Review Article

ROOT CANAL MORPHOLOGY AND ITS RELATIONSHIP TO ENDODONTIC PROCEDURES

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ABSTRACT

Effective endodontic treatments hinge on a thorough understanding of root and root canal morphology. The variability and complexity of external and internal root features have prompted various classifications to define common canal configurations. Advances in nondestructive digital imaging, such as cone-beam and micro-computed tomography, coupled with the integration of magnification in clinical practice, have led to increased recognition of complex root canal anatomy. However, existing classification systems often fall short of accurately categorizing many configurations revealed by these newer techniques.

The Medline, Pubmed, Embase, NCBI, and Cochrane databases were searched for studies of patients with non-alcoholic fatty liver disease. Incidence, etiology, and management options were analyzed. Endodontics demands meticulous attention to tooth anatomy for successful therapy. Reliance on radiographs is crucial, but caution is urged against techniques compromising evaluation. As well, one must acknowledge the complexity of root canals and any classification system of the same must aim for precision. Challenges in diverse tooth anatomies, especially in molars, must also be acknowledged. Advanced imaging, like cone-beam CT, participates in preoperative assessment. Ongoing research explores technology for accurate endodontic interventions, and practitioners are generally encouraged to integrate information from various sources, including radiographs and advanced tools, in navigating the intricate landscape of root canal therapy. The goal remains thorough cleaning and obturation, with high success rates reflecting clinicians' dedication.

Key words: Anatomy, Canal configuration, Classification, Morphology, Root.

Introduction

Before initiating endodontic therapy, it is crucial to visualize and understand the internal anatomy relationships. A careful assessment of two or more periapical radiographs is necessary, as these angled images offer vital insights into root canal morphology [1]. Thus, x-ray tube inclination has a well-documented impact on accurately identifying the root canal system in premolar teeth: adjusting the horizontal angle reveals the actual number of canals in maxillary first and second premolars, as well as for mandibular second premolars, will reveal the correct morphology. We cannot understate the significance of thoroughly evaluating each radiograph before and during endodontic therapy, whose significance is also well-documented [2]. In a case report involving five canals in a mandibular first molar, it was highlighted that the radiographic appearance facilitated the recognition of complex canal morphology. The study cautioned against developing techniques requiring fewer radiographs, as it may lead to missing crucial information for the success of therapy.

However, the correct morphology cannot always be properly determined by radiographs, especially with only a buccolingual view [3]. In another study where the “fast break” guideline was used on 790 radiographed mandibular incisors and premolars to assess canal bifurcation incidence in a root, it was found that relying on a single radiographic view failed to diagnose one-third of canal divisions [4]. Thus, dentists will produce the most accurate evaluation of the root canal system when they combine information from multiple radiographic views which thoroughly explore the tooth's interior and exterior clinically.

The primary goal of root canal therapy is to shape and clean all pulp spaces thoroughly and completely obturate them with inert filling material. The presence of an untreated canal can lead to failure, emphasizing the importance of clinicians using all available tools to locate and treat the entire root

canal system. It is humbling to acknowledge the complexity of the spaces we access, shape, clean, and fill. Despite these challenges, current root canal therapy methods yield exceptionally high success rates, even in difficult circumstances. Diagnostic measures such as multiple pre-operative radiographs, exploration of the pulp chamber floor, and the use of various techniques aid in locating root canal orifices [5]. The dental-operating microscope (DOM) has become a valuable tool in endodontics, providing enhanced lighting and visibility. It brings minute details into clear view, enabling precise dentine removal and minimizing procedural errors. Several studies have demonstrated its effectiveness in increasing the dentist's ability to locate and negotiate canals. Magnification and illumination are deemed essential tools for successful endodontic therapy, as shown by various studies exploring the use of DOM and other magnification devices [6].

Root canal anatomy

Understanding canal morphology and its variations is fundamental for successful endodontic outcomes, alongside diagnosis and treatment planning [7]. Variations in canal geometry before shaping and cleaning procedures have a greater impact on preparation changes than the actual instrumentation techniques. From the pioneering work of Hess and Zurcher [8] to recent studies revealing the intricacies of root canal systems, it has been established that it is not as common as previously thought to encounter a root with a tapering canal and a single foramen. Multiple foramina have been identified, including additional canals, fins, deltas, intercanal connections, loops, 'C-shaped' canals, and accessory canals. Thus, practitioners should approach each tooth assuming that complex anatomy is a common occurrence. Dentists need to familiarize themselves with the plurality of pathways taken by root canals as they make their way to the apex, given the complexity of the pulp canal system. Indeed, canals may branch, divide, and rejoin. Four basic categories of root canal systems have been categorized by Weine [9], while Vertucci and colleagues [10], using cleared teeth stained with hematoxylin dye, identified eight pulp space configurations. Caliskan and colleagues [11] and Kartal and Yanikoglu [12] found additional canal configurations, emphasizing population variations. Gulabivala and colleagues discovered seven more canal configurations in Burmese molars. Sert and Bayirli [13] suggested gender influences canal morphology, emphasizing the need for considering both gender and ethnic origin during preoperative evaluation. Numerous case reports highlight complex canal configurations, acknowledging the increasing awareness of such anatomical variations. Trope and colleagues [14] noted racial differences in canal types, with black patients having a higher incidence of extra canals in mandibular premolars than white patients. Krasner and Rankow [15] proposed laws based on the pulp chamber floor and wall anatomy to aid in determining canal morphology. These laws, including symmetry, color change, and orifice location, provide guidance for locating canal orifices and understanding their configurations. As individuals age, the pulp cavity decreases in size and dentine formation varies, resulting in a flattened pulp chamber. The clinician faces a highly complex and variable root canal system, necessitating the use of all available tools for a successful outcome.

