stress levels can serve as a quantitative indicator justifying an interdisciplinary approach in the treatment of such patients. It also highlights the need for consulting support from specialists for psychological correction. Assessment of stress levels is an objective criterion for the effectiveness of diagnosis and treatment, reflecting changes in the psychological state of patients.

Conclusion

Psychoemotional stress is an important risk factor for the development of disorders of occlusive relationships, having a significant impact on their occurrence and course. The study revealed the most common indicators of psychological stress in patients, including bruxism, clenching, physical malaise, fatigue and sleep disorders. Correlation analysis showed a direct relationship between the level of psychoemotional stress and the severity of occlusive disorders. Determining the role of psychoemotional stress helped to identify key symptoms important for diagnosis in dental practice. However, the implementation of a differentiated diagnostic approach requires a comprehensive assessment of many risk factors, especially taking into account hidden relationships.

Ethical Statement
№089 15/04/2024 IRB 00005839 IORG0004900 Volgograd State Medical University

Project Number
Russian Science Foundation 12/04/2024 No. 24-25-20098, egional budget (Volgograd region) 31/05/2024 No. 10.

Thanks
The study was conducted as part of a scientific project aimed at developing a methodology for neural network analysis and forecasting the risk of occlusal relationship disorders within the framework of implementing the Russian Science Foundation grant No. 24-25-20098 and the Agreement on subsidies from the regional budget (Volgograd region) dated May 31, 2024, No. 10.

Reference

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Comparison of Lengths of Gutta-Percha Cone Tip Fragments after Cutting at Different Magnifications

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Abstract

Background: Because there are significant differences between instruments and guta-percha cones of the same size, cutting and adapting the guta-percha cone to the desired size is very important for apical sealing. The aim of this study was to evaluate the accuracy of the cut lengths of guta-percha cones cut with a scalpel blade under different magnifications using stereomicroscope-based measurements.
Materials and Methods: The tips of the gutta-percha cones were cut 2 mm with the naked eye and under different magnifications using a scalpel blade and stainless steel endodontic finger ruler. The use magnifications were 2.5x Galilean loupe (Keeler, Windsor, UK), a 7.5x prismatic loupe (Admetec, Haifa, Israel) and a 25x operating microscope (Zeiss, Oberkochen, Germany). Each cut guta-percha tip was imaged under a 40x Zeiss Stemi 305 stereomicroscope (Zeiss, Oberkochen, Germany) using Zeiss Zen Lite 2 software and lengths were measured by two observers. Inter-observer agreements were calculated utilising the weighted kappa coefficient. Data were analyzed by Kruskal Wallis H test at $P<0.05$ significance level.
Results: There was no statistically significant difference between cut-lengths of gutta-percha cones depending on the magnification ($p>0.05$). Although there was no statistically significant difference, the mean values of the 25x magnification group were lower than the other groups (26,03).
Conclusions: Given the limitations of this study, similar guta-percha cut lengths were obtained under the naked eye, 2.5x, 7.5x and 25x magnifications. In order to better evaluate the magnification efficiency, studies with larger sample sizes, along with evaluating the morphological surface, are needed.

Research Article (HRU Int J Dent Oral Res 2025; 5(1):7-11)

Keywords: Gutta-percha, gutta-percha adaptation, magnification, stereomicroscope.

Introduction

Optimally, root canal filling materials should adequately seal the root canal system and prevent microleakage within the root canal space (1). For root canal treatment to be successful, the treated canal must be sealed hermetically (2). This is a critical step to prevent bacterial entry and support healing in the treated area, thereby preventing reoccurrence of infection (2, 3).

Classically, the most commonly used filling materials for root canal obturation are gutta-percha and root canal sealers (4). Gutta-percha cones are available in standard and various custom sizes and can be selected according to the root canal's diameter and morphology, and they can be modified by cutting (5). Regardless of the obturation technique used, it is essential to choose a master cone that is well-adapted to the canal for achieving a fluid-tight apical seal (6).

Unfortunately, significant differences exist between files and gutta-percha cones of the same size. Therefore, cutting the gutta-percha cone to the desired size and adapting it to the apical diameter is crucial for ensuring an effective apical seal (7). To our knowledge, the accuracy of gutta-percha cutting lengths under different magnifications has never been compared before. Therefore, the aim of this study was to compare the accuracy of the lengths of the cut pieces measured with a steromicroscope after cutting guta-percha cones under different magnifications using a scalpel.

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Material and Methods

Gutta-percha cones (Pearl Endo, Ho Chi Minh City, Vietnam) of the same size (40/.02) were taken from the same box, and the tips were cut 2 mm using a scalpel (Beybi, İstanbul, Türkiye) (Figure 1) and a stainless-steel endodontic finger ruler (Kelibiz, Sialkot, Pakistan) (Figures 2a and 2b). All cuts were made by the same researcher (EM), with the scalpel placed perpendicularly to the endodontic ruler (Figure 3). The magnifications used were 2.5x Galilean loupe (Keeler, Windsor, UK) (Figure 4a), 7.5x prismatic loupe (Admetec, Haifa, Israel) (Figure 4b), and 25x dental operating microscope (Zeiss, Oberkochen, Germany) (Figure 4c).

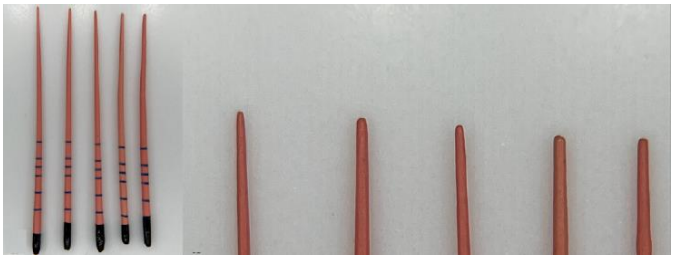

Figure 1. Gutta-percha samples from the same box

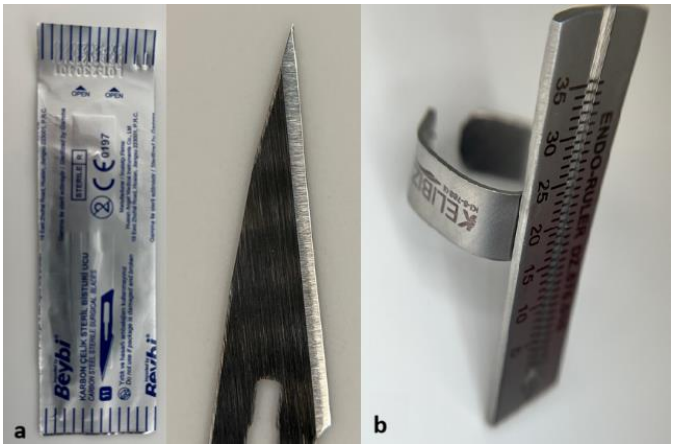

Figure 2. Materials used for the cutting of gutta-percha cones **a.** Scalpel blade **b.** Endodontic finger ruler

Each cut piece of gutta-percha was visualized under 40x magnification using the Zeiss Stemi 305 stereomicroscope (Zeiss, Oberkochen, Germany) with Zeiss Zen Lite 2 software (Zeiss, Oberkochen, Germany). First, the microscope was calibrated, and the image clarity was adjusted in the desired magnification. The image from the stereomicroscope was transferred to a computer (Figure 5). The length of the cut gutta-percha, as displayed on the computer, was measured linearly from the most prominent part of the cone (Figure 6). All measurements were performed by two observers with over 7 years of clinical experience.

The agreement between the observers was assessed using the kappa coefficient. To determine if there was a significant difference in the lengths of the cut gutta-percha pieces based on magnification levels, the Kruskal-Wallis H test was applied at a significance level of $p = 0.05$.

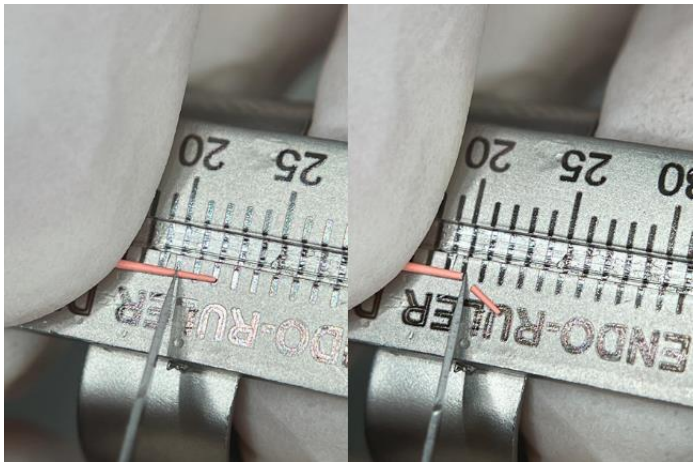

Figure 3. Cutting of the gutta-percha cone on the endodontic ruler

Figure 4. Magnification tools **a.** 2.5x Galilean loupe **b.** 7.5x prismatic loupe **c**. 25x dental operation microscope

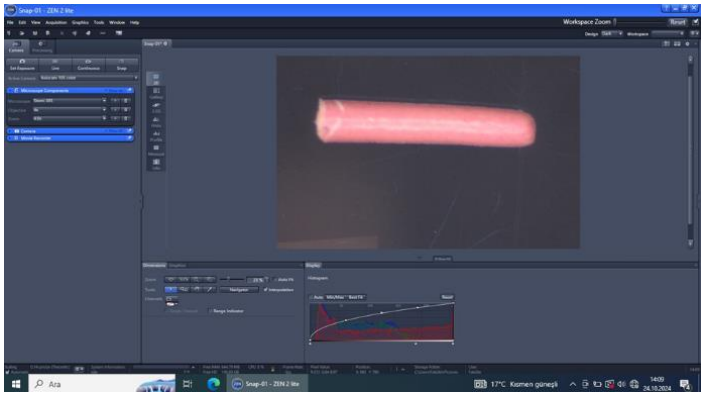

Figure 5. The interface of the Zeiss Zen Lite 2 software

Results

The inter-observer agreement was moderate (.71) in the group measured with the naked eye (Table 1), and strong (.78) in the 2.5x magnification group (Table 2).

No significant difference was found in the rank mean scores of the gutta-percha cutting lengths based on magnification levels (X^2 (3), n=60, 1.845; p>0.05). Although no statistical difference was found, it was observed that the rank mean scores of dental operating microscope measurements (25x) were lower compared to the other groups (Table 3).

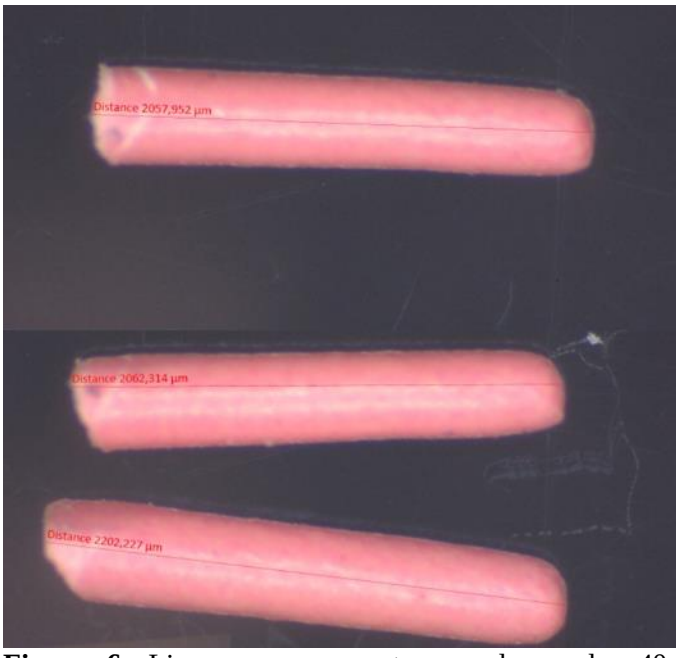

Figure 6. Linear measurement examples under 40x magnification with a stereomicroscope

Discussion

In a successfully completed root canal treatment, coronal and apical sealing is of great importance to prevent the passage of oral flora and toxins to the periapical tissues via the root canal system. Proper adaptation of gutta-percha plays a critical role in achieving an effective apical seal (8).

To this end, root canal instruments and gutta-percha cones are typically manufactured with the same diameter and taper. However, there are studies that report that gutta-percha cones are not standardized (9). To ensure an effective seal in the apical region, gutta-percha cones can be customized (10). A review of the literature revealed that the accuracy of gutta-percha cone cuts performed under different magnifications has not been previously compared. Therefore, the aim of this study was to evaluate the effects of different magnification levels (2.5x, 7.5x, and 25x) on the cutting lengths of gutta-percha cones. According to the results of this study, the cutting lengths of gutta-percha were not affected by the magnification levels. However, it was observed that the closest cut to the
desired length was achieved using the dental operating microscope, followed by cutting with the naked eye. The cuts made with 2.5x and 7.5x magnification loupes followed.

Table 1. Inter-observer agreement for measurements of cuts made with the naked eye.

			Asymptotic		95% Asymptotic Confidence Interval	
Ratings	Weighted Kappa	Std. Error	Z	*p*	Lower Bound	Upper Bound
obs_1- obs_2	,714	,083	4,485	<,001	,551	,876

Table 2. Inter-observer agreement for measurements of cuts made with 2.5x magnification

			Asymptotic		95% Asymptotic Confidence Interval	
Ratings	Weighted Kappa	Std. Error	Z	*p*	Lower Bound	Upper Bound
obs_1- obs_1	,785	,041	5,026	<,001	,703	,866

There is no similar study in the literature to compare the findings of this study. However, Silva et al. (11) investigated the effects of different cutting techniques on the surface properties of gutta-percha and

reported that the smoothest cut surface structure on gutta-percha could be achieved using a specially designed instrument for this procedure. Asgary et al. (12), on the other hand, compared cutting tools such as a scalpel and scissors, and found that the best surface properties were obtained with cuts made using a scalpel on glass surfaces.

In the present study, most measurements, both under all magnifications and with the naked eye, were found to be longer than the desired length. This could be due to the formation of additional edge protrusions as a result of cuts not being made at a perfect perpendicular angle, leading to longer measurements. In other words, angular errors during the cuts may have negatively affected the accuracy of the measurements. Furthermore, to avoid overfilling, it is also possible that the operator unintentionally might cut the cones longer. This could result in the actual length of the cuts deviating from the targeted length. Additionally, the cuts made with the naked eye were found to be more ideal compared to those made with loupes may be due to the clinician making the cuts routine use of the naked eye, which allows for better hand precision compared to working with loupes.

Table 3. Comparison of gutta-percha cut lengths

Dependent Variable	Groups	n	Mean Rank	X^2	Df	*p*
Gutta-percha lenghts	Eye	15	29,60	1,845	3	0,605
	2.5X	15	32,10			
	7.5X	15	34,27			
	25X	15	26,03			

n: sample size, X^2: chi-square value, Df: degrees of freedom, Significance level: p value < 0.05

A limitation of the present study is the lack of examination of the cut surfaces. Therefore, it may be recommended to consider morphological surface analyses in addition to measurement data in order to better evaluate the effect of magnification on cutting accuracy. To comprehensively investigate the effect of magnification on the cutting efficiency of gutta-percha cones and clarify its accuracy, further studies with larger sample sizes are needed. Such studies could increase the generalizability of the results and provide a clearer understanding of the impact of magnification on the cutting accuracy of gutta-percha cones. Furthermore, although gutta-percha cones can not be produced as standard, using files and gutta-percha cones from the same company can improve the apical fit of the cone.

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Author contributions: Literature search, Writing-original draft preparation: HU, EM; Study conception and design, review and editing: EM; Data collection and measurements: HU, EM.

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Evaluation of Color-Matching Ability of Different Single-Shade Composites in Repair of Aesthetic Composite Resins

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Abstract

Aim: The aim of the study was to evaluate the color-matching ability of four different single-shade composite resins used to repair of two multi-shade aesthetic composite resins after thermal aging.
Materials and Methods: A total of 100 disc-shaped samples, 50 from each of two aesthetic composites [GC Kalore (GC), A2 and Filtek™ Ultimate (FU), A2 body] were prepared with a height of 4 mm and a diameter of 10 mm. After initial surface preparation, the samples were aged through 5,000 thermal cycles. Subsequently, the surfaces were treated again using Sof- Lex discs and stored in distilled water at 37 ºC for 24 hours. Initial color parameters (L_1, a_1, b_1, C_1, h_1) were measured using a clinical spectrophotometer. The samples in each group were then randomly divided into five groups (n = 10 each) and numbered. Cavities of 2 mm depth and 6 mm diameter were prepared on the sample surfaces. After acid etching for 30 seconds, a two-step total-etch adhesive (Adper Single Bond 2) was applied, and the cavities were filled with four different single-shade composite resins (Omnichroma, Vittra APS Unique, Charisma Topaz One and Olident ONEshade). Control groups were restored with FU and GC. After polymerization procedure, the samples were again subjected to surface treatment with the disc polishing system and stored in distilled water at 37 ºC for 24 hours. Final color parameters (L_2, a_2, b_2, C_2, h_2) were measured, and the color change (ΔE_{00}) was calculated using the CIEDE2000 formula. The data were analyzed using two-way ANOVA and post-hoc Tukey tests.
Results: The ΔE_{00} values varied significantly depending on the single-shade composite used ($p<0.05$). The ΔE_{00} values of the control samples were 0.95 for GC and 1.20 for FU. Among the single-shade composites, the ΔE_{00} values ranged from 3.30 and 11.21. Olident ONEshade showed better color compatibility with lower ΔE_{00} values compared to other single-shade composites. The Vittra APS Unique group exhibited the highest ΔE_{00} values.
Conclusion: The color-matching ability of single-shade composites in the repair of aesthetic composites were variable. Additionally, all ΔE_{00} values for the single-shade composites exceeded the clinical perceptibility and acceptability thresholds, except for the control groups.

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Keywords: Color-matching, single-shade composite, dental esthetic, dental restoration repair.

