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Dear Colleagues,

It is with pleasure that I welcome you to the first issue of 2025. In this issue, reviews of new developments, case reports and original research in the field of dentistry are included. One of our most important goals is to mediate the sharing of knowledge and experience among dental professionals, researchers and academicians. In this issue, we share with you six articles covering various topics in dentistry.

The first article of our journal, 'Evaluation of the frequency of the second mesiobuccal canal and vertucci classification of the mesiobuccal canals in upper first and second molars in the Turkish subpopulation: a computed tomography study" is an original article and the authors aimed to investigate the presence of the second mesiobuccal (MB2) canal in the mesiobuccal (MB) roots of the upper first and second molars and the MB canal configuration according to the Vertucci classification using cone beam computed tomography (CBCT). The second article "Improving PMMA in prosthodontics: a literature review"is a review. The aim of this review is to explore the advancements in reinforcing PMMA (polymethyl methacrylate) for dental prosthetics by analyzing various modifications. The status of oral dental health is very important in glycaemic control and nutrition of patients with diabetes. Because it is very difficult to regulate blood sugar in a patient who cannot be properly nourished without diet control. For this reason, it is important that diabetic patients are informed about possible oral complications, pay much more attention to oral dental health compared to healthy individuals, and do not neglect dentist controls and treatments The thirth article , " Oral complications in diabetes mellitus" is a review. The aim of this review is to provide an overview of these oral complications and the problems they cause. The fourth article '' Alveolar ridge augmentation with lateral approach maxillary sinus lifting: a case report" is a case report. The aim of this case was to perform a two-stage lateral approach sinus surgery to create an adequate amount of residual crest for rehabilitation of the severely resorbed posterior maxillary bone and then to allow the use of dental implants of adequate length. The fifth article '' Endodontic management of radix entomolaris in mandibular first molar teeth: a case series" is a case report. This case series provides important insights into the clinical management of radix entomolaris (RE) variation based on three cases with RE. Finally, the sixth article," Endodontic treatment of mandibular premolars with root canal variations: a case series" is a case report. The objective of this study is to provide a comprehensive literature review on mandibular premolar teeth with extra roots and canals, as well as to retrospectively evaluate four cases from shaping to obturation.

I would like to thank the authors, reviewers, editorial team and publisher for their hard work and dedication in bringing this issue to fruition. We look forward to providing you with the latest insights and developments in dentistry, and we welcome your feedback and suggestions.

Sincerely,

Assoc. Prof. Elif Pınar BAKIR, PhD
Editor-in-Chief

CONTENTS

Original Article

Reviews

Case Reports

Original Article

Dicle Dent J. 2025;26(1):1-4

Evaluation of the frequency of the second mesiobuccal canal and Vertucci classification of the meziobuccal canals in upper first and second molars in the Turkish subpopulation: a computed tomography study

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ABSTRACT

Aims: This study was to investigate the presence of the second mesiobuccal (MB2) canal in the mesiobuccal (MB) roots of the upper first and second molars and the MB canal configuration according to the Vertucci classification using cone beam computed tomography (CBCT).

Methods: Five hundred and twenty patients' three-dimensional CBCT images of upper first and second molars (n=1555) were analyzed for the presence of MB2 canals and canal configuration types of MB roots according to the Vertucci classification.

Results: MB2 canals were detected in 1141 (73.4%) of the 1555 teeth included in the study. There was a significant gender difference in the presence of MB2 canals (p=0.004). The presence of the MB2 canal was significantly higher in women than in females and males (41.5% and 58.5%, respectively) (p<0.05). The presence of MB2 canals was significantly higher in men (58.5%) than in women (41.5%) (p<0.05). The proportion of type 1 was significantly lower in teeth 16 (16.4%) and 26 (15.9%) than in teeth 17 (33.6%) and 27 (34.1%) (p<0.05). The proportion of type 2 and type 4 were significantly higher in teeth 16 than in teeth 17 (9.3% and 6.7% respectively) and 27 (9.3% and 6.7% respectively).

Conclusion: In parallel with previous studies, our study showed that the frequency of the presence of a second canal in the MB roots in maxillary molars is quite high. CBCT is an imaging technique that is now available in many private clinics and is not as difficult to access as before. We hope that our study will inform dentists who perform root canal treatment from a perspective of maxillary molars.

Keywords: Vertucci, mesiobuccal 2, cone beam computed tomography

INTRODUCTION

For successful root canal treatment, all the canals must be shaped, cleaned, and hermetically sealed. Incomplete cleaning or the presence of undiscovered canals may lead to cause failure.[1]

Pretzl et al.[2] reported that upper molars were the most commonly treated tooth group. Although chemomechanical cleaning, irrigation, and hermetic filling procedures are completely performed in the canal treatment of maxillary molars, the reason for failure is the presence of extra canals in the roots.[3] Bauman et al.[4] reported the presence of a second canal in mesiobuccal (MB) roots between 18% and 95%. The frequency of the presence of a second canal (MB2) in the MB roots of these teeth varies according to the geographical region.[5]

Due to the complex structure of root canal anatomy, detecting the presence of any variation or extra canal in the root before treatment plays an important role in success.[6] Therefore, a thorough understanding of the anatomical variations in the canals in all tooth types is essential before starting root canal treatment.[7]

Cone beam computed tomography (CBCT) provides three-dimensional images of the coronal, sagittal, and axial planes. It prevents superpositions of anatomical structures; thus, it provides a great advantage to physician in endodontic applications for the examination of teeth and surrounding tissues.[8] The endodontic advantages of CBCT include: detection of endodontic or non-endodontic pathologies, presence of internal and external resorption, learning canal morphology before treatment.[9]

The system of canal configurations developed and proposed by Vertucci[7] is the most widely used for classification.[10]

The aim of this study was to evaluate the frequency of the MB2 canals in upper first and second molars in the Turkish

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subpopulation and the Vertucci classification of MB roots using CBCT.

METHODS

This study was approved by the Batman University Ethics Committee (Date: 03.10.2024, Decision No: 2024107-01). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. A total of 1555 cone beam computed tomography images, 233 of which belonged to male patients and 287 of which belonged to female patients, obtained from a private clinic in Batman province between January 2021 and January 2022, were included in this study. As an inclusion criterion; at least one fully developed permanent maxillary first molar should be present in any CBCT image. Teeth with open apices, root resorption, or calcification, and teeth with prior root canal treatment were excluded.

According to the Vertucci[7] classification, the configurations of the canals are as follows:

- **Type 1:** A single canal extends from the pulp chamber to the apex.
- **Type 2:** Two separate canals leave the pulp chamber, near the apex, these canals merge and reach the apex as a single canal.
- **Type 3:** A single canal emerges from the pulp chamber, splits into two separate canals, merges again and reaches the apex as a single canal.
- **Type 4:** Two canals leave the pulp chamber and reach the apex as two canals.
- **Type 5:** A single canal leaves the pulp chamber, splits into two near the apex, and reaches the apex as two separate foramina.
- **Type 6:** Two canals leave the pulp chamber, merge in the middle of the root, and split again near the apex.
- **Type 7:** One canal separates from the pulp chamber, separates, merges in the middle of the root and again forms two separate canals near the apex.
- **Type 8:** Three canals reach from the pulp to the apex (**Figure**).

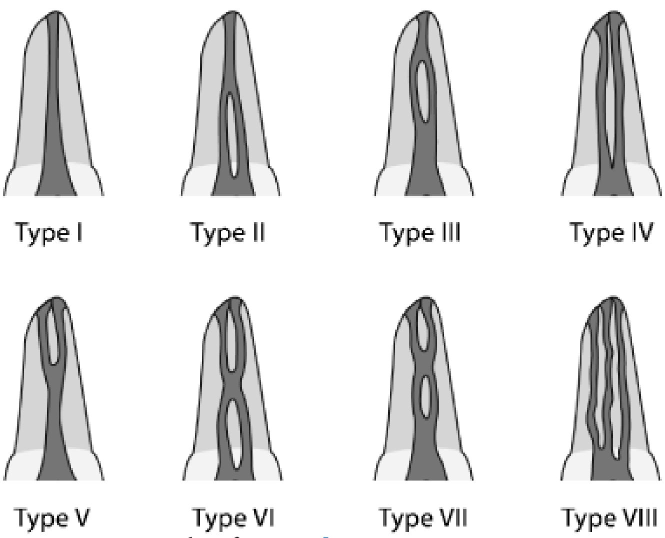

Figure. Vertucci canal configurations[7]

Statistical Analysis

Data were analyzed using Pearson chi-square test with SPSS (version 20.0) software (IBM Corp., Armonk, NY, USA). The significance level was set at α=5%.

RESULTS

Table 1 shows the distribution of MB2 canals in teeth according to gender. MB2 canals were detected in 1141 (73.4%) of the 1555 teeth included in the study. There was a significant gender difference in the presence of MB2 canals (p=0.004). The presence of the MB2 canal was significantly higher than its absence in females and males (41.5% and 58.5%, respectively) (p<0.05). The presence of MB2 canals was significantly higher in men (58.5%) than in women (41.5%) (p<0.05).

Table 1. Distribution of the second mesiobuccal canal in teeth according to gender [n (%)]

Second meziobuccal canal presence/absence	Gender		
	Female	Male	Total
Absence	206^{Aa} (49.8)	208^{Ab} (50.2)	414 (100)
Presence	473^{Ba} (41.5)	668^{Bb} (58.5)	1141 (100)
Total	679 (43.7)	876 (56.3)	1555 (100)

*Pearson chi-square test, a-b: There is no difference between rows with the same letter, A-B: There is no difference between columns with the same letter

Table 2 shows the frequency and percentage of Vertucci types according to the toot type. Statistically, there was a significant difference in the distribution of Vertucci types according to toot type (p<0.001). The proportion of type 1 was significantly lower in the upper first molars [16 (16.4%) and 26 (15.9%)] than in the upper second molars [17 (33.6%) and 27 (34.1%)] (p<0.05). The proportion of type 2 and type 4 were significantly higher in teeth 16 (41.5% and 44.5%, respectively) and 26 (39.9% and 42.1%, respectively) than in teeth 17 (9.3% and 6.7%, respectively) and 27 (9.3% and 6.7%, respectively). Type 1 was more common than types 2 and 4 in all teeth (p<0.05), while there was no significant difference between the teeth in terms of type 2 and type 4 (p>0.05).

Table 2. Distribution of Vertucci types according to teeth [n (%)]

Vertucci classification	16	17	26	27	Total
Type 1	187^{Aa} (16.4)	384^{Ab} (33.6)	182^{Aa} (15.9)	390^{Ab} (34.1)	1143 (100)
Type 2	103^{Ba} (41.5)	23^{Bb} (9.3)	99^{Ba} (39.9)	23^{Bb} (9.3)	248 (100)
Type 4	73^{Ba} (44.5)	11^{Bb} (6.7)	69^{Ba} (42.1)	11^{Bb} (6.7)	164 (100)
Total	363 (23.3)	418 (26.9)	350 (22.5)	424 (27.3)	1555 (100)

*Pearson chi-square test, a-b: No difference between rows with the same letter, A-B: No difference between columns with the same letter

DISCUSSION

Although endodontic treatment is a proven treatment method, failure to clean and fill missed canals negatively affects the success of the treatment. CBCT can be used to determine the anatomy of the root canals before treatment.

Kim et al.[11] argued that CBCT is the best method for detecting the presence of extra canals. Horner,[12] on the other hand, argues that the routine use of CBCT is limited because it exposes patients to additional radiation and is expensive. Therefore, CBCT images previously obtained from patients for dentomaxillofacial reasons were used in this study.

In a study by Stropko,[13] 1732 teeth were examined for the presence of MB2. They found that MB2 was present in 73.2% of the upper first molars and 50.7% of the upper second molars. However, they reported that these rates increased with advanced techniques and operating microscopy and were 93.0% and 60.4%, respectively. We suggest that canals that cannot be found using the naked eye can be found with operating microscopy and improved instruments/devices. We believe that obtaining CBCT images from the patients before the procedure, learning the anatomy of the canals, and starting the treatment will increase the success rate.

Magat and Hakbilen[14] examined, the presence of MB2 canals in 200 patients. They reported that the incidence of MB2 canals was 33.5%, and the distribution of MB2 canals was 23.2% in females and 43.6% in males. They reported that the incidence of MB2 canals was 19.65% in upper first molars and 17.7% in upper second molars.

Akay et al.[15] reported that the incidence of MB2 was 58.6% in females and 59.9% in males in the upper first molars and 27% in females and 35.1% in males in the upper second molars, and these rates were not statistically significant.

Altunsoy et al.[16] found that the frequency of MB2 canals was 62% in upper first molars and 37.5% in upper second molars.

In our study, MB2 canals were found in 1141 (73.4%) of the 1555 teeth. The prevalence of MB2 canals was 41.5% in females and 58.5% in males. We believe that the reason why the prevalence of MB2 in this study was higher than the result of the study by Magat[14] and Akay[15] was due to the high number of our sample.