Before treatment, the real number of root canals cannot in all likelihood be determined by clinicians. The cemento-enamel junction serves as a crucial landmark, and laws proposed by Krasner and Rankow aid in identifying canal morphology. In cases of calcified pulp cavities, magnification, illumination, and occasional radiographs are essential for locating canals. Various tools, including ultrasonic tips and the dental operating microscope, facilitate the location of calcified root canals. Magnification and illumination are crucial for evaluating color changes and working deep inside the tooth. Special care is needed when dealing with complex canal configurations to avoid procedural errors and ensure successful outcomes [15].

New classification system

For 50 years, we have been using a fairly traditional method method of categorizing root canal configuration, using simple Roman numerals. However, recent research has revealed significant variations in root canals, rendering current systems based on a single number inadequate, inaccurate, and potentially misleading [16]. This points to the fact that it is becoming necessary to develop a better coding system that can describe root and canal configurations with more accuracy and would be of greater benefit to educators, researchers, students, and clinicians alike.

This new classification system aims to be straightforward, precise, and practical, additionally, it should provide information on the root and root canal anatomy [17]. Notably, it does not delve into factors such as the degree of root and root canal curvature, separation, bifurcation levels, root fusion types, accessory canals (lateral and furcation canals), or apical deltas. These parameters, though they had been considered while the system was being developed, were deemed to introduce unnecessary complexity and potential confusion [18]. The focus is on simplicity to ensure universal adoption. Existing literature contains numerous comprehensive classifications covering developmental anomalies like dens invaginatus, C-shaped canals, taurodontism, supernumerary roots, root fusions, and more. The proposed classification in this article refrains from reclassifying abnormalities already extensively discussed in the literature. It is important to note that the major apical foramen, as defined by Vertucci in 2005, serves as a crucial reference point for the apical termination of canal instrumentation and filling procedures [19].

Teeth, notably molars, exhibit diverse root canal anatomies, featuring multiple roots and varying canal numbers.

Common variations such as accessory canals, isthmi, and lateral canals pose challenges during the cleaning and shaping phases. Clinical challenges arise when additional canals or complex configurations hinder thorough debridement and disinfection, potentially leading to treatment failure. Precise preoperative assessment, facilitated by advanced imaging like cone-beam computed tomography (CBCT), is paramount for understanding three-dimensional internal anatomy [20]. Ongoing research explores technological advancements such as electronic apex locators and ultrasonic instruments to enhance treatment accuracy.

Population-specific variations in tooth morphology underscore the importance of tailoring endodontic procedures to diverse demographics. Clinical guidelines factor in tooth anatomy, recommending specific techniques based on anatomical characteristics. Relevant literature, found in peer-reviewed journals and endodontic textbooks, provides comprehensive insights into this dynamic interplay, guiding practitioners toward more effective and tailored endodontic interventions [21].

Conclusion

The field of endodontics demands a meticulous approach to the internal anatomy of teeth to achieve successful outcomes in therapy. The reliance on periapical radiographs as a diagnostic tool is underscored, with studies revealing the impact of X-ray tube inclination on accurately identifying root canal systems. However, caution is advised against developing techniques that compromise the thorough evaluation of radiographs, as crucial information for the success of therapy may be missed. The complexity of root canal anatomy is emphasized, acknowledging the myriad variations in canal morphology.

From the pioneering work of Hess and Zurcher to contemporary studies, it is established that assuming complex anatomy as a common occurrence is essential. The proposed new classification system addresses the inadequacies of current methods, aiming for simplicity and precision in describing root and root canal configurations.

The correlation between tooth morphology and endodontic procedures highlights the challenges posed by diverse anatomies, especially in molars with multiple roots and canals. Advanced imaging techniques, such as cone-beam computed tomography, play a crucial role in preoperative assessment. The dynamic interplay between tooth anatomy and evolving endodontic interventions is evident, with ongoing research exploring technological advancements to enhance treatment accuracy. In navigating the intricate landscape of root canal therapy, practitioners are reminded of the importance of combining information from multiple sources, including radiographs, clinical exploration, and advanced tools like the dental operating microscope. The ultimate goal remains shaping and cleaning all pulp spaces thoroughly and obturating them completely. Despite the complexities involved, current root canal therapy methods demonstrate high success rates, reflecting the dedication of clinicians to master the art and science of endodontics.

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