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Introduction

In recent years, composite resin restorative materials have become widely preferred by dentists for restoring teeth to meet individuals' aesthetic expectations (1). Since their introduction to the market, resin composites have undergone continuous development (2). While early research primarily focused on improving physical properties such as polishability, wear resistance, and reducing polymerization shrinkage, manufacturers have recently placed greater emphasis on enhancing the aesthetic and optical properties of resin composites (3, 4). Resin-based restorative materials are commonly used because they easily match the color of natural teeth and meet patients' aesthetic expectations (5). The color-related properties of resin composites directly affect their aesthetic performance (6). For a successful aesthetic outcome, it is crucial for the resin composite used to achieve a seamless color match with the surrounding dental hard tissues (7).

Due to the polychromatic nature of teeth and the different optical properties of enamel and dentin, manufacturers have introduced various enamel and dentin resin composite shades with distinct optical characteristics to replicate natural teeth (2). Most resin composites on the market are available in shades ranging from A1 to D4, encompassing a total of 16 tones based on the Vita Classic shade guide (2). To achieve optimal color-matching and an aesthetically pleasing appearance in composite resin restorations, the layering technique, which involves using composites of different colors and opacities in various layers, has been employed for a long time (8). Since the optical properties of composites used in this technique vary significantly, clinicians should have sufficient knowledge about the materials used to predict the final shade of the restoration (9). The availability of multiple enamel and dentin shades complicates shade selection and matching, requiring a long learning curve for practitioners for each composite system (10).

With the introduction of nanotechnology into dentistry, manufacturers have begun offering single-shade resin composites instead of more complex shade systems (11). Composed of nanomers (nanofillers) and nanoclusters (12), these resin composites are noted for their "chameleon effect," achieving more effective color-matching with dental tissues (13). The concept of single-shade or "one-shade" resin composites has been developed to aesthetically mimic any color using a single nominal shade. These resin composites, formulated based on an extended color-matching approach, appear to blend seamlessly with adjacent teeth (9). The perceived color of a material is determined by the wavelengths of light reflected from its surface (14). In aesthetic restorative materials such as ceramics and resin-based composites, these wavelengths result from pigments incorporated into their composition (11). However, recent technological advancements have introduced single-shade resin composites with no added pigments, relying entirely on structural coloration for their optical properties a concept referred to as "smart chromatic technology" (11). This technology enables resin-based composites to respond to specific light wavelengths and accurately reflect a particular wavelength within the range of natural tooth colors (15).

Dynamic changes in oral pH and temperature caused by dietary habits, salivary composition, and aging can lead to degradation of resin composites during their clinical use (16). These changes may result in discoloration, wear, cracks, or fractures (17). In such cases, dentists may opt to repair a restoration instead of entirely replacing it, as full removal may not always be necessary. Repairing composite restorations is a minimally invasive approach that minimizes impact on the pulp and surrounding dental hard tissues (18). Existing resin composite restorations can be repaired by applying a new layer of resin composite (19). However, the altered optical properties of aged resin composites make achieving color harmony even more challenging (20, 21). In that regard, single-shade resin composites can offer a simpler restorative process and greater convenience for clinicians (2).

There is limited information regarding the color-matching ability of single-shade composites used in the repair of resin composite materials (11). Therefore, this study aimed to evaluate the color-matching ability of single-shade resin composites in the repair of different resin composite materials. The null hypothesis of this study posits that the color changes of aesthetic composites repaired with single-shade composites will be comparable and clinically acceptable.

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Materials and Methods

This study was conducted at the Department of Restorative Dentistry, Faculty of Dentistry, Erciyes University. Six different composite resins were used in this study, including two multi-shade aesthetic composite resins: Filtek Ultimate (A2 Body, 3M ESPE, USA) and GC Kalore (A2, GC Corporation, Tokyo, Japan), as well as four single-shade composite resins: Charisma Topaz One (Kulzer, Germany), ONEshade (Olident, Poland), Omnichroma (Tokuyama, Japan) and Vittra APS UNIQUE (FGM Dental, Brazil). The composition and detailed information of these materials are provided in Table 1. Sample size was determined using G*Power software (G*Power v.3.0.10, Franz Faul, Universitat Kiel, Germany) with an effect size of f = 0.4, a = 0.05 and power of the test p=0.86552 was found. (N=100)

Table 1. Detailed information about the materials used in the study

Composite Resins	Filler Type	Composition	Manufacturer
Kalore, A2 (multi-shade)	Nanohybrid	UDMA, DX-511(UDMA), Bis-EMA, lanthanide fluoride, strontium glass, barium glass, Fluoroaluminosilicate glass, silicon dioxide	GC Dental, Tokyo, Japan
Filtek Ultimate, A2 Body (multi-shade)	Nanofilled	Bis-GMA, UDMA, Bis-EMA, PEGDMA, TEGDMA, Zirconia, Silica	3M ESPE, St. Paul, MN, ABD
Omnichroma (single-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 (single-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
ONEshade (single-shade)	Microhybrid	UDMA, Bis-GMA, BDDMA, SiO_2, glass particles	Olident, Poland
Vittra APS UNIQUE (single-shade)	Nanohybrid	UDMA, TEGDMA, advanced polymerization system(APS) composition, co-initiators, silane, boron-aluminum-silicate glass	FGM Dental, Joinville, Brazil

Abbreviations: BDDMA:1,4-Butanediol Dimethacrylate; Bis-EMA: Ethoxylated bisphenol A glycol dimethacrylate; Bis-GMA: Bisphenol A-diglycidyl methacrylate; Bis-MEPP: bisphenol-A ethoxylate dimethacrylate; BPA: Bisphenol A; PEGDMA: Polyethylene glycol dimethacrylate; TCD: Tricyclodecane; TEGDMA: Triethylene glycol dimethacrylate; UDMA: Urethane dimethacrylate.

To prepare the samples, plastic molds measuring 10 mm in diameter and 4 mm in depth were used. A total of 100 samples, 50 from each of the aesthetic composites (Filtek Ultimate and GC Kalore), were fabricated in 2- mm-thick layers. These layers were cured at a light intensity of 1000 mW/cm² using a Valo light-curing unit (Ultradent, USA). After each 5 samples, the light intensity of the light-curing unit was checked using a radiometer. The surfaces of the samples were standardized by polishing with 600-grit and 1000-grit sandpaper by same operator (SB). Following surface preparation, the samples underwent thermal aging with 5,000 thermal cycles between +5°C and +55°C, with a dwell time of 30 seconds and a transfer time of 5 seconds.

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After thermal cycling, the surfaces of the samples were polished using a disc polishing system (Sof-Lex, 3M ESPE, USA) and subsequently stored in distilled water at 37°C for 24 hours. The initial color parameters of the composite samples were measured three times using a clinical spectrophotometer (Vita Easyshade Compact, Vita Zahnfabrik, Germany) by one operator (SB), based on the CIE L*a*b* color scale, and the average values of L_1, a_1, b_1, C_1, and h_1 were noted. Color measurements were made using a white background under standard conditions, and the device was calibrated at regular intervals using the calibration block on it, taking into account the manufacturer's instructions.

The samples in two groups were then randomly divided into five subgroups (n = 10) using table of random number and the samples were numbered 1 to 10 for each subgroup. Cavities measuring 6 mm in diameter and 2 mm in depth were prepared on the samples. The cavities were etched with acid for 30 seconds and treated with a 5th generation two-step etch rinse adhesive (Adper Single Bond 2, 3M ESPE, USA). Subsequently, the cavities were restored with the control materials (Filtek Ultimate or GC Kalore) or one of the four single-shade composite resins (Omnichroma, Vittra APS Unique, Charisma Topaz One, and Olident ONEshade) and cured 20 sec at a light intensity of 1000 mW/cm² using a Valo light-curing unit. After polymerization, the samples were polished again using the disc polishing system and stored in distilled water at 37°C for 24 hours. Final color measurements were performed three times, and the average values of L_2, a_2, b_2, C_2, and h_2 values were recorded. The images of the stages of the study were presented in Figure 1. Color changes (ΔE_{00}) were calculated using the CIEDE2000 formula (22).

The values were calculated using a formula defined in the Microsoft Excel program. Statistical analyses were performed using two-way ANOVA and Tukey's multiple comparison test. The level of significance was set at 0.05 (α=0.05).

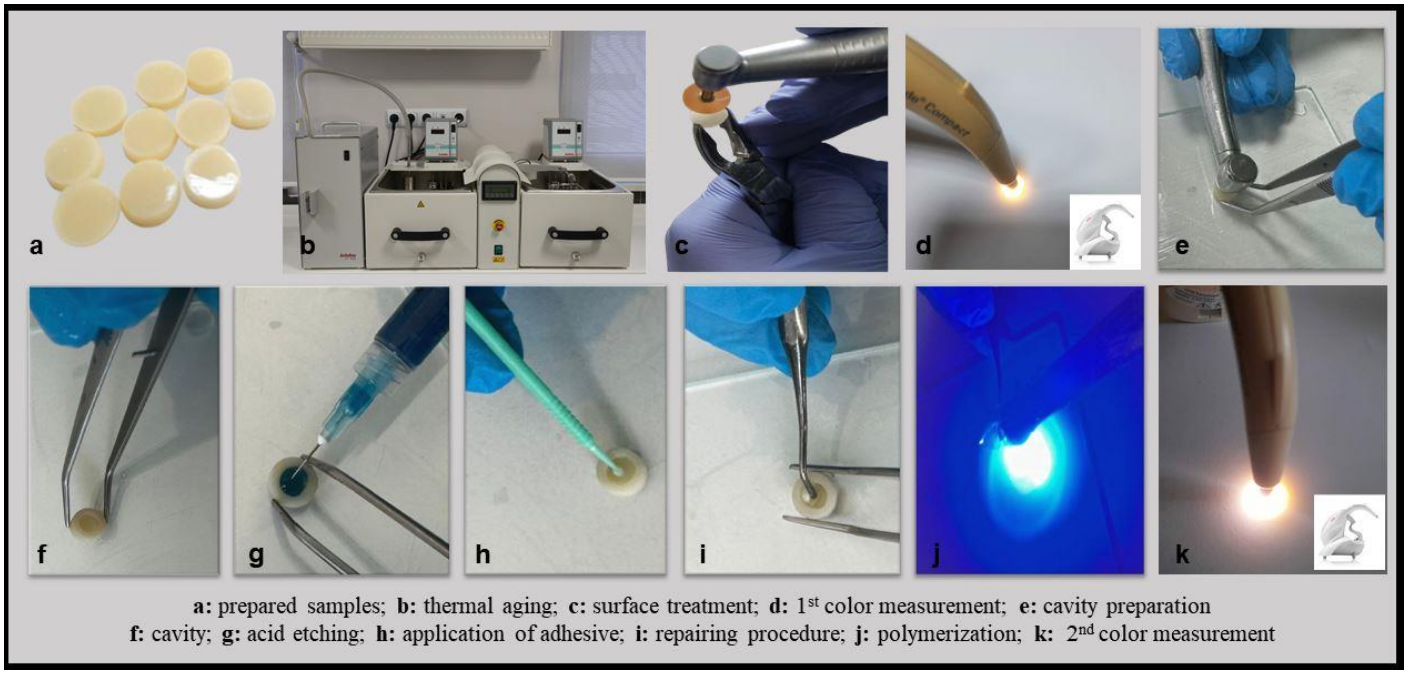

Figure 1. Images of the stages of the study.

Results

The statistical analysis of color change values revealed that the color changes (ΔE_{2-1}) observed in the repaired aesthetic composite resins were significantly influenced by the type of single-shade composite used ($p \leq 0.001$). The lowest values were found in the control group ($p<0.001$). The color changes (ΔE_{2-1}) values are presented in Table 2.

Table 2. ΔE00 values for the study groups

Groups	Kalore	Filtek Ultimate	p values
Control group (KAL-KAL) & (FU-FU)	0.95 ± 0.12 ^{A}	1.20 ± 0.16 ^{A}	0.0756
Omnichroma	7.66 ± 0.38 ^{B}	7.15 ± 0.39 ^{BX}	0.0620
Vittra APS UNIQUE	10.34 ± 0.49 ^{C}	11.21 ± 0.25 ^{D}	<0.001
Charisma Topaz One	6.69 ± 0.29 ^{EX}	6.41 ± 0.28 ^{E}	0.0693
ONEshade	3.68 ± 0.62 ^{F}	3.30 ± 0.22 ^{F}	0.318
p-values	< 0.001	< 0.001	

*Groups with the same superscript capital letters are statistically similar.

Among the single-shade composites, Olident ONEshade demonstrated better color compatibility by exhibiting the lowest color change values. Conversely, the greatest color change values were observed in the Vittra APS Unique group. Except for Vittra APS Unique, the other single-shade composites showed statistically similar color change values for repairing both aesthetic composites ($p>0.05$).

Examining the ΔL, ΔC and Δh values, the lowest values were again found in the control group (Tables 3-5). The highest ΔL and ΔC values were observed in the groups where both composite types were repaired with Vittra APS Unique. The highest Δh value was recorded for the repair of the Kalore composite resin using Omnichroma. While there was no statistically significant difference in the ΔL, ΔC, and Δh values among the control groups, the ΔC values in the repairs performed with ONEshade and the Δh values in the repairs performed with Vittra APS Unique for both aesthetic composites were statistically similar among the single-shade groups ($p>0.05$). The ΔL, ΔC, and Δh values for the other single-shade composites varied significantly depending on the repaired composite resin.

Tablo 3. ΔL values for the study groups

	Kalore	Filtek Ultimate	p-values
Control group (KAL-KAL) & (FU-FU)	0.25 ± 0.06 ^{A}	0.32 ± 0.10 ^{A}	0.0671
Omnichroma	4.46 ± 0.70 ^{B}	1.53 ± 0.25 ^{C}	<0.001
Vittra APS Unique	6.11 ± 0.31 ^{D}	2.34 ± 0.80 ^{E}	<0.001
Charisma Topaz One	5.68 ± 0.55 ^{D}	0.40 ± 0.24 ^{A}	<0.001
ONEshade	2.09 ± 0.52 ^{E}	1.14 ± 0.22 ^{F}	<0.001
p-values	<0.001	<0.001	

*Groups with the same superscript capital letters are statistically similar.

Table 4. ΔC values for the study groups

	Kalore	Filtek Ultimate	p-values
Control group (KAL-KAL) & (FU-FU)	2.34 ± 0.19 ^{A}	2.24 ± 0.14 ^{A}	0.112
Omnichroma	8.19 ± 0.66 ^{B}	10.95 ± 0.58 ^{C}	<0.001
Vittra APS Unique	14.51 ± 0.92 ^{D}	18.07 ± 0.78 ^{E}	<0.001
Charisma Topaz One	9.08 ± 0.27 ^{F}	11.33 ± 0.57 ^{C}	<0.001
ONEshade	6.06 ± 0.83 ^{G}	6.11 ± 0.18 ^{G}	0.231
p-values	<0.001	<0.001	

*Groups with the same superscript capital letters are statistically similar.

Tablo 5. Δh values for the measurements

	Kalore	Filtek Ultimate	p values
Control group (KAL-KAL) & (FU-FU)	2.34 ± 0.19 ^{A}	2.24 ± 0.14 ^{A}	0.092
Omnichroma	23.06 ± 1.28 ^{B}	15.44 ± 1.16 ^{C}	<0.001
Vittra APS Unique	17.18 ± 1.74 ^{D}	19.19 ± 1.33 ^{D}	0.064
Charisma Topaz One	7.67 ± 0.96 ^{E}	3.44 ± 0.31 ^{F}	<0.001
ONEshade	3.07 ± 0.25 ^{F}	1.63 ± 0.10 ^{G}	<0.001
p-values	<0.001	<0.001	

*Groups with the same superscript capital letters are statistically similar.

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Discussion

This study evaluated the color-matching capability of four different single-shade resin composites used for the repair of two aesthetic composite resin materials. Resin-based composite materials, due to their variations in filler particle type, size, and shape, as well as differences in monomer formulations, can exhibit differing optical properties even when labeled with the same color code. These discrepancies can result in varied aesthetic outcomes (23). While color assessment of restorations can be performed visually or using devices, environmental lighting conditions can influence visual assessments. However, device-based measurements are considered more reliable as they provide objective and quantitative data (24). In this study, the Vita Easy Shade Compact dental spectrophotometer was used. Since this device has its own light source to illuminate the tooth surface being measured, the results are unaffected by ambient lighting conditions, as evidenced by various studies (25, 26).

In the literature, there are differing views on the acceptability and perceptibility thresholds of color changes in dental restorations (27). Paravina et al. (28) recently reported that the perceptibility threshold is ΔE_{00} = 0.8, while the acceptability threshold is ΔE_{00} = 1.8. The results of this study demonstrated that the ΔE_{00} values for aesthetic composites repaired with single-shade composites -excluding the control groups- were all above the acceptability threshold (>1.8), with values varying depending on the single-shade composite used. As a result, the null hypothesis was rejected.

The number of studies investigating the color-matching ability of single-shade resin composites for the repair of resin-based materials is limited. In a study by Çalışkan et al. (2), the color compatibility of two different single-shade resin composites was evaluated for the repair of various resin-based materials and ceramic resin hybrid CAD/CAM blocks. Their findings indicated that the color-matching performance of single-shade composites was not clinically acceptable for either early or post-thermal-cycle repairs. The use of multi-shade systems for repairs of materials with the same multi-shade system yielded clinically acceptable ΔE_{00} values (2). Consistently, in our study, while the ΔE_{00} values of aesthetic composites repaired with single-shade composites exceeded the acceptability threshold, the control groups repaired with the same composite material displayed clinically acceptable ΔE_{00} values.

