Dentine thicknesses of first molar roots: A review of the literature with illustrative cases

SADJ MARCH 2025, Vol. 80 No.2 P95-P103

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ABSTRACT

Thin dentinal walls of first molars can significantly impact the success and outcomes of endodontic procedures, including root canal treatment. Root canal treatment is commonly performed on first molars, which are prone to decay due to their early eruption and complex occlusal structure. The treatment entails a series of mechanical and chemical disinfection techniques where the root canal spaces are enlarged and can be compromised by perforations leading to infection, inflammation and eventual tooth loss. The thinner the dentine, the greater the likelihood of perforation. "Danger zones" have been identified as the distal aspect of mesial/mesiobuccal roots and the mesial aspect of distal roots. Knowledge of dentine thickness patterns in dental roots and understanding factors that influence dentine thickness can help reduce the risk of perforation and improve treatment outcomes. This literature review gives an overview of various aspects of the dentine thickness of the maxillary and mandibular first permanent molar. The content is supported by illustrative micro-CT images and clinical cases. Treating physicians should take note that variations in dentine thicknesses have been reported between sexes, with ageing and among populations, but unfortunately no studies on dentine thickness could be found specifically for the South African context.

Keywords

Danger zone, safety zone, iatrogenic perforation, tertiary dentine, mesial root, distal root, mesiobuccal root, mandibular first molar, maxillary first molar, root length.

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INTRODUCTION

The thickness of dentine is of particular importance in root canal treatment. Root canal treatments are very commonly done on first molar teeth as these teeth are the first to erupt and be exposed to the oral environment. In addition, first molars also have a complex occlusal plane with numerous fissures and pits causing a potential risk for carious lesions.[1,2]

The success of root canal treatment relies on various factors, including perforations which involve pathological communications between the root canal system and the surrounding periodontium.[3] Perforations can occur during access preparation as well as during cleaning and shaping in some areas and, in particular, the "danger zone" due to thin dentine. As it is very difficult for a treating clinician to accurately predict the estimated dentine thickness of the tooth before treatment commences[4-6], about 10% of root canal treatment failures are caused by perforation alone.3 Perforations may lead to adverse consequences such as peri-radicular inflammation, endodontic re-infection, destruction of periodontal fibres, bone resorption, the development of a periodontal defect or eventual tooth loss.[7,8] especially when bacterial infection is allowed to establish. Perforations may occur due to pathological processes or treatment consequences. Various dental materials have been proposed over the years for perforation repair with varying degrees of success. The use of bioactive materials, such as mineral trioxide aggregate (MTA It is therefore not surprising that the estimated pooled success rates of primary root canal treatment with a minimum one-year follow-up ranged from only 68% to 85%, according to a study executed by Ng et al (2011).[9]

The aim of this paper is to provide an overview of the available literature on the dentine thicknesses supported by illustrative clinical cases involving root canal treatment. Knowledge of the variations and patterns of dentine thickness of the molar teeth roots may lower the risk for perforation which ultimately improves the success of the treatment.

Pivotal anatomical aspects

Despite the variations in both functional roles and morphological features of human dentition all teeth share a common anatomical blueprint.[10] The following structures all play an important role in tooth health and damage to any of these structures may increase the probability of needing endodontic treatment. Positioned superior to the gingiva, the tooth displays a visible portion known as the crown which is encased externally by a layer of enamel and internally by dentine.[10] The root(s) extend/s beyond the gingiva into their sockets in the alveolar bone of either the mandible or the maxilla and is securely held in place by a layer of cementum.[11] The enamel layer of the crown is continuous with the

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https://doi.org/10.17159/sadj.v80i02.20656

cementum which extends down into the roots. The cemento-enamel junction (CEJ) serves as a continuous junction between the crown and root(s) and is situated on the same plane as the gingiva. The dentine, on the other hand, extends beyond the crown, traversing into the root, and encapsulates a central cavity, namely the pulp chamber.[10] This chamber houses an intricate network of blood vessels, nerves and other organic matter, collectively known as the dental pulp, which is essential for preserving the tooth's vitality.[10]

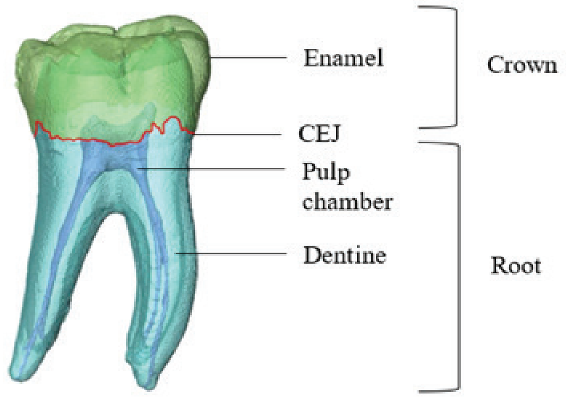

Figure 1: A micro-CT depiction to illustrate the basic structure of a tooth.

