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REVIEW ARTICLE

Extra Roots and Root Canals in Premolar and Molar Teeth: Review of an Endodontic Challenge

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ABSTRACT

The main goal of endodontic treatment is healing of the periapical tissues which are gained by elimination of bacteria and their byproducts from the canal and prevention from reinfection. Understanding of root canal anatomy is an essential part in endodontic treatment. Anatomic forms and variations in special teeth should be well known, one of them is extra roots/canals. Although possible aberrations of canal anatomy should be considered for all teeth, some teeth should be highlighted. This review addresses the prevalence, diagnosis (clinical and radiographic), and endodontic management of teeth with extra roots/canals.

Keywords: Extra root, Anatomy, Endodontics.

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INTRODUCTION

The main objective of root canal treatment is the thorough mechanical and chemical cleansing of the entire pulp cavity and its complete obturation with an inert material and a coronal filling preventing ingress of microorganisms.[1] To do so, the clinician must have a thorough understanding of normal anatomy, and of common variations from the norm. The clinician must also be prepared to identify those teeth that tend to vary greatly from the norm.[2] Hoen and Pink[3] found that in teeth that needed re-treatment the incidence of missed roots or canals was 42%.

The purpose of this review is to address the prevalence, diagnosis (clinical and radiographic), and endodontic management of teeth with extra roots and root canals.

EPIDEMIOLOGY

Maxillary Premolars

In the case of maxillary first premolar, three root canals are found at a frequency of 0.5 to 6%,[4-7] generally with one canal in each of three roots. The incidence of three-rooted maxillary first premolar was 0 to 6% in different studies (Tables 1 and 2).[6,8,9] In the case of second premolar, laboratory studies have demonstrated a lower of three root canals between 0.3 and 2%.[4,6,10,11] Bellizzi and Hartwell[7] found only 1.1% of teeth with three canals, and did not report any with three roots. Kartal et al[9] investigated internal anatomy of maxillary premolars. They found that only 1.66% of maxillary first premolars and 0.66% of maxillary second premolars had three canals. The possibility of three roots in maxillary second premolars is quite small and only few cases have been reported.

Table 1. Percentage of three roots in the maxillary first premolars

Author (Year)	*Percentage*
Ingle (1965)	2.0
Carns and Skidmore (1973)	6.0
Vertucci and Gegauff (1978)	4.0
Pecora et al. (1991)	2.5
Loh (1996)	0.0
Kartal et al. (1998)	1.3
Chaparro et al. (1999)	3.3

Table 2: Percentage of three canals in maxillary first premolars

Author (Year)	*Percentage*
Pineda and Kuttler (1972)	0.5
Green (1973)	0.0
Carns and Skidmore (1973)	6.0
Pecora et al. (1991)	2.5
Kartal et al. (1998)	1.7

Maxillary Molars

Anatomic characteristics of permanent maxillary molars are generally described as a group of teeth with three roots, one palatal and two buccal, each root with one root canal. The occurrence of a second mesiobuccal canal when there are four canals is also common. Some studies report variations in the number of root canals. Beatty[12] as well as Ferguson et al[13] presented a case of a maxillary first molar with five canals, three of which were located in the mesiobuccal root. Bond et al[14] reported a case of maxillary first molar with six canals: two canals with separate foramina in the mesiobuccal root, canals with separate foramina in the distobuccal root and two canals joining in the apical third of the palatal root. Hulsmann[15] presented a maxillary first molar with two distinct canals in the distobuccal root. Slowey[16] showed a case of a maxillary molar with two palatal canals and separate foramina. Martinez-Berna and Ruiz-Badanelli[17] reported three cases of maxillary first molars with six canals: three canals in the mesiobuccal root, two in the distobuccal root and one in the palatal root. Wong[18] reported a case in which the palatal root had a single canal orifice, a trifurcation in the apical third and three separate foramina. Maggiore et al[19] reported a maxillary first molar with two palatal canals, one of them bifurcating approximately 4 mm from the working length and three separate foramina.

