EDITORIAL

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Root canal morphology and its importance for endodontics: an overview.

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Introduction

Root canal therapy (RCT) can be achieved by thorough cleaning, shaping, and filling the root canals. Sometimes, additional retreatment or endodontic surgery (ES) may be required. In these ways, it becomes possible to treat infections and diseases of the dental pulp and periapical tissues.

Understanding tooth anatomy and morphology of root canals is essential for successful therapy.

The complexity of root canal systems varies widely among teeth, obtaining comprehensive knowledge of this subject is crucial for effective endodontic intervention.

To date, root canal morphology has been investigated in numerous experimental and clinical studies [1-9] using various techniques such as decalcification, staining, tooth transparency, radiographic imaging, operating microscope, scanning electron microscopy (SEM), cone beam computed tomography (CBCT), micro-computed tomography (micro-CT), and magnetic resonance imaging. Of these, especially thanks to modern advanced technologies (e.g. SEM, CBCT, and micro-CT) used in recent years, detailed information about teeth and surrounding tissues can be collected. As a result of these studies, it has been reported that root and canal morphology show significant differences between different tooth types and populations, and even among different teeth of the same individual. It was discovered that the knowledge of previous traditional literature we have is rather inadequate, and almost every tooth has a specific anatomy and root canal morphology (Figure 1).

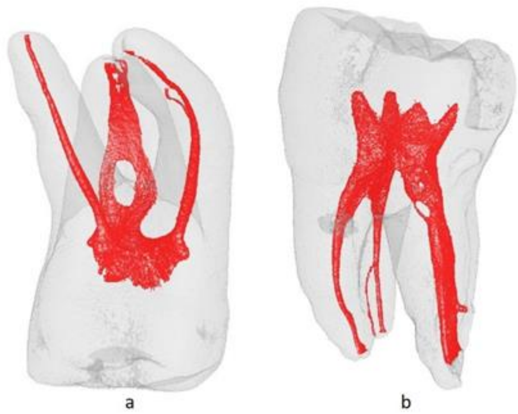

Figure 1. Micro-CT images of (a) maxillary and (b) mandibular molars. Complex root canal configuration is visible.

Revealing the complex structure of root canal morphology has led to the inadequacy of the root canal classification methods that used to describe this anatomy on relatively few parameters (e.g. number of canal orifices and foramina, main root canals) in the past (e.g. Weine and Vertucci classifications) [1-3,10,11]. Additional parameters have emerged due to advances in technologies and new root canal classifications are needed. It has been reported that classifications that include more comprehensive criteria for describing the detailed morphology of root canals, such as the presence of extra canals, canal connections and separations, and accessory canals, would be extremely beneficial for clinicians, researchers, educators, and students/trainees. One of the latest classifications is the method described by Ahmet et al. [12] in 2017. It includes a simple and understandable coding system. This code system allows us to see the data on tooth number and type, number of roots, canal configurations, canal orifices, accessory canals, apical foramen, isthmus, and developmental anomalies (dens invaginatus, C-shaped canals, taurodontism, supernumerary roots, and root fusions). In addition, deciduous teeth are encoded in this classification.

Teeth anatomy and root canal morphologies are currently being examined using artificial intelligence and machine learning to anticipate and classify complex canal systems based on big datasets. These advancements will make our work much easier.

Conclusion and Suggestions

- Understanding root canal morphology is essential for the success of the treatment. Accurate identification of all canals and their configurations (e.g. Figures 2 - 3) increases the likelihood of thorough debridement and reduces the risk of persistent infection.

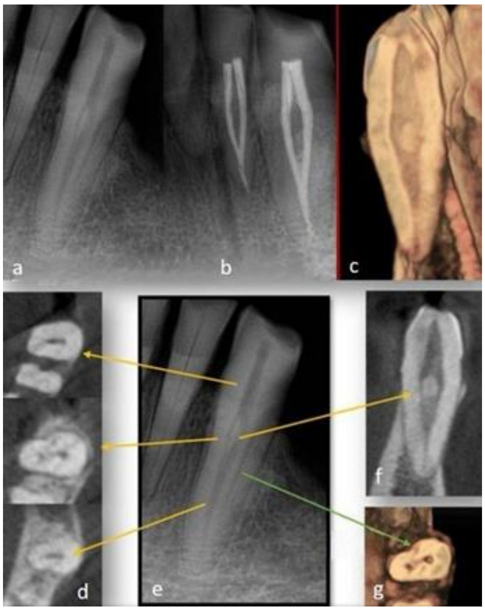

Figure 2. A complex root canal configuration (Vertucci type-3, 1-2-1 canal anatomy) in a mandibular canine. (a) initial radiograph, (b) after filling, (c) 3D reconstruction, (d) axial CBCT images in the coronal, middle, and apical thirds (yellow arrow), (e) 2D radiograph, (f) sagittal CBCT image, (g) root groove (green arrow).