Endodontic treatment

Where the pulpal tissue is irreversibly inflamed due to, for example, trauma or carious exposure, the need for endodontic treatment arises which entails a series of mechanical and chemical disinfection techniques.[12,13]

During the initial stage of treatment, a series of dedicated burs or root canal instruments are used to create access through the crown area of the tooth into the pulp chamber to expose the orifices of the root canals and refine the access.[14]

Traditionally, the root canal space is enlarged through a series of manual stainless-steel instruments.[15] Throughout the cleaning and shaping process of endodontic treatment, a sequence of root canal instruments is introduced at the orifice level and worked apically until the working length is reached. The diameter and size of traditional root canal instruments increase with progression through the traditional cleaning and shaping sequence and a variable amount of tooth structure is removed with each instrument.

In modern times, operators have mainly been using rotary instruments due to their benefits which include reduced clinical chair time and more predictable outcomes.[16] This rotary instrument is usually made of nickel-titanium and eases the process by allowing the canal to be prepared more accurately and evenly. Ultimately, the prepared root canal spaces are filled with an obturation material (gutta percha). Cuspal coverage (for example a crown or onlay) is also advocated as the final restoration to ensure a proper coronal seal and preservation of the tooth after treatment.[17] Figure 2 exhibits a number of teeth restored with indirect restorations (crowns): the right mandibular second premolar and first molar as well as the right maxillary first and second molars.

Following root canal treatment, in preparation for the placement of a crown, a metal band called a dental ferrule may be positioned around the coronal surface of the tooth to support the crown up to 2mm supra-gingivally.[18] However, in certain cases the remaining tooth structure might not be sufficient to support a crown despite the use of an adequate dental ferrule. In these cases, a prosthetic device in the form of a small rod called a post is fitted and cemented inside the root to accommodate a core to serve as a base for a crown.[17] An indirect cast post and core can be cemented prior to crown placement or, alternatively, a suitable core with or without a post (depending on the amount of remaining tooth structure) can be created chairside to facilitate crown placement.[19] A post and core can also be manufactured outside the mouth by a laboratory (indirect method). Figure 3A depicts a virtual illustration using cone beam computed tomography (CBCT) of a post and core placed in a right mandibular first molar (Fig. 3A). Figure 3B illustrates an indirect cast post and core with a covering crown that was placed after root canal treatment had been completed on the

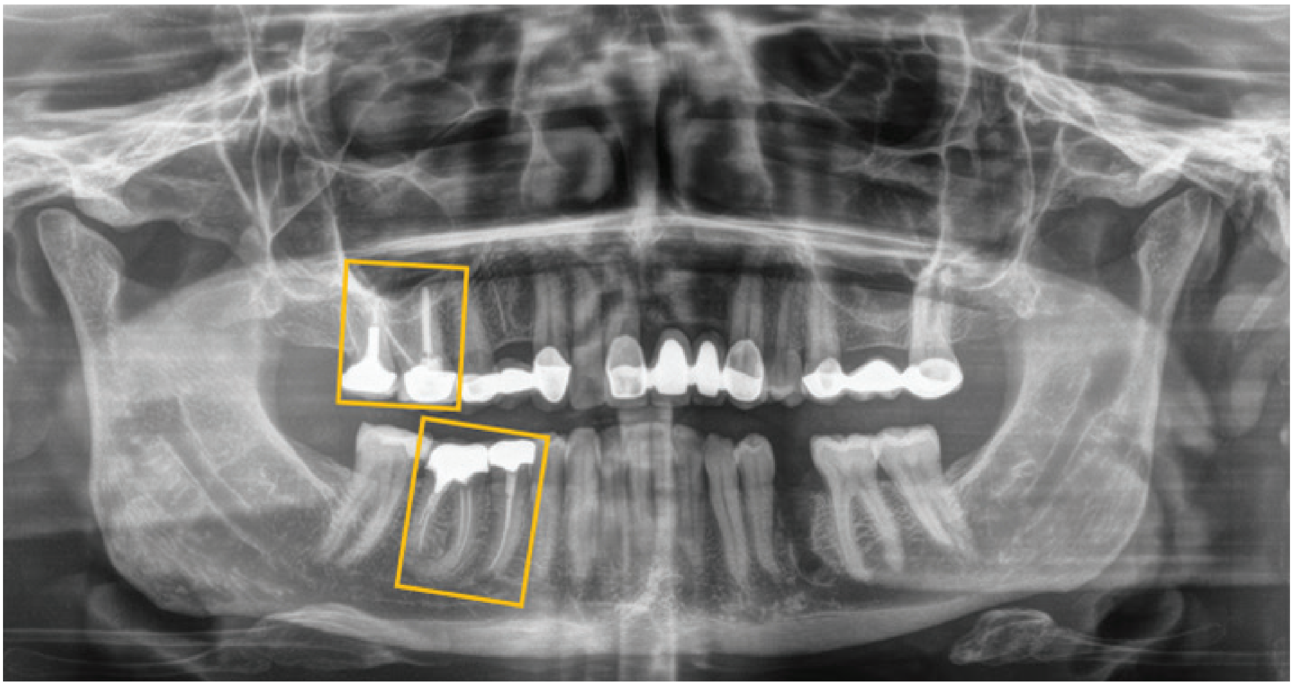

Figure 2: Panoramic radiograph depicting cuspal coverage of the right mandibular second premolar and first molar as well as the right maxillary first and second molars after completion of root canal treatments (yellow boxes).