In a study by Buldur et al. (29), the color compatibility of three different composite resin materials (Omnichroma, ZenChroma, and Charisma Topaz One) was evaluated after repair using identical or different single-shade composites, following aging in coffee solution and distilled water. The evaluation focused on color change parameters (ΔE_{00}, ΔL_{00}, ΔC_{00} and ΔH_{00}). Significant differences were found in the mean ΔE_{00} measurements among the three composite resins across all timepoints ($p<0.05$). Similarly, for each study group, the mean ΔE_{00} measurements for each composite resin over time also showed statistically significant differences ($p<0.05$) (29). In the distilled water-aged groups, initial measurements of the materials repaired with the same material were within acceptable ΔE_{00} thresholds. In the coffee solution-aged groups, the final measurements for the materials repaired with the identical material were also within acceptable ΔE_{00} limits (29).The single-shade composites used in the present study are materials with high translucency properties. Differences in color change values depending on the repair composite used may be due to differences in the content of the material and its translucency properties. During the preparation of the samples, it was observed that the composites had different translucency. In fact, due to their different translucency, color matching abilities may have varied. In clinical conditions, the surface of the composite to be repaired should be prepared and adhesive application should be made before repair. Therefore, adhesive application was made to the surface in a standard manner in all groups. The adhesive applied to the interface may affect the color parameters in the color measurement. This may also affect the color change values due to differences in translucency.

As with all in vitro studies, this study has certain limitations. Restorations in the oral environment are exposed to various factors, such as fluctuating temperatures, masticatory forces, and organic acids produced by bacteria. Additionally, intraoral restorations typically have a convex surface rather than the flat surfaces created in in vitro studies. These differences in surface geometry affect light reflection, thereby directly

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influencing aesthetic parameters. The inability to fully simulate these conditions in in vitro settings constitutes a limitation of this study. With ongoing advancements in the physical, mechanical, and optical properties of single-shade composite materials, there is a growing need for more in vivo and in vitro studies that can better reflect intraoral dynamics to evaluate the color-matching capabilities of these materials when used to repair aesthetic composite resins.

Conclusion

Within the limitations of this study, the degree of color compatibility varied depending on the single-shade composite materials used for repairing aesthetic composites. The color-matching performance of single-shade resin composites utilized for delayed repair of different resin-based materials was not clinically acceptable. The observed color change values, except for the control group, exceeded the clinically acceptable threshold. Clinicians should consider this information when performing repairs using single-shade resin composites.

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Author contributions: SB and VK. conceived the ideas; VK. developed the theory and performed the computations; S.B conducted the method of study; SB and VK collected the data; VK and HB analyzed the data; and all authors discussed the results and contributed to the final manuscript and led the writing.
Conflict of Interest: The authors declare that they have no conflict of interest.
Ethical approval: This article does not contain any studies with human participants oranimals performed by any of the authors.

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Evaluation of Treatment and Dentist Options for Patients with Toothache in Turkey Using Google Trends

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Abstract

Background: This study aimed to explore research conducted by individuals in Turkey using the Google search engine to gather information on treatments for toothaches, specifically extractions or root canal procedures. It also sought to compare how the preference for searching public dental hospitals or private clinics for these treatments has evolved over time.
Materials and Methods: Changes in search terms such as “toothache”, “root canal treatment”, “tooth extraction”, “private dental clinic”, and “public dental hospital” on Google Trends from May 8, 2010, to November 10, 2024, were analyzed. The study was conducted in Turkey; therefore, Turkish equivalents of the terms were utilized in the search. The reasons for these changes and their connections were thoroughly analyzed.
Results: The peak relative search volume (RSV) for toothaches occurred in April 2020, with tooth extraction and root canal treatment being equally popular. In February 2011, most of the searches were conducted for "public dental hospitals." Conversely, in September 2024, "private dental clinics were the most frequently searched terms. Prior to March 2020, public hospitals garnered more interest; however, since then, private dental clinics have become more popular among users.
Conclusion: It can be concluded that they are seeking a reliable dentist for their treatment, rather than any dentist, and gather information about the treatments they are going to undergo. Despite the development of implant treatment over time, it can be concluded that patients search root canal treatment as much as tooth extractions.
Research Article (HRU Int J Dent Oral Res 2025; 5(1):20-23)

Keywords: Toothache, google trends, root canal treatment, tooth extraction.

Introduction

The World Health Organization (WHO) and the World Dental Federation (FDI) have identified the alleviation of toothache as a key priority within the Global Oral Health Promotion Agenda (1). Oral health is an essential element of overall health and wellbeing. Toothache may be caused by a number of factors including tooth decay, periodontal disease, or trauma. This seems to be more prevalent among socioeconomically disadvantaged groups (2). Toothaches have a detrimental impact on the quality of life of individuals. Consequently, individuals experiencing toothache may utilize the Internet to seek appropriate medication and treatment options. Furthermore, Internet users utilize online resources to corroborate professional instructions or self-diagnose changes and/or diseases (2). A significant number of studies conducted worldwide use internet data for analysis, with content analysis of platforms like Google Trends (GT), Twitter, and Instagram being notable examples (3-8). One of the most commonly used tools for studying online behavior is GT. This open-source tool offers data on trends and changes in online interest over time for specific keywords and topics(9).

In 2016, Google launched the GT tool, which provides free and publicly accessible data on online search trends related to Google’s search engine. This represents a pioneering example of the utilization and analysis of big data in infodemiological studies (10).

Targeted oral health promotion strategies have the potential to meet the public's need for oral healthcare during and after the pandemic.
Furthermore, these findings can provide insights applicable to future public health emergencies, thus

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improving preparedness and response measures for oral healthcare.

Materials and Methods

This study examined the fluctuations in search volume for a range of dental-related terms, including toothache, root canal treatment, tooth extraction, private dental clinics, and dental hospital appointments, using Google Trends from 08.05.2010 to 11.05.2024. The objective was to ascertain the reasons for these changes and to identify any connections between them. Changes in search volumes over the years were compared. Google employs a proportional evaluation of the RSV values. The highest search volume was 100 (RSV=100). The keywords were in Turkish, as in the study conducted in Turkey. The terms "toothache", "root canal treatment", "tooth extraction", "public dental hospital" and "private dentist" were used in lieu of "diş ağrısı", "kanal tedavisi", "diş çekimi", "diş hastanesi randevu" and "diş kliniği", respectively (Figure 1). As no living beings were involved in our study, approval from the ethics committee was not obtained.

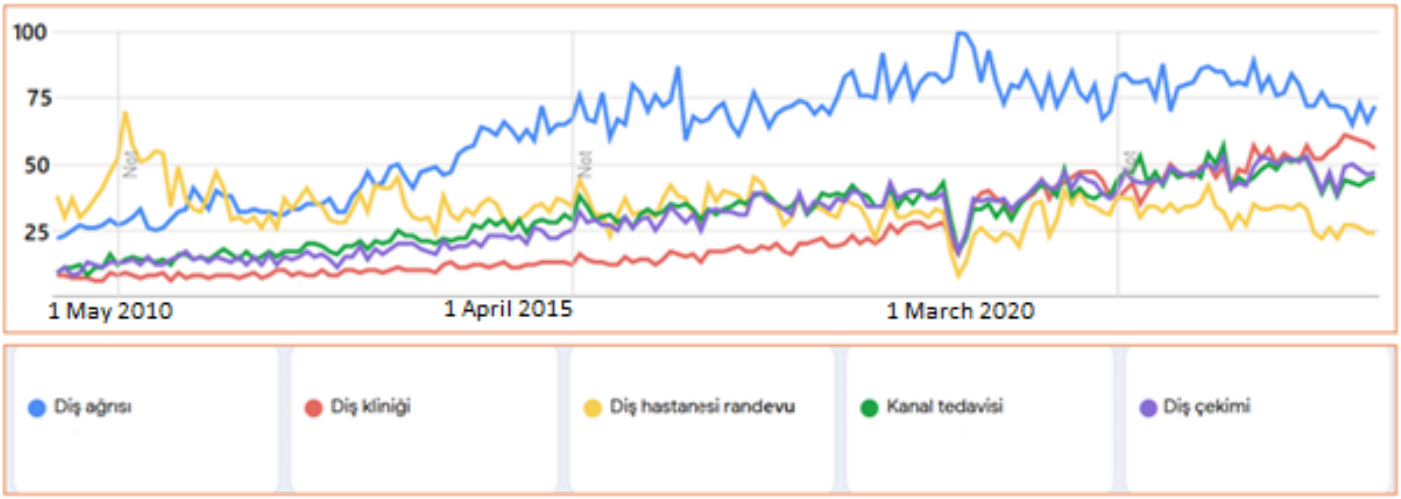

Figure 1. The evolution of search terms related to "toothache"(blue),"private dental clinic"(red), "public dental hospital"(yellow), "root canal treatment"(green) and "tooth extraction"(purple) over time is illustrated.

Results

Most of the online searches were related to toothache information. The highest relative search volume (RSV) for toothaches was observed in April 2020 (RSV=100). It was noted that tooth extraction and root canal treatment were viewed as equally effective. Their lowest during the same period (RSV=15) (Figure 2). During the same period around the world, tooth extraction was a significantly more prevalent procedure than root canal treatment. (Figure 3). In February 2011, there was a notable increase in the number of searches for "public dental hospitals " compared with the previous months (RVS=64). Similarly, in July 2023, there was a surge in searches for "private dental clinics " compared to previous years (RSV=62). Prior to March 2020, there was a clear preference for public hospitals, but since then, there has been a notable shift towards private dental clinics (Figure 4).

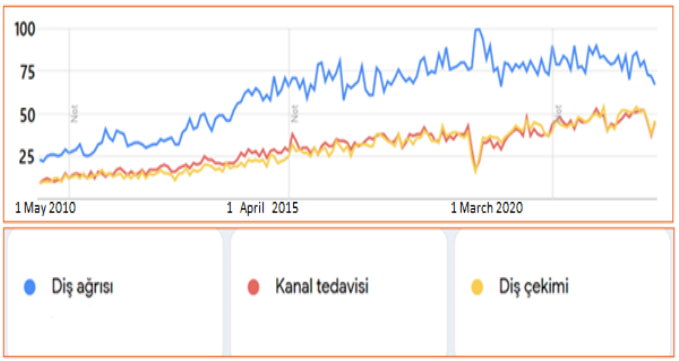

Figure 2. Change in interest in “root canal treatment” (red) and “tooth extraction” (yellow) in patients experiencing “toothache” (blue) over time in Turkey.

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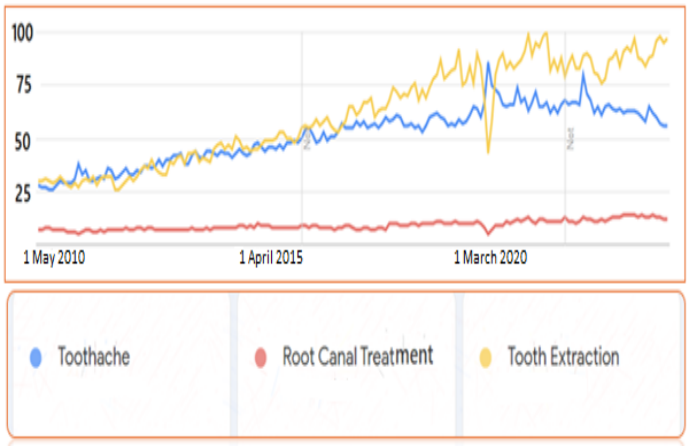

Figure 3. Change in interest in "root canal treatment" and "tooth extraction" among patients experiencing toothaches over time worldwide.

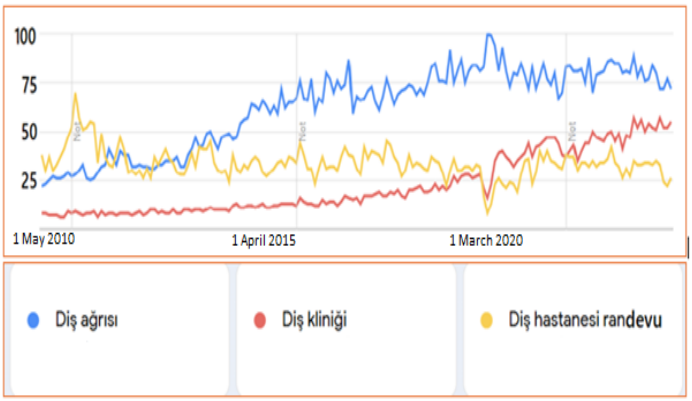

Figure 4. Change in interest in "private clinic" (red) and "public dental hospital" (yellow) in patients experiencing toothache (blue) over time in Turkey.

Discussion

The data and graphs obtained demonstrate a notable increase in the number of individuals searching for information about toothaches on the internet over time. This trend can be attributed to enhanced accessibility and heightened awareness of the Internet in recent years. Although there has not been a notable increase in the number of individuals conducting internet search to determine whether to perform an extraction or a root canal procedure, the observation that the search rates for the two terms are similar indicates that it is primarily the same individuals who are engaged in this search. It is anticipated that individuals experiencing toothache, upon informed that pain is not caused by another factor, will evaluate the
two options of root canal treatment or tooth extraction with equal consideration. Although the number of people using public facilities for their treatment was relatively high in the early years, in recent years, there has been a notable shift in online searches for private clinics. This may be attributed to the challenges encountered in accessing services from public hospitals during the ongoing pandemic, which necessitates the exploration of private dental clinics. Since 2020, the number of searches for private dental clinics has increased in comparison with public dental hospitals. An important indicator is that the gap widened significantly in the last 1-2 years.

The Google Trends search results indicate that globally, tooth extraction is the most commonly sought procedure, followed by toothache and root canal treatment (Figure 3) (11). Because root canal treatments and tooth extractions are performed free of charge by the state in Turkey, this difference is not significant. Therefore, we believe that cost is an important factor in patients' decisions to undergo these procedures.

A study conducted in Sweden revealed that patients were required to pay approximately twice the amount for root canal treatment for tooth extraction (12). In a study conducted in India, the most important criterion for patients when deciding on treatment was cost (61.6%), followed by the dentist's qualification (51.1%). Patients seek successful doctors for treatment procedures because the success of the treatment procedure is related to the expertise of the doctor (13). In a study conducted in Iran, patients expressed a preference for extraction, indicating a desire to pursue more assured procedures throughout the decision-making process (14). This finding suggests that patients lack sufficient knowledge about root canal treatment and are generally receptive to dentists' recommendations. A study conducted in Nigeria found that patients were generally influenced by their dentist's advice when making a decision and were more likely to opt for extraction (15). A study in Australia found that access to private clinics offering treatment to preserve teeth in the mouth required a higher socioeconomic status. Patients from lower socioeconomic backgrounds tend to visit public hospitals where tooth extraction is more common (16). The period when Google searches for toothache was highest in Turkey and worldwide coincided with the global pandemic(17-19).

In 2010, patients began making appointments through the central appointment system (MHRS) via the internet for the first time. Therefore, we decided to begin our study
that year. It is common for patients who lack knowledge of the topic to participate in online search. Therefore, it is considered normal that 2011 was the year in which the term "state dental hospital" was searched.

Conclusion

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In April 2020, "toothache" had the highest search volume (RSV=100), while "tooth extraction" and "root canal treatment" had the lowest and equal search volume (RSV=15). In Turkey, these two values consistently trended together, but globally, "tooth extraction" was always more common than "root canal treatment".
In February 2011, the search volume for “public dental hospital” peaked at (RSV=64), but gradually declined over time. By July 2023, the search volume for “private dental clinic” reached its highest point at (RSV=62), while "public dental hospitals" reached its lowest at RSV=34. In January 2022, these RSV values were equal at (RSV=37).
In Turkey, people are now more attentive to oral health and seek reliable doctors. Despite advancements in implant treatment, patients research root canal treatment as thoroughly as tooth extraction.

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Concept/Idea: AA,SEA **Design:** AA,SEA **Revision/Consultation:** AA,SEA **Data collection or processing:** AA,SEA **Analysis and interpretation:** AA,SEA **Literature review:** AA,SEA **Manuscript writing:** AA,SEA **Critical review:** AA,SEA

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Investigation of the Prevalence of Dental Anomalies in Third Molars Using Cone Beam Computed Tomography

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Abstract

Background: Dental anomalies are one of the problems frequently encountered during dental examinations. The aim of this study is to evaluate the frequency of dental anomalies such as transposition, ectopia, microdontia, taurodontism, dilaceration, paramolar teeth, amelogenesis imperfecta and inversion in sex and third molars.
Materials and Methods: Cone beam computed tomography (CBCT) images of 2300 patients aged between 12 and 65 years who applied to Hatay Mustafa Kemal University Faculty of Dentistry for various reasons between January 2021 and June 2024 were retrospectively evaluated. While scanning the CBCTs, the sex of the patients and the tooth in which the anomaly was present were noted. All scans were performed by three observers reaching a consensus. Descriptive statistics method was used for statistical analysis.
Results:It was observed that the rate of anomalies in all third molars was 10.8%. It was calculated that 54.8% of the individuals with these anomalies were female, 45.2% were male, and the average age was 29.8. It was observed that the most common anomaly in tooth number 18 was ectopia with a rate of 57.14%, the most common anomaly in tooth number 28 was microdontia with a rate of 36.76%, the most common anomaly in tooth number 38 was dilaceration with a rate of 43.9%, and the most common anomaly in tooth number 48 was dilaceration with a rate of 37.72%. It was determined that the most common dental anomaly in women was dilaceration with a rate of 42% and in men was dilaceration with a rate of 57%. Of the anomalies detected, 0.4% were transposition, 11.3% were ectopia, 13.8% were microdontia, 9.3% were taurodontism, 55.48% were dilaceration, 5.89% were paramolar, 2.43% were amelogenesis imperfecta, and 1.2% were inversion.
Conclusion: Dilaceration was found to be the most common dental anomaly, most commonly seen in males and in tooth number 38. After dilaceration, microdontia and ectopia are other common anomalies. It was concluded that microdontia and ectopia were most common in females and in tooth number 18.

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Keywords: Dental anomaly, dilaceration, microdontia, taurodontism, cone beam computed tomography.

Introduction

Dental anomalies are a general expression of conditions that differ from the usual anatomical structure of the teeth in color, size, shape and number. They can be genetically inherited, due to systemic diseases, trauma or local factors. Although the presence of dental anomalies sometimes does not cause problems for people, it may sometimes cause aesthetic or functional problems. Some of these are periodontal problems, malocclusion, difficulty in root canal treatment, esthetic problems and difficulty in tooth extraction. According to Neville's classification of developmental dental anomalies; number anomalies (hypodontia, hyperdontia), size anomalies (microdontia, macrodontia), shape anomalies (gemination, fusion, concrescence, accessory tubercles, dens invaginatus, ectopic enamel, taurodontism, hypersementosis, accessory roots, dilaceration), structural anomalies (amelogenesis imperfecta, dentinogenesis imperfecta, type 1 dentin dysplasia, type 2 dentin dysplasia, regional odontodysplasia) (1).

