Original Article

Method Of Detecting Tooth Root Erosion Using Ct Scan And Radiation After Receiving Orthodontic Treatment

Nadieh Qaderi[1],Mahsa Jahanbin[2], Arezousadat Fatemi[3], Faeze Mirjalili[4], Ali Arayesh[5*]

1.General Dentist, Department of Dentistry, Tabriz university of medical sciences,Tabriz, Iran.
Email:nadiehghaderi@gmail.com
2.school of Dentistry, Tehran university of medical sciences, Tehran, Iran.
Email:jahanbinmahsa7@gmail.com
3.General Dentist, Public Dental clinic practice, Stavanger, Norway.
Email:Fatemiarezoo@gmail.com
4.Assistant Professor, Department of oral and Maxillofacial Radiology, School of Dentistry, Kashan university of medical sciences, kashan, Iran.
Email:drfaezemirjalili@yahoo.com
5*.DDS, Dental school, Shahid Beheshti university of medical sciences, Tehran, Iran.
Email:a.arayesh80@gmail.com
Corresponding Author: Ali Arayesh[5]
*Corresponding Email:a.arayesh80@gmail.com
DOI: 10.47750/pnr.2023.14.02.438

Abstract

Introduction: One of the common causes of non-surgical root canal treatment failure is the inability to effectively treat all root canals due to the complex anatomy of the root canal system. The goal of root canal treatment is complete debridement of the root canal and complete removal of microorganisms and their by-products from the root canal system and effective flooding of the canal system. This goal will not be achieved without complete knowledge of root canal morphology. One of the common causes of non-surgical root canal treatment failure is the inability to effectively treat all root canals. Many studies have been presented on root canal morphology in different populations, which is certainly of great importance for endodontists and general dentists who want to perform root canal treatments.

Materials and methods: In this study, 45 maxillaries first and second molar teeth were used. After disinfecting the teeth, first the number and condition of the roots were recorded for each case. The morphology of the dental canals was determined using Cone Beam Computed Tomography (CBCT) in such a way that after preparing stereotypes, the images in all three axial, sagittal, and coronal sections were morphologically evaluated with the help of Romexis software until the total number of canals for each tooth, the number of canals in each root and the morphology of the canals in one root should be determined.

Results: The prevalence of three-rooted first and second molar teeth was 88% and 85%, respectively, and the prevalence of four-rooted first and second molar teeth was 4% in both cases. In 1% of the second molar teeth, the teeth had two roots. In 3% of first molars and 4% of second molars, root adhesion was observed.

Conclusion: According to the results of this study, the prevalence of the fourth channel in the Iranian race is relatively high. Considering the non-invasiveness and high accuracy of CBCT to identify additional canals and the importance of discovering these canals in the success of a root canal treatment, it is recommended to use CBCT during root canal treatment in cases with anatomical complications.

Keywords: Morphology, Root, CBCT, Axial, Sagittal and Coronal.

Introduction

The first signs of macroscopic development of maxillary milk molar teeth begin at 12.5 weeks. The time of the first signs of calcification of the maxillary first molar teeth is at 15.5 weeks and the maxillary second molar teeth at 19 weeks [1-3]. At birth, three quarters of the occlusogingival height of the maxillary first molar and one quarter of the occlusogingival height of the maxillary second molar are calcified [4]. The first and second permanent molars begin to develop around the 20th week of the embryonic period. This is done in a series of steps. Crown development occurs around 2.5 to 3 years of age. Meanwhile, the tooth root is completed around 9 to 10 years old. These events occur during a sequence including the initiation of cell division, cell growth, differentiation and enamel deposition [5-7].

The tooth first consists of a layer of epithelial cells called dental lamina. The stages of tooth formation from the dental lamina are divided into three stages according to the shape of the tooth. First, a mass similar to a flower bud appears. The characteristic of this stage is the proliferation of epithelial cells into the ectomesenchyme. Then this mass is encased and called a cap-shaped mass. This cell mass is also called the enamel organ [8-10]. Finally, with the growth of the tooth bud and the deepening of this intussusception, the bell-shaped stage occurs. During the development of the tooth crown, the tissue that is trapped inside this intussusception or the same enamel organ produces dental pulp and in the initial stages it is called dental papilla [11]. As a result of differentiation, the cells of the outer layer of the enamel organ become ameloblasts, which produce enamel. On the other hand, internal cells of the enamel organ participate in the formation of dentin by differentiating into odontoblasts. Also, the ectomesenchyme surrounding the enamel organ is transformed into a dental sac and participates in the formation of the periodontal ligament [12].

