Fiber post fitting to canal anatomy: a review of the morphology and shape of root canal system

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Abstract

Objectives: The aim of this literature review was to analyze the root canal shape of human teeth described in anatomical studies as recent wide use of fiber posts resulted in a new interest for the anatomy of coronal and middle portions of the canal, where post-space should be prepared, in order to achieve the best fiber post fitting to the post-space. Material and methods Original scientific papers from peer-reviewed dental journals strictly related to the morphology of human teeth roots and listed in PubMed in the period from 1987 to 2007 were selected using key words. Books related to human teeth anatomy were added by hand searching. **Results:** In this paper 921 papers (94 reviews) founded in PubMed with a search for endodontic, root, canal, anatomy were examined. Discussion: Through the studies included, a classification of root canals according to cross-section shape and a systematic description of canal morphology in each tooth were performed. The knowledge of both basic root anatomy and root canal section morphology is crucial while choosing of the post during the luting procedure as a good post fitting could be a key factor for clinical success of post-retained restorations. Different shapes of root canals, described in literature, enhances the problem of fiber post adaptation to root canals. Conclusions and clinical significance: Knowledge of the anatomy of root canals of each tooth may help the clinician in choosing the best fitting fiber post to the canal treated.

Key Words: Root Canal, Morphology, Root anatomy, Endodontics, Review

Short title: a review of canal anatomy for fiber post fitting.

Introduction

Anatomy of human teeth roots has been investigated and described in many studies reported in the literature. Most of the latter are anatomic reports on number of roots, canals and apical anatomy[1-7]; few studies focused on section, shape and morphology of root canals at different levels as well as on the morphology of canals along the entire length[8-11]. The variability in dental root anatomy according to gender and ethnicity has been also analyzed[12]. An online study guide on root canal anatomy has been recently published in the literature[13]. This study guide consists of a focused review of the essential endodontic literature and cites the main (109) articles related to root canal anatomy including classification systems, individual teeth reviews, furcation canals, apical anatomy, dental anomalies, and demographic/geographic analysis[13].

The number, morphology and variability of the roots as well as the number, course and shape of canals into roots should be well known for endodontic treatment as well as for the restoration of compromised endodontically treated teeth through a fiber post[5,8,9,14,15].

Endodontic treatment aims to achieve a progressively and uniformly conical shape within the canal, in order to completely remove pulp remnants, infected dentin and microorganisms and to assure an optimal obturation of the canals and the seal of apical foramen[8,9,11]. Therefore, during an endodontic treatment the focus is shifted on the anatomy of apical third of canals[8-11].

Recently, wide use of fiber posts to rebuild endodontically treated teeth resulted in a new interest for the anatomy of coronal and middle portion of the canal where the post-space should be prepared. The assessment of anatomy of these portions of canal is critical during the choice of fiber post which should fit as more as possible to post-space where it has to be luted[9,15,16].

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The aim of this literature review was to analyze root canal shape of human teeth through the results and observations reported in anatomical studies in order to help clinicians in choosing one or a combination of fiber posts which best fits to the canal treated[14,16,17].

Materials and Methods

This review of the literature was performed limited to original scientific papers from peer-reviewed dental journals on the morphology of human teeth roots and listed in PubMed in the period from 1987 to 2007 included. The research was conducted using the terms: "endodontic" AND "root" AND "canal" AND "anatomy". The papers cited in the online study guide on root canal anatomy were also analyzed[13]. Books related to human teeth anatomy were added by hand searching of bibliographies.

Results

The PubMed search resulted in 921 papers (94 reviews). The abstracts were analyzed and most of them resulted not linked to studies on the shape of root canal section. The studies not strictly related to root anatomy and canal shape were excluded. Books related to this topic were added by hand searching.

Classification of root canals according to cross-section shape

A first classification of root canals according to cross-section shape was reported by Lautrou who, on the basis of early studies, classified root canals as: laminar or tubular[4,6]. Laminar canals can be semilunar, 'figure of an 8' or straight, while tubular canals may be circular, triangular or oval (Fig. 1). Besides these morphological variations, histological sections and clearing techniques[18] showed that most canal systems have further anatomical complexities and apical deltas which may be impossible to instrument (Fig. 2).

The canals with a great disparity between bucco-lingual and mesio-distal dimensions, more precisely with the ratio between the long and short canal diameter at 5mm from the apex ≥2 (Fig. 3a, b), have been defined as oval-shaped[19-22] they are considered to be difficult to be enlarged homogeneously by traditional methods.

The basic concepts of Anatomic Endodontic Technology (AET) are founded on these anatomical observations[11].

Systematic description of canal morphology

The description of root canals anatomy and morphology reported in the studies selected for this review has been used for systematic description of root canal morphology of each tooth.