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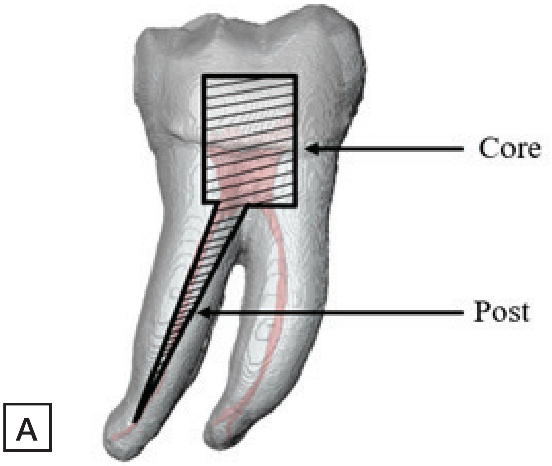
right maxillary second molar. The right maxillary first molar was restored using a direct method to fabricate the core with eventual crown placement. The teeth are viewed through a portion of a panoramic radiograph.



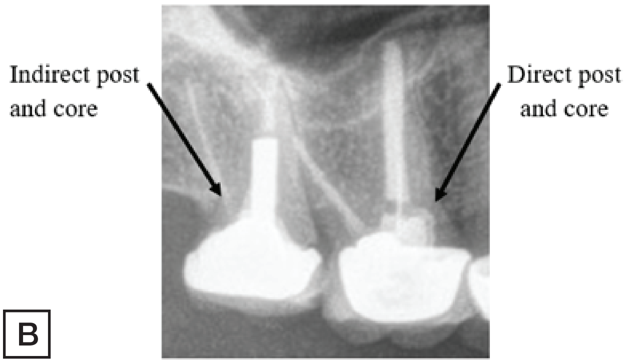


Figure 3A: A micro-CT illustration of the location of a post and core in a first mandibular molar. **B:** Radiographic image of the first maxillary molar where coronal seal was achieved by establishing a suitable core prior to crown placement and a second maxillary molar restored with a cast post and core prior to crown placement.

Unfortunately, the preparation of a post space is not without the risk of perforation.[17] The root canal space in some areas can be extremely vulnerable with high risk of perforation causing a communication between root canal walls and the external tooth surface, known as the periodontal space.[20]

According to Kvinnsland et al (1989),[21] 53% of iatrogenic perforations occur during post insertion, while the remaining 47% occur during routine root canal treatment. As perforations are severe complications that reduce the success rate of root canal procedures[8] and may result in chronic infection and ultimately tooth loss,[7] focus should be on prevention of perforations rather than the management thereof.[8] Modern guided endodontic techniques can facilitate endodontic procedures with a reduced risk of perforation, but a perfect outcome is not always guaranteed. To increase the predictability of an endodontic treatment outcome, knowledge of dentinal factors including dentine thickness patterns in dental roots is needed to guide clinicians to safely execute root canal treatments and avoid perforations.

DENTINAL FACTORS THAT COULD CONTRIBUTE TO PERFORATIONS

Types of dentine

Dentine is a calcified tissue substance which constitutes the bulk of the tooth, providing structure and protection to the more sensitive pulp beneath.[22] The composition of human dentine includes a primary layer which originates in early childhood during the initial stages of tooth development, known as primary dentine, as well as a secondary layer that forms upon tooth eruption and persists throughout an individual's lifetime, known as secondary dentine.[23] Another layer may also grow in reaction to a stimulus such as carious attack or dental wear, which is known as tertiary dentine (Fig. 4).[22]

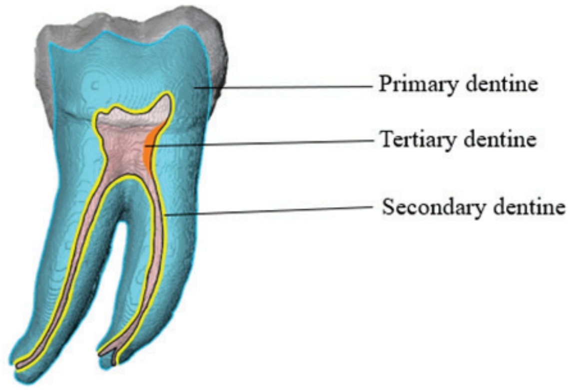


Figure 4: Types of dentine found in the tooth depicted by a micro-CT illustration.

Although dentine is composed of a combination of both organic and inorganic matter, hydroxyapatite, an inorganic mineral, forms the main component.[23,24] Organic matter such as collagen and fluid constitute the lesser half of dentine,[24] with odontoblasts being present in this component.[22] Odontoblasts are specialised cells for unidirectional secretion of dentine and may persist for the lifespan of the individual in the absence of trauma or disease.[22] Through pulp exposure due to a traumatic event or caries, primary odontoblasts are often irreversibly injured.[25] Because they are differentiated cells, odontoblasts cannot proliferate when they are permanently damaged. However, odontoblast-like cells possess the ability to secrete reparative dentine which is known as tertiary dentine.[25] Additionally, orthodontic treatment creates alterations in the blood flow and leads to the release of inflammatory mediators that stimulate odontoblasts. This causes tertiary dentine deposition, reducing pulpal space and increasing dentine thickness, causing the teeth to become darker in colour.[26] This may be investigated as a method to diagnose a potential tooth with thicker dentine and roots.