The beginning of deposition of non-mineralized dentin matrix occurs from the tips of the cusps. The first mineral layer of dentin that is formed is called dentine mantle, which is about 20 microns thick. After the deposition of the first dentin, ameloblasts begin to form enamel, and with the completion of deposition and formation of enamel, the root also begins to form [13]. The place where the internal and external cells of the enamel organ connect to each other is called the cervical loop. As this cervical loop begins to grow, a structure called Hertwig's epithelial sheath is formed (Figure 1). This sheath determines the size, shape and length of the tooth roots [14].

If the tooth has a single root, these pods grow from different sides until only a small hole remains. This proliferation is called epithelial diaphragm. In two teeth, diaphragm roots grow in two areas and meet on both sides, resulting in two holes. In teeth with three roots, this multiplication occurs in three directions and three holes are created.

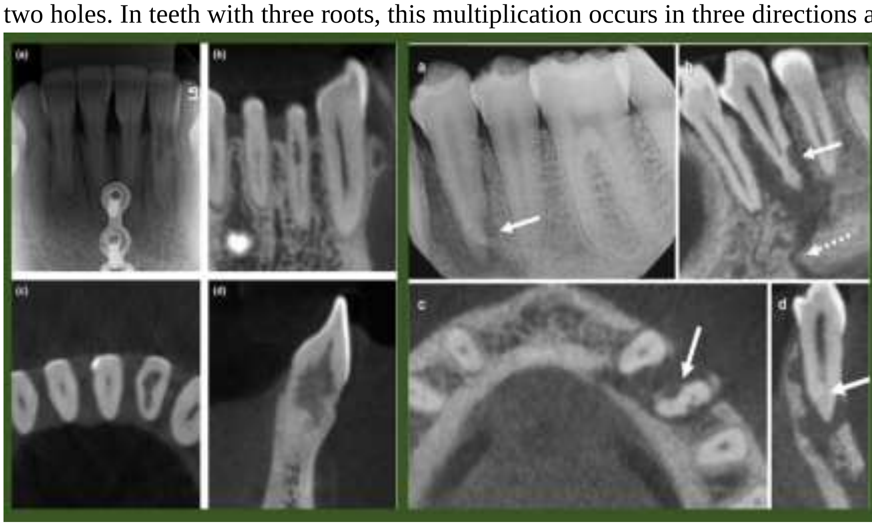

Figure 1. Method of Detecting Tooth Root Erosion Using CT scan and Radiation after Receiving Orthodontic Treatment

When the first layer of dentin is formed in the root, the cells of the dental sac begin to form cementum by migrating near the root and differentiating into cementoblasts [15]. Root formation begins a little before the tooth grows into the mouth, and when the tooth has reached its final position, about two-thirds of the root has been formed. The completion of the root is completed about two to three years after the completion of growth [16].

How to form lateral channels?

When the integrity of Hertwig's sheath is lost or a part of the root of the odontoblasts is not able to make dentin, a defect occurs in the dentin wall of the root, which eventually causes the formation of a secondary canal between the dental sac and the pulp [17]. These secondary channels may be formed in any region of the root, but they are more common in the last third of the root. But the most accepted theory about the formation of secondary channels is the trapping of a blood vessel in Hertwig's epithelial sheath. If the surrounding parts of this vessel do not undergo dentin formation, eventually a sub-channel will be formed [18-20].

Identification of lateral channels

Although these lateral canals may exist in most teeth, due to their thinness and small diameter, it is often difficult to identify and diagnose them through perioral radiographs. These channels are revealed when the channels are filled with filling materials and the sealer penetrates into these channels. It has been observed in various studies that the ability of conventional radiographs to identify sub-channels is significantly lower than other methods [21-23]. To discover these channels, CBCT, micro-CT, ultrasonic, or the use of a microscope are auxiliary methods with high accuracy. However, two radiographic signs that can indicate the existence of sub-channels are:

- Localized expansion of the periodontal ligament on the lateral surfaces of the root;
- The presence of a clear lateral lesion that is not due to root fracture.

