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Apical Delta an Unsolved Mystery– Review

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I. Introduction:

Anatomy is the foundation of art and science of healing. Of all the phases of anatomic study in human system, one of the most complex is root canal system. The terminal part of root canal is the center of most activity and concern in the treatment and filling of root canal. It has long been established that a root with a tapering canal and a single foramen is the exception rather than the rule. Investigators have shown multiple foramina, additional canals, fins, deltas, inter canal connections, loops, C shaped‘ canals and accessory canals.Consequently the practitioner must treat each tooth assuming that complex anatomy occurs often enough to be considered normal (1).The apical limit of root canal instrumentation and obturation is one of the major controversial issues in root canal therapy. For decades this subject has been, and still continues to be, a topic of discussion between endodontists. So, knowledge of the anatomy and histological composition of the apical third of the tooth in determining the ideal apical limit for instrumentation and filling of the root canal is of vital importance. Apical delta is an intricate system of cavities which allows free passage of numerous blood vessels and nerves from the pulp cavity to the root apex (2,3).Its morphological feature may be depicted as a root canal dividing into three or more ramifications near the root apex, with the main canal becoming indistinguishable (4,5). The apical delta is different from the accessory canal in which the main pulp canal is still distinguishable. Clinically, the inflamed, sometimes infected tissue in the apical delta is associated with periradicular disease (6,7). Biofilms that colonize the apical delta in advanced stages of apical periodontitis or in cases with longstanding necrosis may jeopardize the prognosis of root canal treatment (8). Because the ramifications within the apical delta are difficult to clean with root canal instruments and irrigants, the presence of incompletely cleaned apical deltas may adversely affect the long-term prognosis of root canal therapy (9,10). The prevalence of apical deltas in human permanent teeth varies among tooth locations, populations and study methods. Apical deltas are mostly found in maxillary second premolars, mandibular lateral incisors, and mandibular second premolars (11). Using a clearing technique, Vertucci reported that the prevalences of apical deltas in the mandibular central incisors, lateral incisors and canines were 5%, 6% and 8%, respectively in an American patient population (12). Caliskan and colleagues, however, reported that the prevalences of apical deltas in those teeth were 9.8%, 23.5% and 7.8% in a Turkish patient cohort (11). For the mesiobuccal root of maxillary first molars, Rwenyonyi and coworkers identified a 5% prevalence of apical deltas in a Uganda population (13) while Bhuyan and coworkers reported a 25% prevalence in an Indian population (14). Studies on the morphology of apical delta are mostly conducted using the canine model. The typical apical delta of a dog is manifested as “sprinkler-rose” anatomy with numerous narrow channels radiating peripherally (Fig. 1). Almost 60% of the apical deltas in dogs have more than 10 branches and the foramina have a diameter ranging from 20 to 150μm (15). Ninety-seven percent of those apical deltas have vertical extensions that are less than 3mm from the anatomical apices. Acquisition of such information is essential to simulate the apical delta accurately in fluid dynamics simulations of the root canal spaces, explore the efficacy of canal debridement technique, as well as in root-end resection procedures in surgical endodontics. This review will describe the significance of apical delta in endodontic management.

Apical anatomy:

The classic concept of apical root anatomy is based on three anatomic and histologic landmarks in the apical region of a root: the apical constriction (AC), the cementodentinal junction (CDJ), and the apical foramen (AF) (16). Apical foramen is an aperture at or near the apex of root, through which the nerve and blood vessels of pulp pass, represents the junction of the pulp and periodontal tissue. In young incomplete developed tooth, apical foramen is funnel shape, so called bluder buss apex. Apical foramen may be round, oval or elliptical, semilunar in shape. Location and shape of the fully formed foramen vary in each tooth and in the same tooth at different periods of life (16,17).

The apical foramen is not always located in the center of the root apex. Usually, the apical foramen opens 0.5 – 1.0 mm from the anatomical apex. This distance is not always constant and may increase as the tooth ages because of the deposition of secondary cementum. It may exit on the mesial, distal, labial or lingual surface of the root, usually slightly eccentrically (18).

This apical portion of the root canal having narrowest diameter is called apical constriction. It occurs about 0.5 – 1.0 mm from the apical foramen. It has also been called minor apical diameter. Postoperative discomfort generally greater when this area is violated by instruments or filling materials and the healing process may be compromise. Again, the portion of the apical constriction varies with age as deposits of secondary dentin, within the root canal; site of the constriction is away from the apex. Ideally, the root filling should stop at this constriction as it would serve as ―apical dentin matrix‖. Several shapes of apical ―constriction‖ given by Dummer et al., Parallel 35%,Single 18%, Tapering (―Classic‖) 15%, Flaring 18%,Delta 12% (18) (Fig. 1).