In a study by Mathew et al.,[17] 372 upper first molars were evaluated using CBCT, and the prevalence of MB2 canals was found to be 52.6%. They reported that the rate of teeth with Vertucci type 2 canal configuration was 83.4% and the rate of teeth with Vertucci type 4 canal configuration was 33.6%.

In a study conducted by Alavi et al.[18] in Thailand, it was reported that 65% of upper first molars and 55% of the upper second molars had MB2 canals. They reported that 44.2% of the MB roots of the upper first molars were Vertucci type 4.

Neelakantan et al.[19] reported that the most common canal morphology in the mesiobuccal roots of three-rooted upper first and second molars was Vertucci type 1 (51.8% and 62%, respectively), followed by type 4 (38.6% and 50%, respectively).

In a study by Zhang et al.,[20] the rate of MB2 in the MB roots of the upper first molars was 52% and 22% in the upper second molars. They reported that when the MB2 canal was present in the first molars, 14%, 69%, and 16% of the MB roots had type 2, 4, and 5 canal configurations, respectively; when the MB2 canal was present in the second molars, 18%, 58%, 10%, and 3% of the MB roots had type 2, 4, 5, and 6 canal configurations, respectively.

In a study by Reis et al.[21] on upper molars, it was reported that these teeth had three roots and four canals, and the fourth canal was located in the MB root. They reported that the MB root configuration was Vertucci type 2.

In our study, the rate of Vertucci type 1 was higher than type 2 and type 4 in all teeth, while no significant difference was observed between the teeth in terms of the rate of type 2 and type 4. Type 1 ratio was significantly lower in the upper first molars [16 (16.4%) and 26 (15.9%)] than in the upper second molars [17 (33.6%) and 27 (34.1%)]. Type 2 and type 4 rates were significantly higher in the upper first molars [16 (41.5% and 44.5%, respectively) and 26 (39.9% and 42.1%, respectively)] than in the upper second molars [17 (9.3% and 6.7%, respectively) and 27 (9.3% and 6.7%, respectively)]. In parallel with our study, Ng et al.[22] found that the Vertucci type 1 configuration was most common in MB roots. We believe that the reason why Vertucci canal configurations were different from those in other studies may be due to changes in dental anatomy according to the geographical region where the study was conducted.

CONCLUSION

In parallel with previous studies, our study showed that the frequency of the presence of a second canal in the MB roots of maxillary molars is quite high. CBCT is an imaging technique that is now available in many private clinics and not as difficult to access as before. We hope that our study will inform dentists who perform root canal treatment from the perspective of maxillary molars.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was conducted with permission from the Batman University Ethics Committee (Date: 03.10.2024, Decision No: 2024107-01).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All authors declare that they have participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Review
Dicle Dent J. 2025;26(1):5-10

Improving PMMA in prosthodontics: a literature review

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ABSTRACT

Since its introduction in the 1930s, PMMA has been the primary denture base material in use. This is due to the fact that PMMA is affordable, visually pleasing, and medically compatible. Nonetheless, PMMA's intrinsic flaws-primarily its poor flexural strength and impact resistance-make it imperative to look for solutions to address these two crucial deficiencies. The latest developments involve the insertion of silver, zirconium oxide (ZrO_2), and titanium dioxide (TiO_2) nanoparticles, which are said to increase the mechanical characteristics even further, such as flexural strength, hardness, and wear resistance. To further increase the impact strength and durability of PMMA, fibers can be added to the material. These fibers can be synthetic (like polyester or carbon) or natural (like sisal or bamboo). Improvements in surface treatments and bonding methods have also strengthened PMMA's binding and made it more compatible with other materials. Aging research demonstrates that reinforced PMMA is more resilient to environmental stress, making it a material of choice for long-term dental applications. Furthermore, the use of antimicrobial compounds and nanoparticles offers additional benefits, such as the presence of antifungal qualities that mitigate biofilm development and improve the overall biocompatibility of dental prostheses. These developments thus suggest that there is still a lot of promise for the modified PMMA in dental applications, both in terms of improving performance and extending its useful life in a clinical setting. The aim of this review is to explore the advancements in reinforcing PMMA (polymethyl methacrylate) for dental prosthetics by analyzing various modifications.

Keywords: Polymethyl methacrylate, PMMA, nanoparticle reinforcement, fiber reinforcement, denture base materials, mechanical properties

INTRODUCTION

Polymethyl methacrylate (PMMA) has long been established as the primary material for denture bases due to its advantageous properties, such as ease of manipulation, aesthetic appeal, biocompatibility, and cost-effectiveness. Since its introduction in the 1930s, PMMA has revolutionized prosthodontics, offering a practical solution for denture fabrication and other dental applications. Its ability to be easily molded, colored, and processed at relatively low temperatures makes it an ideal choice for dental laboratories and clinicians like. Despite these benefits, PMMA has inherent limitations, particularly in its mechanical properties. One of the significant drawbacks is its low flexural strength, which can lead to fractures under the repetitive stress and strain encountered in the oral environment. Impact resistance is another concern, as PMMA can be prone to cracking or breaking if subjected to sudden forces, such as accidental drops or heavy occlusal loads.[1]

For instance, the inclusion of nanoparticles like titanium dioxide (TiO_2)[2] and zirconium oxide (ZrO_2)[3] has been shown to improve the flexural strength and hardness of PMMA, thereby increasing its resistance to wear and fracture.

Fiber reinforcement is another approach that has gained popularity. By integrating different types of fiber into PMMA, the impact resistance and fracture toughness can be significantly improved.[4] These reinforcements help distribute the applied stress more evenly throughout the material, reducing the likelihood of failure under load[4] Additionally, the incorporation of antimicrobial agents, such as, into the PMMA has been explored to further enhance the material's resistance to microbial colonization. Nanoparticles such as TiO_2[5] nanosilver (AGNP)[6] ZnO and nano silicon dioxide (SiO_2)[7] can also confer additional benefits, such as antimicrobial properties, which are particularly valuable in reducing biofilm formation on denture surfaces. The aim of this review is to explore the advancements in reinforcing PMMA for dental prosthetics by analyzing various modifications.

NANOPARTICLE REINFORCEMENT IN ACRYLIC RESINS

The growth and nanotechnology and scope of its application has revolutionized the dental field progressing to the emergence of "nano dentistry".[8] The incorporation of nanoparticles into acrylic resins has garnered significant recent research interest, particularly concerning their influence on the mechanical and thermal properties of denture-based materials.[9] For instance, the addition of nanoparticles such as silver (Ag) has been shown to enhance hardness and wear resistance.[10] Other

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nanoparticles, such as aluminum oxide [11]and cerium oxide,[12] have been identified to improve thermal conductivity and mitigate mechanical degradation, respectively. These findings highlight the inherently trade-off nature of reinforcement in dental materials.

In a recent study, Elhmali et al.[13] examined the mechanical performance of PMMA modified with poly (4-styrenesulfonic acid-co-maleic anhydride) sodium salt and strontium titanate, showing effective enhancement in terms of strength and durability. Similarly, other studies have examined acrylic resins modified with metal and ceramic nanoparticles, reporting enhanced hardness and physical properties. [14]Another investigation focused on the tribological, microhardness, and color stability properties of heat-cured acrylic resin denture bases reinforced with various nanofillers, highlighting the multifunctional benefits achieved through nanoparticle incorporation.[15]

Barapatre et al.[16] studied the reinforcement of PMMA resin with nanoparticles of polyetheretherketone, zirconium oxide, and their mixture for the improvement of flexural strength, which could prove to have improved mechanical properties. Karci et al.[17] evaluated the flexural strength of various denture base materials reinforced with different nanoparticles, showing that these reinforcements significantly enhance the material's performance. Alzayyat et al.[18] investigated the effects of silicon dioxide (SiO_2) nanoparticles on the flexural properties of denture base resins, demonstrating that such reinforcement significantly enhances durability and mechanical properties. Their findings included the use of SiO_2 nanoparticles to improve the flexural strength of repaired acrylic denture base materials, showcasing the potential of nanoparticles to extend the life span of dental prosthetics. [19] Nanoparticles are also instrumental in reducing polymerization shrinkage, a common challenge in dental resins, by modifying the resin matrix. Methacrylate- and epoxy-functionalized nanocomposites have been developed to enhance the stability and longevity of dental restorations.[20] Additionally, nanoparticles improve the heat resistance of dental resins, mitigating the risk of thermal degradation and ensuring long-term material performance.[21] Due to their nanoscale size, these particles enable precise control over the optical properties of dental materials, leading to superior aesthetic outcomes as resins can closely replicate the natural appearance of teeth.[22] The use of biocompatible nanoparticles, such as titanium dioxide and iron oxide, ensures that modified resins are safe for use in the oral cavity. These nanoparticles also reduce microbial adhesion, further improving the clinical performance of dental resins.[23] Despite their numerous benefits, challenges such as nanoparticle agglomeration and chemical instability must be addressed to fully realize their potential in clinical applications. Ongoing research is focused on overcoming these obstacles to develop more effective and reliable dental materials.[24]

FIBER REINFORCEMENT IN ACRYLIC RESINS

One critical area of study aimed at improving the mechanical properties and expanding the applications of polymer composites, particularly acrylic resins, is the integration of various types of fibers. Among the options explored, natural fibers, such as those derived from bamboo and pineapple leaves, have shown considerable promise as environmentally friendly solutions for reinforcement. Research suggests that these fibers enhance the mechanical properties of composite materials while supporting the development of sustainable alternatives.[25,26]

In contrast, synthetic fibers, such as polyester and polypropylene, have been extensively investigated for their ability to enhance the physical characteristics and durability of composite materials. Studies indicate that combining natural and synthetic fibers can yield notable improvements in material performance, making synthetic fibers a valuable component in composite reinforcement.[27] Additionally, high-performance fibers, such as aramid and carbon fibers, are recognized for their superior mechanical properties, including increased stiffness, durability, and resistance to corrosion. The work of Alam et al.[28] underscores the relevance of these high-performance fibers in advanced engineering applications requiring exceptional material performance. This ongoing research offers a more comprehensive understanding of the roles played by high-performance, natural, and synthetic fibers in enhancing the mechanical properties and real-world applications of polymer composites.

In a study examining the impact strength of fiber-reinforced acrylic resin following sisal fiber alkalization, Benyamin et al.[29] demonstrated the effectiveness of natural fibers in enhancing the toughness of denture bases. Similarly, Sharhan et al.[30] explored the benefits of synthetic fiber reinforcement, specifically polypropylene and polyacrylonitrile fibers, in improving surface roughness, hardness, and compression resistance for denture applications. Gonçalves et al.[31] investigated the impact of polymeric nanofibers on the mechanical properties of PMMA resin, demonstrating the potential of both natural and synthetic fibers to enhance material performance. Further advancements in the field were highlighted by Ardakani et al.[32] who examined the flexural strength of PMMA reinforced with metal mesh and high-performance polymers, reporting significant improvements for stress-bearing applications. Nayak et al.[33] compared various fiber reinforcement patterns and their effects on the mechanical properties of heat-polymerized acrylic resin. Their findings revealed that fiber reinforcement in meshwork patterns significantly enhances the flexural strength of PMMA compared to transverse reinforcement patterns. Moreover, PMMA reinforced with basalt fibers (BF) exhibited superior flexural strength compared to those reinforced with glass fibers (GF).

High-performance fibers, such as poly (p-phenylene-2,6-benzobisoxazole) (PBO), have been shown to significantly enhance the mechanical properties of dental fiber-reinforced composites (FRCs), broadening their utility in various applications. The integration of nanomaterials, such as ZnO nanoparticles and nanowires, into PBO fibers has improved interfacial adhesion with the resin matrix, resulting in notable increases in interfacial shear strength and flexural properties. For instance, the innovative PBO-ZnO nanowire and polyhedral oligomeric silsesquioxane (POSS) hierarchical reinforcement configuration achieved an exceptional flexural strength of 925.0±39.2 MPa and a flexural modulus of 39.39±1.41 GPa. These properties are comparable to those of human dentin, highlighting its potential for dental applications.[34] Synthetic fibers, particularly glass and carbon fibers, have seen widespread use in dental applications due to their advantageous mechanical properties. Glass fibers, in particular, are favored for their superior aesthetic qualities and their ability to form strong bonds with resins when treated with silane coupling agents. This treatment enhances adhesion in composite materials and facilitates effective load transfer from the weaker polymer matrix to the more robust reinforcing fibers, substantially improving the overall strength and longevity of composite materials used in dental restorative practices.[35] Despite their advantages, fiber-reinforced composites face challenges such as fractures, wear from mastication, and delamination. While these issues can often be resolved cost-effectively, they underscore the need for careful material selection and design in dental applications. Additionally, the mechanical properties of fiber-reinforced composites may deteriorate after hydrolytic aging, which is a significant consideration for ensuring their long-term durability.[36]

SURFACE TREATMENTS AND BONDING TECHNIQUES

The intrinsic qualities of PMMA (polymethyl methacrylate) often present challenges in direct bonding and material compatibility, necessitating tailored surface treatments to enhance bond strength and compatibility.[37] Klaiber et al.[37] investigated the bonding behavior of industrial CAD/CAM PMMA, artificial resin teeth and traditional PMMA, concluding that monomer application was the most effective surface treatment. Similarly, Gad et al.[38] explored the incorporation of zirconium oxide nanoparticles and surface treatments to improve the flexural strength of PMMA denture base materials, showcasing advancements in nanotechnology for PMMA enhancement.