In investigating the origin of a sinus tract, in the case that gutta-percha tends to the lateral surfaces of the root, in this case, the lesion is probably related to additional channels.

Search strategy and selection of articles

Search in Scopus, Google scholar, PubMed databases and by searching with keywords such as "Nursing Services"," Medical Services", " Diabetes" and “High Blood Pressure” to obtain articles related to the selected keywords [15]. Case report articles, editorials, and articles that were not published or only an introduction of them were available, as well as summaries of congresses and meetings that were in languages other than English, were ignored. Only the original research articles that evaluated the effectiveness of different drugs in the treatment of COVID-19 using standard methods were studied (figure 2).

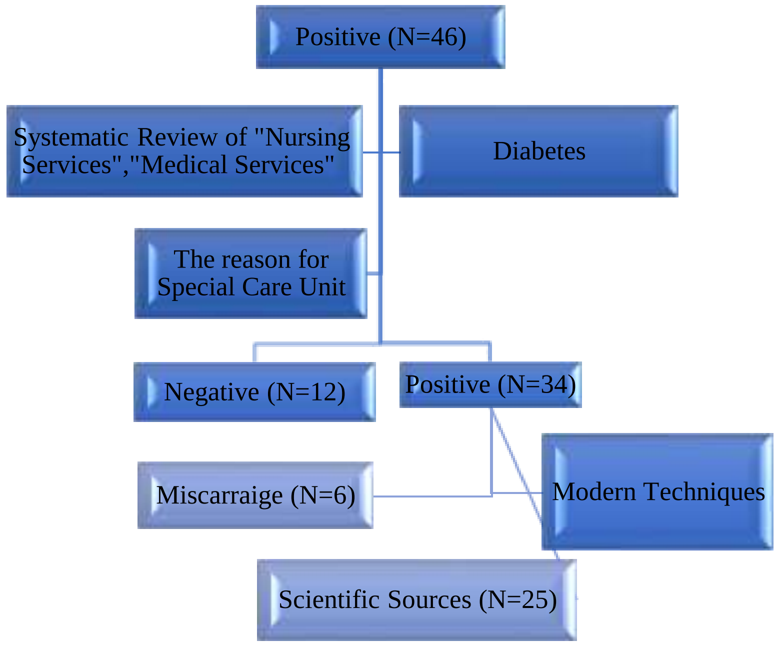

Figure 2. Flow chart of included subjects

Location and distribution of lateral channels

Lateral canals can be seen at any level of the root. But these channels are mostly seen in the last third of the root. These channels are mostly seen in the roots of molar and premolar teeth. However, these canals are also observed in the coronal third of the root or in anterior teeth [24-26].

Different shapes of root canals

Different scientists have so far presented different classifications for the different shapes of root canals in different teeth. One of these classifications is Wein's classification:

- ❖ Type I: A canal ending in an apical foramen.
- ❖ Type II: Two canals ending in an apical foramen.
- ❖ Type III: Two canals ending in two apical foramens.
- ❖ Type IV: A canal ending in two apical foramina.

In another division, Mr. Vertucci divided the different shapes of the root canal into 8 groups

- ❖ Type I: A single canal from the pulp chamber to the apex;
- ❖ Type II: Two canals leave the pulp chamber separately and connect near the apex;
- ❖ Type III: A canal leaves the pulp chamber and becomes two canals that finally connect;
- ❖ Type IV: Two separate canals from the pulp chamber to the apex;
- ❖ Type V: One canal leaves the pulp chamber and becomes two canals that end in two separate apical foramens.
- ❖ Type VI: Two separate canals leave the pulp chamber and unite in the root trunk and finally separate and end in two apical foramens.

- ❖ Type VII: A canal leaves the pulp chamber and divides into two canals in the root trunk and connects again and finally separates and ends in two apical foramens.
- ❖ Type VIII: Three distinct canals from the pulp chamber to the apex [27-29].

