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Review article

CLINICAL DIFFICULTIES IN ENDODONTIC TREATMENT OF PREMOLARS WITH ATYPICAL ANATOMY

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ABSTRACT:

To achieve high levels of success in endodontic treatment requires in-depth knowledge of the anatomy and morphology of the root canal system. Premolars are a group of teeth which shows a wide spectrum of different variations, reaching the apical opening. The frequency of one root canal at the apical tip for the maxillary first premolars is 8.66%, while 89.64% of the examined teeth show two root canals at the apical tip. The frequency of two or more root canals in the mandibular first premolars varies between 2.7% to 62.5%, while the frequency of two or more root canals in the mandibular second premolars varies between 0% and 34.3%. Some of the clinical aspects in the treatment of such aberrated premolars include implementing detailed preoperative evaluation- X-Rays and CBCT, sufficient opening of the endodontic access and careful three-dimentional cleaning of the root canal system with combination of different endodontic instruments and hybrid techniques of work and following hermetic sealing of all portals of exits. A 3D printing after a CBCT scan is a method of choice when a clinician wants to master the anatomy of a premolar. Knowledge of the complex root canal system is essential for understanding the principles and problems of shaping and, cleaning, determining the apical boundaries and dimensions of the root canals.

Keywords: Vertucci, premolars, atypical anatomy, aberrations,

BACKGROUND

Achieving high levels of success in endodontic treatment requires knowledge of the anatomy and morphology of the root canal system of different groups of teeth. This knowledge is necessary for finding, cleaning, and shaping the root canals and their proper three-dimentional obturation. When performing an endodontic treatment, the clinician must have in-depth knowledge and understanding of both normal anatomy and general variations of the norm [1].

REVIEW RESULTS

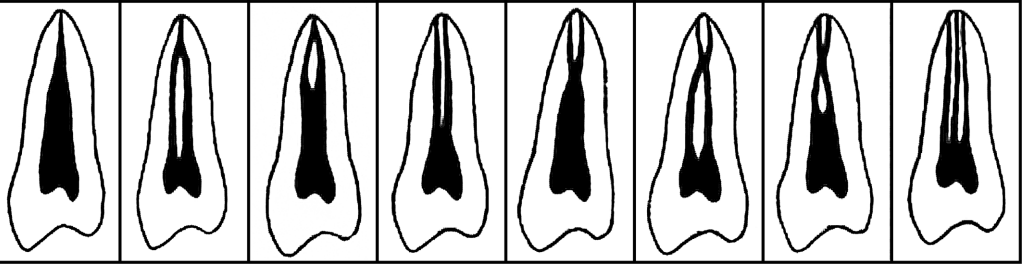
PECULIARITIES OF THE ROOT-CANAL SPACE IN UPPER AND LOWER PREMOLARS

The root canal system often shows a spectrum of different variations, reaching the apical opening. Regarding these facts, in a study of 2400 extracted teeth, Vertucci *et al.* managed to classify the variety of root canal configurations into eight basic endodontic morphotypes (Figure 1). From the collected data, it is clear that premolars and molars show a higher frequency of deviations [1, 2].

Endodontic treatment of premolars can be a challenging task in endodontics, as they often exhibit variable anatomy of the root canal system. The percentage distribution of the number of roots and root canals in premolars varies widely. Normally, the pulp chamber of the maxillary premolars is wider in buco-palatal direction and has two pulp horns (buccal and palatal) located below the cusps of the same name. These teeth can be single-rooted or double-rooted but always have two root canals [3, 4, 5]. Normally, the pulp chamber of the mandibular premolars is oval in shape, wider vestibulo-lingually, with two pulp horns. This group of teeth most often has one root with one root canal, but although rare deviations in the number of roots and root canals, divided at different levels (middle and apical third) [6, 7, 8, 9, 10].

Deviations in the root canal system of human teeth have been studied by numerous authors. Different variations in the anatomy of the premolars have been identified for different populations according to the Vertucci classification. Early diagnosis of such aberrations is crucial for accurate endodontic treatment [3, 4, 5, 7, 8, 11].