Further studies have explored plasma and laser treatments for PMMA surface modification, underlining the importance of ongoing research in this area.[39]

Schauperl et al.[40] examined the effects of various surface treatments on acrylic denture base materials reinforced with woven glass fibers, demonstrating improved bonding and overall mechanical properties. Taczała-Warga et al.[41] highlighted the significance of pre-treating acrylic surfaces in denture restorations, particularly for cellulose fiber-reinforced denture base acrylic. Deb et al.[42] assessed how different acrylic resin repair methods influence the flexural strength of denture bases, providing practical guidelines for successful repairs. Alumina abrasive blasting (AB) has emerged as a proficient technique for improving surface roughness and adhesive strength. Integrated treatments combining AB with chemical agents like methylene chloride (CH) significantly enhanced flexural, shear, and impact strengths, though careful regulation of exposure duration is crucial to prevent adverse effects.[43] Adhesive primers also significantly enhance PMMA bond strength, particularly with silicon soft denture liners (SDL) under thermocycling conditions, which simulate thermal stress in oral environments.[44] Production methods impact PMMA-based material performance, with conventional and subtractive techniques yielding higher shear bond strength than additive methods. Airborne-particle abrasion with 50 µm particles effectively maintains adhesion in such contexts.[45]

In digital workflows, surface treatments play a critical role in integrating custom artificial resin teeth into milled PMMA bases. Monomer application remains the most effective treatment, while treatments like nitrogen plasma may impair bond strength.[46] Despite these advancements, challenges such as material compatibility and treatment specificity persist. Research into hybrid materials and alternative thermoplastics may offer novel solutions, paving the way for superior dental prosthetic materials. [47]

AGING AND DURABILITY OF REINFORCED ACRYLIC RESINS

Environmental stress significantly affects the performance and longevity of reinforced acrylic resins, emphasizing the need for materials with enhanced durability. Studies comparing sandwich constructions with polystyrene cores and cellulose foam under UV and rain exposure have illustrated variable degradation effects.[48] Davies et al.[49] found that seawater impacts acrylic matrix composites differently, with certain reinforced resins demonstrating superior resistance to water-aging processes.

Al-Jumal et al.[50] examined the hardness of heat-cured denture base resin modified with recycled acrylic resin during artificial aging, underscoring the importance of long-term material durability. Rahaman Ali et al.[51] evaluated the impact of heat cycles on the flexural properties of denture base acrylic resins reinforced with microcrystalline cellulose (MCC), identifying MCC as a viable substitute for synthetic reinforced PMMA resins. Çakmak et al.[52] investigated heat cycling's effects on flexural strength and hardness in new-generation denture base materials, finding that thermal cycling reduced flexural strength across all resins. Notably, thermal cycling decreased the microhardness of milled PMMA but did not affect 3D-printed resin. Apimanchindakul et al.[53] highlighted the potential of 1% short E-glass fiber reinforcement in self-cured acrylic resin to increase flexural strength. Environmental factors such as temperature and humidity profoundly influence the mechanical properties of acrylic resins. High temperatures can cause thermal oxidative degradation, weakening the material's mechanical strength over time.[54] Humidity affects dimensional stability, potentially causing cracks due to volume changes.[55] UV exposure accelerates polymer degradation, leading to embrittlement and reduced mechanical performance, primarily due to polymer chain scissions compromising material integrity.[56]

ANTIFUNGAL AND ANTIMICROBIAL PROPERTIES

PMMA faces challenges in terms of mechanical strength and surface characteristics, leading to potential issues with fungal adhesion and biofilm development, both of which contribute to denture stomatitis.[18] Researchers have explored various strategies to enhance the material's resistance to these issues. Jang et al.[57] assessed the antifungal and physicochemical properties of a polymerized acrylic resin modified with strontium-based phosphate glass. Their findings suggested that incorporating nanoparticles could improve antibacterial activity. Al-Eraky et al.[58] investigated the antifungal and antibiofilm effects of caffeine against *Candida albicans* on PMMA denture base material, offering a novel approach to enhancing the safety and biocompatibility of dental prostheses. In a similar vein, Alzayyat et al.[59] explored the antifungal efficacy of PMMA denture base material enhanced with SiO2 nanoparticles, providing an effective solution for combating infections commonly associated with dentures. Further investigations by Gad et al. [3]incorporated ZrO2 nanoparticles and glass fibers into PMMA, leading to enhanced mechanical strength and antifungal properties. Silver nanoparticles (AgNPs) are widely recognized for their potent antimicrobial effects, and when added to PMMA, they exhibit significant antibacterial and antifungal activity against pathogens like Streptococcus mutans, Lactobacillus, and *Candida albicans*. The inclusion of AgNPs in PMMA not only enhances antimicrobial properties but also improves the material's mechanical strength, making it more suitable for dental applications.[60] Zinc oxide (ZnO) nanoparticles have similarly demonstrated antimicrobial effects, particularly when combined with silver ions, boosting overall antimicrobial activity against oral pathogens.[60] Bioactive glass and calcium phosphate compounds are integrated into PMMA to improve its bioactive and antimicrobial properties. Although bioactive glass enhances mineral induction capacity, its direct antimicrobial effects may be somewhat limited.[7] Chitosan nanoparticles and organic coatings such as ammonium chitosan and sodium alginate further improve the antimicrobial properties of PMMA by acting as barriers to microbial adhesion and facilitating the targeted delivery of antimicrobial agents.[7] However, while nanoparticles enhance antimicrobial properties, careful evaluation of their cytotoxicity is crucial. Studies have shown that PMMA composites containing nanoparticles like silver and peppermint oil are biocompatible, but the concentration and distribution of these nanoparticles need to be optimized to prevent adverse effects.[61]

SELF-HEALING PMMA

Self-healing PMMA is a promising area of research, utilizing nanocapsules that contain healing agents. These capsules release their contents upon damage, initiating a repair process. For example, a dual nanocapsule system containing an initiator and a monomer has shown the ability to enable self-healing in dental resins. In one study, 33% of samples demonstrated the capacity to be reloaded and tested in tension after healing.[62] The self-healing property is particularly valuable in extending the lifespan of dental prostheses, as it enables the material to repair micro-cracks that often lead to failure in dental applications.[63] Recent developments in photo-initiator systems and the use of biocompatible materials have significantly improved the biocompatibility of self-healing systems, reducing the risk of adverse reactions in dental polymers.[64]

Self-healing systems, which rely on the incorporation of microcapsules within the PMMA matrix, have shown promising results. When fractures occur, the capsules release healing agents that restore the material's integrity, effectively repairing damage to the material and prolonging the life of dental prostheses.[65] According to Harb et al.[66] self-healing PMMA- cerium oxide coatings with outstanding anticorrosive performance and endurance have prospective applications. Cerium ions act as self-healing agents by preventing the corrosion front from advancing. Although the development of self-healing PMMA for dental applications is highly promising, challenges remain in optimizing the efficiency of healing processes and ensuring the biocompatibility of the materials used.

CONCLUSION

Because of its many advantageous qualities, PMMA has long been used as a foundational material in prosthodontics, particularly in the field of denture bases. But its shortcomings in terms of durability and mechanical strength have sparked a lot of study into improving its overall performance. Fiber reinforcement with nanofillers the flexural strength, impact strength, and general toughness of PMMA were greatly increased by the addition of nanoparticles and fiber reinforcement, which made it more resilient to the demanding circumstances found in the oral environment. Its compatibility was further increased by bonding procedures and surface treatments, and then antimicrobial agents were added to make it more resistant to microbial colonization and more biocompatible. These advancements in the field have not only increased the longevity of PMMA-based materials but, interestingly, have also expanded its clinical applicability, demonstrating the material's continued importance and value in contemporary dentistry. PMMA-based materials will become even more resilient and adaptable via more research and development in this area, confirming its significance for use in dental prostheses and other applications.

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The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Oral complications in diabetes mellitus

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ABSTRACT

Diabetes mellitus is a chronic metabolic disorder characterised by high blood glucose levels that can lead to various systemic complications. Among these complications, oral complications play an important role due to the high vascularisation and innervation of the oral cavity. Regular dental examinations, effective oral hygiene practices and treatments to regulate blood glucose levels are the main methods that contribute to the effective management of complications. Understanding the relationship between diabetes mellitus and oral health and implementing preventive strategies are crucial to improve the overall health and quality of life of individuals with diabetes mellitus. The aim of this review is to provide an overview of these oral complications and the problems they cause.

Keywords: HbA1c, complications, oral physiopathology

INTRODUCTION

Diabetes mellitus is a common metabolic disease in the population that occurs with impairment of insulin secretion or insulin activity or both.[1] It is characterised by high blood glucose levels and glycosuria. It is a disease that affects carbohydrate, fat and protein metabolisms and many other systems in the body and affects the quality of life negatively with severe complications. It may have an asymptomatic insidious onset and a family history is frequently present.[2] Diabetes mellitus (DM) is recognized as a major global health concern, affecting a significant portion of the population worldwide. Estimates from the International Diabetes Federation (IDF) suggest that the prevalence of diabetes will increase considerably by 2045, with projections indicating that approximately one in eight adults around 783 million individuals will be living with DM.[3]

DIABETES MELLITUS

According to the 2023 Guideline for the Diagnosis and Treatment of Diabetes, it is sufficient to meet only one of the following criteria to make a diagnosis of diabetes:[4]

- Glycosylated haemoglobin (HbA1c) value ≥6.5%
- Plasma glucose ≥126 mg/dl measured after 8 hours fasting
- Plasma glucose ≥200 mg/dl measured by oral glucose tolerance test after 75 grams of oral glucose intake following a 12-hour overnight fast
- Plasma glucose ≥200 mg/dl measured at any time of the day with diabetes symptoms is one of the diagnostic criteria.

Clinical symptoms include dry mouth, overeating or loss of appetite, excessive thirst, excessive urination, frequent urination at night, weight loss, blurred vision, numbness in the feet, tingling, burning, urinary tract infections, itching, dry skin and fatigue.[5]

ORAL COMPLICATIONS

Many oral complications can occur in patients with poorly controlled diabetes. These include increased susceptibility to infection, delayed wound healing, xerestomia, increased periodontal disease, loss of attachment and alveolar bone resorption, recurrent periodontal abscesses, gingival overgrowth, oral candidiasis, acetone breath odour, increased salivary glucose levels, Plaque accumulation due to increased glucose in saliva and increase in caries development, taste disturbances, oral lichen planus, ulcerations, pulp infections, alveolitis, hyperkeratosis, erythroplakia, leukoplakia, lesions affecting the tongue (such as geographic tongue, tongue pain) and burning in the mouth.[6]

Xerostomia has a negative effect on the quality of life of patients by causing many problems including difficulty in eating, swallowing and speaking. An increase in salivary dysfunction has been found in diabetics with poor glycaemic control.[7]

The prevalence of dental caries is increased in diabetic patients (**Figure 1**). The factors that cause this include decreased salivary secretion and buffering capacity, increased salivary glucose level, increased levels of streptococci and lactobacilli, and pulp necrosis resulting from irreversible pulpitis may also be seen as a result of chronic hyperglycaemia.[8] Apical abscesses formed after pulp necrosis may progress to lodge abscesses and osteomyelitis (**Figure 2**).[3]

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Figure 1. Root caries in the lower anterior teeth of a patient with diabetes[9]

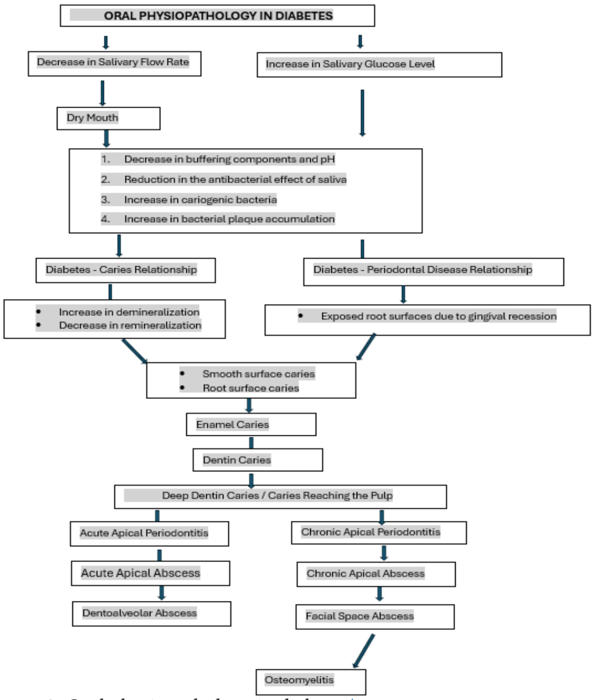

Figure 2. Oral physiopathology in diabetes[4]