The number of roots in maxillary molars can also vary. Diamond[20] reported two extracted maxillary first molars with four roots two of which were palatal, large and divergent. Slowey[21] also reported the treatment of a maxillary first molar with two palatal roots and showed a maxillary second molar with four independent roots.

Libfeld and Rotstein[22] examined 1200 molars and found a 0.4% incidence of maxillary molars with four roots. Barbizam et al[23] reported a maxillary first molar with two buccal and two palatal roots and a second maxillary molar with two root canal orifices at the palatal root and two at the buccal roots. Christie et al[24] reported 14 maxillary second molars and 2 maxillary second molars with two palatal roots found during 40 years of daily clinical practice. They classified maxillary molars according to the shape and root separation as types I, II and III. Type I maxillary molars have two widely diverge palatal roots, which often long and tortuous. Type II have four separate roots, but the roots often are shorter, run parallel, have buccal and lingual root morphology, and have blunt root apices. Type III are constricted in root morphology with the mesiobuccal, mesiopalatal, and distopalatal canals encaged in a web of root dentin. The distobuccal root in these cases seems to stand alone and may even diverge to the distobuccal.

Sabala et al[25] found that type II palatal roots are bilateral in 90% of cases. Furthermore, Deveaux[26] reported bilateral maxillary second molars with two palatal roots.

MANDIBULAR PREMOLARS

Mandibular premolars have gained a reputation for having aberrant anatomy. They are considered to be the most difficult teeth for endodontic treatment. This fact can be explained by the presence of multiple root canals, apical deltas and lateral canals.[27] Different studies have looked at the root canal morphology of mandibular premolars over the years and reported a fairly high percentage of these teeth to have more than one canal.[28-31] There seems to be a racial predisposition for the presence of two or more canals in premolars[32,33] as well as their bilateral occurrence.[25] The occurrence of three canals with three separate foramina (type V, Vertucci) in mandibular premolars is very rare. Vertucci[34] Zillich and Dawson[35] reported the occurrence of three canals in mandibular first premolars at 0.5 and 0.04%, respectively. Their studies in second premolars showed these percentages at 0.0 and 0.4%, respectively. Pineda and Kutler[5] reported 0.9%, and Kerekes and Tronstad[36] reported 5% of mandibular first premolars to have three root canals.

MANDIBULAR MOLARS

It is known that the mandibular first molar can display several anatomical variations. The majority of mandibular first molars are two-rooted with two mesial and one distal canal.[37] In most cases the mesial root has two root canals, ending in two distinct apical foramina (59.5%). In 40.5%, these merge together at the root tip to end in one foramen. The distal root typically has one kidney-shaped root canal, although if the orifice is particularly narrow and round, a second distal canal may be present.[38] A number of anatomical variations have been described in the mandibular first molar. In 1974, Vertucci and William,[39] as well as, Barker et al[40] described the presence of an independent middle mesial canal. Since then, there have been multiple case reports of aberrant canal morphology of the mandibular first molar.[41-44] These reports have described aberrant canals in the mesial root of the mandibular first molar. Additionally, Stroner et al[45] and Beatty and Interian[46] have reported on more obscure cases in which a third canal was located in the distal root. Martinez-Berna and Bandanelli[47] presented two cases with six canals. Both teeth had three canals in the mesial and distal roots. In both cases the distal canals have independent orifices in the pulp chamber floor but join immediately, forming two canals. However, the mesial canals maintain

their independence throughout the root. Reeh[48] reported a case with seven canals, consisting of four canals in the mesial and three in the distal root.

On the other hand, according to Mortman and Ahn,[49] the third mesial canal is not a true extracanal but rather is the sequel of preparing the isthmus between the mesiobuccal and mesiolingual canals. The isthmus is a narrow connection between two root canals that contains pulp tissue.