Fig. 1. Vertucci classification. Type I: single canal (1-1 configuration); type II: two separate canals that leave the chamber but merge to form one canal (configuration 2-1); type III: one canal that splits in two and then merges to come out as one (configuration 1-2-1); type IV: two separate canals from the pulp chamber to the end of the canal (2-2 configuration); type V: a single canal leaving the camera and divided into two separate canals in the end channel network (configuration 1-2); type VI: two separate channels that leave the pulp chamber, merging into the root body and dividing again into two separate canals, towards the end of the canal (configuration 2-1-2); type VII: one canal that divides, merges and exits into two separate canals, short of the end point of the canal (configuration 1-2-1-2); type VIII: three separate canals from the pulp chamber to the end point of the canal (3-3 configuration) (2).

	Type I	*Type II*	*Type III*	*Type IV*	*Type V*	*Type VI*	*Type VII*	*Type VIII*
Root canals leaving the pulp chamber	1	2	1	2	1	2	1	3
Root canals along the dental root	1	2	2	2	1	1	2 *into* 1	3
Root canals with separate apical foramina	1	1	1	2	2	2	2	3
Illustration								

In an original study by Kartal [5] (Table 1), variations in the root canal anatomy of the maxillary premolars are studied. The examination of the teeth is based on the Vertucci classification. The frequency of type I, II and III configuration (one root canal at the apical tip) for the maxillary first premolars is 8.66%, while 89.64% of the examined teeth show two root canals at the apical tip (from type IV to VII). Only 1.66% of the maxillary first premolars are type VIII (with three root canals at the apical apex). With respect to the maxillary second premolars, the frequency of type I, II and III configurations (one root canal at the apical apex) are 48.66%, while for type IV to VII (two root canals at the apical apex), it is 50.64%. Type VIII (three root canals at the apical tip) is found in 0.66% of the teeth examined [5].

Table 1. Results of Kartal et al. for variations in maxillary premolars.

	Type I, II, III	**Type IV, V, VI, VII**	**Type VIII**
Root canal anatomy for maxillary first premorals	8,66%	89,64%	1,66%
Root canal anatomy for maxillary second premolars	48,66%	50,64%	0,66%

There is a discrepancy in the scientific literature regarding the anatomy of the root canals in the mandibular premolars. The authors differ significantly in the results they report for this group of teeth. The frequency of two or more root canals in the mandibular first premolars varies between 2.7% to 62.5%, while the frequency of two or more root canals in the mandibular second premolars varies between 0% and 34.3% [7, 8, 9, 11]. Examining 800 extracted teeth using the decolorization technique, Vertucci [2], for the first time, provides convincing data on the endodontic macro- and microanatomy of this group of teeth. The mandibular first premolars end with one root canal at the apical tip in 74.0% of the teeth (type I, II and III configuration), two root canals at the apical tip in 25.5% (type IV to VII configurations), and three root canals the canal at the apical tip in 0.5% of the examined teeth (type VIII configuration). The mandibular second premolars terminate with one root canal at the apical tip in 97.5% (type I, II and III configurations) and two root canals at the apical tip in 2.5% of the teeth (type IV to VII configurations) (Table 2) [2].

Table 2. Vertucci [2] results for variations in mandibular premolars.

	Type I, II, III	Type IV, V, VI, VII	Type VIII
Root canal anatomy for mandibular first premolars	74%	25,50%	0,50%
Root canal anatomy for mandibular second premolars	97,50%	2,30%	0,20%

Additional anatomical variations of the premolars include fusion or gemination, fusion with adjacent or supernumerary teeth, dens invaginatus, dens evaginatus, C-shaped canals, and supernumerary premolars. Such premolars with developmental abnormalities should be fully evaluated, clinically and radiologically, to determine the type and extent of variation and to be treated according to the individual variant presented [12, 13].