Reduced saliva, an impaired defence mechanism and poor metabolic control may play an important role in the development of increased oral infections (**Figure 3**).[10] Candida infection has been found to be more common in diabetic patients who smoke, use dentures, have poor glycaemic control and use steroids and broad-spectrum antibiotics.[11]

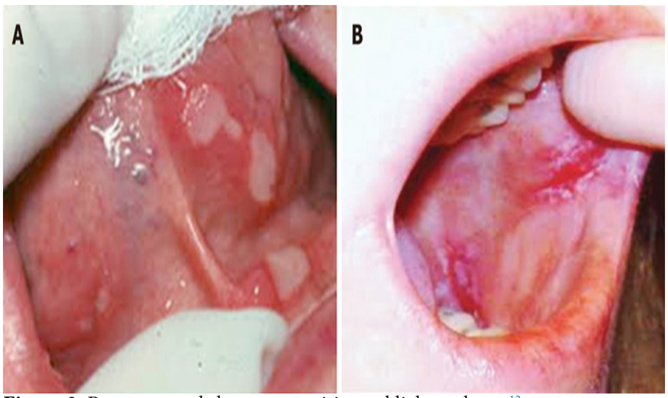

Figure 3. Recurrent aphthous stomatitis, oral lichen planus[12]

The complaint of burning mouth in diabetics is attributed to poor glycaemic control, metabolic changes in the oral mucosa, angiopathy, candida infection and neuropathy.[8] Patients with diabetes may experience impairment in the perception of sweet and salty flavours.[13] Disorders in taste perception may occur due to a decrease in the amount of saliva and neuropathy.[4]

Fissured tongue, geographic tongue, recurrent aphthae, lichen planus and similar lesions may also be associated with diabetes (**Figure 4**).[10]

Figure 4. A 32-year-old male patient diagnosed with diabetes mellitus with papillary atrophy in the central area along the central longitudinal fissure of the tongue[14]

Impairment of the immune system in diabetes, microcirculatory changes with decreased blood flow, dry mouth, changes in the flow and composition of saliva and smoking are thought to be effective in the aetiology of these lesions.[8]

Delayed healing of mouth sores is also a common condition in diabetes. Factors that delay wound healing in the body in general in diabetes are also valid in the mouth. Delayed vascularisation and impaired defence response, decreased blood flow and hypoxia are effective factors.[15]

There is a bidirectional relationship between diabetes and periodontal diseases that affects each other in many ways. It is estimated that the risk of developing periodontal disease increases 2-3 times in diabetic individuals.[16] Diabetes increases susceptibility to periodontal disease through various biological mechanisms. These include impaired neutrophil function, increased collagenase activity, and alterations in the subgingival microbiota. Elevated glucose levels in the gingival crevicular fluid create a favorable environment for the proliferation of pathogenic bacteria responsible for periodontitis. Moreover, alterations in the inflammatory response in diabetic patients lead to increased production of proinflammatory cytokines, contributing to the tissue destruction observed in periodontal disease.[17] Periodontal disease is considered the sixth most common complication in patients with diabetes.[18] Increased gingival infection, loss of attachment and alveolar bone resorption, and recurrent periodontal abscesses are common complications in diabetic patients. The severity of periodontal disease also increases especially in long-term diabetic patients with poor blood glucose control (**Figure 5**).[19] According to the new classification of periodontitis, the level of glycaemic control in diabetes affects the grading of periodontitis.[20]

Figure 5. Patient with uncontrolled type 2 diabetes and no previous professional dental care[21]

It has been observed in many studies that oral flora also changes in patients with diabetes. Although specific bacterial species increased and decreased in the studies, it was observed that pathogenic species increased.[2] Microenvironments high in glucose may determine the habitat to favour filtration and anaerobic growing bacteria that feed on glucose-rich food. This is supported by the high numbers of *Propionibacterium, Corynebacterium, Sphingomonas, Capno-cytophaga, Neisseria, Pseudomonas* and *Bergeyella* in hyperglycaemic subjects.[22]

CONCLUSION

Chronic and lifelong diabetes is a global public health problem with its increasing prevalence. For this reason, measures to be taken for prevention, treatments in case of disease and prevention of related complications are of great importance. The status of oral dental health is very important in glycaemic control and nutrition of patients with diabetes. Because it is very difficult to regulate blood sugar in a patient who cannot be properly nourished without diet control. For this reason, it is important that diabetic patients are informed about possible oral complications, pay much more attention to oral dental health compared to healthy individuals, and do not neglect dentist controls and treatments. In this regard, dentists and medical doctors should work in coordination and inform the patient.

ETHICAL DECLARATIONS

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Case Report
Dicle Dent J. 2025;26(1):15-18

Alveolar ridge augmentation with lateral approach maxillary sinus lifting: a case report*

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ABSTRACT
In the maxillary posterior region, increased sinus pneumatisation, decreased density and residual alveolar bone height create difficulty in placing dental implants. Therefore, it is necessary to surgically increase the bone height to obtain sufficient bone height for implantation. The aim of this case was to perform a two-stage lateral approach sinus surgery to create an adequate amount of residual crest for rehabilitation of the severely resorbed posterior maxillary bone and then to allow the use of dental implants of adequate length. A 2-stage lateral approach sinus lifting operation was planned for a patient with insufficient vertical crest height in the region of tooth #26. The patient waited 6 months after the lateral approach sinus lifting operation and Adequate vertical crest height was obtained for implant placement. External sinus lifting is a highly effective technique for increasing vertical bone heigh in atrophic maxillary crests.
Keywords: Sinus lifting, dental implant, PRF

*A summary of this case report was published as an abstract at the FDI World Dental Congress 2024.

INTRODUCTION
Sinus lifting is a predictable surgical technique for reshaping the highly resorbed posterior maxillary bone in patients with missing teeth so that they can be rehabilitated with implant placement and prosthetic restoration.[1-4] Long time after tooth loss and pneumatisation of the maxillary sinus leads to the need for bone grafting. Lateral approach sinus floor augmentation (LASFA) involves raising the Schneiderian membrane by creating a lateral window in the alveolar bone followed by bone grafting.[4,5] LASFA is an effective technique that is safely preferred when the residual crest height is <5 mm.[6-8] A bone graft with optimum properties should be biocompatible, osteoconductive, osteoinductive, preserve graft volume, have good mechanical properties, be non-allergenic, sterile and have appropriate handling properties.[9-11] The gold standard imaging for accurately assessing sinus anatomy is considered to be cone beam computed tomography (CBCT).[12,13] CBCT provides valuable and important information in the examination of anatomical formations such as the wall thickness of the lateral bone, the thickness of the Schneiderian membrane and septa.[13]

CASE
A 51-year-old male patient was admitted to the Periodontology Department of Dicle University Faculty of Dentistry with the clame of missing tooth number 26. No systemic disease was found in the anamnesis of the patient. It was learned that he had his tooth extracted 2 years ago due to deep caries. For implant planning, CBCT image was obtained and measurements were taken. Measurements were made mesio-distally from ten equally spaced sections separately. The numerical average of these ten values was then taken. The measurements showed that the residual bone height (RBH) was <5 mm (3.95 mm). Buco-lingually width, 6.8 mm bone was measured. The residual bone density was measured using the Hounsfield unit (HU) and it was observed that the bone density was very low and had a spongy bone structure. HU value was found between 300-400. The course of the PSAA was found to be in a position that would not jeopardize the operation. In the light of these findings, a two-stage LASFA was planned.

Before the operation, the patient was informed about the procedure and a written consent was obtained. The surgical field was anesthetized with adrenaline local anesthetic. The flap was lifted to provide adequate access to the surgical field. An oval lateral entry window was prepared using a piezotome. The membrane was carefully elevated starting from the sinus floor. It was extended to the anterior and posterior walls with the sinus curettes. The final elevation was up to the medial wall, allowing the expected graft placement. The bone in the middle of the lateral window was elevated together with the Schneiderian membrane. To ensure sinus membrane integrity, the patient was asked to breathe deeply and membrane

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mobility was observed. Injectable platelet-rich fibrin (iPRF) and advanced platelet-rich fibrin (aPRF) were obtained from the patient's blood. Medium thickness Cerabone® (Botis, Berlin, Germany) bovine xenograft was used. iPRF was mixed with xenograft and placed into the cavity created after membrane elevation. The resulting aPRF was made into a membrane and the antrostomy window was closed. The flap was closed primary without tension by providing sufficient elasticity. Postoperative medications included oxymetazoline hydrochloride spray and chlorhexidine mouthwash twice a day, analgesics (aceclofenac 100 mg, paracetamol 325 mg) and antibiotics (amoxicillin 500 mg) three times a day for one week to aid healing. After 10 days, sutures were removed. A panoramic image taken at 6 months post-op showed sufficient vertical height. A crestal incision was made in the relevant area under anesthesia. The socket was prepared using implant drills. Bilimplant® (İstanbul, Turkiye) 4.1 diameter and 12 mm long implant was placed. The flap was closed primerally. Chlorhexidine mouthwash, analgesics (aceclofenac 100 mg, paracetamol 325 mg) and antibiotics (amoxicillin 1000 mg) were administered twice daily for one week to aid healing. Sutures were removed after one week (Figure 1-10).

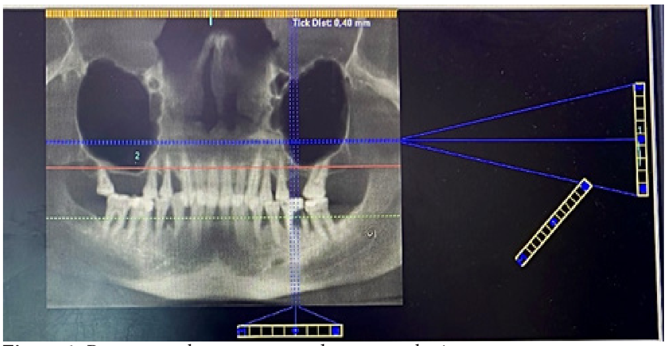

Figure 1. Preop cone beam computed tomography image

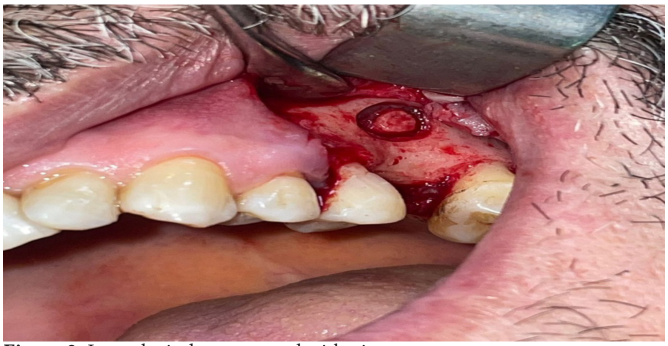
Figure 2. Lateral window prepared with piezotome


Figure 3. Valsalvas manevrs

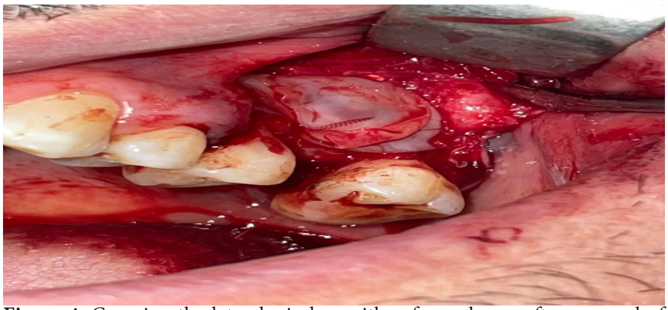
Figure 4. Covering the lateral window with prf membrane after removal of the Schneiderian membrane and grafting

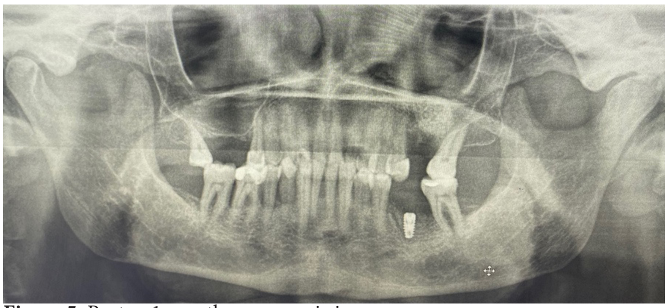
Figure 5. Postop 1 months panoramic image