Like the number of root canals, the number of roots may also vary. An additional third root, first mentioned in the literature by Carabelli, is called radix entomolaris (RE). This supernumerary root is located distolingually in mandibular molars, mainly first molar. An additional root at the mesiobuccal side is called the radix paramolaris (RP).[50]

Radix Entomolaris

The presence of a separate RE in the first mandibular molar is associated with certain ethnic groups. In African populations a maximum frequency of 3% is found,[51] while in Eurasian and Indian populations the frequency is less than 5%.[52] In populations with Mongoloid traits (such as the Chinese, Eskimo and American Indians) reports have noted that the RE occurs with a frequency that ranges from 5% to more than 30%.[52] Because of its high frequency in these populations, the RE is considered to be a normal morphological variant (eumorphic root morphology). In Caucasians the RE is not very common and with a maximum frequency of 3.4 to 4.2%, is considered to be an unusual or dysmorphic root morphology.[52]

The etiology behind the formation of the RE is still unclear. In dysmorphic, supernumerary roots, its formation could be related to external factors during odontogenesis, or to penetrance of an atavistic gene or polygenetic system (atavism is the reappearance of a trait after several generations of absence). In eumorphic roots, racial genetic factors influence the more profound expression of a particular gene that results in the more pronounced phenotypic manifestation.[52] Curzon[53] suggested that the 'three-rooted molar' trait has a high degree of genetic penetrance as its dominance was reflected in the fact that the prevalence of the trait was similar in both pure Eskimo and Eskimo/Caucasian mixes.

A RE can be found on the first, second and third mandibular molar, occurring least frequently on the second molar.[52] Bilateral occurrence of the RE has also been reported from 50 to 67%.[54,55]

The RE is located distolingually, with its coronal third completely or partially fixed to the distal root. The dimensions of the RE can vary from a short conical extension to a 'mature' root with normal length and root canal. In most cases the pulpal extension is radiographically visible. In general, the RE is smaller than the distobuccal and mesial roots and can be separate from, or partially fused with, the other roots.[52] A classification by Carlsen and Alexandersen 56 describes four different types of RE according to the location of the cervical part of the RE: types A, B, C and AC. Types A and B refer to a distally located cervical part of the RE with two normal and one normal distal root components, respectively. Type C refers to a mesially located cervical part, while type AC refers to a central location, between the distal and mesial root components. This classification allows for the identification of separate and nonseparate RE.

In the apical two thirds of the RE, a moderate to severe mesially or distally orientated inclination can be present. In addition to this inclination, the root can be straight or curved to the lingual. According to the classification of De Moor et al[50] based on the curvature of the separate RE variants in buccolingual orientation, three types can be identified. Type I refers to a straight root/root canal, while type II refers to an initially curved entrance which continues as a straight root/root canal. Type III refers to an initial curve in the coronal third of the root canal and a second curve beginning in the middle and continuing to the apical third.

Radix Paramolaris

This macrostructure is very rare and occurs less frequently than the RE. The prevalence of RP, as observed by Visser, was found to be 0% for the first mandibular molar, 0.5% for the second and 2% for the third molar. Other studies have, however, reported RP in first mandibular molars.[52]

The RP is located (mesio) buccally. As with the RE, the dimensions of the RP can vary from a 'mature' root with a root canal, to a short conical extension. This additional root can be separate or nonseparate.[52] Carlsen and Alexandersen[56,57] describe two different types: types A and B. Type A refers to an RP in which the cervical part is located on the mesial root complex; type B refers to an RP in which the cervical part is located centrally, between the mesial and distal root complexes.

DIAGNOSIS

Accurate preoperative radiographs, straight and angled, using parallel technique are essential in providing clues as to the number of roots that exist. In premolars with three canals, the cervical half of the root is generally wider than usual, with little or no taper. Root canals may not be evident radiographically or may look unusual. Root canal space may disappear halfway through the roots. Careful interpretation of the periodontal ligament space may suggest the presence of an extra root or canal. Mesial and distal angled views will

often reveal the presence of a furcation of the root canal. Furthermore, sudden change in the radiographic density of the root canal space at the middle and apical portion has a diagnostic value. Gingival recession may reflect the furcal morphology in these teeth and thus hint at the presence of two buccal roots. Probing the buccal sulcus to feel the root eminences and furcal anatomy may also help to identify the presence of two buccal roots if present.[2]