CLINICAL ASPECTS IN DIAGNOSIS AND TREATMENT OF PREMOLARS WITH ATYPICAL ANATOMY

The success of endodontic treatment of teeth with atypical anatomy of the root canals relies on the universal endodontic axiom: adequate preparation of the root canal; thorough disinfection; three-dimensional hermetic obturation of the canal; high-quality coronary restoration [14]. Conventional radiographs are an integral part of endodontic treatment, helping to identify the number, configuration, and curvature of root canals, but they offer limited two-dimensional information about three-dimensional structures. In addition, their interpretation may be erroneous due to the presence of unwanted shadows, geometric distortions, and overlays [3]. Cone-beam computed tomography (CBCT), on the other hand, overcomes these limitations by providing accurate, three-dimensional, high-resolution images. The use of CBCT as an adjunct in endodontics can greatly facilitate the detection and mapping of the root canal system of the teeth and has the potential to significantly improve the quality of root canal treatments. Accessory canals are often a challenge for observation in conventional radiography. Common signs of the presence of an accessory canal are a sudden change in X-ray opacity or a sharp contraction of the root canal [3].

A comprehensive preoperative clinical evaluation is the first step in detecting endodontic aberrations of the maxillary and mandibular premolars. Careful observation of coronary and radicular anatomy is a prerequisite for detecting variable anatomy. Atypical crown size and excessive cusps indicate abnormal endodontic morphology. Probing the gingival sulcus to sense root elevations and furcation anatomy can also help identify more roots. A clinical trace of possible deviant root morphology in mandibular premolars is the diameter of the cervical area below the enamel-cement border - the wider diameter often indicates the presence of two or more root canals [15, 16].

The various anatomical variations in the radicular morphology of the maxillary and mandibular premolars cause several clinical difficulties during endodontic treatment, such as: difficult preparation and obturation of the root canal system; failure to treat an undiscovered root canal; tool separation; transportation of the apex; root fracture, etc. [13].

During the endodontic treatment, several different steps can be taken, to overcome the listed clinical difficulties [13, 15]:

Endodontic access

In single-canal premolars, access is oval in nature. However, if a second root canal (or bifurcation) is suspected, a buccolingually oriented elliptical shape of the endodontic access is more appropriate. If the pulp chamber deviates from the normal configuration and acquires a triangular shape with a wider mesiodistal diameter, the presence of more than two root canals should be suspected.

When a canal splits in two in a bucco-lingual direction, the lingual canal usually separates from the main at an acute or almost right angle. Slowey likens this endodontic configuration to the lowercase letter “h”. The buccal canal would be the rectilinear part of the letter “h”, while the lingual canal separates around the middle of the root at an acute angle from the right buccal canal. In addition, the lingual inclination of the crown tends to direct the instruments buccally, increasing the difficulty in finding the orifice of the lingual canal. To overcome this situation, the clinician may need to widen the lingual wall of the endodontic access in lingual direction to achieve unobstructed passage of the instruments into the lingual canal [13, 15].

Working length

Detection of accessory canals and their apexes on radiography may be difficult due to their close location or overlapping of roots. In such cases, the use of an apex locator is very useful. It can be used to detect the working endodontic length before confirming it by radiography [13, 15].

Preparation

An important aspect of the machining of additional root canals is the presence of sharp corners, especially in the area of †bi- or trifurcation. The use of new tools, frequent inspection of distortion files, use of flexible Ni-Ti hand and rotary files are recommended. Any breakage of an instrument in the root canals makes its removal very difficult, and this increases the risk of perforation of the root walls.

The root canal preparation of premolars with atypical anatomy can be performed using any of the following techniques [13, 15, 16].

1. Manual preparation according to the standard Ingle technique. K-files are used, the apical opening be-

ing prepared to a size of 0.30 mm. After each file, a recapitulation is made to check the passability with a K-file No.10. During instrumentation, after each instrument, the canal is firrigated with 2.5% sodium hypochlorite, 2 ml. Irrigation ends with 17% EDTA, 5ml for 1 minute, followed by 5ml of distilled water.