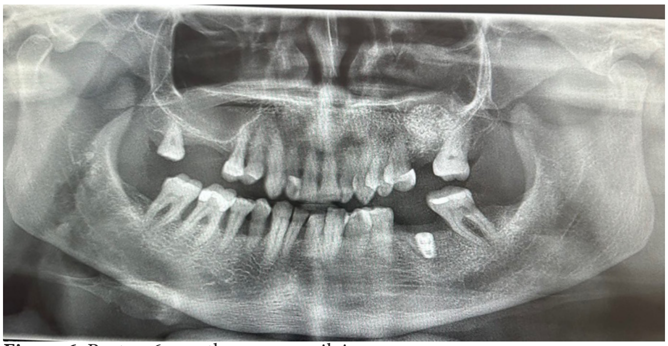
Figure 6. Postop 6 months pamoramik image


Figure 7. Alveoler ceest at the operation

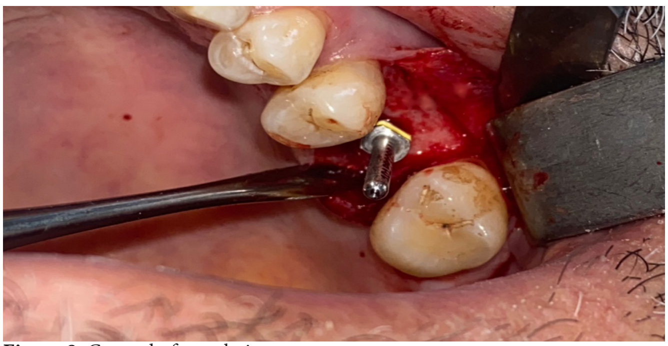
Figure 8. Control of angulation

Figure 9. Subcrestal placement of the implant

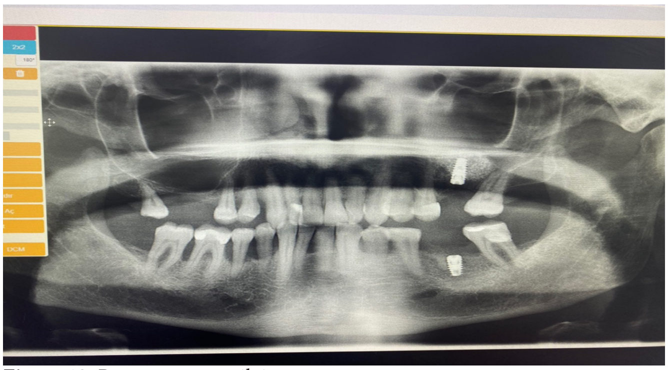

Figure 10. Postop panoramik image

DISCUSSION

The use of dental implants to restore aesthetics, function and phonation has become widespread.[14] The maxillary sinus is the largest of the 4 paranasal sinuses. When teeth are lost in the maxillary posterior region, resorption is observed both due to the normal bone remodelling process and due to sinus pneumatization.[15] Increased sinus pneumatisation, low bone density and decreased RBH in the maxillary posterior pose difficulties in the application of dental implants. Therefore, in order to be able to implant dental implants in the over-resorbed maxillary posterior region, the RBH in the sinus area must be increased by a surgical technique.[14] CBCT imaging before maxillary sinus lift allows a more detailed examination of the surgical field, It allows the detection of pathologies and helps to plan the technique more precisely.[16,17] In this case, the surgical technique was decided using CBCT images. It's effectiveness has been documented in studies that have upgraded LASFA. LASFA is a safe and highly predictable technique.[18-21] It is well known that a minimum RBH of 5 mm is recommended to achieve adequate implant stability and osseointegration.[22,23] When the RBH is ≥5 mm, the implant is placed simultaneously with the sinus elevation operation; however, in general clinical practice, if the RBH is <5 mm, a two-stage technique is applied and a LASFA is applied and implants are placed 6 months later.[24] In this case, RBH was found to be <5 mm. A two-stage technique was applied and implants were placed 6 months after surgery. The biological properties of PRF membranes include the proliferation of a large number of live blood cells, as well as the capacity of PRFs for cell proliferation and cell adhesion during the healing process and in general tissue engineering.[25] In this case, xenograft was mixed with iPRF and membrane derived from aPRF was used for closure of aPRF lateral antrostomy. At the end of 6 months, when the panoramic film was examined, it was observed that sufficient bone was formed for implant placement (>12 mm) and the lateral window was completely filled with bone and healed.

CONCLUSION

According to the results of this case, CBCT is one of the reliable methods to be used in the evaluation of the operation field before surgical approaches. In the patient with RBH is <5 mm, it was seen that sufficient vertical bone height for implant placement could be obtained by performing sinus lifting with a lateral approach.

ETHICAL DECLARATIONS

Informed Consent

The patient signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Case Report

Dicle Dent J. 2025;26(1):19-23

Endodontic management of radix entomolaris in mandibular first molar teeth: a case series

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ABSTRACT

The success of endodontic treatment depends on a correct understanding of root canal anatomy, identification of anatomical variations, and correct canal positioning. Mandibular molars, which usually have two roots, may harbor an additional root, such as the radix entomolaris (RE), incompatible with this expected anatomy. The location of this variant root, especially close to the distolingual root, can complicate the endodontic procedure. This case series provides important insights into the clinical management of RE variation based on three cases with RE. The clinical evaluation, diagnosis, and root canal treatment procedures are presented. The teeth were asymptomatic at follow-up examinations, and radiographic examinations revealed normal/healthy periapical status. Endodontic specialists and endodontic treating physicians must take a careful and conscious approach to the presence of additional roots in mandibular molars during root canal treatment processes. Proper understanding and handling anatomical variations such as RE is a critical factor in the success of root canal treatment.

Keywords: Radix entomolaris, distolingual root, mandibular molar, anatomical root variation

INTRODUCTION

Knowing and correctly understanding the basic anatomical structure of the teeth, anatomical variations, and possible localization of the canals is the first step in ensuring endodontic treatment success. Attention to this step prevents potential errors and opens the door to successful endodontic treatment and follow-up.[1,2] Studies on the anatomy of multi-rooted teeth have revealed deviations from the expected morphological structure and root canal variations.[3-6] Usually, mandibular molars have two roots (one mesial and one distal), while a third root is an important feature that makes these teeth anatomically more complex.[2,7] These additional root structures are usually located in the distolingual or mesiolingual regions and are defined as the radix entomolaris (RE) and radix paramolaris (RP). In addition, these roots have specialized canals.[8,9] Among these anatomical variations, the RE is the most common and can be observed as an independent root or partially fused with the main roots. Although RE can occur in all mandibular molars, it has been reported least frequently in second molars.[8] The prevalence rate varies among different populations. It has been reported to be approximately 4% in the Caucasian population and over 30% in the Mongolian population.[2,7-9]

Detecting these anatomical root variations poses a significant challenge because they are located in the same buccolingual plane as the distolingual root.[8] This positional proximity can lead to superposition on right-angled periapical radiographs, making it simple to miss this anatomical variation. Failure to detect and treat an additional root canal during root canal treatment is highly associated with the development of post-treatment apical periodontitis.[10]

Considering the clinical consequences of overlooking these anatomical variations, physicians must be alert and knowledgeable about the potential presence of additional roots in mandibular molars during root canal treatment. In this context, this study aims to present three cases involving RE, providing awareness and insights into the clinical management of these variations and their follow-up.

CASES

Case 1

A 19-year-old female patient was admitted to our clinic with a complaint of pain in the mandibular right first molar tooth. In her anamnesis, it was learned that she had no systemic disease, complained of spontaneous, long-lasting pain in the mandibular right first molar tooth, and could not chew with the related tooth. Intraoral examination revealed the presence of an occlusal amalgam filling. The tooth was percussed and palpated. There was no mobility. No fistula was found in soft tissues. Pulp sensitivity tests, including the cold test (Super Spray, Seçkin Dental, İstanbul, Turkiye) and EPT (C-Pulse Pulp Tester, Coxo, Foshan, China), confirmed that the tooth was devitalized. A radiographic examination revealed that

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the tooth had an extra root (**Figure 1a**). It was determined that there was no periapical pathology in the tooth's roots, but there was a gap in the periapical ligament. The patient was diagnosed with acute apical periodontitis, and root canal treatment was decided. Isolation of the tooth was provided with a rubber dam.

While opening the endodontic access cavity considering the apical radiograph, it was observed with the dental loop that the distolingual canal was positioned more lingual than it should be, and the presence of a RE with a distolingual canal entrance was confirmed. Using an apex locator and radiography, root canal lengths were determined with a #15 K-type file (Dentsply Maillefer, Ballaigues, Switzerland). The canals were prepared by the crown-down technique using nickel-titanium T-endo MUST files (Dentac, İstanbul, Turkiye). After each file change, the root canals were irrigated with 2 ml of 5.25% sodium hypochlorite (NaOCl). As the final irrigation, 10 ml of 5.25% NaOCl, 10 ml of 17% EDTA, and 10 ml of saline were used. NaOCl and EDTA were activated in each canal sequentially for 1 minute and 30 seconds, respectively, using the sonic activation device EndoActivator (Dentsply Tulsa Dental, Tulsa, OK, USA) according to the manufacturer's instructions. The root canals were dried with paper cones and filled with AH Plus (Dentsply Sirona, Konstanz, Germany) root canal paste using the lateral condensation method (**Figure 1b**). In the clinical and radiological follow-up of the patient at the 9th and 12th months, tooth 46 did not show any symptoms and was found to be periapically healthy (**Figure 1c, 1d**).

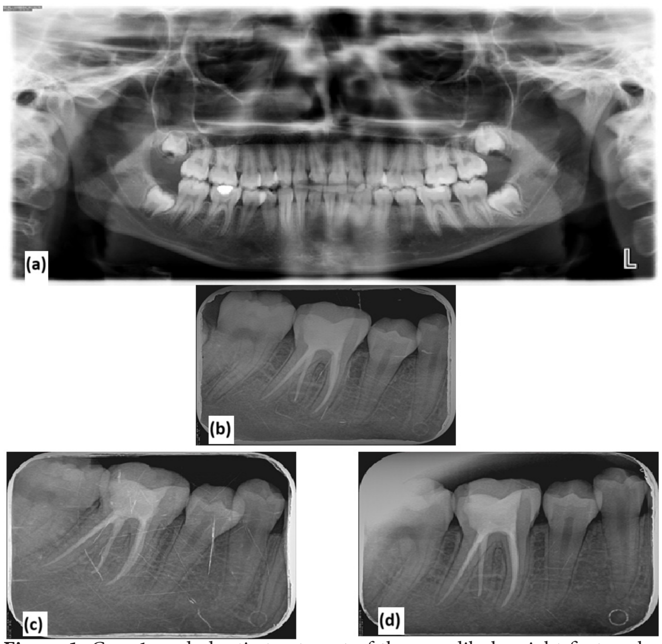

Figure 1. Case 1: endodontic treatment of the mandibular right first molar. a) Panoramic radiograph of the patient before treatment. b) Periapical radiograph of the patient immediately after the procedure. c) Periapical radiograph of the patient at the 9th month. d) Periapical radiograph of the patient at the 12th month

Case 2

A 20-year-old female patient was admitted to our clinic with a complaint of pain in the mandibular left first molar. In the anamnesis, it was learned that the patient had no systemic disease and had long-lasting pain in the mandibular right first molar that started spontaneously. Clinical examination revealed a deep carious cavity in the tooth. Percussion and palpation tests revealed pain and no tooth mobility. EPT revealed that the tooth responded earlier than the symmetrical tooth and was vital. No swelling was found in soft tissues. A radiographic examination revealed the presence of an extra root distal to the tooth (**Figure 2a**). It was determined that there was no periapical pathology in the tooth's roots, and the lamina dura was normal. The patient was diagnosed with pulpitis, and root canal treatment was decided. The tooth was isolated with a rubber dam. After the endodontic access cavity was opened, root canal preparation was performed according to the sequence in case 1. After the root canals were dried with paper cones, they were filled with the single cone method using Bioserra (Imicryl, Konya, Turkiye) root canal paste with bioceramic content and gutta-percha (**Figure 2b**). At the sixth month of clinical and radiological follow-up of the patient, the mandibular left first molar did not show any symptoms and was periapically healthy (**Figure 2c**).