The cemetodentinal junction is the point in the canal where cementum meets dentin.it is the point where pulp tissue ends and periodontal tissue begins. The location of cementodentinal junction is generally not the same area as the apical constriction and estimate place it appromixately 1mm from the apical foramen. This variability reconfirmed that the CDJ and AC are generally not the same area and that the CDJ should be considered just a point at which two histologic tissues meet within the root canal. The diameter of the canal at the CDJ was highly irregular and was determined to be 3.53 mm for maxillary centrals, 2.92 mm for lateral incisors and 2.98 mm for canines (19). Kuttler (1955) concluded that the root canal had two main sections, a longer conical section in the coronal region consisting of dentin and a shorter funnel shaped section consisting of cementum located in the apical portion. The shape of this apical portion is considered to be an inverted cone; its base being located at the major apical foramen (19) (Fig. 2). The apex of the inverted cone is the minor foramen that is often thought to coincide with the apical constriction regarded as being at or near the cemento-dentinal junction (CDJ).

Accessory canals are channels leading from the radicular pulp laterally through the root dentine to periodontal tissue. It may seen anywhere along the root dentine, but particularly numerous at apical third. some open approximately at right angles to the main pulp cavity are termed ―lateral canals.‖ Lateral canals are found more in roots of posterior teeth and occasionally in roots of anterior teeth (20), more common in bifurcation and trifurcations regions of molar teeth. Hess in 1925, by the use of vulcanite corrosion specimens detected, the incidence of 16.9% of lateral canals in all teeth. According to Hess (1983) accessory foramina have a mean diameter of 6 to 60 µm (20,21). In many teeth, the width of the accessory canals and sometimes lateral canals is exceedingly small, permitting only presence of small caliber blood vessels and their supporting stroma. Usually these small canals cannot be observed on radiographs. If root canal break up into multiple tiny canal it is referred to as delta system because of its complexity (21,22).

Apical delta

Apical delta is not exactly an accessory or lateral canal. "An apical delta is the multiple accessory canals that branch out from the main canal at or near the root apex. Apical deltas are not taken into consideration in many of the classifications. H. M. A. Ahmed et al in 2018 proposed a new system for classifying accessory canal morphology. If one of the roots has an accessory canal(s) in two of the three-thirds of the root, then the code 2 TN R1 (TaO-CaF,TaO-C-aF) R2, n TN R1(TaO-C-aF,TaO-C-aF) R2 Rn will be used for double- and multirooted teeth, respectively. 2Lateral radiolucent areas are related usually to accessory canals located in the middle third of the root (Silveira *et al*. **2010**). Accessory canals located in the apical third, as well as apical deltas, are one of the main causes for persistent apical periodontitis (Iqbal *et al*. **2005**, Arnold *et al*. **2013**). Therefore, a root-end resection of at least 3 mm has been advised to remove the majority of accessory canals and any potential apical delta, thus, reducing the risk of periapical inflammatory responses and eventual failure (Kim &Kratchman **2006**) (23).

Formation of Apical delta

Lateral and apical ramifications of the main root canal are formed after a localized fragmentation of the epithelial root sheath develops, leaving a small gap, or when blood vessels running from the dental sac through the dental papilla persist.Dentinogenesis does not occur in this specific area, giving rise to a canal containing small blood vessels and nerves (8).

Histological types of Apical delta

Type I : very thin dentin, big pulp cavity and open root apex, a small amount of HERS also present
Type II: The root apex was closed, dentin was thin, pulp cavity was big

Type III a: apical delta was low, thicker dentin
Type III b: apical delta was very deep, and had thicker dentin and a narrow pulp cavity (24).

Morphology and prevalence of Apical delta

Studies on the morphology of apical delta are mostly conducted using the canine model.The typical apical delta of a dog is manifested as “sprinkler-rose” anatomy with numerous narrow channels radiating peripherally. Almost 60% of the apical deltas in dogs have more than 10 branches and the foramina have a diameter ranging from 20 to 150μm. Ninety-seven percent of those apical deltas have vertical extensions that are less than 3mm from the anatomical apices.Gao et al. demonstrated a micro-CT evaluation of apical delta morphologies on human teeth. 136 apical deltas were detected in 1400 teeth (Table: 1). Molars had more apical deltas (15.8%) than anterior teeth (6.3%). In maxillary molars, the mesiobuccal root had a significantly high prevalence of apical delta than the palatal or distobuccal root. The median vertical distance of the apical delta was 1.87mm with 13% more than 3mm. The median diameter and length of the apical delta branches were 132.3 and 934.5μm. Apical delta branches were not straight with cross-sectional shapes being non-circular. These morphological features of apical delta may complicate debridement of the infected root canal system (25,26).