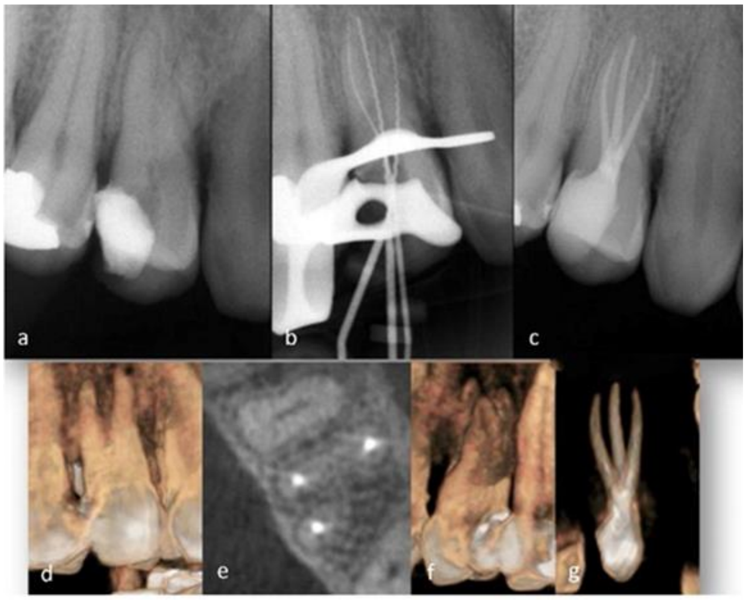

Figure 3. RCT of a maxillary first premolar with a 3-root and 3-canal. (a) initial radiograph, (b) working length determination, (c) after filling, (d) 3D reconstruction-buccal view, (e) axial CBCT image, (f) 3D reconstruction-palatinal view, (g) 3D reconstruction-root canal filling.

- Clinicians can avoid common pitfalls, such as perforations or missed canals. The reasons for failure, particularly in endodontic retreatment cases, should be evaluated morphologically. A thorough evaluation, typically assisted by imaging modalities such as CBCT, allows clinicians to prepare more efficiently.
- Each tooth presents unique anatomical challenges. Knowing the particular

morphology enables customized methods, such as selecting instruments and techniques appropriate for the given situation.

- Properly treated root canals in the initial treatment phase significantly enhance the prognosis for tooth survival and reduce the likelihood of future endodontic failures.
- When examining the collected data (e.g. patient history, internal/external/radiographic examinations), it should be evaluated using the following possible configurations that may be encountered: additional root/canal, C-shaped canal (Figure 4), isthmus, root canal curvature, mesiobuccal-2 and palato-mesiobuccal canals in maxillary molars, midmesial canal in mandibular molars (Figure 5), furcal canals, dilacerations, root fusion, radix entomolaris/paramolaris (Figure 6), taurodontism, accessory canals, palatogingival groove, dens invaginatus [13-19].

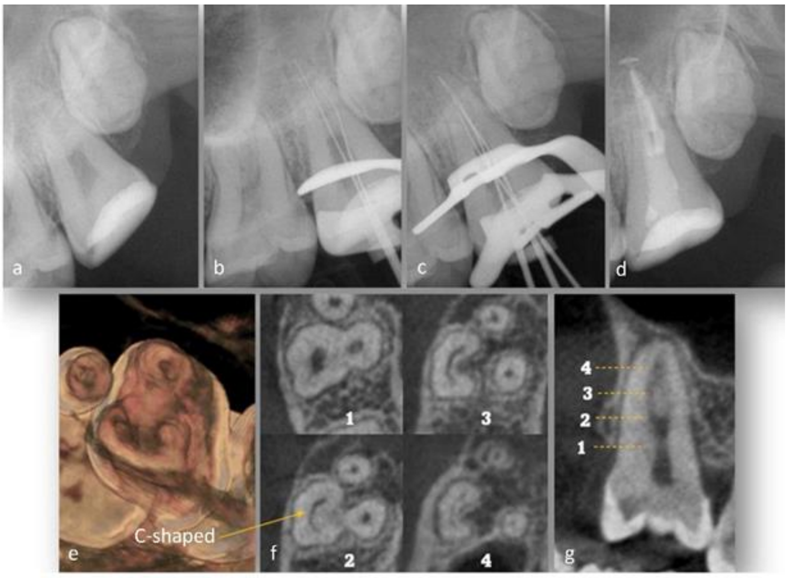

Figure 4. RCT of a maxillary second molar with a C-shaped canal. (a) initial radiograph, (b,c) working length determination, (d) after filling, (e) 3D reconstruction, (f) axial CBCT image from different levels (1-4) of the root canal, (g) sagittal CBCT image.