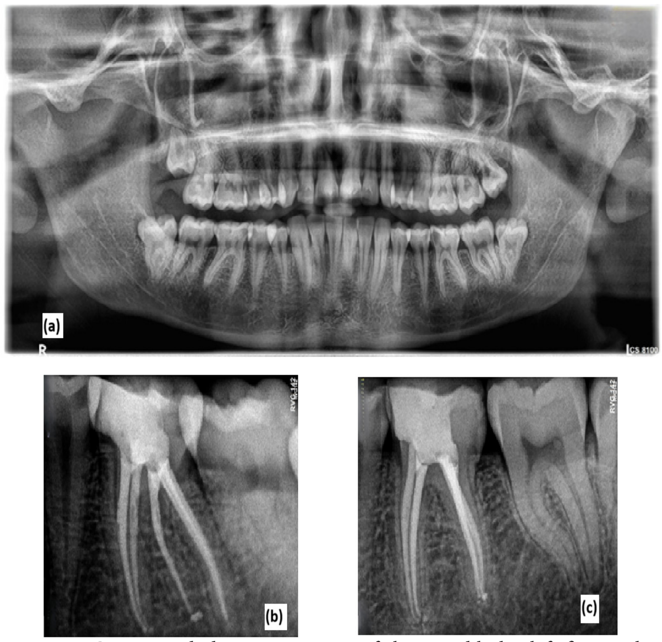

Figure 2. Case 2: endodontic treatment of the mandibular left first molar. a) Panoramic radiograph of the patient before treatment. b) Periapical radiograph of the patient immediately after the procedure. c) Periapical radiograph of the patient at the 6th month

Case 3

A 32-year-old male patient was admitted to our clinic with complaints of pain in the mandibular left first molar. In the anamnesis, it was learned that he did not have any systemic disease. He had long-lasting pain and night pain in the mandibular left first molar, which started spontaneously 1 month ago, but he was asymptomatic at the moment. Clinical examination revealed an occlusal amalgam filling in the relevant tooth. The presence of percussion and palpation was observed and no mobility was found. Pulp vitality tests, including the cold test (Super Spray, Seçkin Dental, İstanbul, Turkiye) and EPT (C-pulse Pulp Tester, Coxo, Foshan, China), revealed that the tooth was devitalized. A radiographic examination revealed that the tooth had an extra root (**Figure 3a**). It was determined that there was no periapical pathology in the tooth's roots, but there was enlargement of the periapical ligament. The patient was diagnosed with acute apical periodontitis, and root canal treatment was decided. Isolation of the tooth was provided with a rubber dam. When opening the access cavity, a dental microscope (Semorr 3000 E-4 K, Bondent, China) was used to locate the canal opening of the distolingual root. Thus, less material was removed from the tooth, and the risk of complications was minimized. The root canal disinfection procedure in Case 1 was followed. Since the root canals could not be dried with paper cones, calcium hydroxide was placed in the canal for 10 days. In the second session, calcium hydroxide was removed with abundant irrigation and activation, as in the first session. After the final flushing procedure, the canals were filled with AH Plus (Dentsply Sirona, Konstanz, Germany) root canal paste using lateral condensation (**Figure 3b**). At the sixth month of clinical and radiological follow-up, the mandibular left first molar showed no symptoms and was periapically healthy (**Figure 3c**).

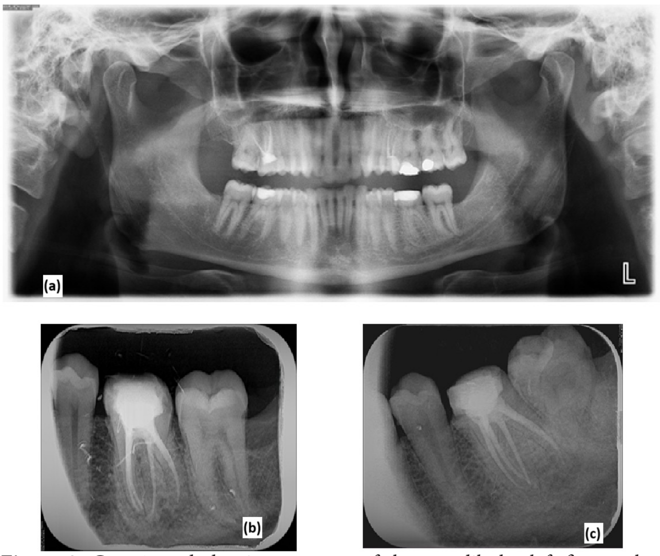

Figure 3. Case 3: endodontic treatment of the mandibular left first molar. a) Panoramic radiograph of the patient before treatment. b) Periapical radiograph of the patient immediately after the procedure. c) Periapical radiograph of the patient at the 6th month

DISCUSSION

These case reports emphasize the importance of detailed clinical and radiographic evaluations and an in-depth understanding of tooth anatomy in diagnosing and treating teeth containing RE. These anatomical variations in mandibular molars involve extra canals; overlooking or inadequate cleaning of these canals can significantly adversely affect the prognosis of endodontic treatment.[2,10,11] These successful treatment results, achieved during a follow-up period of at least 6 months, are based on correctly identifying the extra root, accurate diagnosis, and effective management of these anatomical variations.

Correctly identifying extra roots before endodontic treatment, making the correct diagnosis, and creating appropriate treatment plans are important steps in ensuring success. In addition, this process requires a careful examination of the chronal features that can provide predictions to the dentist. One of the important indicators in this respect is the presence of an extra tubercle, usually observed in conjunction with a prominent distolingual lobe and cervical convexity, which should raise suspicions of the presence of an additional root. An important indicator in this context is the presence of an additional tubercle, often observed with a prominent distolingual lobe and cervical convexity. Along with this, the significantly wider distance between the distobuccal and distolingual tubercle tips should raise suspicion of the presence of an additional root.[8,12,13] Furthermore, a meticulous review of periapical radiographs taken from different angles can reveal subtle but critical details indicating extra roots.[14] Studies have examined various angular projections to determine the optimal angle for the accurate visualization of RE. In periapical radiographs, images taken with a slight distal angle show the RE moving distally, overlapping the image of the distobuccal root moving mesially. The RE type can only be accurately assessed if the radiographic beam is directed at a larger angle from the distal direction. The study has revealed that mesial projections better detect extra roots than distal projections. Furthermore, the optimal angle for ensuring the best visualization of RE has been determined to be 25 degrees in mesial projections.[14] Specific radiographic findings should be considered When conventional periapical radiographs detect extra roots such as RE and RP. In this context, important indicators of the presence of an extra root include the intersection of a translucent line in the pulp cavity, the intersection of the periodontal ligament space, the lack of clarity or loss of distinct borders of the distal root contour or root canal, and the clear visibility of an extra root between the mesial and distal roots.[15] Although detecting an extra root with two-dimensional radiographs is possible, previous studies have shown that cone beam computed tomography (CBCT) is a superior method for evaluating dental structures.[16,17] Periapical radiographs have disadvantages, such as their inability to prevent superposition and the potential to trigger the gag reflex when used in posterior regions. CBCT is an excellent option for detecting anatomy and eliminating the disadvantages of periapical radiographs. Three-dimensional images created with axial, sagittal, and coronal sections help identify other features of RE, such as determining the spatial location of structural elements like the entrance of the RE orifice, thereby aiding in accurate diagnosis. CBCT not only confirms the presence of anatomical variations, such as extra roots and missed canals, but also provides a significant advantage in detecting the location and direction of these variations with extreme precision. This characteristic feature is a decisive factor, particularly in distinguishing between RE and RP. The canal localization in the extra root can also pose a challenge in treatment. In this context, the design of a suitable access cavity is critical. This is because it provides a clearer view of the pulp chamber floor and allows direct access to the canal orifices by creating a suitable pathway.[8,18] The canal orifices of extra roots are usually located in the lingual position, either mesial or distal to the distal root canal.[19] This specific location suggests that in teeth with this variation, the conventional access cavity may not adequately expose these orifices, and a wider access cavity is often required.[8,9] In cases where it becomes difficult to locate the canal orifice, it is paramount to carefully examine the pulp chamber floor and walls, especially in distolingual areas.1 In the cases presented, a critical step was to meticulously assess the pulp floor and trace the dark lines with an endodontic explorer (DG16) to locate the canal. This method helped to expose the debris on the pulp roof that concealed the entrance to the root canal. A dental microscope has been very useful in identifying the canals more precisely. These optical instruments significantly improve examination accuracy, making it possible to study the complex structure of dental anatomy more detail and effectively.[20]

It has been reported in the literature that canals in extra roots usually have smaller diameters and show different curvatures in the coronal, middle, or apical triads. This increases the risk of shaping errors during endodontic treatment. These errors can lead to problems such as root canal straightening, step formation, canal migration, or endodontic file breakage.[8,9] Considering such difficulties, a careful approach is required during canal preparation. This should include the creation of a smooth glide path with a small K file up to size 15 before the rotary instruments are used. This initial preparation reduces the torque stress applied to the rotary tools, allowing for a more controlled and safe operation. Taking a conservative approach to shaping the grooves using files with fewer tapers can help to reduce the risk of over-preparation and potential errors. Minimizing the amount of canal expansion enables clinicians to preserve the natural anatomy of the tooth and reduces the likelihood of complications related to excessive dentin loss. These strategies and precautions are critical to overcome the challenges associated with extra roots and thus contribute to safer and more predictable treatment outcomes.[1,8,21]

CONCLUSION

The current knowledge of the prevalence of potential anatomical variations and morphological features clearly emphasizes the importance of preoperative planning. Periapical radiography and CBCT for diagnosis, operating microscopy and dental loupe for magnification, and sonic/ultrasonic devices and NiTi instrument systems with advanced metal technology for treatment are extremely valuable tools in the management of mandibular first molars with RE. This case series presented the understanding of the anatomical variation of mandibular molars and the accurate identification of additional roots and their treatment with advanced treatment tools. It also demonstrated that successful treatment results could be achieved.

ETHICAL DECLARATIONS

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

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Case Report
Dicle Dent J. 2025;26(1):24-30

Endodontic treatment of mandibular premolars with root canal variations: a case series

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ABSTRACT

Mandibular premolar teeth predominantly have a single root and canal. However, they may sometimes present with additional roots and canals. The objective of this study is to provide a comprehensive literature review on mandibular premolar teeth with extra roots and canals, as well as to retrospectively evaluate four cases from shaping to obturation. A literature review was conducted on cases involving the number of roots and canals in mandibular premolar teeth with additional roots and canals between 2021 and 2024. The diversity of root canal configurations in mandibular premolars was assessed using PubMed and Google Scholar databases. Patients presenting with endodontic treatment needs were evaluated at the Endodontics Clinic of Kahramanmaraş Sütçü İmam University Faculty of Dentistry Hospital. Patients with mandibular premolar teeth exhibiting additional root and canal variations were selected, and endodontic treatment of these teeth was performed using personalized treatment methods tailored to each case. A review of the literature revealed that while mandibular premolar teeth predominantly have a single root, variations in root morphology, including two roots, three roots, taurodontism, and C-shaped configurations can occur. These variations may be accompanied by diverse canal structures ranging from one to five canals with various configurations. It was found that 78.3% of mandibular first premolars and 90.3% of mandibular second premolars had single canals. The frequency of double-rooted premolars was found to be higher in males compared to females. During the examination of our cases, difficulties in accessing the root canal system were frequently encountered when additional root canals were present, requiring the adaptation of standard root canal treatment techniques to meet individual patient needs. Consequently, extended treatment durations were needed, often requiring multiple treatment sessions compared to standard root canal therapy. A literature review revealed that mandibular premolar teeth with extra roots and canals exhibit highly diverse canal configurations. However, such cases require extended treatment durations with multiple sessions and personalized treatment techniques tailored to each case due to the difficulty in accessing the root canal system.
Keywords: Additional root, additional canal, accessory canal, mandibular premolar teeth

INTRODUCTION

The success of root canal treatment depends on a comprehensive knowledge of root and root canal morphology to accurately locate all canals and properly clean, shape, and fill the canal space three-dimensionally.[1]

While mandibular premolar teeth are typically described in textbooks as having a single root and canal, they may possess additional roots and canals that are not easily diagnosed with periapical radiographs.[2] Morphologically, these teeth may exhibit two roots, three roots, Tomes' root, and radicular grooves in the root, as well as additional canals, accessory canals, and isthmuses.[3] Mandibular premolar teeth have the highest incidence of endodontic failure among all teeth due to numerous variations in root canal morphology and the difficulty in accessing additional canal systems.[1]

When evaluating root canals, it is crucial to examine their arrangement, path, and shape. The Vertucci classification system is used to understand the root canal system. This classification system analyzes anatomical variations and helps in understanding root canal configurations.[4]

Due to these variations in mandibular premolars, it is of paramount importance to develop personalized treatment strategies.[3] Accurate determination of root canal anatomy through thorough pre-operative assessment will positively influence the clinical success of canal treatment.[5]

Conventional radiography, despite its limitation of producing two-dimensional images of three-dimensional structures, remains a valuable diagnostic tool. The careful analysis of multiple intraoral periapical radiographs, captured at various horizontal angles, allows clinicians to discern intricate structural and anatomical details of root canal systems. These radiographic examinations are particularly effective in elucidating the morphological characteristics of root canals.