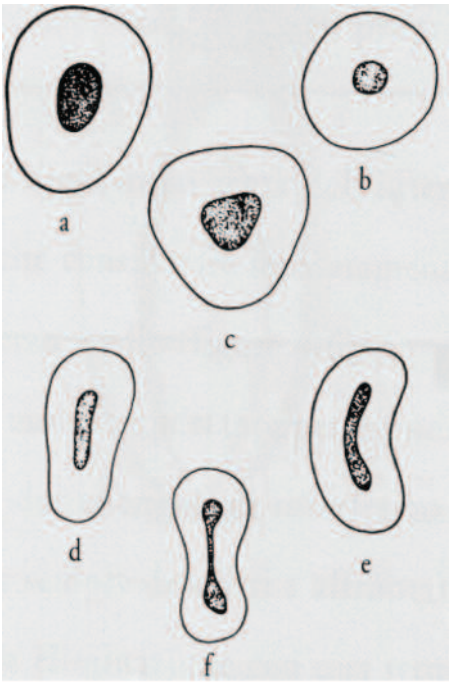

Figure 1: Root Canal Section Shape (From Lautrou[6], modified). Tubular Canals: (a) Oval; (b) Rounded; (c) Triangular. Laminar Canals: (d) Straight ; (e) Semilunar; (f) "8" shaped with buccal and lingual enlargements.

Mandibular incisors

Most of the canals of lower incisors have not circular shape. As reported by Mauger et al[23], after resecting the apices of mandibular incisors with a 20 degree buccal bevel, the average buccal-lingual diameter of the canals resulted more extended than the average mesio-distal along entire length. In its largest portion the canal is often divided in two separate branches, a lingual and a labial respectively, that reunify at 3mm above the apex[4,19,21].

Maxillary incisors

The first central incisor presents a rough oval canal in cross section; the second incisor results similar to the latter, generally thinner with a more complex variability[19,21].

Mandibular Canine

The root is single and presents mostly an oval canal with a flat shape in mesio-distal direction along entire length, in alternative it can present a single canal at the orifice, dividing at apical third in two canals exiting at the apex. Rarely it presents two roots, buccal and lingual respectively. Sometimes this anomaly is associated to an apparent duplication of the canal with a labial and lingual separation[4,19,21,24].

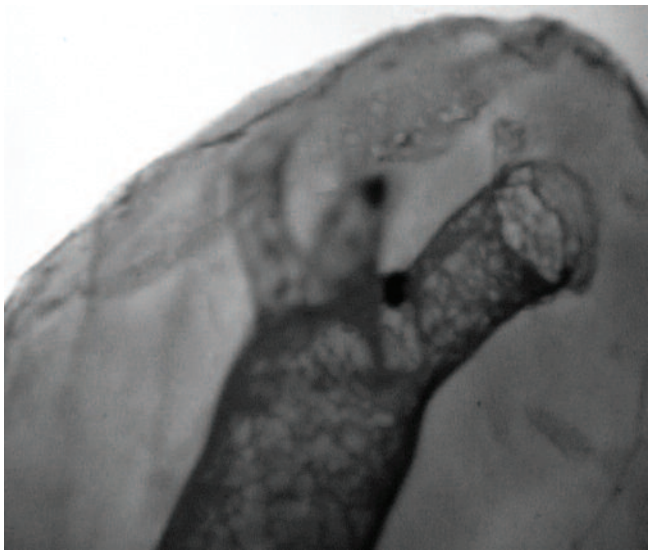

Figure 2: Anatomical complexity: apical delta.

Maxillary Canine

The canal is generally wide, circular, triangular or oval, slightly flat in mesio-distal direction[19,21]. Variations are extremely rare.

Maxillary first premolar

The root presents two separate canals: buccal is generally wide with a round shape and palatal is rounded; single oval canals are rare[19,25,26].

Maxillary second premolar

The root presents a single, wide, oval canal with the buccal-lingual diameter longer than the mesio-distal. In some cases the canal divides into two within the root and then merges to exit as one single canal. Sometimes there are two separated root canals, generally circular[4,19,25,27]. In rare cases, it can appear as a small molar with three separated canals.

Mandibular first premolar

The root canal is wide and straight, generally oval as the buccal-lingual diameter is longer compared to the mesio-distal; several lateral canals are often present[21,25,28,29].

Mandibular second premolar

It presents a single canal with a circular section; several lateral canals are often present[21,25,30].

Maxillary first molar

It generally presents four canals. It is well accepted that the widest canal is the palatine with a round or slightly oval shape. Distal-labial and mesio-palatal canals have round shape. Mesio-labial canal has a round shape, too, but sometimes it is slightly oval with the longer buccal-lingual diameter, especially when it is unified with mesio-palatal canal. Mesio-palatal or fourth canal is often thin and usually rounded[4,20,29,31-34].

Maxillary second molar

It is similar to the first upper molar, except of the prevalence of mesio-palatal canal absence. Therefore it presents three canals, whose orifices often locate along the deepest line visible on the floor chamber. Frequently the roots are fused to get two canals (labial and palatal) or, rarely, a single canal with circular shape[4,20,31-35].