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Taurodontism is a shape anomaly in which vertical expansion of the pulp chamber, apical shift of the pulp base and bifurcation, absence of narrowing at the enamel-cementum alignment and shortening of the roots are observed (2). Its etiology is not known exactly. It is thought to be caused by failure of Hertwig's epithelial root sheath to close according to the normal level or by infection during tooth development. It is mostly seen in molars and premolars and less frequently in incisors (3).

Microdontia is a general term for a tooth size that is smaller than the normal size. Microdontia can be seen in a single tooth or in more than one tooth. There is a relationship with some syndromes in terms of the rate of detection of microdontia. Microdontia is frequently seen in third molar and mesiodens (3).

Dilaceration is the name given to the curvature or angulation seen in a region of the tooth. Generally, dilaceration occurs in the root. Although it has been reported that dilaceration occurs developmentally, traumas on the eruption path are an effective factor in the formation of dilaceration. Dilacerations in the root were observed more frequently in mandibular third molar (4).

Paramolar tooth means an extra tooth in number. The etiology is still not clearly defined. Today, the commonly accepted etiologic condition is hyperactivity of the dental lamina (5). Amelogenesis imperfecta occurs as a result of defects in Amelogenin (AMELX), Enamelin (ENAM), Kallikrein 4 (KLK4), Matrix Metalloproteinase 20 (MMP20) and Distal Less Homeobox 3 (DLX3) genes involved in enamel production. There are autosomal dominant (OD), autosomal recessive (OR) or X-linked subtypes (3).

The displacement of the tooth from its normal position to the neighboring teeth is called transposition. It can be seen in a single or double jaw, unilateral or bilateral. It is generally seen in the maxilla and unilaterally (6).

Inversion is the name given to eruption of the erupting tooth in the opposite direction of the normal eruption direction. It is mostly observed in third molar and supernumerary teeth (7).

Ectopic tooth anomaly is the name given to the development of the tooth in a different location in the jaw bones but outside its normal location. Ectopic eruption is frequently observed in permanent molars in the maxilla(8).

Cone beam computed tomography (CBCT) is an imaging method that offers three-dimensional imaging, has low radiation and clearly shows anatomical points without superposition (9). Panoramic radiography may not accurately show dental anomalies such as dilaceration because it gives a two-dimensional image. CBCT, on the other hand, is preferred over panoramic radiography because it offers the opportunity to examine dental anomalies in a larger area and shows them in detail without superposition of surrounding anatomical structures (10).

The aim of this study was to investigate the frequency of dental anomalies such as transposition, ectopia, microdontia, taurodontism, dilaceration, paramolar tooth, amelogenesis imperfecta and inversion in the sexes and in third molar teeth.

Materials and Methods

Between January 2021 and June 2024, CBCT images of 2300 patients aged between 12 and 65 years who were admitted to Hatay Mustafa Kemal University Faculty of Dentistry for various reasons were retrospectively analyzed. Patients with no image artifacts, no trauma to the head and neck region, no cyst tumors in the relevant regions, and any third molar teeth were included in our study. While scanning the CBST, the sex of the patients and the third molars with dental anomalies were noted. Dental anomalies of the third molars were then classified as transposition, ectopia, microdontia, taurodontism, dilaceration, paramolar tooth, amelogenesis imperfecta and inversion.

All CBCT scans were obtained on the same device (Kavo 3D Op Pro, Biberach, Germany) with the same acquisition parameters (13x15 cm FOV, 380 µm voxel size and 0.38 mm slice thickness) and the images were verified in all three dimensions by examining them in axial, coronal and sagittal planes. All scans were performed by consensus of three observers (Z.E.H, M.K., E.Ç.E). All data were saved in Microsoft Excel (Microsoft Corp., Redmond, WA, USA). All evaluations were performed on a single monitor (1,366x768 pixel liquid crystal display; Dell 14-inc.; Dell. Round Rock. Texas. USA) to ensure standardization. Screen features such as changing screen brightness and zooming were allowed to be used for clearer evaluations. Descriptive statistics method was used for statistical analysis.

Results

A total of 5292 third molar teeth were detected in 2300 CBCT images. Dental anomalies were detected in 490 of these 5292 teeth. The incidence of dental anomalies was 10.8% in all third molars, 54.8% (194 patients) were female, 45.2% (160 patients) were male, and the average age was 29.8 years.18 The most common anomaly in tooth number 18 was ectopia with a rate of 57.14%, the most common anomaly in tooth number 28

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was microdontia with a rate of 36.76%, the most common anomaly in tooth number 38 was dilaceration with a rate of 43.9%, and the most common anomaly in tooth number 48 was dilaceration with a rate of 37.72%. It was determined that
the most common dental anomaly was dilaceration with a rate of 42% in females and 57% in males. The distribution of dental anomalies according to sex is shown in Table 1.

Table 1. Distribution of dental anomaly by sex.

Dental Anomaly	*Females*	*Males*
Transposition	%50,0	%50,0
Ectopia	%50,8	%48,2
Microdontia	%63,23	%36,77
Taurodontism	%65,21	%34,79
Dilaceration	%48,29	%51,71
Paramolar	%55,17	%44,83
Amelogenesis Imperfecta	%50,0	%50,0
Inversion	%25,0	%75,0

It was observed that the most common dental anomaly accompanying all third molars was dilaceration with a rate of 55.48%, followed by microdontia with 13.8%. Microdontia and ectopic tooth anomaly were detected in 13.8% and 11.3% of third molars, respectively. These were followed by taurodontism with 9.3%, paramolar tooth with 5.89%, amelogenesis imperfecta with 2.43%, and inversion with 1.2%. The least common third molar anomaly was transposition with a rate of 0.4%. The distribution of dental anomalies according to third molars is shown in Table 2.

Discussion

Knowing the frequency of dental anomalies accompanying the third molars is an important consideration in interventions or examinations in this region. Early detection of dental anomalies provides correct treatment planning by preventing orthodontic problems that may occur in the future and reduces the complications and complexity of the treatment plan (11). Since third molars are often used as the basis for forensic age estimation, estimates based on pulp chamber width in cases of taurodontism may be misleading and should be carefully examined (12). Kuzin AV et al. (13) reported that the relationship of dilaceration in the roots of mandibular impacted third molar teeth with the mandibular nerve increases the risk of complications in surgical extractions. When ectopic teeth are closely associated with different tissues such as the maxillary sinus, they may create local foci of infection (14). Root dilacerations may lead to complications such as instrument fracture, canal obstruction, and elbow formation during endodontic treatment (15). Lambada et al. (16) concluded in their case study that third molar teeth ectopically located in the mandibular ramus constitute an etiologic factor for osteomyelitis. The aim of this study was to investigate the frequency of dental anomalies accompanying third molars.

Table 2. Distribution of dental anomalies according to third molar teeth.

Dental Anomaly	*#18 (n)*	*#28 (n)*	*#38 (n)*	*#48 (n)*
Transposition	%100,0 (2)	%0,0	%0,0	%0,0
Ectopia	%57,14 (32)	%30,35 (17)	%0,0	%1,78 (1)
Microdontia	%47,05 (32)	%36,76 (25)	%7,35 (5)	%8,82 (6)
Taurodontism	%23,9 (11)	%19,56 (9)	%23,91 (11)	%32,60 (15)
Dilaceration	%9,52 (26)	%8,79 (24)	%43,95 (120)	%37,72 (103)
Paramolar	%27,5 (8)	%37,93 (11)	%13,79 (4)	%20,68 (6)
Amelogenesis Imperfecta	%25,0 (4)	%25,0 (4)	%25,0 (4)	%25,0 (4)
Inversion	%0,0	%0,0	%33,3 (2)	%66,66 (4)

n: Number of patients

Studies calculating the prevalence of dental anomalies in different populations are available in the literature. In studies conducted in Saudi Arabia, Alhumaid et al. (17) reported that the prevalence of dental anomalies was 37.8% for all teeth. Chen et al. (18) found that the rate of dental anomalies in all teeth was 36.3%. Gupta et al. (19) found the prevalence of dental anomalies to be 34.06% in a study on the Indian population. Nemati et al. (20) reported this rate as 47.5% in their study on Iranian population. In studies conducted on the Brazilian population, Vagner et al. (21) reported a prevalence of 56.9% and Goncales et al. (22) reported a prevalence of 61.3% (21-22). In a study conducted in the Turkish population, the frequency of dental anomalies was found to be 68.9% (23). In our study, the prevalence of developmental dental anomaly was found to be 10.8% and this value was found to be lower compared to other

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studies. It is thought that the inclusion of all teeth in the study had a great effect on the prevalence of dental anomalies.

When the prevalence of each dental anomaly was investigated, Hamasha et al. (24) reported the prevalence of dilaceration as 3.78% and Alhumai et al. (17) reported this rate as 30.2%. In our study, 55.48% of third molars were found to have dilaceration anomaly. In their study, Gupta et al. (19) found the prevalence of ectopic teeth to be 7.93%, and in another study, Bilge et al. (28) concluded that the prevalence of ectopic teeth was 4.46%. In our study, the prevalence of ectopic teeth was found to be 11.3%. Nemati et al. (20) reported that the prevalence of transposition was 0.1% and Papadopoulos et al. (27) reported that this rate was 0.33%. In our study, this rate was calculated as 0.4% in accordance with Nemati et al. (20).

As a result of epidemiologic studies, the prevalence of microdontia is between 1.5-2% and is higher in women than in men (28). It has been reported that the most affected teeth are maxillary lateral teeth (29-31). Neville et al. (31) reported that the worldwide prevalence of microdontia anomaly is between 0.8-8.4% as a result of their study. Gupta et al. (19) reported this rate as 2.4%. In our study, this rate was determined as 13.8%. The reason for this higher rate compared to the literature is thought to be the calculation of microdontia seen only in third molars in our study.

In their study, Süsgün et al. (32) found that the incidence of inversion anomaly was 1.7% and it was mostly seen in posterior teeth. In our study, 1.2% inversion was found in accordance with the literature. Martínez-González et al. (33) reported that 36 patients had paramolars (26.47%) in their study on the prevalence of dental anomalies in 130 patients. In our study, the rate of detection of paramolars was 5.89%. The reason for this difference with the literature is thought to be the difference in the number of patients examined. In our study, CBCT images of 2300 patients were scanned and 490 third molars with dental anomalies were classified.

In a study by Gadhia et al. (34), the prevalence of amelogenesis imperfecta was found to be 0.03%, while in our study, the prevalence was significantly higher at 2.43%. Similarly, Saberi et al. (35) found taurodontism to be the most common shape anomaly, with a prevalence of 5.38%. In contrast, our study found the prevalence of taurodontism in third molars to be 9.3%, which is higher than what has been reported in the literature. This difference may be attributed to the specific group of teeth examined in our study.

Renugalakshmi et al. (36) observed a higher prevalence of dental anomalies in male children, while another study by Sella Tunis et al. (37) concluded that the occurrence of dental anomalies was independent of sex and age. Our study also found sex differences in anomaly prevalence, with specific anomalies more frequently observed in males, particularly dilaceration.

CBCT is a valuable imaging method that allows dental professionals to examine not only the dental structures but also their relationship with surrounding anatomical structures in three dimensions. CBCT is particularly useful for evaluating areas like the maxillary third molar region, as it allows for examination without anatomical superimposition. This capability provides more accurate evaluations, especially in cases requiring three-dimensional assessments, such as evaluating the angle of root dilacerations and identifying taurodontism. Additionally, CBCT can help prevent complications during invasive procedures such as tooth extractions in this region (10). For these reasons, CBCT was preferred over panoramic radiography in our study.

Conclusion

In this study, the prevalence of dental anomalies in third molars was determined to be 10.8%, with a higher frequency in females (54.8%) compared to males (45.2%). Dilaceration was identified as the most common anomaly, predominantly observed in males and tooth #38.

Awareness of the prevalence and characteristics of dental anomalies in third molars is crucial for clinicians performing dental procedures in this region. CBCT is highly recommended for the accurate detection of dental anomalies due to its ability to provide detailed and comprehensive imaging without superimposition.

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Selecting patient data, evaluating images were done by ECE, MK, ZEH and CAB. Writing publications were done by MK, ZEH, ECE and CAB. Making measurements were done by ECE, MK, ZEH and CAB. The final manuscript has been read and approved by all authors.

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Usage Areas of Mineral Trioxide Aggregate in Endodontic Treatments

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Abstract

Mineral Trioxide Aggregate (MTA) is a material developed from Portland cement. MTA, possessing an alkaline pH and exhibiting antibacterial and antifungal properties, is well-tolerated by tissues and simultaneously capable of inducing hard tissue formation. This study aimed to retrospectively evaluate the treatment methods implemented using MTA in our clinic.

Patients presenting at the who required apexification, internal resorption, external resorption, iatrogenic perforation repair, vital pulp capping treatment, and regenerative endodontic therapies and who met the necessary indications for MTA application, were identified. Following the preparation of teeth in accordance with the appropriate treatment modalities for the relevant indications, endodontic treatments were administered using MTA.

Patients were summoned for follow-up examinations at specified intervals. Teeth treated with MTA were evaluated clinically and radiologically. No symptoms such as dental pain, percussion sensitivity, or mobility were observed, and improvements were noted in periapical lesions. Radiographic examination revealed an increase in root length in teeth with incomplete root development following regenerative endodontic treatment procedures.

It has been determined that MTA is a well-tolerated material by tissues in vital pulp therapies where it comes into contact with the periapical region and vital dental tissues, and simultaneously induces hard tissue formation.

Case Report (HRU Int J Dent Oral Res: 2025;5(1):30-35)

Key words: MTA, MTA Plug, regeneration, vital pulp therapy, resorption.

Introduction

An optimal orthograde or retrograde filling material should effectively seal the communication pathways between the root canal system and the surrounding tissues. Moreover, the material should exhibit non-toxic, non-carcinogenic, and non-genotoxic properties, demonstrate biocompatibility with host tissues, remain insoluble in tissue fluids, and maintain dimensional stability (1).

Mineral trioxide aggregate (MTA), has gained significant application in dentistry in recent years due to its possession of the aforementioned properties. MTA is a hydrophilic and biocompatible endodontic cement that exhibits the capacity to stimulate healing and osteogenesis. Upon hydration, dust forms a colloidal gel characterized by a pH of 12.5, which subsequently solidifies over a period of approximately 3 to 4 hours (2).

Upon direct interaction with human tissues, MTA exhibits the capacity to liberate calcium ions, which subsequently facilitate cellular proliferation. Consequently, MTA facilitates the migration and differentiation of cells responsible for hard tissue formation, which results in the development of hydroxyapatite on its surface and establishes a biological seal (2) (Figure 1).

The application of MTA as a root-end filling material resulted in the formation of fibrous connective tissue and thin hard tissue layers in immediate contact with the material. MTA elicits a biological response in osteoblasts and furthermore provides a biocompatible surface for cell adhesion. Moreover, it has been effectively employed for repairing external root resorption, as well as furcation and root perforations (3).

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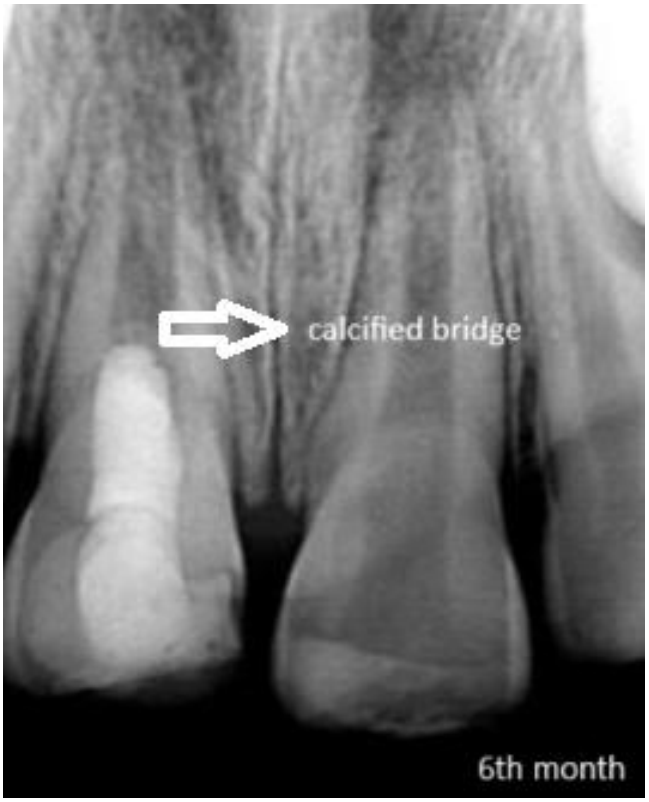

Figure 1: Formation of a calcified bridge following the coverage of the coagulation area with MTA in regenerative endodontics.

Over the past decade, MTA has been successfully used in the field of dentistry for the implementation of numerous specific treatment procedures within conservative and endodontic therapies (2). MTA is successfully utilized in the endodontic clinic as a capping material in vital pulp therapy, for creating an apical barrier during apexification, in the repair of iatrogenic perforations, in the treatment of internal and external resorption, as a root-end filling material, and in the treatment of complicated crown fractures and partial pulpotomy in traumatized teeth.

The objective of this study is to evaluate treatments performed using MTA in cases with diverse indications. This study's results constitute a substantial contribution to validating the safety and reliability of oral rehabilitations performed using these biomaterials, while also paving the way for future enhancements of their properties.

Use of MTA in the Treatment of Internal Resorptions

Case 1:

A female patient presented to our clinic with a complaint of pain in tooth number 37. Clinical examination revealed a fallen filling cavity and caries in the tooth. Severe percussion pain was present. Radiographic examination revealed lesions at the root apices and internal resorption in the middle third of the mesial root near the apex.

Cone-beam computed tomography (CBCT) was obtained to precisely determine the localization and boundaries of the resorption area. Imaging revealed that the resorption occurred within the mesiolingual canal without affecting the external root boundaries.