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In cases where conventional radiographic techniques cannot provide clear information and further detail is required, advanced diagnostic radiographic techniques such as cone beam computed tomography (CBCT) can be highly useful in detecting these variations.[6] However, CBCT should not be employed in every case, but rather in accordance with the as low as reasonably achievable (ALARA) optimization principle, following a cost-benefit analysis, when digital radiography proves insufficient in identifying root canal configuration.

Given the atypical and intricate canal morphology, the present cases, in conjunction with a literature review, suggest that mandibular premolar teeth with additional roots and canals can be effectively managed through conventional endodontic treatment.

CASES

Patients presenting at Kahramanmaraş Sütçü İmam University Faculty of Dentistry Hospital with indications for root canal treatment in mandibular premolar teeth were examined. Through radiological examination, patients with mandibular premolar teeth exhibiting additional root and canal system variations were selected. These variations were demonstrated through four cases, and personalized treatment methods appropriate for each case were implemented. Informed consent forms containing treatment-related information were obtained from the patients.

Case 1

A 41-year-old female patient was referred to the endodontics clinic with a complaint of pain in the right mandibular second premolar tooth. The intraoral clinical examination revealed percussion sensitivity in the tooth. There was no swelling or fistula present. A previously placed restoration was noted. Radiographic examination showed evidence of a prior unsuccessful root canal treatment attempt. The presence of two roots and two canals was identified, with one canal incompletely filled and the other appearing untreated and unfilled (**Figure 1a**). A decision was made to perform retreatment on this tooth. Radiographically, a root bifurcation was observed in the middle third of the root.

The tooth was isolated with a rubber dam. The old restoration was completely removed and secondary caries were eliminated. Access to the pulp cavity was established, exposing the gutta-percha at the canal access. A path was created through the gutta-percha using a size 10 K-type file with a 0.2 taper (Jensen JP-1, Dresden, Germany) in a rotational motion. Subsequently, a size 15 manual steel H-type file (Jensen JP-1, Dresden, Germany) was used to advance through the created path, attempting to remove the gutta-percha with a pulling motion. Progressively larger H-type hand instruments were used to remove all the gutta-percha. The access cavity was then enlarged up to the middle third of the root, where the bifurcation was observed, using long-shank burs and Gates Glidden drills (Dia Dent Gate Drills, Dentsply Sirona, Germany). Two canals, one buccal and one lingual, were identified using a size 10 K-type manual file (Jensen JP-1, Dresden, Germany). Working lengths were determined using an apex locator (WOODPECKER Woodpex-3 Gold Plus, Guilin Woodpecker Medical Instrument Co. Ltd., China). Both canals were manually instrumented, with the final instrument being a size 25 K-type manual steel file (Jensen JP-1, Dresden, Germany). Irrigation with 2.5% NaOCl (microvem sodium hypochlorite, Sakarya, Turkiye) was performed between each file. Irrigation activation was achieved using an EndoActivator (Dentsply-Sirona, Germany). Calcium hydroxide (saver calcium hydroxide, India) was placed, and a follow-up appointment was scheduled for one week later.

During the second appointment, the calcium hydroxide (Saver Calcium Hydroxide, India) paste was removed using NaOCl (microvem sodium hypochlorite, Sakarya, Turkiye) irrigation and an EndoActivator (Dentsply-Sirona, Germany). The bifurcated portions of the canals were filled using 0.2 taper size 25 gutta-percha points (Pearl Endo Gutta Percha Points, Brussels, Belgium). The root portion up to the bifurcation in the middle third was filled using a warm obturation technique (DiaDent Gutta Percha Obturator, Korea). The coronal restoration of the tooth was completed using composite resin (Nova Compo C A2 Imicryl, Konya, Turkiye), and a final radiograph was obtained (**Figure 1b**).

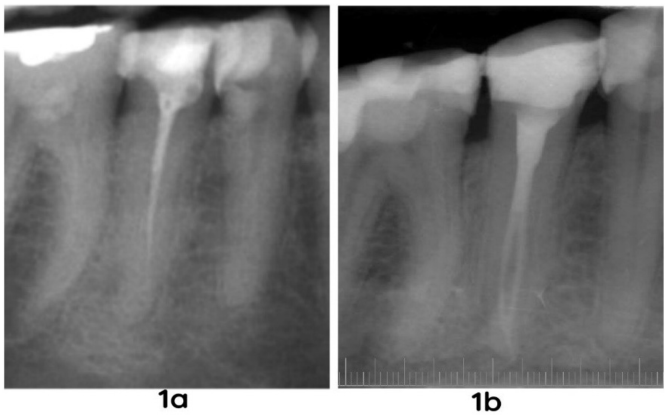

Figure 1. Retreatment of the right mandibular second premolar tooth

*a) Initial film showing incomplete root canal treatment and periapical lesion of the right mandibular second premolar tooth. b) Final film taken after treatment of two roots and two canals

Case 2

A 14-year-old male patient presented to the clinic with severe pain in tooth number 34. Clinical examination revealed pain on percussion and a deep carious lesion in the tooth. The periodontal tissues appeared healthy. Radiographic examination indicated that the caries had reached the pulp, necessitating root canal treatment. The radiographic image revealed that the tooth had two roots, with bifurcation beginning from the middle third of the root (**Figure 2a**). Following local anesthesia (Maxicaine (40 mg/ml articaine hydrochloride and 0.009095 mg/ml epinephrine bitartrate), Vem Pharma, İstanbul, Turkiye), tooth 34 was isolated with a rubber dam. After complete removal of the carious tissue, an access cavity was prepared. The root canal orifice appeared oval, similar to that of a single-rooted tooth. An attempt was made to access the canals using a size 10 K-type stainless steel hand file with a diameter of 0.2 mm (Jensen JP-1, Dresden, Germany). While the buccal canal was easily accessible, access into the lingual canal was not possible. The coronal portion up to the middle third of the root was enlarged buccolingually using long burs and Gates Glidden drills (DiaDent Gate Drills, Dentsply Sirona, Germany). However, access to the lingual canal remained unattainable. Calcium hydroxide (saver calcium hydroxide, India) was placed in the accessible canal and root interior, and the patient was scheduled for a second appointment.

During the second appointment, the calcium hydroxide paste (Saver Calcium Hydroxide, India) was removed from the canals using saline and 2.5% NaOCl (microvem sodium hypochlorite, Sakarya, Turkiye). Access to the lingual canal was achieved using a size 8 K-type stainless steel hand file with 0.2 taper (Jensen JP-1, Dresden, Germany) and a pre-bent tip towards the lingual aspect. It was observed that the lingual canal separated from the main canal at a sharp angle resembling a right angle. The working length was determined using an apex locator (Woodpecker Woodpex-3 Gold Plus, Guilin Woodpecker Medical Instrument Co. Ltd., China). The lingual canal was manually instrumented up to a size 20 K-type file with 0.2 taper (Jensen JP-1, Dresden, Germany), while the buccal canal was instrumented using an endomotor (Woodpecker Ai Endo Motor, Guilin Woodpecker Medical Instrument Co. Ltd., China) up to a size 25 NiTi file with 0.4 taper and 25 mm apical diameter (NIC Super Files Gold Rotary, Ireland). Irrigation with 2.5% NaOCl (Microvem Sodium Hypochlorite, Sakarya, Turkiye) was performed between each file. Activation was achieved using EndoActivator (Dentsply-Sirona, Germany). After drying the canals with paper points (Pearl Endo Paper Points, Brussels, Belgium), the lingual root was filled with a size 20 gutta-percha cone with 0.2 taper (Pearl Endo Gutta Percha Points, Brussels, Belgium), and the buccal root was filled with a size 25 gutta-percha cone with 0.4 taper (Pearl Endo Gutta Percha Points, Brussels, Belgium), and canal sealer (Meta Biomed Adseal, Ruhr, Germany). The gutta-percha points were sectioned at the bifurcation, and the coronal portion of the root was filled using a warm vertical compaction technique (DiaDent Gutta Percha Obturator, Korea). After sealing the canal orifices with resin-modified glass ionomer cement, the tooth's coronal restoration was completed using composite resin (Nova Compo C A2) (**Figure 2b**).

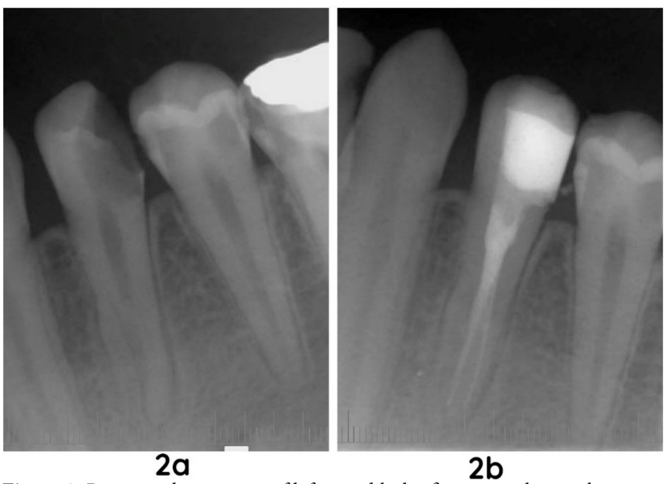
2a 2b

Figure 2. Root canal treatment of left mandibular first premolar tooth

*a) Initial film showing the two roots and two canals of the left mandibular first premolar tooth with a deep carious cavity. b) Final film showing the root canal treatment

Case 3

A 38-year-old female patient presented to the clinic with a complaint of pain in tooth number 45. Following clinical and radiographic examination, root canal treatment was deemed necessary. Radiographic analysis revealed a pulp cavity extending to the apical region of the root, resembling taurodontism, along with bifurcating roots at the apex (**Figure 3a**).

Local anesthesia (Maxicaine (40 mg/ml articaine hydrochloride and 0.009095 mg/ml Epinephrine Bitartrate), Vem Pharma, Istanbul, Turkiye) was administered, and a rubber dam was placed. After caries removal, an access cavity was prepared. Pre-curved 0.2 taper size 15 K-type stainless steel manual files (Jensen JP-1, Dresden, Germany) were introduced into the canals, one directed mesially and the other distally. Canal length and location were confirmed radiographically. Working lengths were determined using an apex locator (WOODPECKER Woodpex-3 Gold Plus, Guilin Woodpecker Medical Instrument Co. Ltd., China). Both root canals were instrumented using an endomotor (Woodpecker Ai Endo Motor) with 0.4 taper, 25 mm apical diameter nickel-titanium rotary files (NIC Super Files Gold Rotary). The portion above the bifurcation was manually shaped using hand files. The mesial and distal roots were obturated with 0.4 taper size 25 gutta-percha points (Pearl Endo Gutta Percha Points, Brussels, Belgium) and canal sealer (Meta Biomed Adseal, Ruhr, Germany), while the coronal portion of the roots was filled using a warm vertical compaction technique (DiaDent Gutta Percha Obturator). The coronal restoration was completed using composite resin (Nova Compo C A2) (**Figure 3b**).


3a 3b

Figure 3. Root canal treatment of the right second mandibular premolar tooth with taurodontism

*a) Initial radiograph showing deep carious cavity, periapical lesion and branching in the last third of the root in the right mandibular second premolar tooth. b) Final radiograph

Case 4

A 58-year-old female patient presented to our clinic for endodontic treatment of her right mandibular first premolar tooth. Clinical examination revealed a fixed prosthetic restoration on the tooth. The patient reported nocturnal pain, and percussion sensitivity was present. Radiographic examination showed a previous unsuccessful root canal treatment, a periapical lesion, and confirmed that the tooth had two roots and two canals (**Figure 4a**). Local anesthesia (Maxicaine (40mg/ml Articaine Hydrochloride and 0.009095 mg/ml Epinephrine Bitartrate), Vem Pharma, Istanbul, Turkiye) was administered. The fixed prosthetic restoration was removed from the tooth. Caries was observed on the distal aspect of the tooth. The carious tissue was removed, and an access cavity was prepared. Two separate canal orifices were identified using a 0.2 mm diameter #10 K-type steel hand file (Jensen JP-1, Dresden, Germany). The canal orifices began at the cementoenamel junction as two separate accesses, with one canal located buccally and the other on the mesiolingual aspect of the tooth. Canal lengths were determined using an apex locator (Woodpex-3 Gold Plus, Guilin Woodpecker Medical Instrument Co. Ltd., China). Both canals were shaped using an endomotor (Woodpecker Ai Endo Motor, Guilin Woodpecker Medical Instrument Co. Ltd., China) with a 0.4 taper, 25 mm apical diameter nickel-titanium endomotor file (NIC Super Files Gold Rotary, Ireland). Both canals were filled with 0.4 taper, 25 mm diameter gutta-percha (Pearl Endo Gutta Percha Points, Brussels, Belgium) and canal sealer (Meta Biomed Adseal, Ruhr, Germany). The coronal portion of the tooth was restored with composite resin (Nova Compo C A2) (**Figure 4b**).