Probing the palatal sulcus to feel the root eminences and furcal anatomy may also help to identify the presence of two palatal roots in maxillary molars.[23] When examining preoperative periapical radiograph of maxillary molars, if the outline of the roots are unclear, the root canals show sharp density changes, or the apices cannot be well defined, the extra roots should be suspected.[21]

In maxillary premolars, Sieraski et al[58] found that whenever the mesiodistal width of the mid-root image was equal to or greater than the mesiodistal width of the crown, the tooth most likely had three roots. Some of the other diagnostic measures to identify missed canals are as follows: examination of the pulp chamber floor with a sharp explorer, troughing of grooves with ultrasonic tips, staining the pulp chamber floor with 1% methylene blue dye, performing the sodium hypochlorite champagne bubble test and visualizing canal bleeding points.[59] Furthermore, Stropko[60] recommended the use of 17% EDTA, 95% ethanol to clean and dry the pulp chamber floor prior to visually inspecting the canal system.

IDENTIFICATION AND PREPARATION

In endodontic access cavity preparation, enough tooth structure should be removed to allow instruments to be placed easily into the orifice of each canal without interference from overhanging walls. The clinician must be able to see each orifice and easily reach it with the instrument point. In cases suspected to have extra roots or root canals at the diagnosis stage, the outline form has to be modified to search for and the ultimate cleaning, shaping and filling of the extra roots and root canals.

Luebke has made the important point that an entire wall need not be extended in the event that instrument impingement occurs owing to a severely curved root or an extra canal. In extending, only that portion of the wall needed to free the instrument, a cloverleaf appearance may evolve as the outline form. Luebke has termed this a 'shamrock preparation'.[38]

The anatomy of maxillary premolars with three root canals, mesiobuccal, distobuccal, and palatal, is similar to that of adjacent maxillary molars, and they are therefore sometimes called small molars or ridiculous. Buccal canals in three-rooted premolars normally lie close to each other and are often covered by a projection of cervical dentin. Thus, an Endo Access bur is used to modify the edges of the access opening in order to make a triangular conformation at the base, in the buccal direction. Furthermore, a uniform cut should be made with a slow-speed diamond bur at the bucco-proximal angles from the entrance of the buccal canals to the cavo-surface angles, resulting in a cavity with a T-shaped outline.[61]

In maxillary molars, the mesiobuccal root has the most complex canal system. A variety of methods have been suggested to aid in locating mesiolingual canals. A single mesiobuccal canal is oval and wider buccolingually, but two or three canals are more circular. Neaverth et al[62] advocated using a heart-shaped access and countersinking the floor of the pulp chamber lingual and mesial to the mesiobuccal canal with a round bur. Pomeranz and Fishelberg[63] discussed the importance of improved access and thoroughly probing the fissure and groove between the mesiobuccal and palatal canals to locate the mesiolingual canal. Dental operating microscope (DOM) has been used to study the location of the MB-2 canal in maxillary molars. Baldassari-Cruz et al[64] showed an increase in the number of MB-2 canal located from 51% with naked the eye to 82% with the DOM. Coelho de Carvalho and Zuolo[65] concluded that the DOM made canal location easier by magnifying and illuminating the grooves in the pulpal floor and differentiating the color differences between the dentin and the floor and walls. The DOM enabled them to find 8% more canals in mandibular molars. Gorduysus et al[66] studied[45] maxillary molars *in vivo*, and concluded that 69% of distolingual canals could be negotiated without magnification, but this rate reached to 80% using SOM. However, Sempira and Hartwell[67] reported that the use of SOM did not increase the number of MB-2 canals located. Taken together, it seems clear that the use of magnification is essential to ensure the long-term success of endodontic therapy of maxillary molars. The ultrasonic units and tips specifically designed for endodontic procedures can be valuable aid in the preparation of access cavities. Ultrasonic tips can be used to trough and deepen the developmental grooves to remove tissue and explore for canals. They are particularly advantageous in MB-2 canal location due to the cavitations effect. Furthermore, ultrasonic tips provide excellent visibility compared with conventional hand piece heads, and are more conservative. It has been found that SOM in combination with ultrasonics increased the rate of MB-2 canal detection in extracted permanent maxillary first molars.