Debriding and cleaning of Apical delta

Extensions of the main root canal, such as lateral canals, ramifications in the apical delta, isthmuses, and dentinal tubules are generally difficult to clean, because the irrigant does not easily penetrate those regions. Complete debridement of these regions through mechanical instrumentation alone is impossible, and necrotic tissue remnants and microorganisms in the apical portion of the canal are common place in cases of persistent infection. Irrigation of the canals with various irrigants alone is not efficient enough in debridement of canals with multiple complexities. Activation of the irrigant could help to improve irrigant delivery throughout the root canal system and also enhance themixing,refreshment, and the chemical properties of the irrigant. Diffusion of the irrigant into a lateral canal can be improved by increasing the concentration or temperature of the irrigant. Lateral flows can be induced by the sonic, ultrasonic, or laser activated systems, thereby enhancing tissue dissolution in lateral canals, tissue dissolution or partial debris removal from isthmuses, or dentin debris removal from oval extensions. Furthermore, the acoustic streaming induced by ultrasonic activation and bubbles generated by ultrasonic and laser activation can enhance the convection near the lateral canal entrance and thereby increase irrigant transport within such canals (27,28). .

The sealing of the complexities is as difficult as achieving complete debridement of canals through irrigation and different irrigating techniques. Providing a three dimensional hermetic seal is the main objective of endodontic treatment. Proper seal is required to cease the chance of proliferation of bacteria and future occurrence of any pathology. The sealer and the obturating material should form a interface with the dentine (28).

Obturation of apical delta

Many techniques have been administered to obturate a canal. A group at Harvard Institute developed an injection device in 1977 to deliver heatsoftened gutta-percha to the canal space. Heating of gutta-percha outside the tooth and injecting the material into the canal is an additional variation of the thermoplastic technique. The Obtura, Calamus, Elements, HotShot, and Ultrafil 3D are available devices. The Obtura system heats the gutta-percha to 160°C. The Obtura system (Obtura Spartan) consists of a hand-held “gun” that contains a chamber surrounded by a heating element into which pellets of gutta-percha are loaded .Silver needles of size 23 is attached to deliver the thermoplasticized material to the canal. The control unit allows the operator to adjust the temperature and thus the viscosity of the gutta-percha. At 6 mm from the apex a study found that the highest internal temperature with the Obtura system was 27°C24 .The thermoplasticized techniques allow the high compaction forces to be directed towards the gutta-percha within the accessory canals, resulting in a complete three-dimensional filling of ramifications of the middle and coronal regions (27,28)

Termination of cleaning and shaping and obturation

Vital cases: The bulk of the tissues in ramifications remained undisturbed and uninflamed in the absence of bacteria. This is because, tissue vitality and relative normality are maintained by PDL blood circulation.

Maintaining the vitality is desirable, because with forceful extrusion of materials such as root canal sealers into these ramifications would unnecessarily create a large wound (8).

Non vital teeth: Application of intracanal medicaments with calcium hydroxide display the potential to reach these areas to exerts disinfecting effects.Filling of apical deltas with warm vertical condensation obturation technique provide better than using lateral compaction technique. The vertical extension of the apical delta suggests that resection of the apical 3 mm of a root may include the whole apical delta and residual microorganisms from 87% of roots with apical delta (8).

Apicectomy

The exposed ramifications of the resected root end may become a potential route for microleakage of bacterial by-products after retrograde filling. Hence, meticulous examination under a surgical microscope with dyes on the resected root end and extending the resection length correspondingly are mandatory to avoid leaving behind open ramifications of the apical delta(Fig 1) (29,30).

II. Conclusion

The morphological variation and technical challenges involved in treatment of the apical third seems infinite. The root apex is morphologically, therapeutically a challenging zone and prognostically an important but unfortunately unclear area.Soendodontist should have detail knowledge of anatomic variation and mechanical challenge involve in treatment of apical third for effective management of endodontic therapy

References

[1]. Frank J. Vertucci; Root canal morphology and its relationship to endodontic procedures. Endodontic Topics 2005; 10(1): 3–29.

[2]. Barker et al. Utilization of the mandibular premolars of the dog for endodontic research. Aust. Dent. J. 1971; 16:280-286.

[3]. Harvey et al. Anatomy of the oral cavity in the dog and cat. In. Veterinary Dent. 1985; Harvey C.E ed. 11-22.

[4]. Verma, P. & Love, R. M. A micro CT study of the mesiobuccal root canal morphology of the maxillary first molar tooth. IntEndod J.2011; 44, 210–217.

[5]. Liu, N. et al. A micro-computed tomography study of the root canal morphology of the mandibular first premolar in a population from southwestern China. Clin Oral Investig. 2013; 17, 999–1007.

[6]. Shrestha, A. &Kishen, A. Antibacterial nanoparticles in endodontics: A review. J Endod. 2016; 42, 1417–1426.