2. Preparation via machine-driven endodontic files by Crown Down technique with an apical narrowing size of 0.30 mm. Rotary nickel-titanium systems of different designs and conicity can be used. After each file, a recapitulation is made to check the passability with a K-file No.10. During instrumentation, after each instrument, the canal is flushed with 2.5% sodium hypochlorite, 2 ml. Irrigation ends with 17% EDTA, 5ml for 1 minute, followed by 5ml of distilled water.

3. Hybrid preparation, by superimposing the previous two techniques:

Initially, the coronary and middle parts of the canal are enlarged following the sequence:

• Introduction of manual K-file No.10 and 15 until resistance is felt

• Introduction of machine-driven files with conicity 2% 1 mm shorter than the length of the inserted hand files. Enlargement of the coronary 2/3 of the canal with brushing movements in the coronary direction.

• If there is a bifurcation of the canals, this preliminary expansion is done to the level of bifurcation. If there is a curvature of the apical 1/3 of the canal, the expansion is made to the level of curvature

The working length is measured with a hand K-file No.10. The apical part of the canal is widened with hand files using the Step-back technique. After each file, a recapitulation is made to check the passability with a K-file No.10. During instrumentation, after each instrument, the canal is flushed with 2.5% sodium hypochlorite, 2 ml. Irrigation ends with 17% EDTA, 5 ml in 1 minute, followed by 5 ml of distilled water [13].

The pulp cavity in the apical part of the root canal often contains isthmus, lateral canals, and apical branches. The use of ultrasonic irrigation can be useful to achieve thorough disinfection and cleaning of impossible for mechanical instrumentation apical bi- and trifurcations and lateral branches.

Obturation

For obturation of the endodontic space of the maxillary and mandibular premolars with atypical anatomy, the use of warm techniques with thermoplasticized guttapercha or the technique of hydraulic condensation is recommended [17]. The aim is a three-dimensional and hermetic filling of all macro- and micro-spaces of the endodontium, thus preventing the development of reinfection. The use of classical techniques for filling root canals with a sealer and a single gutta-percha cone is limited due to the impossibility of achieving a homogeneous filling of the accessory root canals [13].

DEVELOPMENT OF MODELS FOR IMPROVEMENT OF CLINICAL PROCEDURES

For a detailed study of endodontic aberrations in the maxillary and mandibular premolars, two modern methods can be applied:

1. "Transparent tooth" technique [2, 18, 19].

It is a method that is applied to extracted teeth. After preparation of the endodontic access, all samples are placed in a 2.5% sodium hypochlorite solution for 48 hours, after which the samples are washed under running water for 2 hours. After washing, all samples are transferred to 5% nitric acid for decalcification for 72 hours, the acid being changed every 24 hours and stirred once every 8 hours. After decalcification, the samples are washed under running water and dehydrated in ascending order with 70%, 80%, 90% and 100% isopropyl alcohol for 2 days. The teeth become transparent after immersion in methyl salicylate for 15 minutes. Finally, Indian ink is injected into the root canals to visualize the configurations of the Vertucci classification.

2. Digital 3D printing of replicas of human teeth using data from cone-beam computed tomography [1].

Cone-beam tomography is a useful tool for preoperative diagnosis of complex root canal anatomy. CBCT also eliminates the problem of superimposing roots from surrounding anatomical structures and gives an idea of the spatial relationship of anatomical variations. Even more accurate and clear information is obtained if the CBCT data is converted into 3D models with the help of software, such as MIMICS, which in turn can be used for 3D printing of artificial teeth using the MJP (Multijet printing) technique. After appropriate treatment, the printed models make it possible to study the anatomical variations and to plan endodontic treatment to minimize possible complications.

CONCLUSION

Extensive knowledge of the morphology of the teeth, careful interpretation of X-rays under different angulation, proper preparation of the endodontic access, as well as a detailed examination of the internal anatomy of the teeth (by CBCT) are key prerequisites for successful root canal treatment. The detailed description and illustration of the anomalies in the morphology of the teeth provides an opportunity to improve the clinical aspect of endodontic procedures. In-depth knowledge of the complex root canal system is essential for understanding the principles and problems of shaping and, cleaning, determining the apical boundaries and dimensions of the root canals.

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