In maxillary molars with two palatal roots, the pulp chamber floor has the shape of s quadrangle with one canal orifice located at each corner.[23]

In mandibular premolars, usually the main canal orifice may split into two or three canals deep within the root. Thus, it is important to obtain straight line access to all the canals. This may be achieved by Gates-Glidden drills 4, 3 and 2 set on a slow hand piece rotating at 750 to 1000 rpm utilized in a crown down fashion. These drills should be withdrawn against the canal walls and away from the root concavities. This will reduce stress on the files used subsequently to shape the canals and minimize the risk of instrument separation and canal transportation.[2]

In mandibular molars, RE is a challenge for root canal therapy. Because RE is mostly situated in the same buccolingual plane as the main distal root, a superimposition of both roots can appear on the preoperative radiograph, resulting in an inaccurate diagnosis. A thorough inspection of the preoperative radiograph and interpretation of particular marks or characteristics, such as an unclear view or outline of the distal root contour or the root canal, can indicate the presence of a hidden root. To reveal the RE, a second radiograph should be taken from a mesial or distal angle (30°).[52]

Apart from a radiographic diagnosis, clinical inspection of the tooth crown and analysis of the cervical morphology of the roots by means of periodontal probing can facilitate identification of an additional root. An extra cusp (tuberculum paramolare) or more prominent occlusal distal or distolingual lobe, in combination with a cervical prominence or convexity, can indicate the presence of an additional root.[52]

The location of the orifice of the root canal of RE has implications for access cavity preparation. The orifice of the RE is located disto - to mesiolingually from the main canal(s) in the distal root. An extension of the triangular cavity to distolingual results in a trapezoidal outline form. Visual aids such as loupe and SOM can be useful. Furthermore, a dark line on the pulp chamber floor can indicate the precise location of the RE canal orifice. An initial relocation of the orifice to the lingual is indicated to achieve straight-line access.[52]

OBTURATION

There are several obturation techniques to filling the root canal system. The most popular obturation technique is lateral compaction, which is quick and easy. However, other techniques have also been advocated to fill the teeth with extra roots and canals. In maxillary premolars with three canals, in addition to the lateral compaction technique, hybrid technique has also been suggested to obturate the root canal system.[61] In some cases of maxillary molars with extra canals (three palatal canals) Microseal technique (Analytic Endodontics, Orange, California, USA) has been suggested to fill the palatal canals. Furthermore, hybrid technique has been advocated to fill two separate canals in the palatal root.[19]

In mandibular premolars, due to the fact that the main canal orifice may split into two or three canals deep within the root, special considerations should be done to obturate the root canal system. According to Nallapati,[2] after the master cones are selected and fit, a heat carrying plugger (Touch and Heat, Sybronendo) that binds 4 to 5 mm short of working length, is prefitted for each canal. The plugger is leaved in the canal to keep the canal patent while the canal adjacent is being obturated. The use of vertical compaction with apical backfilling technique has been shown to allow the creation of an effective apical plug and an excellent adaptation of backfilling to apical gutta-percha and to root canals. Using this technique, seat the master cone and sever it with multiple heat bursts to below the level of division of the canals. Remove the plugger that was in the adjacent canal and place the other master cone with sealer and repeat the procedure just discussed. Repeat the same in the third canal. Insert the prefitted heat carrying plugger into each of the three canals, activate it, and down pack to within 5 mm of the apex. Backfill each of the canals to the level of furcation with the Obtura II (Obtura Corp, Fenton, MO) and compact the warm gutta-percha with heat pluggers. The rest of the canal space is obturated as a single canal with Obtura II.

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