The tooth was isolated utilizing a rubber dam, and the previous root canal treatment was removed. Reshaping was subsequently performed. 2.5% NaOCl was used with sonic activation. Calcium hydroxide dressing was applied until the tooth became asymptomatic. The distal canal and mesiobuccal canal were obturated with gutta-percha. MTA was applied using MTA pluggers, and the access canal, including the resorption area, was filled with MTA (Figure 2).

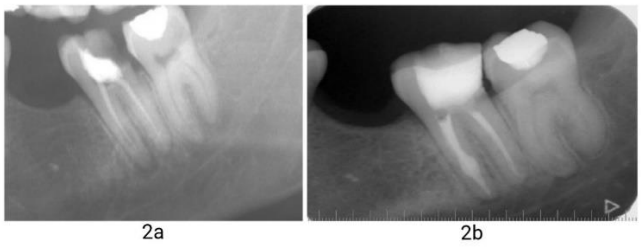

Figure 2: Treatment of internal resorption in tooth 37.
*2a: Symptomatic tooth 37 requiring retreatment. Internal resorption area observed in the apical portion of the middle third of the mesial root. Periapical lesion visible at the root apices.
2b: Post-treatment radiograph of tooth 37 following obturation of the resorption area with MTA

Case 2:

The patient presented with a complaint of pain in tooth number 21. Upon examination, a fistulous tract was observed in the buccal gingiva, and the tooth exhibited pain upon percussion. Radiographic examination revealed an area of internal resorption in the middle third of the root, with calcification of the root canal observed apical to this region. CBCT analysis confirmed that the external root boundaries remained intact without perforation. EDTA (Etilen diamin tetra asetik asit) and a 0.2 mm diameter K-type manual steel file (size 15) were used to access the calcified area apically. Following four visits of calcium hydroxide dressing, the tooth became asymptomatic,

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and the access canal, including the resorption area, was subsequently filled with MTA (Figure 3).

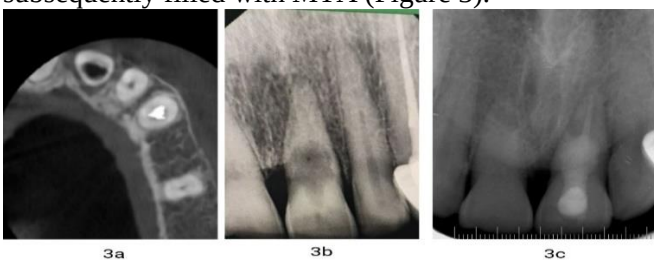

Figure 3: Treatment of internal resorption in tooth number 21
*3a: CBCT image demonstrating the absence of perforation in the external walls of the tooth.
3b: Periapical radiograph showing the internal resorption area and the calcified root canal apical to this region.
3c: Periapical radiograph illustrating that the apical portion of the calcified canal has been reached and the root canal, including the resorption area, has been filled with MTA.

Use of MTA in the Management of External Root Resorption

Case 3:

A patient sought medical attention due to discomfort in tooth #11. Upon clinical assessment, the tooth was found to be free of decay but exhibited grade I mobility. External root resorption was identified in the mesial portion of the root through CBCT imaging. The resorption area was surgically exposed and, following curettage of the resorptive tissue, sealed with MTA. Following the surgical procedure and subsequent wound healing, the canal treatment was completed. In ongoing follow-up examinations, it was observed that mobility had ceased and the tooth had become asymptomatic (Figure 4).

Use of MTA in Apical Closure Treatment for Permanent Teeth with Open Apices

Case 4:

A male patient who had experienced trauma to tooth number 12 during childhood presented to our clinic with complaints of gingival dehiscence and inflammation. Clinical examination revealed no carious lesions on the tooth, and there was no percussion pain or mobility. The tooth was asymptomatic, and the root was visible through a large fenestration area in the buccal gingiva.

Due to the thinness of the canal dentin walls, minimal shaping was performed, and disinfection was achieved through copious irrigation with activated 2.5% NaOCl solution. CaOH was applied in three visits. After ensuring complete cleaning of the canals, the apical portion of the root was sealed with MTA. The coronal portion of the root was subsequently obturated with gutta-percha using the warm vertical compaction technique. Following the completion of endodontic therapy, the fenestration area in the buccal mucosa was surgically closed. One-year post-treatment revealed the tooth to be asymptomatic, with periapical tissues exhibiting normal health (Figure 5).

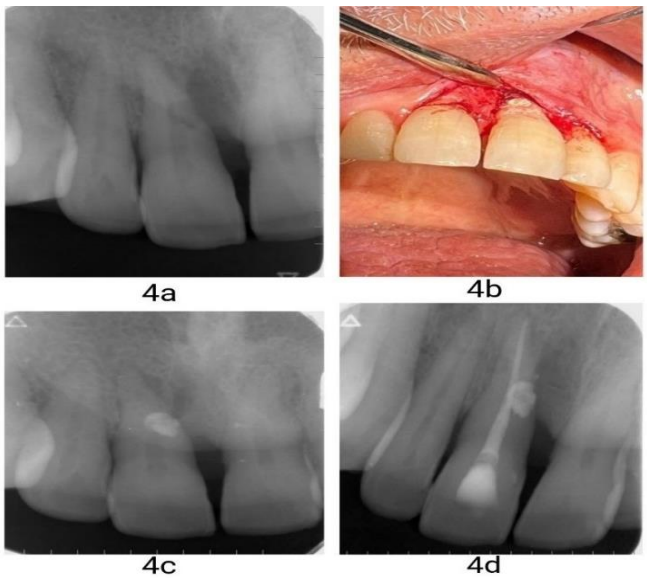

Figure 4: Tooth with external resorption repaired using MTA
*4a: Periapical radiograph showing the area of external resorption on the mesial aspect of the root.
4b: Surgical exposure of the resorption area and repair of the defect using MTA.
4c: Post-surgical radiographic image.
4d: Periapical radiograph taken after repair of the external resorption area and completion of root canal treatment.

Use of MTA as Pulp Capping Material in Vital Teeth

Case 5:

Clinical examination of the patient who presented for treatment of tooth number 26 revealed no percussion pain and healthy periapical tissues. The tooth exhibited no symptoms and demonstrated a positive response to vitality testing.

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A periapical radiograph revealed a deep carious lesion in close proximity to the pulp. During the removal of carious tissue, pulpal perforation occurred.

The hemorrhage in the perforation area was controlled with NaOCl, and the cavity was irrigated with saline solution. Following the drying procedure, MTA was placed in the perforation area. A base was constructed using conventional glass ionomer cement. The permanent restoration was completed using composite filling material (Figure 6).

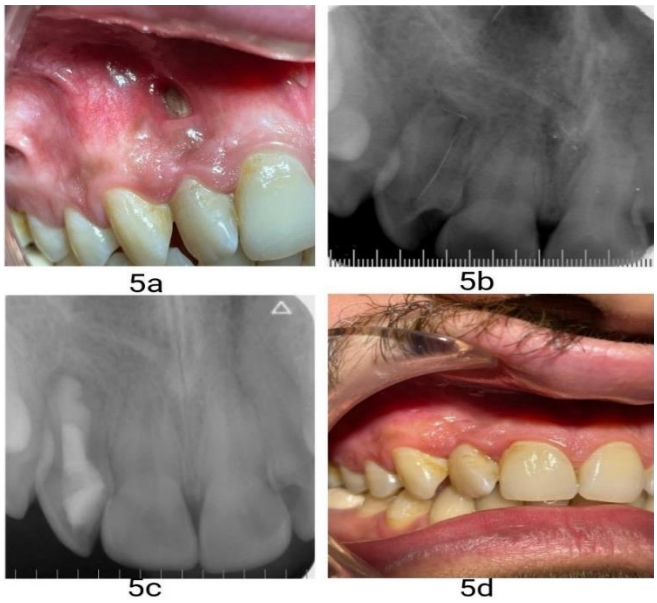

Figure 5: Treatment stages of tooth number 12 with fenestration area.
*5a: Photograph depicting the fenestration area in the buccal mucosa.
5b: Periapical radiograph of the same case.
5c: Periapical radiograph demonstrating the apical portion of the root sealed with MTA and the coronal portion filled with warm gutta-percha.
5d: Follow-up photograph one year after the surgical procedure

Use of MTA in the Repair of Iatrogenic Errors

Case 6:

A patient who developed a furcal perforation during root canal treatment of tooth number 46 was referred to our clinic with accompanying radiographs. The perforation area was sealed with Teflon tape. The canal orifices were obturated with gutta-percha to preserve canal locations, and the perforation area was subsequently sealed with MTA.

The patient was recalled 24 hours after MTA application, and the root canals were disinfected with 2.5% NaOCl irrigation, completing the canal shaping process. The tooth was restored with composite resin (Figure 7).

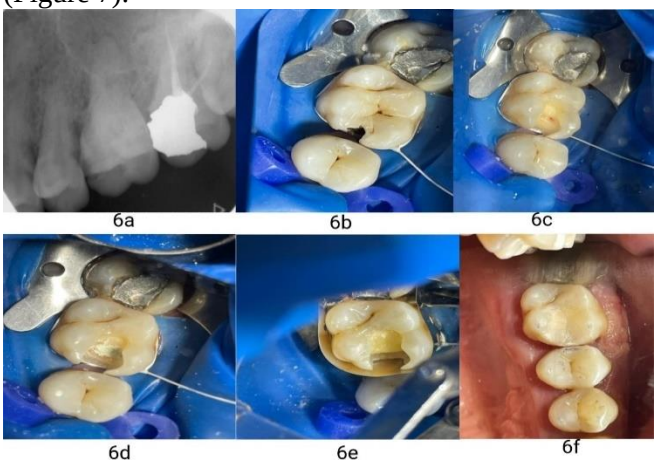

Figure 6: Vital pulp therapy application on tooth number 26
*6a: Periapical radiograph depicting the carious lesion on tooth number 26.
6b: Tooth with carious cavity under rubber dam isolation.
6c: Exposed pulp tissue following caries removal.
6d: Sealing of the perforation area with MTA.
6e: Placement of conventional glass ionomer base material and application of bonding agent.
6f: Completion.

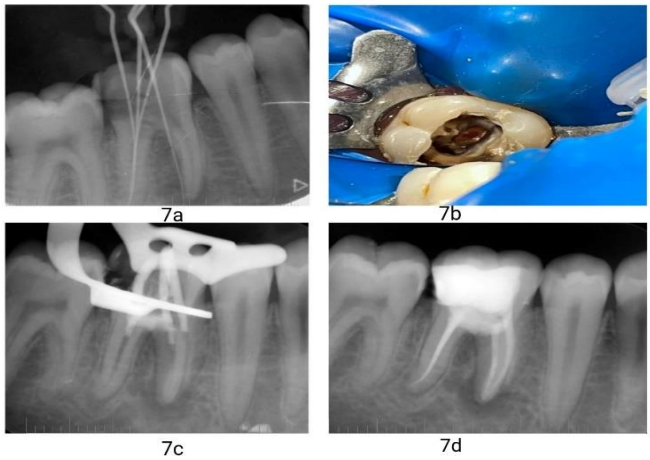

Figure 7: Perforation repair in tooth 46
*7a: Periapical radiograph of tooth 46 with furcal perforation. 7b: Perforation site observed in the furcation area. 7c: Sealing of canal orifices with gutta-percha and repair of the perforation area with MTA. 7d: Periapical radiograph demonstrating the completion of root canal treatment along with the repair of the perforation area.

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Use of MTA in Regenerative Endodontic Treatments

Case 7:

A 9-year-old patient presented with complaints of pain and discoloration in an anterior tooth. Clinical examination revealed the presence of a pre-existing fracture on the incisal edge due to trauma and discoloration of the tooth. Considering the patient's age and evaluating the regenerative potential, it was decided to perform regenerative endodontic treatment to promote root development.

Informed consent was obtained from the patient's guardian. Irrigation with 1% NaOCl. A triple antibiotic paste was applied, and a follow-up appointment was scheduled for three weeks later. The triple paste was removed, and irrigation was performed using 1% NaOCl and 17% EDTA. Bleeding was induced by extending a K-type steel manual file (size 25, 0.2 mm diameter) 2-3 mm beyond the apex. Following coagulation, a collagen barrier was placed, and a plug was created by applying MTA to a thickness of 4-5 mm. A base was constructed on the MTA using traditional glass ionomer cement, and the restoration was completed (Figure 8).

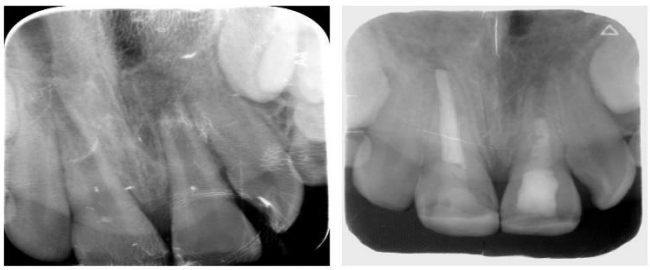

Figure 8: Application of regenerative endodontic treatment in tooth #21
*8a: Necrotic immature tooth #21 with open apex.
8b: Tooth #21 after regenerative treatment, with the coronal portion of the root sealed with MTA.

Discussion

The prevalence of MTA-based materials is attributed to their hydraulic properties, which confer the capacity for setting in a moist environment such as root canals. MTA serves multiple clinical functions, encompassing vital pulp capping, perforation repair, apexification, apexogenesis, root canal obturation, and application as an endodontic filling material (4).

Although numerous aspects of internal root resorption have been investigated, the precise mechanism of its development remains elusive. It is characterized as a destructive process that occurs within root canals or the pulp cavity (5). Clinically, the condition is asymptomatic; consequently, the presence of resorption may be incidentally detected through radiographic examination. External root resorption originates from the root surface and primarily affects cementum and occasionally dentin, manifesting radiographically only in atypical widespread lesions (5).
In a case report, the treatment of a tooth with internal resorption were filled with MTA (6). Follow-up radiographic examinations conducted 5- and 10-years post-treatment revealed that the tooth remained asymptomatic and the pathology had resolved. In our cases, we aimed to achieve similar success through the utilization of MTA.

In our case, similar to the external resorption procedure we applied, the surgical treatment of the lesion involved raising a flap and repairing the external resorption area with MTA. During the two-year follow-up of this case, it was observed that the tooth remained asymptomatic and the periapical region had completely healed (7).

Endodontic treatment of immature teeth presents significant clinical challenges. In such instances, appropriate preparation and obturation are rendered complex due to the interruption of root formation, thin and fragile dentin walls, and the challenge of achieving apical retention of root fillings against a widely patent apex (8). MTA is a material with a pH value of 12.5, low cytotoxicity, and effective bacterial sealing properties. Recent studies have reported that the MTA plug facilitates enhanced root development (9). MTA, when used in the treatment of open apex, promotes the formation of new cementum and PDL. A study presenting three cases of apexification treatment with MTA following trauma demonstrated MTA's excellent compatibility with periapical tissues and its success in apical closure therapy. This was evidenced by the asymptomatic nature of the teeth and the resolution of periapical pathology during a 12-month follow-up period (10).

Vital pulp therapy(VPT) is a restorative dental procedure (11). The efficacy of VPT is dependent upon multiple factors, including the volume of infected tissue, sufficient vascular supply to the tooth, a healthy periodontal structure, and the capacity to establish an appropriate coronal seal. In these cases, MTA demonstrates highly successful outcomes due to its

biocompatibility, moisture resistance, and excellent sealing properties. Furthermore, its bioinductive characteristics stimulate the formation of dentin bridges (11).

Furcal perforation is characterized as a pathological or mechanical communication between the root canal system in the interradicular region of multi-rooted teeth and the external tooth surface. In the context of root canal procedures, inadvertent perforations have been documented to account for as much as 29% of all treatment-related iatrogenic errors (12).

To mitigate environmental contamination, the repair material should exhibit appropriate physicochemical properties and facilitate periradicular tissue regeneration (12). MTA exhibits the most predictable biological behavior (12).

Similar to our case, a perforation area in the furcal region of tooth number 36 in a 24-year-old patient was repaired with MTA, and an indirect onlay composite restoration was subsequently placed (13). In our case, as in this case, MTA perforation was observed to have good closure capability for repair.

Regenerative endodontic therapy (RET) is a biologically-based procedure that functions as an alternative to apexification. Several studies implementing RET in patients have reported successful outcomes (9). A case report of regenerative endodontic treatment using MTA demonstrated successful outcomes at five-year follow-up (14). In the regenerative therapy protocol, MTA is applied to create a coronal plug due to its excellent sealing properties, biocompatibility, bioactivity, and structural stability in the presence of moisture. In our case study, we successfully used MTA.

Conclusion

Our study has demonstrated that MTA is a viable material for application in numerous endodontic cases. Future advancements are likely to further expand the scope and efficacy of this material.

Conflict of Interest: There is no conflict of interest the authors.

Our study titled "MTA Applications in Endodontics" was evaluated by the scientific committee and accepted and presented as an oral presentation at the Gaziantep University 1st International Dentistry Congress held at Gaziantep Mavera Congress and Art Center between 25-27 October 2024.

AUTHOR CONTRIBUTIONS

The author contributions are listed as follows: **Concept/Idea:** EÜT, AK, EB **Design:** EÜT, AK, EB. **Revision/Consultation:** EB, AK **Resources:** EÜT **Materials:** EÜT **Data collection or processing:** EÜT, AK, EB **Analysis and interpretation:** AK, EÜT, EB **Literature review:** EÜT **Manuscript writing:** EÜT, EB **Critical review:** AK, EB

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Rehabilitation of Anterior Region Tooth Size Discrepancies After Orthodontic Treatment: A Case Series

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Abstract

Multidisciplinary approaches are used to treat aesthetic and functional problems related to teeth. Following orthodontic treatment, patients may require restorative dental treatment for aesthetic adjustments. Especially in maxillary anterior region, direct composite resin restorations which are one of the restorative treatment options following orthodontic treatment are frequently preferred today due to their minimal invasive and conservative nature. In this case report, it was aimed to eliminate the aesthetic problems observed due to tooth size discrepancies in the anterior region of the maxillary arch with direct composite resin restorations after orthodontic treatment. The patients whose orthodontic treatments were about to be completed at Erciyes University Department of Orthodontics were referred to the Department of Restorative Dentistry for consultation regarding their aesthetic complaints in anterior maxillary region before debonding. As a result of intraoral examinations of three patients, tooth size discrepancies and consequently polydiastema were observed. Following the evaluation, it was decided to apply direct aesthetic composite resin restorations to the cases. Tooth size discrepancies and diastemas observed after orthodontic treatment were rehabilitated using direct composite restorations. Minimally invasive rehabilitation of aesthetic problems after orthodontic treatment is possible with direct composite resins.