[7]. Zhang, L. et al. Tumor necrosis factor receptor-associated factor 6 plays a role in the inflammatory responses of human periodontal ligament fibroblasts to enterococcus faecalis. J Endod.2015; 41, 1997–2001.

[8]. Ricucci, D. &Siqueira, J. F. Fate of the tissue in lateral canals and apical ramifications in response to pathologic conditions and treatment procedures. J Endod. 2010; 36, 1–15.

[9]. Arnold, M., Ricucci, D. &Siqueira, J. F. Infection in a complex network of apical ramifications as the cause of persistent apical periodontitis: a case report. J Endod. 2013; 39, 1179–1184.

[10]. Wada, M. et al. Clinical study of refractory apical periodontitis treated by apicectomy. Part 1. Root canal morphology of resected apex. IntEndod J. 1998; 31, 53–56.

[11]. Calişkan, M., Pehlivan, Y., Sepetçioğlu, F., Türkün, M. &Tuncer, S. Root canal morphology of human permanent teeth in a Turkish population. J Endod. 1995; 21, 200–204.

[12]. Vertucci, F. J. Root canal anatomy of the mandibular anterior teeth. J Am Dent Assoc. 1974; 89, 369–371.

[13]. Rwenyonyi, C. M., Kutesa, A. M., Muwazi, L. M. &Buwembo, W. Root and canal morphology of maxillary first and second permanent molar teeth in a Ugandan population. IntEndod J. 2007; 40,679–683.

[14]. Bhuyan, A. C., Kataki, R., Phyllei, P. & Gill, G. S. Root canal configuration of permanent maxillary first molar in Khasi population of Meghalaya: An in vitro study. J Conserv Dent. 2014; 17, 359–363.

[15]. Takahashi, K., Kishi, Y. & Kim, S. A scanning electron microscope study of the blood vessels of dog pulp using corrosion resin casts. J Endod. 1982; 8, 131–135.

[16]. SachdevaGs, Ballal S, Gopikrishna V, KandasWamy D; Endodontic management of a mandibular second premolar with four roots and four root canals with the aid of spiral computed tomography: a case report. J Endod., 2008; 34(1):104-107.

[17]. Smulson MH, Hagen JC, Ellenz SJ; Pulpoperiapical pathology and immunologic considerations. In Weine FS, editor; Endodontic Therapy, 5 th edition, St. Louis, Mosby, 1996.

[18]. Dummer PM, McGinn JH, Rees DG; The position and topography of the apical canal constriction and apical foramen. IntEndod J 1984; 17(4): 192–198.

[19]. Kuttler Y; Microscopic investigation of root apexes. J Am Dent Assoc., 1955; 50(5): 544-552.

[20]. Vertucci FJ; Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol., 1984; 58(5): 589-599.

[21]. Vertucci FJ, Anthony RL; A scanning electron microscopic investigation of accessory foramina in the furcation and pulp chamber floor of molar teeth. Oral Surg Oral Med Oral Pathol., 1986; 62(3): 319-326.

[22]. Vertucci FJ, Seelig A, Gillis R; Root canal morphology of the human maxillary second premolar. Oral Surg Oral Med Oral Pathol., 1974; 38(3): 456-464.

[23]. Ahmed et al. A new system for classifying accessory canal morphology. Int. Endod. J. 2017; 51(2):164-176.

[24]. Formation of apical delta in dogs teeth; watanabe et al; j. vet. Med. Sci; 2001

[25]. Takahashi et al. A scanning electron microscope study of the blood vessels of dog pulp using corrosion resin casts. J Endod. 1982; 8:131–135.

[26]. Gao et al. Micro-CT evaluation of apical delta morphologies in human teeth. J sci. rep. 2017; 6:36501.

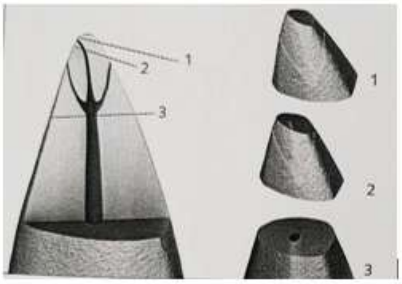
[27]. Cohenca et al. Disinfection of root canal systems: The treatment of Apical Periodontitis.John Wiley & Sons. 2014; IncISBN:9781118914014

[28]. Ingles textbook

[29]. Jang et al. Influence of apical root resection on the biomechanical response of a single-rooted tooth: a 3-dimensional finite element analysis. J Endod. 2014; 40:1489–1493.

[30]. Gamm, D., Howar, P., Walia, H. &Nencka, D. Prevelence and morphologic features of apical deltas in the canine teeth of dogs. J Am Vet Med Assoc. 1993; 202:63–70.

Figure 1



	1mm	2mm	3mm
Apical ramifications	52%	78%	98%
Lateral canals	40%	86%	93%

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