As a mineralised connective tissue, dentine is well adapted to its functional role as a major structural component of the tooth. However, dentine has been shown to decrease in elasticity and increase in hardness with increasing age.[24] This may be due to the decrease of collagen which main function is to provide elasticity to the tooth, as well as the deposition of precipitation of mineral salts associated with the ageing process.[24] An increase in hardness may result in the practitioner pressing down harder during post preparation, which in turn may increase the risk of perforation.

Dentine thickness in the danger and safety zones of the tooth roots

A site for possible perforation, namely a danger zone, has been identified in the coronal area of the root canal system (Fig. 5).[27-29] The danger zone is known as the thin area of root dentine extending from the outer surface of the root canal wall to the furcation area between the roots of multi-rooted teeth (inner aspect of the roots).[30] In contrast, the safety

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zone is known as the thicker area of root dentine extending from the outer surface of the root canal walls to the external aspect of the roots.

In the mesial root of the first mandibular molar, the danger zone will be situated on the distal side of the root while the safety zone will be situated on the mesial side of the root (Fig. 5). In the distal root of the first mandibular molar, the danger zone will be situated on the mesial side of the root while the safety zone will be situated on the distal side of the root (Fig. 5).

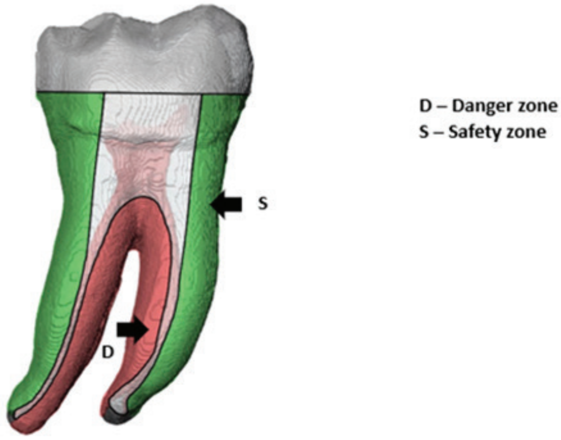

Figure 5: A micro-CT depiction to illustrate the position of the danger and safety zone in a mandibular first molar.

In the mesiobuccal root of the first maxillary molar, the danger zone will be situated on the distal side of the root while the safety zone will be situated on the mesial side of the root (Fig. 6). In the distobuccal root of the first maxillary molar, the danger zone will be situated on the mesial side of the root while the safety zone will be situated on the distal side of the root (Fig. 6). Lastly, in the palatal root of the first maxillary molar, the danger zone will be situated on the buccal side of the root while the safety zone will be situated on the palatal side of the root.

Mandibular molars

Most of the literature reviewed on the dentine thickness has been performed on the mesial root of the first mandibular molar (Table 1). Although it has been established that the danger zone in the mesial root of the first mandibular molar is situated on the distal side of the root, it is not agreed at what level the smallest dentine thickness will be found and what the exact dentine thickness is. Various modalities have been used in the past involving divergent populations to determine the level and the dentine thickness. Although most researchers describe the level with regard to the furcation[2,28,31-36] (Table 1), some use the distance below the canal orifices,[37,38] one from the junction between the apical and middle thirds of the root[39] and another from the root apex.[30] The thinnest part of dentine in first mandibular molars ranged from 1.5mm to 4.37mm below the furcation, while Chang et al found the smallest dentine thickness at 5mm below the canal orifice and Tabrizizadeh et al at 4mm.[37,38] As Micro-CT has been proposed as the most suitable method to describe fine morphological detail in dental studies,[40] it is noteworthy that the Micro-CT studies referred to in Table 1 report the smallest dentine thickness of MB: 1.13mm; ML: 1.10mm, 4.37mm below furcation[34] which was similar to another study reporting MB: 1.14mm; ML: 1.11mm; MM: 0.97mm at 5mm below furcation,[35] while Harris et al. found the smallest distance 3mm from apex MB/ML: MB/ML: 0.22mm-1.13 mm.[30]

These average thicknesses can be considered as crucial information considering the amount of tooth structure being removed during cleaning, shaping and post preparation, as well as the size of endodontic instruments rotating inside the root canal space.

Maxillary molars

Considering the maxillary first molar, the morphology of the crown shows a distinct lingual groove and root depression on the palatal side, an 8.0mm to 11.0mm zone of significantly thinner dentine. Root canal instruments with large tapers should be carefully operated or avoided, if possible, when creating coronal flaring and canal shaping in these high-risk areas.[41] A study conducted by Ordinola-Zapata et al (2019)[42] showed that at least 50% of the samples in the study exhibited dentine thickness of less than 1mm in the danger zone of the second MB canal (Table 1). For the first maxillary molar Ordinola-Zapata et al reported the smallest dentine thickness as MB1: 1.24mm; MB2: 0.99mm at 3mm from the furcation[42] (Table 1). In accordance, Azimi et al (2020)[43] also showed that the dentine thickness in the second MB root canal was significantly lower than that in the first MB root canal across all specimens in the study (Table 1).