Case Report (HRU Int J Dent Oral Res 2025; 5(1): 36-39)

Keywords: Aesthetic, direct composite restoration, minimally invasive, polydiastema, tooth size discrepancy.

Introduction

Aesthetic and functional problems observed in teeth hold great importance for patients. There are various treatment options for solving these problems. Aesthetic problems are generally treated with multidisciplinary approaches (1). Orthodontic treatment is commonly employed for problems such as tooth size discrepancies, diastema, dental anomalies, crowding, malocclusion. In some cases, in addition to this treatment, restorative procedures are also required in the anterior region to achieve optimal aesthetic outcomes (2). To avoid aesthetic complaints especially in the anterior region at the end of the prodecure, the treatment should be completed with a multidisciplinary approach.

Direct composite resin restorations, one of the restorative treatment options, are highly preferred today because they offer minimally invasive and more conservative approaches (3). These restorations have advantages such as ease of application, repairability, low cost and being completed in a single appointment (4).

The purpose of this case report is to eliminate aesthetic problems caused by tooth size discrepancies in the anterior region of the maxillary arch using direct composite resin restorations as a minimally invasive approach after orthodontic treatment.

Presentation of the Cases

Patients whose orthodontic treatments were about to be completed at Erciyes University, Department of Orthodontics, were referred to the Department of Restorative Dentistry for consultation regarding aesthetic complaints in the anterior maxillary region before debonding. Then, before starting the treatment, the patients were informed verbally and in writing that the information and photographs related to the case could be

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used for publication purposes, and an informed consent form was obtained from the patients.

Case 1: As a result of the intraoral examination performed on a 20-year-old female patient without any systemic disease, it was determined that the patient had tooth size discrepancies, polydiastema and peg-shaped lateral incisors. Based on the evaluation, direct aesthetic composite resin restorations were planned. Following shade selection with the button technique, the teeth were isolated with a rubber dam, polished using a fluoride-free prophylaxis paste, and etched with 37% phosphoric etching gel for 30 seconds. After rinse and drying, a two-step etch-and-rinse adhesive (Adper Single Bond 2, 3M ESPE, St. Paul, MN, USA) was applied according to the manufacturer's instructions. The teeth were restored using nanofilled composite resin [Filtek Ultimate, A2 Body and Enamel, 3M ESPE, St. Paul, MN, USA]. Finishing and polishing were used with yellow-banded diamond burs, abrasive discs (Sof-Lex, 3M ESPE, St. Paul, MN, USA), and spiral polishing discs (Clearfil Twist Dia, Kuraray, Tokyo, Japan). Procedures and protocols for this case are shown in Figure 1. Post-debonding (before restorative treatment) and after restorative treatment photographs are presented in Figure 2.

Figure 1. Case 1: Procedures and steps: etching, bonding, modelling, finishing, polishing & glossing.

Figure 2. Post-orthodontic treatment and post-restorative treatment: initial and final photographs of case 1.

Case 2: Following the examination of a 19-year-old female patient with no systemic disease after orthodontic treatment, midline diastema and peg-shaped lateral incisor teeth were detected. Direct aesthetic composite resin restorations were planned after examination. Following shade selection using the button technique, the teeth were isolated with a rubber dam, polished with fluoride-free prophylaxis paste, and etched with 37% phosphoric etching gel for 30 seconds. The teeth were then rehabilitated and restored using the materials and methods in Case 1. Pre- and post-restorative treatment photographs are shown in Figure 3.

Case 3: As a result of the intraoral examination performed on a 20-year-old male patient whose orthodontic treatment was about to be completed, tooth size discrepancies and consequently polydiastema were observed. Direct aesthetic composite resin restorations were planned for this case. Following shade selection, the teeth were isolated with a rubber dam, polished using fluoride-free prophylaxis paste, and etched with 37% phosphoric etching gel for 30 seconds. The teeth were then rehabilitated and restored using the materials and methods in Case 1. Initial and final photographs of case are shown in Figure 4.

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Figure 3. Post-orthodontic treatment and post-restorative treatment: initial and final photographs of case 2.

Figure 4. Post-orthodontic treatment and post-restorative treatment: initial and final photographs of case 3.

Discussion

Tooth size discrepancies and unequal spaces between the anterior teeth of the upper and lower jaws pose significant aesthetic concerns for patients (5). Aesthetic treatment options for size discrepancies include orthodontic, restorative and prosthetic treatments. Orthodontic treatments are more complex, time-consuming and costly and require fixed appliances. Restorative dentistry offers simple, fast, predictable and low-cost solutions. On the other hand prosthetic treatments involve more invasive procedures (6).

When treatment methods are examined, direct composite resin restorations stand out as a non-invasive approach that preserves aesthetic and functional changes, presenting a low risk in terms of periodontal health (6,7). Resin-based composites are preferred for achieving maximum bonding strength, aesthetic, and functional improvement with minimal loss of enamel or dentin surface (8).

The use of composite resins has increased due to their better aesthetic properties and the need to remove less sound tissue compared to former restorative materials and they may be considered clinically long-lasting. (9).

This case report evaluates composite resins applied due to aesthetic concerns in the anterior region, focusing on color matching, anatomical structure, discoloration and marginal adaptation. Aesthetic concerns and functional requirements were successfully eliminated with composite resins, and the results obtained after the 12-week clinical follow-up were found to be of ideal quality. The findings from this case report suggest that direct composite resin restorations can offer an alternative treatment option for patients with aesthetic complaints after orthodontic treatment.

Conclusion

Direct aesthetic composite resin restorations were found to be successful in restoring tooth size discrepancies in the anterior region. The anatomical restoration of the tooth is performed by selecting the appropriate shade. Thus, complementary treatment can be completed with a minimally invasive aesthetic and functional approach for patients who have completed orthodontic treatment. It was observed that ideal results could be achieved with short-term clinical treatment procedures.

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Author contributions: EBG and VK. selected the cases. EBG completed the cases with the guidance of VK. All authors discussed the results and contributed to the final manuscript and led the writing.

Conflict of Interest: The authors declare that they have no conflict of interest.

Ethical approval: Before starting the treatment, the patients were informed verbally and in writing that the information and photographs related to the case could be used for publication purposes, and an informed consent form was obtained from the patients.

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Regenerative Endodontic Treatment of Immature Permanent Tooth With Necrotic Pulp: Case Report

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Abstract

Regenerative endodontic therapy represents an innovative treatment approach designed to restore the physiological functions of the pulp-dentin complex and facilitate continued root development in immature teeth with necrotic pulp. This method holds promise for reducing the risk of fractures in immature teeth by encouraging the thickening of the root canal structures and facilitating ongoing root development. This case report details a 24-month follow-up of an immature permanent tooth with necrotic pulp managed using a regenerative endodontic treatment approach. As part of the regenerative endodontic treatment protocol, 1.5% sodium hypochlorite and 17% ethylenediaminetetraacetic acid were used as irrigation solution, and a dual antibiotic paste (1:1 ciprofloxacin: metronidazole) was applied as intracanal medication. Following the induction of bleeding into the root canal, mineral trioxide aggregate was placed as a coronal plug over the formed blood clot, and the tooth was subsequently restored with composite resin material. At the 24-month clinical and radiographic assessment, the tooth exhibited a favorable response to cold and electric pulp testing, with no signs of sensitivity upon percussion or palpation. Periapical radiographs showed resolution of the periapical lesion and indicated ongoing root development. In conclusion, regenerative endodontic therapy offers a promising substitute for traditional apexification, particularly for immature permanent teeth, by promoting the thickening of the root canal structures and supporting the restoration of the tooth's physiological function.

Case Report (HRU Int J Dent Oral Res 2025; 5(1): 40-44)

Keywords: Immature tooth, MTA, necrotic pulp, regenerative endodontic treatment.

Introduction

Both traditional apexification using calcium hydroxide and apical plug formation with mineral trioxide aggregate (MTA) are common methods for managing immature permanent teeth with necrotic pulp. Both techniques aim to create a hard apical barrier but are limited in fostering continued root development. Calcium hydroxide requires prolonged treatment and may weaken the root dentin, increasing the risk of fractures [1]. Apical plugging using MTA involves fewer visits and creates a rapid apical barrier; however, this technique does not facilitate the thickening of the root canal walls or encourage continued root growth. As a result, it can increase the tooth's fragility and elevate the risk of long-term failure [2, 3]. These challenges have spurred interest in alternative treatment approaches that foster biological root growth, such as regenerative endodontic therapy, for the management of immature permanent teeth with necrotic pulp that have not yet completed apex development. Regenerative endodontic treatment can stimulate both root growth and the thickening of root canal walls, thereby enhancing the biomechanical strength of the tooth and promoting long-term success. Regenerative endodontic treatment has been developed to facilitate the repair and regeneration of the pulp-dentin complex. It involves minimal or no instrumentation, intra-canal disinfection using various

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irrigation solutions and medicaments, followed by the placement of MTA or bioceramic-based cement over the blood clot formed by inducing bleeding into the root canal, and finalizing the treatment with coronal restoration [4-6]. In light of this information, this case report presents the clinical and radiographic outcomes of a 24-month follow-up of an immature permanent tooth with necrotic pulp treated using regenerative endodontic therapy.

Case

A 23-year-old male patient was referred to the endodontics clinic due to a fractured restoration on his right upper central incisor. From the anamnesis, it was learned that the patient fell and fractured his right upper central incisor when he was 8-9 years old, then the fractured part was restored with composite resin by a dentist and he had no complaints of pain, swelling, etc. until now. Clinical examination revealed no response to cold or electric pulp tests, and the composite restoration was fractured (Figure 1). Radiographic analysis showed a radiolucent periapical area and incomplete apical root development (Figure 2). The tooth was diagnosed with pulp necrosis and chronic apical periodontitis. Treatment risks and alternative treatments were explained to the patient. Conventional root canal treatment and regenerative endodontic treatment options were presented. Regenerative endodontic treatment was decided as the treatment plan. Informed consent form was obtained from the patient. During the first appointment, local anesthesia was administered, and access was gained under rubber dam isolation (Figure 3). The working length was established using an electronic apex locator and radiographic verification. No preparation was performed, and the canal was irrigated with 1.5% sodium hypochlorite and saline. Irrigation was performed using an irrigation needle (Steri Irrigation Tips, Diadent, Cheongju, Korea) with a closed side port, positioned 1 mm short of the apex. A dual antibiotic paste (1:1 ciprofloxacin: metronidazole) was placed, and the cavity was sealed temporarily. The access cavity was provisionally sealed using glass ionomer cement. Three weeks later, on the second visit the patient presented without any symptoms. Local anesthesia with 3% mepivacaine (epinephrine-free) was administered, and rubber dam isolation was achieved. Upon removal of the temporary restoration, the root canal was irrigated with 17% ethylenediaminetetraacetic acid (EDTA) aqueous solution, followed by saline to eliminate the medicament. A K-type file with an anterior beveled tip was advanced 2 mm beyond the apical foramen and rotated to induce bleeding into the root canal. A sterile cotton pellet was used to tamponade the bleeding for 10-15 minutes to stop the bleeding and ensure clot formation. MTA (Angelus Soluções Odontológicas, Londrina, Brazil) in powder-liquid form was mixed and prepared on a mixing pad with the help of a spatula and placed on the blood clot with a thickness of 3-4 mm. After allowing MTA to cure for 15 minutes, the access cavity was sealed with glass ionomer cement and composite (Figure 4). The tooth was referred for restorative treatment. After 3 and 6 months, the tooth remained asymptomatic, and radiographs showed a significant reduction in the periapical lesion (Figures 5 and 6). At the 24-month follow-up, the tooth responded positively to pulp tests, exhibited no sensitivity to percussion or palpation, and showed root development with periapical healing (Figure 7).

Figure 1. Preoperative Intraoral Photograph

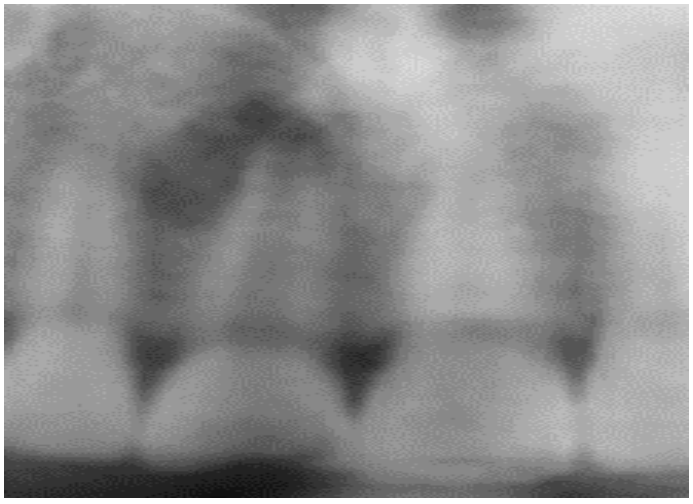

Figure 2. Preoperative Periapical Radiograph

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Figure 3. Rubber Dam Application and Endodontic Entry Cavity Preparation

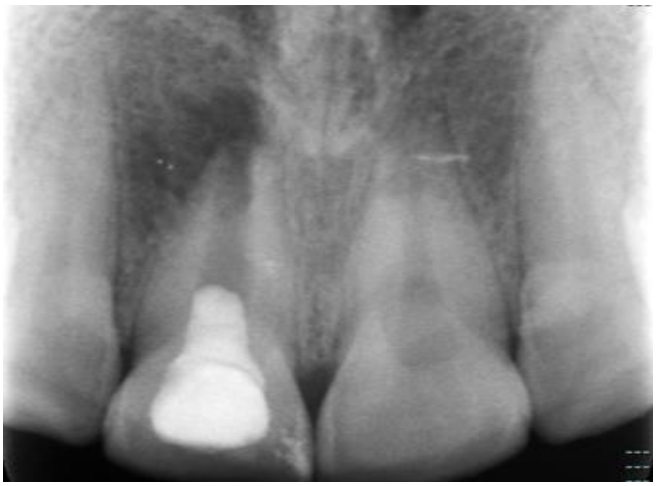

Figure 4. Radiograph taken after the 2nd Session MTA Application

Figure 5. 3rd Month Radiography

Figure 6. 6rd Month Radiography

Figure 7. 24rd Month Radiography

Discussion

This case report evaluates the regenerative endodontic treatment and 24-month follow-up results of an immature permanent tooth with early pulp necrosis and periapical lesions caused by trauma. While apexification and apexogenesis treatments primarily focus on creating a hard tissue barrier at the apical region of the tooth, regenerative endodontic treatment fosters the repair of both dentin and pulp tissues. This makes it possible to thicken the root canal walls and promote apical closure. Furthermore, regenerative endodontic treatment is becoming a more attractive treatment option because it can be performed in shorter sessions and a better biological response can be achieved [7]. In regenerative endodontic treatment procedures, in immature permanent teeth, mechanical preparation may

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cause brittleness due to incomplete root development and the thin structure of the dentin walls; therefore, the root canal walls cannot be cleaned with mechanical instruments as in conventional root canal treatment. Hence, low concentrations of sodium hypochlorite, EDTA, and especially biocompatible disinfectants are preferred as antimicrobial irrigation solutions for root canal disinfection in regenerative endodontic treatment applications [8]. The guidelines provided by the 'European Society of Endodontology' and the 'American Association of Endodontists (AAE)' widely endorse the use of a triple antibiotic paste, composed of ciprofloxacin, metronidazole, and minocycline, as an intra-canal medication to eradicate infection within root canals in cases of regenerative endodontic treatment [4, 9]. Since root canal infections are polymicrobial in nature, it is usually not possible to eliminate all pathogens with only one antibiotic. Therefore, the combination of metronidazole, ciprofloxacin and minocycline can help to successfully control infections in the root canal system by providing an effective antimicrobial spectrum against both aerobic and anaerobic bacteria [10, 11]. However, minocycline in the triple antibiotic paste may cause discolouration, especially in the coronal region of the tooth [12, 13]. Some researchers suggest removing minocycline from the paste or using different antibiotics to prevent coronal colouration [14, 15]. Calcium hydroxide ($Ca(OH)_2$) may also be preferred as an alternative to triple antibiotic paste, although there is no definite protocol on the choice of medicament. Calcium hydroxide is an alternative medication that can be used in this situation, but some previous studies have reported better antibacterial activity and a higher rate of root wall thickening with antibiotic paste [16, 17]. In this case, dual antibiotic paste (1:1 ciprofloxacin: metronidazole) was used as an intracanal medication considering that minocycline causes tooth discolouration.

To support the survival of stem cells, it is recommended to use 17% EDTA as part of the irrigation protocol [9]. It is suggested that the use of 17% EDTA in the final irrigation plays an important role in reducing the negative effects of NaOCl, which has a destructive effect on tissues [18]. EDTA also contributes to root development by promoting the release of growth factors from dentin [19, 20]. For these reasons, 1.5% NaOCI and 17% EDTA were used as irrigation solutions in this case.

The formation of a blood clot that serves as a tissue scaffold within the root canal is critical for the success of regenerative endodontic treatment. This blood clot acts as a natural framework for the positioning of stem cells and the release of growth factors [4]. However, forming an adequate blood clot may be challenging or insufficient in certain patients. In these instances, biomaterials such as platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) are recommended as alternatives to blood clots [21].

A proper coronal seal is essential for the success of regenerative endodontic treatment. Effective coronal restorations that prevent leakage play a crucial role in safeguarding the pulp-dentin complex and reducing the risk of post-treatment infection [8]. In the current case, following the formation of the blood clot, it was covered with MTA and a composite resin restoration, as recommended in several previous studies [8, 22].