Maxillary third molar

It often presents a fused root and one or two canals with a round shape section. It is characterized of high variability[20,31-33].

Mandibular first molar

The distal canal is generally wide with an oval shape, with the longer diameter buccal-lingually oriented. Mesial canals are usually thin and round, rarely they join together. A median canal with a rift shape is rare and, almost always, without an independent exit. Sometimes it is present a secondary distal lingual root with a round canal. When two distal roots are present, both canals are circular[4,20,29,33,36].

Mandibular second molar

It is similar to mandibular first molar. In a study of Gulabivala[36] it has been reported that a single narrow C-shaped canal with lingual curvature is present in 10% of the cases, while in other cases it presents two separate roots. The most of these teeth have three (58%) or two (23%) canals. Sometimes (less than 20%), they present a single wide root canal. When more than one canal are present, they often tend to join in proximity of the apex and the mesial canals often have a single exit[4,20,33,36].

Mandibular third molar

According to several studies[37], mandibular third molars are associated with various types of root and canal morphology. Most of these teeth have two roots that could be either separate (68%) or fused (19%). Other root morphologies include three roots (1%), a single conical root (1%), four roots (1%) and a surprisingly high prevalence of C-shaped roots (11%). Most of these teeth have only two root canals (61%). The canals are usually thin, curved and round or slightly oval in cross section[4,20,33,36].

Discussion

The knowledge of both basic root anatomy and root canal section morphology as well as the variations of root canal system is crucial for achieving a successful non-surgical

endodontic treatment and a successful post retained restoration[8].

Ingle et al.[38] reported that the most frequent reason of failure of endodontic treatments was incomplete canal instrumentation, followed by incorrect canal obturation[8,10]. Slowey et al.[39] indicated that the variation of the income anatomy of root canal system could probably account for the high frequency of endodontic flare-up and failures.

Fiber posts have been widely used in clinical practice as they may preserve most of remaining tooth structure[40,41] and may allow for the retention of a prosthodontic restoration. Some clinical studies reported that post debonding was the main reason for failure of post-retained restorations[17,42,43] and they showed that this event is more likely to happen in the absence of a ferrule effect or in the presence of an excessive amount of cement, especially at the coronal level[17,42,44]. A thin and uniform cement layer between post and canal walls, which could reduce the incidence of post debonding, could be achieved only with a good post fitting, which could be a key factor for clinical success of restorations[16,45]. In fact, post adaptation to the canal walls represents an important element in the biomechanical performance of the prosthetic restoration[46]. Stress transmission to the root through passive fitting dental posts is partly influenced by the thickness of the cement layer between the post and the prepared root canal surface as well as by the fit of the post in the root canal[45]. Therefore the fiber post adaptation to the root canals should be taken into consideration while choosing of the post: the knowledge of the anatomy of the coronal and middle portion of the treated canal becomes a decisive factor during the fiber post luting procedures.

As mentioned above, it is well-known that the shape of root canals is often not circular[8-10]. Among the factors that influence post-retained restoration outcomes in long-term, preoperative root-canal anatomy and instrument tip design are reported to be the main[8-10]. Therefore the different shapes of root canals, described in literature, as well as the type of instrument used for post space preparation enhance the problem of fiber post adaptation to root canal. The use of preformed circular posts implies the need of adapting the canal to fit the post, especially not circular canals[47,48] through the use of preformed drills for post-space preparation, which modify the canal anatomical shape sacrificing sound dentin tissue, which could lead to a reduction of the root strength[14]. A more conservative post-space preparation could be achieved by using drills which are reported to respect the canal shaping[49]. Such an approach could reduce the risk of root fracture and perforations that can occur when a post space is enlarged with large drills[8,15,50]. The attempt of preserving dentin tissue through the choice of an undersized preformed post may occur only with an increase of the cement volume around the post[48], this can lead to a higher incidence of post debonding and therefore of clinical failures.

The problem of post fitting improves in oval-shaped canals as the adaptation of a circular post is difficult to achieve. Many attempts to improve the adaptation of fiber posts to canal anatomy have been tested such as combining a fiber post with a dual-curing resin cement in order to create an "anatomical post"[51] or inserting two or more small fiber posts to be compacted laterally[52], or modulating a fiber post to canal anatomy by using a diamond-coated bur[47,48]. A more conservative clinical protocol might consist in using tips whose design reproduces the particular shape of these canals, such as an ultrasonic tip with oval section[53], and in using posts with a shape similar to the tip employed, as oval fiber posts, or, as an alternative, combinations of posts of different sizes[52]. This can result in a thinner and more uniform cement layer around the posts luted in oval canals, that could represent an advantage, since variations in the cement film thickness along the fiber post could result in a non-homogeneous stress distribution to the root which might increase the failure rate of post retained restorations in the long term.

Clinical success of teeth restorations through fiber posts can improve with a good post fitting which is strictly correlated to the anatomy and shape of root canal system and its variations: it is therefore fundamental a huge knowledge of it.

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