The safety zone, as indicated in Fig. 6, exhibits a thicker dentine layer,[42] which is often minimally instrumented by endodontic instruments. In short, Abou-Rass et al (1980)[27] pointed out the importance of this anatomical area during canal shaping and, since then, many studies have evaluated the safety of various preparation techniques in mesial canals of mandibular molars.[29,31,35,44-46]

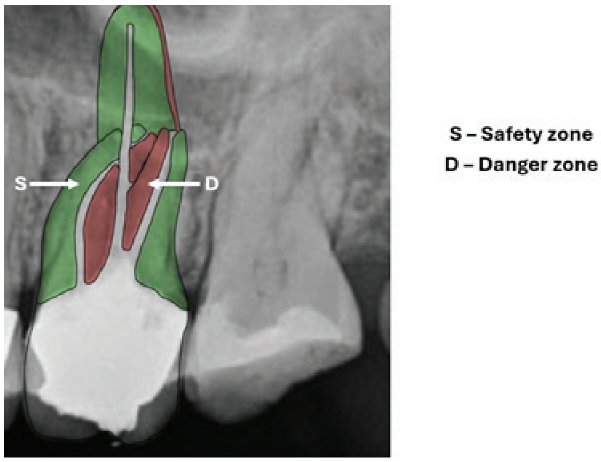

Figure 6: Safety zone (green) and danger zone (red) in a maxillary first molar.

However, preparation of the safety zone is not guaranteed to be without error. Figure 7A indicates a perforation on the mesial side (safety zone) which occurred during the cleaning and shaping of the canal with a rotary instrument. The restoration thereof can be noted in Figure 7B.

DENTINAL THICKNESS FROM THE PULPAL CHAMBER FLOOR TO ROOT FURCATION

Although dentinal thickness in tooth roots is of extreme importance, the dentinal thickness from the pulpal chamber floor to the furcation is also important to note (Fig. 8). During

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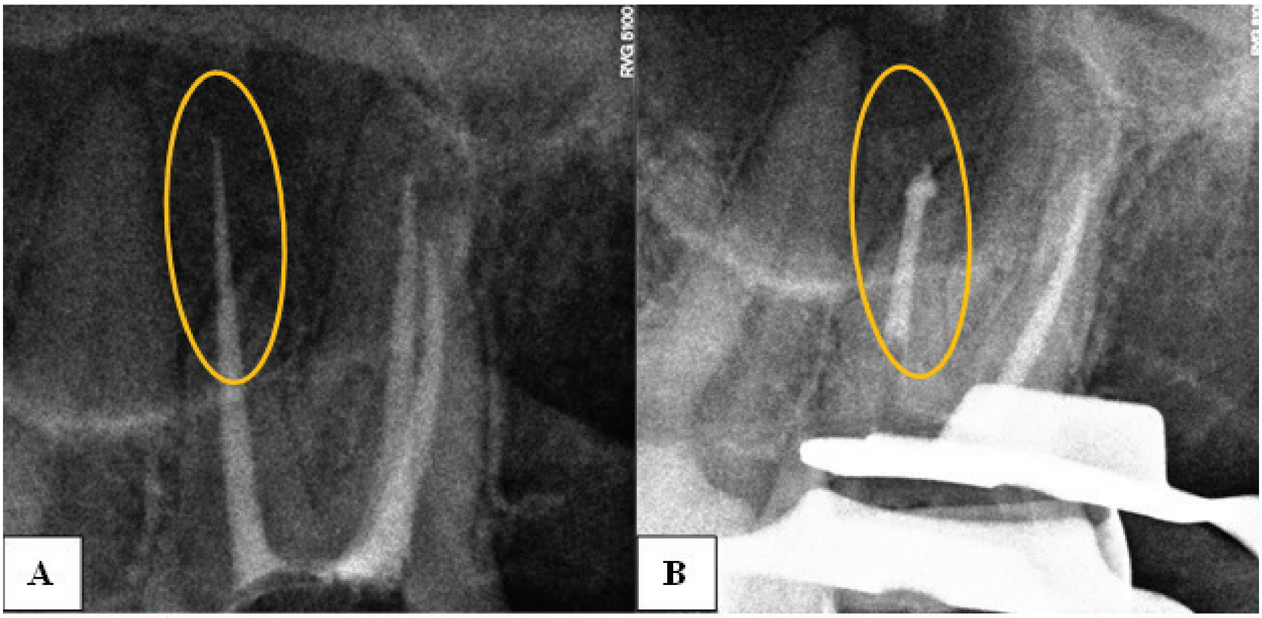

Figure 7A: The encircled area indicates a perforation that occurred in the mesio-buccal (MB) root of the left maxillary first molar during root canal treatment. B: Post treatment radiograph of the perforation site using Mineral Trioxide Aggregate (MTA) (Dentsply, Sirona). The encircled area indicates complete obturation of the apical and middle thirds of the MB root using MTA. The procedure was completed using the Dental Operating Microscope (DOM) (Carl Zeiss, Germany) under strict rubber dam isolation.