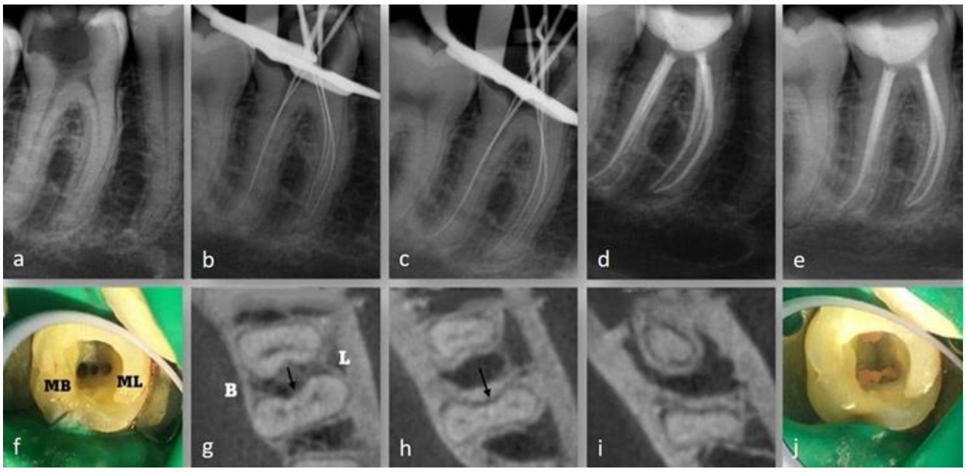

Figure 5. A midmesial canal in a mandibular first molar. (a) initial radiograph, (b,c) working length determination, (d,e) after filling, (f) canal orifices in mesial root, (g) coronal third- (black arrow shows midmesial canal), (h) middle third- (black arrow shows midmesial canal), (i) apical third-CBCT images, (j) canal orifices after filling.

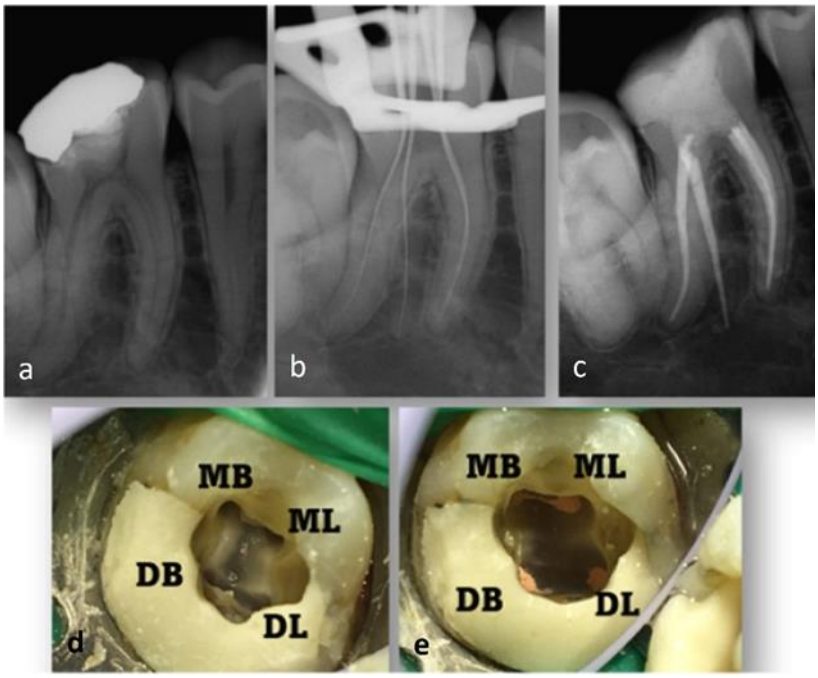

Figure 6. RCT of a mandibular molar with a radix entomolaris. (a) initial radiograph, (b) working length determination, (c) after filling, (d) canal orifices before filling, (e) canal orifices after filling.

- In procedures such as RCT and ES, the relationship of the related teeth with the surrounding anatomical structures and the apical region of the teeth is an important prognostic factor in both treatment options and treatment results. Therefore, these structures include the inferior alveolar neurovascular bundles, mental foramen and nerve, mandibular incisive canal, the anterior loop of the mental canal, and maxillary sinus should be thoroughly investigated prior to treatment [20-22].
- The current classification systems for root canal configurations and anomalies must be understood by everyone involved.
- Treatment procedures must be performed using magnification devices (dental loop/operation microscope).
- Using advanced technologies will increase the ability of clinicians to understand and visualise root canal morphology. Therefore, current developments should be followed.