Conclusion

According to the success criteria established by the American Association of Endodontists (AAE), the primary objective of regenerative endodontic treatment is to achieve biological healing of the tooth. These criteria include the resolution of the periapical lesion, thickening of the root canal walls, and closure of the open apex [9]. In the case presented, it was observed that the periapical lesion healed and the open apex closed, meeting these key success criteria. The results of this case show that a regenerative endodontic procedure can be successfully applied in the treatment of a permanent tooth with arrested root growth due to early pulp necrosis caused by trauma. However, long-term follow-up studies are needed before this treatment option can be used routinely.

Conflict of Interest: There is no conflict of interest the authors.

This study presented as an oral presentation at the Gaziantep University 1st International Dentistry Congress held at Gaziantep Mavera Congress and Art Center between 25-27 October 2024.

AUTHOR CONTRIBUTIONS

The author contributions are listed as follows:

Concept/Idea: BA, AD **Design:** BA, AD **Revision/Consultation:** BA, AD **Data collection or processing:** AD **Analysis and interpretation:** BA, AD **Literature review:** AD **Manuscript writing:** BA, AD **Critical review:** BA

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The Role of Diagnostic Radiology in Orthodontics

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Abstract

Diagnostic radiology constitutes an indispensable element of the diagnostic process and treatment planning in orthodontics. Panoramic and cephalometric radyographies, in conjunction with cone beam computed tomography, facilitate a comprehensive examination of tooth and jaw structures. These methodologies are employed in critical applications, including the identification of malocclusion types, the evaluation of growth and development stages, the assessment of impacted teeth positioning, and the monitoring of alterations occurring during orthodontic treatment. However, given the potential risks of radiation exposure, it is imperative to prioritize the acquisition of the most informative images while minimizing the radiation dose. The utilization of advanced imaging techniques should be reserved exclusively for circumstances where their application is medically justified, and patient safety must remain the paramount concern.

Review (HRU Int J Dent Oral Res 2025; 5(1): 45-50)

Keywords: Diagnostic radiology, orthodontics, panoramic radiography, cephalometric radiography, cone beam computed tomography.

Introduction

Diagnostic radiology constitutes the diagnostic branch of radiology, a field that plays an indispensable role in orthodontic treatment planning and patient follow-up. Contemporary radiological methodologies facilitate meticulous evaluation of teeth, jaw bones, and the adjacent tissues, thereby enabling precise identification of orthodontic concerns and the formulation of efficacious treatment modalities (1,2)

The Application of Diagnostic Radiology

1. Evaluating the alignment and positioning of the teeth
2. Determining the type of malocclusion
3. Planning of orthognathic surgery
4. Examination of the location of impacted teeth and their relationship with surrounding tissue
5. Root resorption in orthodontic treatment follow-up, monitoring the effect of orthodontic appliances
6. Evaluation of changes occurring in bone
7. Examination of cysts, tumors and inflammation

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8. Diagnosis and follow-up of syndromic conditions (3,4)

The issue of the minimal radiographic recording system that is planned to be used in determining the diagnosis and treatment in orthodontics has been discussed by researchers for years, yet no consensus has been reached (4-7). The presence of risk should be accepted when evaluating the cytocastic effects of radiation, which occur even at low doses. This is due to the fact that patients exposed to radiation usually consist of children and young adults with high radiosensitivity (4). When determining the necessary radiographic records, orthodontists should adopt the principle of "lowest reasonably achievable" radiation and choose the method that provides optimal information with appropriate indications for the patient (4,8). The radiographs obtained in a standard orthodontic clinic consist of panoramic, cephalometric, and wrist radiographs, which are two-dimensional (2). However, these techniques have disadvantages, such as magnification, overlapping of anatomical points, and artifacts related to patient positioning. In light of these limitations, three-dimensional (3D) methods can be used in orthodontic diagnosis and treatment planning (6, 9).

The upper canines, which are planned to be retained for treatment in orthodontics, are the most frequently impacted teeth after the lower jaw third molars, and the frequency of impacted canines varies between 1% and 4% (10). The maxillary canines teeth are developed in the deeper regions of the jawbone and must traverse a greater distance to reach the oral cavity than other teeth (11). In addition to panoramic, periapical, lateral cephalometric, and posteroanterior cephalometric radiography, cone beam computed tomography (CBCT) can be used as a reliable method for visualizing these orthodontically important teeth (8,12). It has been reported that images obtained with CBCT result in alterations to treatment plans created using 2D radiographs (8). Maxillofacial surgeons have recommended CBCT as a fundamental method for diagnosing impacted maxillary canines. However, orthodontists predominantly favor conventional radiographic techniques over CBCT for routine diagnostic purposes (13).

Radiologic Techniques

1. Panoramic Radiography

Panoramic radiography is frequently regarded as the preferred initial imaging modality for orthodontic patients in the field of dentistry (14). This technique, classified as an extraoral method, generates two-dimensional data regarding the facial-jaw skeleton, teeth, and hard tissue elements of the temporomandibular joint (TMJ). This technique provides crucial insights into various conditions that affect orthodontic treatment planning. These include the examination of impacted or supernumerary teeth, dental age determination, and comprehensive evaluation of the entire dentition (15).

The panoramic radiographic image is formed by the synchronized movement of the X-ray tube and detector along a specific trajectory in the opposite direction around the patient's head (Figure 1). During this process, the X-rays, which are moving away from the tube, rotate around the jaw and teeth, while the detector on the opposite side records the received data. During this movement, only structures in a specific focal plane (focal trough) are clearly visualized, while areas outside this plane appear blurred. This technique is employed to generate a detailed two-dimensional image of the jaw, teeth, and surrounding structures (15,16).

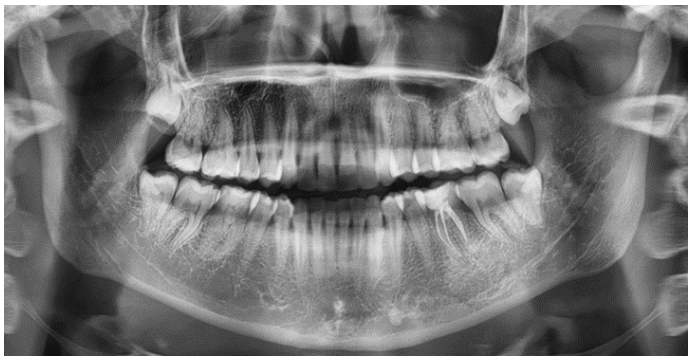

Figure 1. Example of a panoramic radiograph.

In the discipline of orthodontics, panoramic radiographs play a critical role in determining the density of bone tissue, trabeculation, the ratio of spongiosis and cortical bone, and the distance of the maxillary sinus, mental foramen, and mandibular canal to the alveolar crest prior to mini screw placement (2). In the evaluation of the eruption status of the teeth, a decision is made for extraction or surgical exposure of the impacted tooth based on their position in relation to the midline and alveolar crest (17).

According to the findings of studies cited in the literature (18-20), upper canine teeth are more frequently impacted in the palatinal region. It has been documented that these teeth are responsible for inducing root resorption in adjacent teeth (20-22). The limitations of panoramic radiography in providing information regarding the buccopalatinal position of teeth underscore

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the necessity of additional diagnostic modalities in the evaluation of impacted canines and the associated root resorption (23). In such cases, the utilization of 3D imaging techniques, such as CBCT, is recommended (24). Furthermore, in cases where the angle of the impacted maxillary canine tooth with the midline exceeds 30 degrees, and/or there is suspicion of inducing root resorption in an adjacent tooth, it is advised to employ CBCT in the smallest imaging area (17).

2. Periapical, Bitewing and Occlusal Radiographs

In addition to panoramic radiography, periapical, bitewing, or occlusal radiographs should be utilized solely when additional detail is required. Periapical radiography is the most informative and simplest of the techniques using X-rays. These radiographs offer superior visual clarity, facilitating the discernment of root structure (length, inclination), periapical tissues, and bone structure of the teeth. The comprehensive nature of this information is paramount in the field of orthodontics. This modality facilitates meticulous examination of the location of impacted teeth, root resorption, periapical lesions, periodontal problems, and post-treatment complications. While this technique offers the advantage of high-resolution evaluation of the targeted area, it is limited in its ability to provide information regarding the buccolingual position of the tooth. A comprehensive evaluation is only achieved when this technique is employed in conjunction with other methods (2,25,26).

In a patient with adequate oral hygiene, panoramic radiography is sufficient if no obvious pathological condition is present. However, if there is suspicion of caries at the interface of the teeth, bitewing radiography should be obtained. In the case of a deep caries, periapical radiography should be obtained from the affected area. In the presence of periodontal disease, periapical or bitewing radiographs should be obtained from the affected area (2).

In panoramic radiographs, the anterior maxilla is frequently distorted by factors such as magnification and superimposition. This results in various pathologies, impacted/erupting and supernumerary teeth being missed. Occlusal radiography, on the other hand, facilitates the detection of these structures in the maxilla, their palatinal/lingual positioning, maxillary expansion, and asymmetries. Furthermore, mandibular imaging provides crucial information regarding the buccolingual position of impacted teeth (27-30). Panoramic radiography is employed to obtain the requisite data for diagnosis, with the objective of minimizing radiation exposure. Periapical or other radiographs are requested only in select circumstances (2).

3. Cephalometric Radiography

Cephalometric radiography is a diagnostic tool employed in the analysis of malocclusions, the evaluation of basic skeletal incompatibilities, and the assessment of facial and dental proportions. This radiographic technique facilitates the elucidation of the anatomical origins of malocclusions. It demonstrates the relationship between the cervical vertebrae, cranial base, cranium, and jaws, as well as any degenerative changes (2,31). While cephalometry remains a cornerstone of orthodontic imaging, the use of lateral cephalometric radiography offers a distinct advantage in evaluating vertical relationships, though it provides limited insight into the transverse dimensions and bilateral assessment of malocclusions (32). The recommended approach involves the utilization of lateral cephalometry when the objective is to ascertain skeletal relationships and measurements or to determine the inclination and position of the upper and lower incisors (4).

Lateral cephalometric radiography is a diagnostic tool that allows for the observation of changes in airway volume in the sagittal plane, particularly in patients diagnosed with obstructive sleep apnea. The literature has examined alterations in the airway following orthodontic treatment using lateral cephalometry (33, 34). Nevertheless, the utilization of surface area or volume measurements in the diagnosis of airway narrowing has been regarded as more precise, and CBCTs have been employed for this purpose (35).

Posteroanterior cephalometric radiographs are employed to evaluate facial asymmetries by examining dentoalveolar and skeletal relationships in the transverse direction. However, patient positioning is a significant challenge, and its effect on the measurements made must be considered (36).

4. Radiography of the hand and wrist

The identification of the stage of growth and development constitutes the most fundamental element of orthodontic evaluation and treatment planning. For this purpose, hand-wrist radiographs are widely used in orthodontic clinics and are considered the gold standard for determining the pubertal growth stage. However, it is important to note that this procedure does involve the administration of additional radiation to the patient, an

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undeniable fact that has been documented in the extant literature (37).

A review of the literature on this subject, conducted as part of the preparation of the clinical practice guideline, revealed that measurements of cervical vertebral maturation made using lateral cephalometric radiography can be used as an alternative to wrist x-rays and provide reliable information (4, 37-42).

5. Cone Beam Computerized Tomography

The CBCT was originally developed for utilization in the field of dentistry in 1987, and its functionality in the domain of orthodontics was thoroughly examined and documented during the Orthodontic and Aesthetic Science and Technology Congress in 2002 (43,44).

In the domain of orthodontics, conventional radiographs are often supplemented by CBCT imaging when a more comprehensive evaluation is necessary (see Figure 2). In contradistinction to 2-dimensional radiographs, CBCT images offer several notable advantages. These include the absence of superposition and magnification, the acquisition of cross-sectional images in different planes, the monitoring of the airway volume, the determination of the exact position of impacted teeth, and the presence of soft tissue contrast (45,46).

Furthermore, the bone density and mineralization amounts can be calculated on CBCT. Indications for CBCT include the following: ectopic impacted/erupting teeth, cleft lip and palate, obstructive sleep apnea, orthognathic surgery planning, patients with facial asymmetry, syndromic conditions and deformities, and bone tissue evaluation of the TMJ. The presence of ectopic teeth, their location, and the potential for resorption of permanent tooth roots can be assessed on CBCT. Furthermore, the direction in which the impacted tooth should be moved to prevent damage to neighboring teeth can be determined. The knowledge of the actual three-dimensional position of the impacted tooth is of paramount importance, as it affects the treatment method to be applied by the orthodontist in a timely manner and the necessary anchorage efficiency (2,8).

The efficacy of orthodontic treatment, as evidenced by the reduction in the dimensions of the buccal cortical bone resulting from accelerated palatal expansion, can be assessed through the use of CBCT (47). While CBCT has been found to produce precise outcomes in the assessment of alveolar bone defects, it has also been observed to yield false positive results in the detection of fenestrations (48, 49).

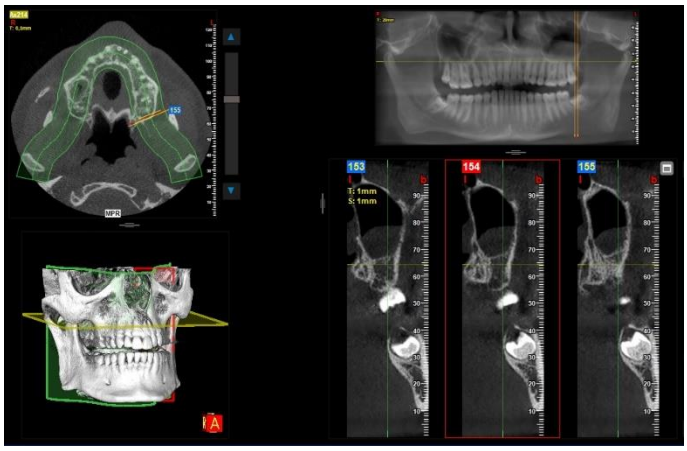

Figure 2. This figure illustrates a cone beam computed tomography image.

While some orthodontists advocate for the routine use of CBCT in addition to panoramic and cephalometric radiography, it is imperative to acknowledge the significant increase in the level of radiation absorbed by patients. When acquiring CBCT images from patients, it is imperative to utilize the smallest feasible imaging area to minimize the overall radiation exposure (2).

6. Magnetic resonance imaging

Magnetic resonance imaging (MRI) is an imaging technique that uses radiofrequency waves as opposed to x-ray-based methods (Figure 3).In dentistry, MRI is mainly used to evaluate soft tissues in the neck region, TMJ disc dislocations and pathologies, TMJ anomalies, and salivary glands. Recent studies have demonstrated its application in the visualization of dentoalveolar structures, periapical and periodontal inflammation, caries, and the location of impacted teeth. The absence of ionizing radiation allows for reproducible recordings, especially in pediatric and adolescent patients (50, 51).

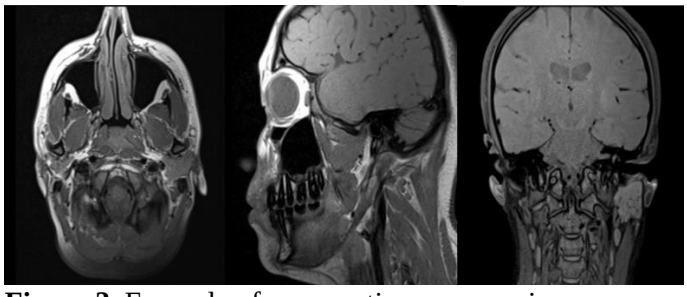

Figure 3. Example of a magnetic resonance image.

Cephalometric analyses can also be performed on MRI; however, they require specialized equipment and settings, which may not be available in all healthcare

institutions. Another limiting factor is the need for a trained radiologist to interpret cephalometric data. Consequently, cephalometric radiographs are frequently the preferred modality due to their convenience, practicality, and accessibility. However, in certain cases where more detailed visualization of soft tissues is required, MRI can be utilized (50).

Metal components in orthodontic appliances, such as brackets and wires, pose a concern as they are susceptible to heating and movement during MRI procedures, potentially causing discomfort to patients. Additionally, these appliances may introduce artifacts in MR images, complicating interpretation. Therefore, in certain circumstances, it may be advisable to remove these appliances prior to undergoing MRI (50, 52).

Minimization of Radiation Dose

Despite the widespread use of diagnostic radiology, it is imperative to minimize patient exposure. In accordance with the ALARA (As Low As Reasonably Achievable) principle, the acquisition of the greatest amount of diagnostic information should be balanced with the requirement of the lowest possible radiation dose. The utilization of advanced techniques, such as CBCT, should be reserved exclusively for cases where there is a clear medical necessity, and the potential risks of radiation exposure to patients must be meticulously evaluated (53,54).

Conclusion

Diagnostic radiology is vital for both diagnosis and treatment planning in the orthodontic treatment process. Methods such as panoramic, cephalometric and CBCT help to determine the extent and severity of orthodontic problems and allow monitoring of treatment effectiveness. Careful and informed use of these technologies increases both patient safety and treatment success.

Authors Contributions

NB: Lıterature Research: NB **Wrıtıng The Manuscript:** NB, NGE **Designed the study:** NB **Manuscript translation:** NGE

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Sustainable Dental Approaches for The Environment And Human Health: A Traditional Literature Review

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Abstract

The world is on the brink of environmental crises, making the role of the healthcare sector increasingly critical. Dentistry is in a position to be a pioneer in this transformation with both its impact on the global environment and its potential to shape the future of sustainable healthcare. Efforts in the sector embody green dentistry, including eco-friendly practices.. In this context, green dentistry is an innovative approach that minimises environmental damage and prioritises patient safety by using resources in the most efficient way. Elements such as waste management, energy efficiency and digitalisation are key components of this approach. It is not only an environmental requirement, but also an opportunity that increases patient satisfaction, provides efficient clinical management and economic benefits in the long term. Starting from the historical development of green dentistry, this study comprehensively addresses the methods that can be applied for sustainability. It also emphasises the importance of training programs and international collaborations to raise the awareness of dentists and healthcare professionals. The dissemination of environmentally friendly practices can transform the entire healthcare system, not just the dental practices or polyclinics. Raising awareness of green transformation in the sector, developing sustainable policies and adopting feasible solutions at the individual level are critical to the success of the idea. Future studies should focus on innovative methods that will increase the applicability of this framework. In the future, thanks to innovation and conscious policies, more sustainable and effective dental practices with minimised environmental impact will be at the forefront.