endodontic treatment, undesirable results such as iatrogenic perforation of the furcation while gaining access to the pulp chamber of molar teeth may occur.[45,47]

This complication could arise due to the procedure being qualitative in nature and having the dentist rely on their previous experience, tactile perception and knowledge of dental anatomy to successfully perform the procedure.[48] Furthermore, calcification of the pulp cavity may reduce tactile perceptions leading to treatment failure.[49]

Thorough understanding of the pulpal space anatomy may assist dentists in attaining successful outcomes during endodontic treatment.[47]

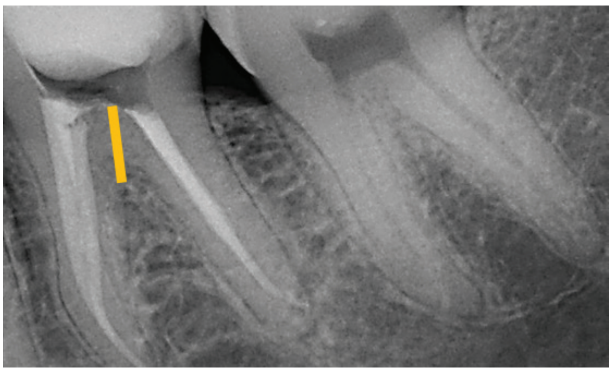

Figure 8: Remaining dentinal thickness from pulp chamber floor to furcation area after root canal treatment on a left mandibular first molar. Shaping of the root canals was completed using the WaveOne Gold Primary reciprocating file (Dentsply Sirona) after glide path preparation with stainless-steel hand files and a ProGlider rotary instrument (Dentsply Sirona). The prepared root canals were obturated using matching gutta-percha cones and BioRoot RCS bioceramic root canal sealer (Septodont). The tooth was temporary restored before crown preparation was scheduled.

Majzoub and Kon (1992)50(d reported that in maxillary first molars, the mean distance from the pulp chamber floor to the furcation was equal to or less than 3mm in 86% of the teeth used in their study. In accordance, Sterrett et al51 reported in 1996 that the mean distance ranged from 2.7mm to 3mm for both mandibular and maxillary first and second molars. Deutsch and Musikant (2004)[47] also measured anatomical landmarks in the pulp chambers of maxillary and mandibular molars and concluded that in maxillary molars, the mean distance is 3.05mm while in mandibular molars, the mean distance is 2.96mm. Chang et al (2007)[37] also measured dentine thickness and estimated that in mandibular first molars, the mean distance between the canal orifice of the mesial root and the furcation is 2.4mm (Table 1).

More recently, Dabawala et al (2015)[49] reported thinner pulp chamber floor measurements of 1.70±0.38mm for the maxillary first molar and 1.59±0.31mm for the mandibular first molar. In 2018, Leite Pinto et al[33] established that the average distance from the pulp chamber floor to the furcation in first mandibular molars was 2.23mm.

Several studies suggest that secondary dentine apposition occurs primarily on the pulp chamber floor instead of the ceiling.[52] Philippas (1961)[53] conducted a study comparing ancient and contemporary populations revealing no significant changes in the dentine thickness at the roof of the pulp chamber with increasing age but showed a significant increase in the dentine thickness at the floor of the pulp chamber with increasing age. This may explain the difference in dentinal thicknesses displayed by the abovementioned studies, as Dabawala et al[49] used a much younger study group (four to eight years) than the other studies, whose study groups were all classified as adults.

Factors associated with dentine thickness variations

Several variants exist in the root morphology that could have an effect on dentine thickness.[46] According to Martin et al (2021),[46] individuals with C-shaped rooted mandibular molars exhibit thinner dentine layers than those who do not exhibit C-shaped rooted molar teeth. Furthermore, length of the tooth may also play a role in dentine thickness. Sauaia et al (2010)[32] established that the narrowest walls occurred

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in the longest teeth, whereas shorter teeth exhibited thicker dentine walls (Table 1). Chang et al (2007)[37] also concluded that the distal wall of the mesial root is thinner than the mesial wall and that the wall thickness decreases as the distance from the canal orifice increases (Table 1). Similarly, Dwivedi et al (2014)[39] also established that in longer mandibular molars, the root wall on the distal surfaces of the mesial roots is thinner compared to shorter teeth (Table 1). In contrast, Zhou et al (2020)[2] found that short teeth exhibited thinner dentine thickness values at all locations (Table 1). With regard to maxillary molars specifically, the morphological differences observed are greatly influenced by individual patient characteristics. Dentine thickness in maxillary molars with fused roots showed significantly thinner dentinal walls than maxillary molars with unfused roots.[54]

Treating physicians should take note that variations in the morphology of the roots and canals have been reported between sexes, with ageing and among populations.[2,55] Zhou et al (2020)[2] established that dentine thickness increases with age in both men and women (Table 1). An increase in age indicates an increase in possible dental injury due to trauma, caries or cavity preparation in both maxillary and mandibular molars, which will lead to the secretion of tertiary dentine to protect the tooth from further infection.[56] In another study executed by Mireku et al (2010),[57] their findings indicated that the resistance to vertical root fractures (VRF) of root filled teeth restored with posts decreases with increasing patient age and low dentine thickness. Moreover, Hakami et al (2023)26 also concluded that males in their study exhibited darker tooth shades compared to females of the same age group, suggesting that males have thicker dentine layers than females. The findings of a study by Zhou et al (2020)[2] also demonstrate thicker dentine layers in the first mandibular roots of men when compared to women (Table 1). This may indicate a decreased risk of perforation in males.