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References
1. Okumura T. Anatomy of the root canals. J Am Dent Assoc. 1922; 14: 632-6.
2. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol Oral Radiol. 1984; 58: 589-99.
3. Vertucci F, Seelig A, Gillis R. Root canal morphology of the human maxillary second premolar. Oral Surg Oral Med Oral Pathol. 1974; 38: 456-64.
4. Sert S, Bayirli GS. Evaluation of the root canal configurations of the mandibular and maxillary permanent teeth by gender in the Turkish population. J Endod. 2004; 30: 391-8.
5. Perlea P, Nistor CC, Toma C, Dimitriu B. Endodontic configuration of the lower incisors in a Romanian population: a radiological study. Rom J Morphol Embryol. 2013; 54: 775-8.
6. Leoni GB, versiani MA, Pécora JD, de Sousa-neto MD. Micro-computed tomographic analysis of the root canal morphology of mandibular incisors. J Endod. 2014; 40: 710-6.
7. Crăciunescu EL, Boariu M, IoniŢă C, Pop DM, Sinescu C, Romînu M, NegruŢiu ML. Micro-CT and optical microscopy imagistic investigations of root canal morphology. Rom J Morphol Embryol. 2016; 57: 1069-73.
8. Drăgan OC, Fărcăşanu AŞ, Câmpian RS, Turcu RV. Human tooth and root canal morphology reconstruction using magnetic resonance imaging. Clujul Med. 2016; 89: 137-42.

9. Keleş A, Keskin C. Apical root canal morphology of mesial roots of mandibular first molar teeth with Vertucci type II configuration by means of micro-computed tomography. J Endod. 2017; 43: 481-5.
10. Weine F, Hayami S, Hata G, Toda T. Canal configuration of the mesiobuccal root of the maxillary first molar of a Japanese sub-population. Int Endod J. 1999; 32: 79-87.
11. Weine FS, Healey HJ, Gerstein H, Evanson L. Canal configuration in the mesiobuccal root of the maxillary first molar and its endodontic significance. Oral Surg Oral Med Oral Pathol. 1969; 28: 419-25.
12. Ahmed H, Versiani M, De-Deus G, Dummer P. A new system for classifying root and root canal morphology. Int Endod J. 2017; 50: 761-70.
13. Aydın H, Er K. Diversity of root canal morphology in mandibular premolars and its treatment strategies: diversity in mandibular premolars. G Ital Endod. 2023; 37: 92-110.
14. Keleş A, Keskin C, Çiftçioğlu E, Alak G. Evaluation of the band-shaped isthmuses in the mesiobuccal root canal system using micro-computed tomography. Clin Oral Investig. 2022; 26: 5909-14.
15. Versiani MA, Taşdemir T, Keleş A. Identification and characterization of a previously undiscovered anatomical structure in maxillary second molars: the palato-mesiobuccal canal. J Endod. 2023; 49: 730-4.
16. Aydın H. Correlations between additional roots in maxillary second molars, maxillary first premolars, mandibular first molars and mandibular first premolars: a retrospective cone-beam computed tomography analysis. Odontology. 2022; 110: 584-95.
17. Aydın H, Mobaraki S. Comparison of root and canal anatomy of taurodont and normal molar teeth: a retrospective cone-beam computed tomography study. Arch Oral Biol. 2021; 130: 105242.
18. Aydin H, Er K. Root canal treatment of maxillary molars with double palatal roots: case series. Clin Dent Res. 2020; 44: 30-40.
19. Er K, Kuştarci A, Ozan U, Taşdemir T. Nonsurgical endodontic treatment of dens invaginatus in a mandibular premolar with large periradicular lesion: a case report. J Endod. 2007; 33: 322-4.
20. Tuğ Kılkış B, Er K, Taşdemir T, Yildirim M, Taskesen F, Tümkaya L, Kalkan Y, Serper A. Neurotoxicity of various root canal sealers on rat sciatic nerve: an electrophysiologic and histopathologic study. Clin Oral Investig. 2015; 19: 2091-100.
21. Er K, Ayar A, Kalkan OF, Canpolat S, Tasdemir T, Ozan U. Neurotoxicity evaluation of three root canal sealers on cultured rat trigeminal ganglion neurons. J Clin Exp Dent. 2017; 9: e34-9.
22. Yanık D, Nalbantoğlu AM, Er K. Sinus membrane thickness of healthy endodontically treated maxillary molars. Clin Oral Investig. 2024; 28: 418.

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