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Keywords: Public health dentistry, dental waste, carbon footprint, recycling, dental clinics.

Introduction

Our world and its inhabitants confront numerous challenges, such as climate change, biodiversity loss, air and water contamination, and the depletion of the ozone layer. The World Health Organization (WHO) declares that protecting public health through ecologically responsible actions is an ethical duty of every state(1). While one of the greatest challenges of the twenty-first century is the contamination of natural resources due to increased waste production, the global shift toward ecological sustainability has become imperative(2). Recently, rising environmental awareness, often termed “eco-consciousness”, has evolved into a gradual global movement aimed at reducing environmental harm, ultimately paving the way for “green” transformations(3). It is paradoxical that healthcare services, whose fundamental principle is to support and protect health and life, contribute to climate change through unsustainable practices, leading to increased mortality and diminished quality of life(4). Eco-friendly dentistry is a dental practice that simultaneously embraces sustainability, prevention, caution, minimally invasive patient-centered care, and a globally focused treatment philosophy. It is an emerging concept that benefits the environment, patients, clinical staff, and dentists alike(5). Not only does it help control waste pollution in dental clinics, but it also conserves water, energy, and other resources. Sustainability; one of the core principles of eco-friendly dentistry, refers to meeting the needs of the present

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without compromising the ability of future generations to meet their own(5) The field of dentistry is encouraged to integrate sustainable development goals into daily practice and promote the shift toward a green economy. Dental professionals have a duty to minimize their environmental footprint while advancing oral health for everyone and maintaining patient safety. (6). Advancements in eco-friendly dentistry may be achieved via two main avenues: developing and implementing customized policies, and leveraging the authority held by dentists themselves(7).

History of Green Dentistry

The concept of "green dentistry" was first discussed during the 5th European Dental Students' Association Congress in Belgrade, Serbia, in March 2003, when the delegation outlined the idea and proposed its acceptance by the assembly. The first international reference to eco-friendly dentistry was published on April 3, 2007, by Dr. Ali Farahani and Mittale Suchak(8). In 2008, Dr. Fred Pockrass and Ina Pockrass founded the Eco-Dentistry Association (EDA) to minimize waste and pollution, conserve energy, water, and financial resources, utilize cutting-edge technology, and integrate holistic approaches that emphasize healthy living(9). EDA provides education, standards, and networking for patients and dentists practicing green dentistry(7). On December 22, 2009, Dr. Steven Koos, Goran Kralj, and Mladen Kralj trademarked eco-friendly dentistry and officially defined it(8,9). In August 2017, the FDI World Dental Federation released a document titled "Sustainability in Dentistry," based on the United Nations report "Transforming Our World"(10).

The 5R Principle

Green dentistry is built upon the five-R model: Rethink, Reduce, Reuse, Recycle, and "Energy Recovery/Molecular Redesign"(11,12). When determining which materials are truly needed, healthcare teams can select suppliers that explicitly list raw materials and chemical contents, have a sustainable supply chain, and operate under eco-friendly, ethical working conditions. Reducing the purchase of packaged materials and maximizing the use of reusable products can help "reduce" waste(9). Single-use items should be replaced with reusable versions. Existing recycling programs—capable of recycling paper, metal, plastic, and gypsum—should be identified.(5,12) However, the large-scale reuse of retail packaging is limited by transport distances and conditions when returning empty cartons to suppliers. Some portion of the energy content in plastics can be recovered via incineration, achieving reasonable energy efficiency when co-firing in furnaces. Because part of the energy content is recovered, incineration is more advantageous than landfilling. Nonetheless, energy recovery does not reduce the demand for raw materials in plastic production and is thus considered less energy-efficient than recycling (12).

Concerns about emissions from incineration plants further reduce the appeal of this disposal method (13).

The 4A Management Protocol

Adapted from smoking cessation strategies, this protocol has been proposed as a method for achieving sustainability. "Ask"- Gather detailed information about all routine dental practices from the healthcare team. "Assess"- Evaluate which practices can be modified and encourage eco-friendly dentistry. "Advise"- Propose a guideline to follow. "Assist"- Help develop a framework suited to the conditions of the dental clinic or hospital (14).

Green Healthcare Approaches Worldwide and in Turkey

In 2022, Dentsply Sirona conducted a global survey involving more than 1,300 dentists from the USA, Europe, Asia, and Latin America to gain in-depth insights into sustainability in the dental sector, as part of their "BEYOND: Taking Action for a Brighter World" initiative (15). In collaboration with the FDI World Dental Federation, they also published a "Consensus Statement on Environmentally Responsible Oral Health," proposing strategies to reduce the environmental impact of the sector. They established a new online toolkit (MOOC) to provide global guidance and practical support to dentists on environmental issues, as part of the "Sustainability in Dentistry" initiative(16). In the United Kingdom, the National Health Service (NHS) uses carbon footprint analysis(17), and life cycle assessment (LCA), which examine broader environmental impacts, to understand the ecological impact of products and services(18). A carbon footprint is a measure that assesses how human activities affect the environment and demonstrates sustainable resource management(9). It comprises total emissions produced by supply chain participants, with its magnitude directly proportional to its impact on climate change(4,19). Global healthcare contributes significantly to national CO_2 emissions, accounting for around 5% on average(20). LCA, referred to as "cradle to grave," encompasses all aspects of a product's lifecycle, from raw materials to production,

use, transportation, and disposal. Alongside other healthcare organizations, NHS established the Coalition for Sustainable Pharmaceuticals and Medical Devices (CSPM), which recommends LCA for comparing services and aiding policymakers in making informed decisions. Another relevant measure is the human health burden, or DALY (Disability-Adjusted Life Years), reflecting the years of life lost due to both morbidity (disease and disability) and mortality
(premature death) within a population(18). DALYs can be calculated via LCA modeling based on the environmental impact of producing, using, and disposing of a product. The European Union recently adopted the Product Environmental Footprint (PEF) to standardize and compare environmental impacts(21). In Germany and Austria, there is a quality label called "DIE GRÜNE PRAXIS" (the green practice), which recognizes eco-friendly clinics(22). Currently, Turkey does not have organizations, projects, or associations capable of evaluating these criteria. However, dentists can individually refer to the "Sustainability in Dentistry" project established by the FDI World Dental Federation, use the Eco-Dentistry Association's GreenDOC Dental Office Certification Program for guidance, or utilize the University of Michigan's "Greening the Dental Clinic" assessment survey to form their own green teams(22).

Methods for Achieving Green Dentistry

- **Education**

For Dentists; Dental schools can integrate green dentistry into their curricula. The Sustainability in Dentistry Resource Kit, developed by Dentsply Sirona as part of the DS Academy Clinical Education Program, offers Continuing Education credits for completed courses taught by experienced dentists and sustainability experts, providing valuable insights into sustainable dental practices (16,23). ProDental CPD offers the "P300 Essentials of Sustainability in Dentistry" course, designed to educate dentists and support staff about dentistry's impact on climate change and ecological degradation(24).

For Patients; Posters can be displayed in waiting areas or shared electronically(25). Patients may be advised to use bamboo or, alternatively, recycled plastic-handled toothbrushes. Although some evidence suggests electric toothbrushes reduce plaque and gingivitis more than manual toothbrushes, no clinical data indicate that any particular toothbrush is more effective at preventing dental caries or periodontal disease(26). According to Lyne et al., the climate change impact of an electric toothbrush is 11 times higher and its effect on biodiversity and habitat loss is more than 36 times higher than that of a bamboo toothbrush(17). One study calculated the DALYs associated with manual plastic, manual bamboo, replaceable-head recycled plastic, and electric toothbrushes, finding that electric toothbrushes had the highest impact(27). Some companies have started labeling toothpaste tubes with #2 high-density polyethylene (HDPE) recycling codes. Patients can be informed about these codes and instructed on proper recycling procedures(28).

- **Recycling**

Healthcare waste is broadly categorized into general and hazardous waste(29). Traditional disposal methods (incineration or landfill), contribute to pollution and resource depletion. Recycling, by contrast, reduces the need for raw materials and minimizes waste(30). In a multi-stakeholder statement by Martin et al. regarding "Environmentally Sustainable Oral Health," the top (most preferred) tier of the waste pyramid is resource reduction, followed by repurposing, energy recovery, and, least preferred, disposal or direct release into the environment(31). According to EPA, the most effective way to manage waste is to avoid creating it in the first place. Reducing and reusing products are the best strategies for conserving natural resources, protecting the environment, and saving money(32).

Materials that can be recycled in dental clinic and laboratory;

Gypsum: Dental stone, plaster of Paris, investment plaster, and dental plaster can be recycled effectively without extensive chemical or physical modifications. Methods include using a 20% ammonium bicarbonate solution, semi-dry pressing, and calcination. Recycling one metric ton (1,000 kg) of gypsum can save 28 kWh of energy and 1.8 kg of aluminum (33).Recycled gypsum can be used as fertilizer, or in cement and specialized ready-mix concrete, as well as in plastics, adhesives, and insulation materials(30). Dental clinics should establish procedures for identifying and separating gypsum waste to facilitate proper disposal(34). They must also review and comply with national waste management policies; failure to do so may result in inspections by local authorities responsible for supervising various waste streams(30).

Broken or Unused Instruments: Dentists can recycle old hand instruments via Hu-Friedy's "Envirodent" program,

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initiated 31 years ago, which allows them to exchange these instruments for new ones free of charge (35).

Contaminated Waste: Infectious waste constitutes 10–25% of total healthcare facility waste, emphasizing the importance of proper waste management(36). Items such as IV tubing, catheters, syringes, and gloves are recyclable but must be placed in red bags. Specific solid wastes including anatomical waste (human or animal origin), body fluids, cotton swabs, expired medications, liquid waste, and laboratory waste go into yellow bags. General solid waste is disposed of in black bags. Infectious sharps (needles) go into white bags, while implants, glassware, vials, and ampoules go into blue bags, thus pre-sorting them for recycling(37). Artificial intelligence–based technologies (smart bins, sorting robots, wireless sensors) enable real-time monitoring of waste bins, predictive waste collection, and optimization of waste processing(38). Traditional bins simply collect waste, requiring manual checks by healthcare workers. This process is inefficient for routine waste management, and frequently filled bins can encourage the proliferation of pathogens and insects. Researchers are currently exploring methods to integrate waste-sorting robots into existing systems, enabling automated separation before it reaches landfills(39). To further enhance these robots, optical(40) and olfactory sensors(41), as well as microwaves(42), infrared, and gas sensors, are being investigated. Such robots could significantly boost efficiency, cut labor costs, and improve waste classification, making them highly relevant for the healthcare sector(38).

- **Green Building**

A green building emphasizes the use of locally available natural materials(43).

Flooring: Linoleum flooring is recommended for designing an eco-friendly dental clinic(7,44).

Paint: One of the most harmful chemicals in commonly used paints for clinic walls are volatile organic compounds (VOCs), which easily vaporize into the air and contain carbon. As paint dries, it releases these hazardous compounds(7). Recent technological advances in the paint industry have made it possible to reduce VOCs; therefore, ultra-low or zero-VOC paint is recommended(7,44–46).

Lighting: Compact fluorescent bulbs should be used, as they last 8–12 times longer than incandescent bulbs and cost only about one-quarter as much per hour(5).

Construction Materials: Concrete can replace brick to reduce heating and cooling demands and increase thermal efficiency. Double-glazed windows can maximize natural light while minimizing direct heat gain(47).

- **Electricity Consumption**

Nearly 90% of the energy consumed by washing machines is spent heating the water, so washing clinic gowns in cold water conserves energy. Set the washing temperature to cold or warm, with a cold rinse cycle(48). Additionally, “vampire power” refers to devices plugged in but not in active use; unplugging them after hours saves energy. Turn off unnecessary transformers, equipment, surge protectors, TVs, monitors, and computers when the clinic is closed(44).

- **Water Consumption**

Dental vacuum systems are essential in any practice, but their high water usage can lead to waste and water pollution(49). There are three types of dental vacuum pumps: water-consuming, water-recycling, and dry pumps. A “green” approach is the dry vacuum system, which can save approximately 1,400 liters of water daily compared to a wet vacuum in a typical clinic. This equates to around 12,000 half-liter bottles of drinkable water(47,48). Sensor-operated faucets, starting the autoclave only when fully loaded, and even rainwater harvesting can further reduce water consumption(50).

- **Hazardous Waste Management**

Amalgam and Composite Resins: Dental amalgam is an alloy containing elemental mercury. Mercury is a bioaccumulative toxicant, and evidence shows that dental amalgam is a primary source of mercury in the human brain and kidneys(51). The most toxic form of mercury is organic methylmercury, which, even at low concentrations, is highly damaging to water and soil quality(52,53). Elemental mercury can transform into methylmercury upon contact with aquatic organisms(37). Mercury in dental amalgam can contaminate the environment via spills or the extraction of amalgam-filled teeth. Amalgam waste, classified as mercury-contaminated, should be stored in designated containers with mercury-suppressing agents to prevent vapor exposure. Installing amalgam separators in units

facilitates the removal of amalgam particles from wastewater, ensuring that amalgam waste is properly collected and disposed of as hazardous(37). Likewise, microparticle pollutants that can contaminate the waste system are generated during placement and removal of resin-based composites(54). Commonly termed microplastics, these particles pose a significant environmental threat, potentially affecting aquatic life, soil, and food webs due to bioaccumulation(55). Microplastic pollution is defined as the release of synthetic plastic particles(56). In 2015, an estimated 800 million direct composite restorations were applied(57), and about 6% are expected to fail within 10 years, equating to 48 million restorations that must be removed or replaced, releasing composite resin particles into municipal landfills, incinerators, and wastewater(58). Assuming an average weight of 0.3 g per composite restoration, extrapolations suggest as much as 14.4 tons of particulate waste could enter wastewater annually. One meta-analysis indicates that 32 million posterior restorations placed in 2015 will require replacement or repair by 2025, underscoring the potential for resin microparticles in the waste stream(59). Still, composite resins are indispensable in restorative and esthetic dentistry(9).

- **Gloves and Rubber**

Incineration of chlorine-containing materials such as gloves and rubber can release dioxins, which have been linked to cancer and reproductive disorders(60). Non-chlorinated latex gloves are a viable alternative(32).

- **Integrating Quality of Life into Dentistry**

Aromatherapy and the use of greenery in the clinic can help patients relax naturally. A HEPA UV germicidal air purifier can remove airborne particles(61). Establishing a green area with native, insect-friendly plants, avoiding herbicides, and providing bird feeders and natural habitats (leaving branches, leaves) further supports local ecosystems. A green wall in the waiting area not only reduces patient anxiety but also promotes smoking cessation(25).

- **Digitalization**

Radiographic waste poses an environmental challenge. Popa D and colleagues found that dental clinics generate approximately 4.8 million lead foils and 28 million units of toxic radiographic material(62). Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) systems eliminate the need for radiographic waste and the disposal of silicone or alginate impression materials.

- **Reducing the Greenhouse Effect**

Using nitrous oxide with oxygen as a dental anesthetic raises environmental concerns because nitrous oxide is estimated to contribute about 5% to the greenhouse effect(63,64). Consequently, sevoflurane has been recognized as a safe and effective alternative that can contribute to making dental procedures more environmentally friendly(65). Travel-related emissions can be minimized by utilizing technology for communication and professional interactions(66), scheduling appointments for multiple family members on the same date, or combining multiple treatments in one visit. Likewise, it is advisable to consolidate deliveries with technicians and suppliers to reduce shipping frequence(25).

- **Green Dentistry in Treatments**

Another sustainability concern is the pharmaceutical regimens that support dental care. Antibiotic overuse and the subsequent rise in antibiotic resistance exemplify this issue(67). Research on novel components like Camellia sinensis extract and ozonated natural olive oils in toothpaste and mouthwash arises from the understanding that the composition and balance of the oral microbiome play a crucial role in overall health. Probiotics have also been shown to benefit oral health(68,69).

Discussion

Studies investigating awareness of biomedical waste management among dentists report high levels of awareness. However, more education is needed to achieve comprehensive understanding, particularly regarding color-coded waste disposal(70). Inappropriate disposal of single-use items (syringes, gloves, masks) pollutes soil and groundwater, posing threats to terrestrial and aquatic ecosystems. Inadequate waste management systems and weak regulations exacerbate these environmental risks(2). Seven out of ten dentists want to adopt more sustainable practices but do not know how to begin, and six out of ten believe that creating a positive impact on the environment and society is the top priority for the dental sector. Nevertheless, in many markets, sustainability triggers positive emotions in fewer than half of dentists. Although most dentists wish to play a role in making dentistry more sustainable, 69% admit

they are unsure how to implement concrete actions or how these would affect everyday patient cared(71,72).

Conclusion

Awareness is vital for integrating sustainability into dentistry and developing eco-friendly behaviors in dental practices. A lack of professional and public awareness, knowledge and educational gaps, and factors related to the production and disposal of materials all hinder environmentally responsible practice(71,72). Individuals who are mindful of environmental considerations in their daily lives are more receptive to the same principles in dental settings. While sustainability is not yet a primary criterion for patients choosing a dental clinic,

its significance is expected to rise. Dentists must recognize the need to create eco-friendly clinical environments to be community-focused. Reducing one's carbon footprint is a frequently mentioned commitment to sustainability objectives. It is unfortunate that, this measure alone does not accurately reflect the full environmental impact, which also includes biodiversity loss, ecotoxicity, and air pollution, all linked to deteriorating human health(27). Such issues extend beyond the direct intervention and encompass every stakeholder in the healthcare supply chain(25). Measuring and reducing the ecological footprint of healthcare-related technologies is inevitable(19).

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