Although studies regarding the root canal morphology of mandibular and maxillary first permanent molars have been done on various populations, studies regarding dentine thickness are limited to certain geographical regions, teeth and dental roots. From the 15 studies in Table 1 conducted since 2003, six originated from Brazil, three from Iran and one each from Korea, US, India, Türkiye and China. Ten studies were conducted on the first mandibular molar, mesial root, while two studies looked at the mesial root but do not mention from which mandibular molar, and two other studies incorporated the mesial root of the second molar tooth. Only two studies were performed each on the mesiobuccal root of the first maxillary molar and pulpal floor thickness respectively, while only one study looked at the distal root of the first mandibular molar tooth.[33,37]

Although root morphology of mandibular and maxillary molars of a South African population has been investigated,[55] to date no research studies have specifically focused on the dentine thickness of a South African population of different ages and both sexes. There is a clear need to identify and describe crucial morphological characteristics including dentine thickness of the maxillary and mandibular first molar teeth to reduce complications during root canal procedures.

The measurement modalities used in the literature reviewed have a large range of resolution from photographs with a six and 10 times magnification to a microscope with 10 times magnification and a stereomicroscope with a 36 times magnification as well as CBCT and Micro-CT (Table 1). The findings of Berutti and Fedon (1992) showed that the dentine thickness observed on histological sections is one fifth less than that appearing on radiograms. The impact of modality on the observed distances is important as even differences as small as one or two decimal places of a millimetre can be critical.[28]

Table I: Studies conducted on dentine thickness of first molars unless otherwise stated

Author, year of study and location	Root/s	Measurement modalities	Location of sections	Measurements in mm
Berutti & Fedon, 1992[28] Italy, Europe	15 extracted mesial roots of mandibular molars	Photographs at 12x magnification	1.5mm below furcation	1.2-1.3
Garcia Filho et al, 2003[31] Rio de Janeiro, Brazil	200 extracted mesial roots of mandibular molars	Microscope with 10x magnification and a precision of 0.001mm	2mm below furcation	Distance to distal wall: Average MB/ML: 0.79
Chang et al, 2007[37] Korea	20 intact mesial roots of mandibular first molars	CBCT images	Pulpal floor thickness	2.40
			Distance below canal orifice: 3mm 4mm 5mm	Distance to distal wall: MB: 1.04, ML: 1.11, Central: 1.09 MB: 0.92, ML: 0.97, Central: 0.93 MB: 0.88, ML: 0.93, Central: 0.91
			Distance below canal orifice: 3mm 4mm 5mm	Distance to mesial wall: MB: 1.21, ML: 1.36 MB: 1.12, ML: 1.23 MB: 1.01, ML: 1.09

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Author, year of study and location	Root/s	Measurement modalities	Location of sections	Measurements in mm
Sauáia et al, 2010[32] Brazil	285 extracted mesial roots of mandibular first molars	Photographs at 10x magnification	2mm below furcation	Distance to distal wall Long roots: MB: 0.92, ML: 0.93, MB-ML:3.54 Medium roots: MB: 0.97, ML: 0.91; MB-ML:3.26 Short roots: MB: 1.01, ML: 0.94; MB-ML:2.97
Tabrizizadeh et al, 2010[38] Iran	53 extracted mesial and distal roots of mandibular first molars	Photographs at 6x magnification	4mm below canal orifice	Mesial roots: MB/ML MB/ML: distance to distal wall: 1.2 & distance to mesial wall: 1.96 MB: distance to buccal wall: 2.17 ML: distance to lingual wall: 2.2 Distal roots: MB/ML MB/ML: distance to distal wall: 1.98 & distance to mesial wall: 1.3 MB: distance to buccal wall: 2.33 Min. distance to lingual wall: 2.38
Harris et al, 2013[30] Minneapolis, US	22 extracted mesial and distal roots of mandibular molars	Micro-CT	1.5mm from furcation 1.5mm from furcation 3mm from apex 0.5mm from apex 0.5mm from apex	MB-ML: 1.43-3.09; DB-DL: 1.98 Central: 4.35 Distance to distal wall MB/ML: 0.81-1.22 MB/ML: 0.22-1.13 Average distance: 1.28 Distance to mesial wall DB/DL: 0.25 DB/DL: 1.47
Dwivedi et al, 2014[39] India	45 extracted mesial roots of mandibular first molars	Stereomicroscopic integrated camera 36x magnification	2mm below furcation Junction between the apical and middle thirds of the roots	Distance to distal wall Long roots: MB: 1.07, ML: 1.14, MB-ML: 2.71 Medium roots: MB: 1.33, ML: 1.04; MB-ML: 2.76 Short roots: MB: 1.88, ML: 1.69; MB-ML: 2.97 Long roots: MB: 0.82, ML: 0.81, MB-ML: 2.13 Medium roots: MB: 0.90, ML: 0.88; MB-ML: 3.18 Short roots: MB: 1.06, ML: 0.91; MB-ML:1.01
Leite Pinto et al, 2018[33] Brazil	50 extracted mesial roots of mandibular first molars	CBCT	Pulpal floor thickness 0mm 1mm 2mm 3mm 4mm below furcation	2.23 Distance to distal wall MB/ML: 1.14 MB/ML: 0.95 MB/ML: 0.86 MB/ML: 0.81 MB/ML: 0.86 Distance to mesial wall
			0mm 1mm 2mm 3mm 4mm below furcation	MB/ML: 1.56 MB/ML: 1.37 MB/ML: 1.21 MB/ML: 1.06 MB/ML: 1.03
De Deus et al, 2019[34] Brazil	50 extracted mesial roots of mandibular first and second molars	Micro-CT	4.37mm below furcation	Minimum distance to distal/mesial wall MB: 1.13; ML: 1.10
Keles et al, 2019[35] Türkiye	11 extracted mesial roots of mandibular first molars	Micro-CT	5mm below furcation	Distance to distal wall MB: 1.14; ML: 1.11; MM: 0.97 Distance to mesial wall MB: 1.03; ML: 1.19; MM: 0.93
Ordinola-Zapata et al, 2019[42] Brazil	100 extracted mesiobuccal roots of maxillary first molars	Micro-CT	Median distances at: 2mm 3mm from furcation towards apex	Distance to distal wall MB1: 1.26; MB2: 1.00 MB1: 1.24; MB2: 0.99