LITERATURE REVIEW

In our study, a comprehensive literature review was conducted to examine cases involving root and canal numbers of mandibular premolar teeth with additional roots and canals between 2021 and 2024. The literature search utilized PubMed and Google Scholar databases. Keywords such as additional roots, mandibular premolar, and additional canals were employed in the database searches. A total of 18 studies published between 2021 and 2024 were evaluated, along with our own cases, resulting in the assessment of 24 cases. The inclusion criterion was the presence of additional canals and roots, as well as taurodontism. Teeth with a single root and single canal were excluded (**Table**).[7-18]

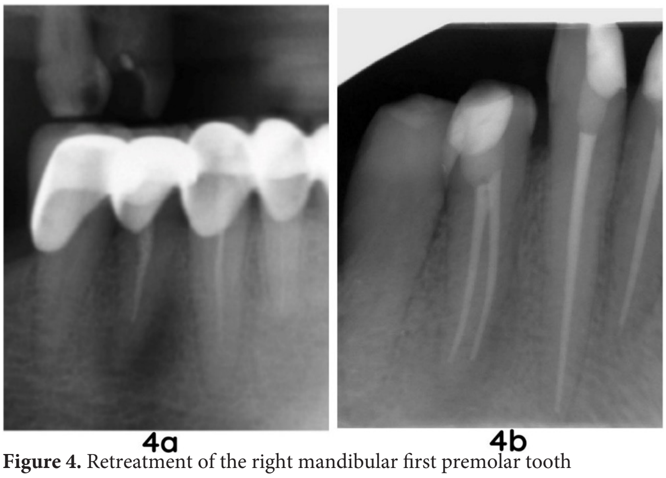

Figure 4. Retreatment of the right mandibular first premolar tooth

*a) Initial film showing the lesion at the root apex of the right mandibular first premolar tooth treated with fixed prosthetic restoration with incomplete root canal treatment. b) Final film of the root canal treatment

Since **Table** in the material method section of the main text of our article was placed at the end of the main text while being revised in accordance with the criteria of your journal, sources numbered 4, 6, 9, 14, 16 in the main text and sources numbered 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, which are not included in the text but only in the table, were included in the **Table**.[7-18]

Table. A literature review encompassing the years 2021-2024 regarding cases demonstrating root and canal diversity in mandibular premolar teeth[7-18]

Study name and date	Gender and age	Tooth	Number of roots and canals
Gurav, Tikesh 2024[9]	Male, 42	Mandibular 1st premolar	2 roots, 2 canals
Arevalo, Llani 2024[4]	Female, 22	Mandibular 1st premolar	3 roots, 3 canals
M. Mohammedi 2024[15]	Female, 36	Mandibular 2nd premolar	Taurodontizm, 3 canals
Aras, Sanket 2024[6]	Female, 19	Mandibular 2nd premolar	2 roots, 2 canals
Solete, 2023[16]	Male, 21	Mandibular 1st premolar	3 roots, 3 canals
Solete, 2023[16]	Male, 29	Mandibular 1st premolar	1 root, 3 canals
Solete, 2023[16]	Male, 39	Mandibular 2nd premolar	2 roots, 3 canals
Solete, 2023[16]	Female, 74	Mandibular 2nd premolar	1 root, 3 canals
Solete, 2023[16]	Male, 37	Mandibular 2nd premolar	2 roots, 4 canals
Brar, Prabhle, 2023[17]	Male, 25	Mandibular 2nd premolar	1 root, 3 canals
Davaji,Mina,2023[18]	Female, 38	Mandibular 2nd premolar	2 roots,4 canals
Mahdavisefat, 2023[19]	Male, 26	Mandibular 1st premolar	3 roots, 3 canals
Awooda, Elh.., 2023[20]	Male, 24	Mandibular 2nd premolar	3 roots, 3 canals
Sibal, Akash, 2022[14]	Male, 27	Mandibular 2nd premolar	2 roots, 2 canals
Sibal, Akash, 2022[14]	Female	Mandibular 2nd premolar	1 root, 2 canals
Jain, Rachit, 2022[21]	Male, 48	Mandibular 1st premolar	1 root, 3 canals
Jain, Rachit, 2022[21]	Male	Mandibular 1st Premolar	2 roots, 2 canals
Niavarzi, 2022[22]	Male, 50	Mandibular 2nd premolar	1 root, 4 canals
Arroyo-Bote, 2022[23]	Male, 59	Mandibular 2nd premolar	3 roots, 3 canals
Shah, Shahz, 2022[24]	Female, 22	Mandibular 2nd premolar	1 root, 2 canals
Penukonda, 202[25]	Male, 35	Mandibular 1st premolar	2 roots, 4 canals
Nouroloyouni, 2021[26]	Male, 18	Mandibular 1st premolar	2 roots, 5 canals
Moghadam, 2021[27]	Male, 19	Mandibular 1st premolar	1 root, 3 canals
Case 1	Female, 41	Mandibular 2nd premolar	1 root, 2 canals
Case 2	Male, 14	Mandibular 2nd premolar	2 root, 2 canals
Case 3	Female, 38	Mandibular 2nd premolar	Taurodontizm, 2 canals
Case 4	Female, 58	Mandibular 1st premolar	2 roots, 2 canals

RESULTS

A recent study conducted in 2024 found that 78.3% of mandibular first premolars and 90.3% of mandibular second premolars consist of single canals. Subgroup analyses revealed higher incidences of single-rooted and single-canal premolars in Asians compared to Caucasians. Furthermore, the study observed a higher frequency of single-rooted premolars in females, while males exhibited a higher frequency of double-rooted premolars.[19] Dental morphology studies have revealed that the majority of examined teeth possess a single root and canal structure. However, the findings indicate that 18% of the teeth exhibit two roots, while 26% demonstrate the presence of two canals.[2] According to a study conducted in 2023, the prevalence of single roots in mandibular first premolars was found to be 98.9%, two roots 1.1%, and the occurrence of three roots was negligible. In mandibular second premolars, single roots were observed in 98.8% of cases, two roots in 1.2%, and the incidence of three roots was negligible.[20]

The data obtained from the literature review are presented in **Table**. Consistent with the literature findings, three of the four cases we evaluated were second premolars, and one was a first premolar. One case a single root with two canals, two cases had two roots with two canals, and one case presented with taurodontism and two canals. Canal bifurcations were observed in the apical third in the case of taurodontism, while in one case, there were two separate entrances near the coronal portion of the root. In two cases, the canals originated from a single entrance and diverged at different levels in the middle third of the root. Consequently, each case required treatment with individualized therapeutic techniques.

DISCUSSION

Although existing cases predominantly show single roots in mandibular premolar teeth, the root morphology may present as two roots, three roots, or taurodontism. This observation highlights the necessity for endodontists to remain prepared for potential variations in each case.

The success of non-surgical root canal treatment (NSRCT) is contingent upon a comprehensive understanding of root and root canal morphology to accurately locate all canals and appropriately clean, shape, and fill the canal space three-dimensionally.[1]

Mandibular premolars predominantly exhibit a single canal morphology. Specifically, 78.3% of mandibular first premolars and 90.3% of mandibular second premolars possess a single canal. Subgroup analyses revealed higher incidences of single-rooted and single-canal premolars among Asian populations and females. Furthermore, while females demonstrated a higher prevalence of single-rooted premolars, males exhibited a higher frequency of double-rooted premolars.[19]

In mandibular first premolars, Vertucci type 1 and type 4 canal configurations are predominantly observed, whereas in second mandibular premolars, Vertucci type 1 and type 5 canal configurations are most frequently encountered.[2] Vertucci's research revealed that 0.5% of mandibular first premolars possess three canals at the apex, 25.5% have two canals, and 74% have a single canal. Two roots and two foramina constitute 4% of the cases.[21]

Second mandibular premolars are predominantly single-rooted (89.5-100%), followed by two-rooted mandibular second premolars with a frequency of less than 8%, while three roots have been reported in only 0.1% to 3.5% of cases.[10] The most frequently observed canal type is Vertucci type I, followed by Vertucci type V and Vertucci type IV. In mandibular second premolars, Vertucci type I is the most commonly observed classification, with a prevalence of up to 99.6%. The second most frequently reported type in mandibular second premolars is Vertucci type V, with a prevalence of 57.1%.[22]

The data obtained through literature review has demonstrate that mandibular premolar teeth predominantly exhibit a single root; however, two roots, three roots, taurodontism, and C-shaped root morphology can also be observed. Consequently, endodontists should be aware of the potential for encountering unexpected variations in each case. Due to these variations in mandibular premolars, it is of paramount importance to develop individualized treatment strategies.[3]

Understanding the root canal configuration in such teeth, attempting to access all canals using alternative techniques, and adapting standard canal treatment techniques to these teeth require extended working time and additional sessions. This necessitates patience from the clinician.

Prior to initiating treatment, radiographs should be obtained from different angles to determine the number and configurations of root canals. During radiographic examination, the internal and external contours of the tooth should be carefully observed. The presence of intersecting lines suggests additional canals. If a radiolucent line is present mesial or distal to the main canal, an additional canal should be suspected. If the radiographic image of the middle third of the root appears equal to or larger in diameter than the crown portion, a variation in root canal configuration may be considered. Radiographs taken from different angles also assist in visualizing additional canals. If the pulp space is observed to suddenly disappear or narrow on the radiograph, the presence of a bifurcation in that area should be considered.[23] Radiographic features, particularly the abrupt narrowing pattern evident in panoramic images of mandibular first premolars with multiple root canals, play a crucial role in enhancing diagnostic precision. This distinctive pattern is characterized by an intensification of radiographic opacity within the apical third of the root. Notably, the occurrence of the abrupt narrowing pattern is significantly more frequent in teeth possessing multiple root canals compared to their single-canal counterparts.[24]

These four distinct cases demonstrate that radiographs can often be sufficient in determining root canal configuration. When standard radiographic techniques prove inadequate for detecting anomalies or necessary information, CBCT imaging may be preferred.

In a study examining the diversity of root morphology in mandibular premolar teeth and associated clinical strategies, it is particularly challenging to fill the root canal below the bifurcation when multiple root canals are present and the bifurcation occurs in the apical third of the root. In such cases, when performing root canal filling, the root should be divided into segments, including the apical portion below the bifurcation and the more coronal section. After completing the filling of the apical segment, the filling of the upper segment is initiated. If the space in the upper portion is too narrow to accommodate multiple main cones simultaneously, the root canal filling sequence may proceed from the more difficult to the easier segments. The selected main gutta-percha cone is cut extraorally at the tooth level, and subsequently, the easier canal is filled. Bioceramic sealer may provide a superior solution to the filling problem in such challenging cases. During application, an appropriate amount of bioceramic sealer can be applied to the main gutta-percha tip to prevent excessive overflow and impairment of visibility. When filling separately, a paper cone or gutta-percha point can be inserted into another root canal to be filled to prevent the sealer or excess gutta-percha from obstructing the unfilled root canal. After radiographic examination confirms the completion of the filling in the apical segment, the upper portion of the root canal is filled. The upper segment can be filled using warm gutta-percha vertical compaction technology. To prevent thermal damage to the periodontal tissue due to the thin dentin wall transferring heat to the outer surface of the root, appropriate working time and temperature should be controlled during filling. A study similar to ours has also presented a comparable approach as a clinical strategy.[25]

In one case, shaping was performed using only hand instruments, while in another, both hand instruments and an endodontic motor were used. The remaining two cases were shaped exclusively using an endodontic motor. Consequently, when treating teeth with variable root canal configurations, it is essential to develop alternative treatment techniques and formulate personalized treatment strategies.

In the cases included in our study, we determined the root morphology and number solely through 2D radiographic imaging, without the use of CBCT. Clinical success can be achieved through careful planning, investigation, biomechanical preparation, and obturation of all canals. In a study similar to ours, endodontic treatment of a premolar tooth with two roots and canals was successfully completed without the use of CBCT.[26,27]

In cases of mandibular premolars exhibiting complex multi-root canal morphology, the use of CBCT imaging is imperative.

CONCLUSION

A comprehensive review of the literature has revealed that mandibular premolars frequently possess additional roots and canals. This anatomical characteristic negatively impacts the success rate of root canal therapy in these teeth. Endodontists must be prepared for the potential presence of additional roots and canals in these teeth and develop diverse treatment strategies accordingly. Extended treatment sessions and, in some cases, multiple appointments may be necessary. Our investigation has also shown that numerous cases can be effectively diagnosed and treated using conventional radiographic techniques without the need for CBCT imaging. The combination of literature analysis and existing case studies supports the conclusion that mandibular premolars with supplementary roots and canals can be successfully treated through conventional root canal therapy procedures.

ETHICAL DECLARATIONS

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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