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https://doi.org/10.17159/sadj.v80i02.20656

Author, year of study and location	Root/s	Measurement modalities	Location of sections	Measurements in mm		
			2mm 3mm from furcation towards apex	Distance to mesial wall MB1: 1.40; MB2: 1.20 MB1: 1.33; MB2: 1.17		
Azimi et al, 2020[43] Iran	50 intact mesiobuccal roots of maxillary first molars	CBCT	0mm 2mm 4mm from furcation towards apex	Distance to distal wall MB1: 1.01; MB2: 0.90 MB1: 1.02; MB2: 0.91 MB1: 0.90; MB2: 0.81		
Zhou et al, 2020[2] China	1792 intact mesial roots of mandibular first molars	CBCT		Minimum distance to distal wall No significant difference between MB and ML. In MB roots:		
			Men:	18-30 years	31-50 years	>51 years
			1mm	0.80	0.96	1.01
			2mm	0.78	0.82	0.85
			3mm	0.80	0.80	0.82
			4mm	0.78	0.79	0.83
			5mm	0.95	0.81	0.83
			below furcation			
			Women:	18-30 years	31-50 years	>51 years
			1mm	0.89	0.93	0.97
			2mm	0.76	0.79	0.84
			3mm	0.74	0.79	0.81
			4mm	0.76	0.80	0.81
			5mm	0.76	0.80	0.82
			below furcation			
			Men:	Long	Medium	Short
			1mm	0.97	0.93	0.92
			2mm	0.82	0.79	0.76
			3mm	0.78	0.76	0.74
			4mm	0.78	0.76	0.75
			5mm	0.78	0.78	0.75
			below furcation			
			Women:	Long	Medium	Short
			1mm	0.97	0.91	0.87
			2mm	0.82	0.77	0.73
			3mm	0.79	0.75	0.71
			4mm	0.82	0.75	0.73
			5mm	0.82	0.76	0.74
			below furcation			
Sousa et al, 2022[36] Brazil	210 extracted mesial roots of mandibular first and second molars	CBCT	1mm 3mm below furcation	Distance to distal wall MB: 1.06; ML: 1.07 MB: 0.88; ML: 0.92		
Bolbolian et al, 2023[41] Qazvin, Iran	210 intact mesial roots of mandibular first molars	CBCT	Average distance to furcation 1.58mm	Average distance to distal wall MB: 0.88; ML: 0.90		

https://doi.org/10.17159/sadj.v80i02.20656

CONCLUSION

Improved knowledge of the pattern of dentine thickness along the molar roots may lower the risk for perforation which ultimately could improve the success of the treatment. The thinnest dentine layer in the mesiobuccal canal in the mesial root of the first mandibular molar is reported as 1.13mm from the root canal outline to the distal surface of the mesial root and 1.10mm in the mesiolingual canal. These sites are located 4.37mm below the furcation, while the root surface 3mm from the apex revealed an even thinner dentine layer. On the other hand, the smallest dentine thickness in the first mesiobuccal canal for the first maxillary molar is 1.24mm from the root canal outline to the distal surface of the mesiobuccal root and 0.99mm for the second mesiobuccal canal, both sites located 3mm from the furcation. Treating physicians should take note that variations in dentine thickness have been reported between sexes, with ageing and populations, among others, but unfortunately no studies on dentine thickness in first molars could be found specifically for the South African context.

Authors' declaration

The authors declare that there is no financial interest in this paper and that this paper has not been submitted elsewhere for publication. All authors agree with the content of the manuscript. This manuscript did not receive any funding from funding agencies in the public, commercial or not-for-profit sectors.

Conflict of interest

The authors declare there is no conflict of interest.

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