Morphology of maxillary first and second molar teeth

The maxillary first molar is the largest tooth in terms of volume and is one of the most complex teeth in terms of canal and root anatomy [30]. The largest width of the palpi chamber is in the buccolingual dimension and has 4 palpi tentacles. The border of the palpi chamber in the cervical is a rhombus. The entrance of the main mesiobuccal canal is located in the buccal and mesial entrance of the distobuccal canal in the maxillary first molar. The entrance of the second mesiobuccal canal (MB2) is palatal and mesial to the main canal. In this tooth, the longest and thickest root is the palatal root. This root usually curves towards the buccal side in the apical third. The distobuccal root is conical and may have one or two canals. The mesiobuccal root has been searched and clinically investigated more than any other root in the mouth and may have one, two or three canals. The position of the MB2 channel is very variable [31-33].

Crossing this channel is often difficult because an ivory step covers its entrance. Also, the entrance of the canal on the floor of the pulp chamber has a mesiobuccal slope and there are one or two sharp curves in its path. This canal can be discovered by removing these dentine obstacles by ultrasonic tips in the mesial and apical length of the pulp mesiobuccal groove. The maxillary second molar is similar to the first molar in terms of crown and root and canal anatomy. The differences between these two teeth are related to the closeness and closeness of the tooth roots, the greater curvature of the tooth roots and the fact that the roots of the second molar are shorter than the first molar [34].

Types of methods to identify the morphology of dental canals in laboratory

In laboratory studies, various methods have been used to investigate the different shapes of dental canals. One of the most common methods used is coloring with Indian ink and then demineralization of the teeth.

Another method is cutting the teeth, which is the gold standard for identifying the morphology of the canals. In more recent studies, the technique of Cone-Beam Computed Tomography or CBCT is used. Cone Beam Computed Tomography (CBCT) is a new technology to obtain a three-dimensional image of the desired location from a cone-shaped beam source and also a two-dimensional detector is used to obtain images of the desired area [35-37].

The basis of this technology is the simultaneous movement of X-rays on one side and the detector on the other side, and in fact, a rotating scan of more than 180 degrees. During rotation, multiple exposures are made at certain intervals, and the resulting images are called "Base images". The set of basic images are analyzed by computer software programs in order to process the final image. This technique has advantages over other laboratory techniques (Figure 3). The first point is its non-invasiveness, which makes it possible to conduct further studies on dental samples. Also, this method has a very high accuracy [38]. Unlike other laboratory techniques, this technique can be performed on patients in addition to drawn samples. But the use of CBCT requires more equipment and facilities, which may not be used in some studies. Also, due to the conical nature of the CBCT output beam, most of the photons are affected by Compton interferences and lead to the production of scattered X-rays. These scattered rays are absorbed and recorded by the pixels on the detector, which causes noise [39-41].

Figure 3. Types of methods to identify the morphology of dental canals in laboratory

An overview of the studies done

Abuabara and his colleagues in 2013 investigated the effectiveness of different diagnostic methods in identifying the MB2 canal in maxillary first molar teeth. They observed this channel in 8% of teeth in the initial radiographic images. This channel was diagnosed in 50% of cases in clinical examination and in 54% of cases using CBCT. This channel was identified in 54% of clinical examinations after CBCT and in 58% of clinical examinations using a microscope. Using Start X ultra-sonication, two additional cases were detected and a total of 62% identification of MB2. According to Vertucci's classification, 48% of mesiobuccal roots were type I, 28% were type II, 18% were type IV, and 6% were type V. They found no significant difference between the diagnostic ability of CBCT and clinical examination. But periapical radiography was significantly different from other techniques. They concluded that the simultaneous use of different techniques can increase the probability of identifying the MB2 channel. There is no difference between CBCT, microscope and ultrasound in this regard [42-44].

In 2013, Domark and his colleagues compared the three techniques of periapical radiography, CBCT and micro-CT in identifying the mesiobuccal root canals of the maxillary first molar. They evaluated 18 mesiobuccal roots. They observed that the accuracy of CBCT in identifying mesiobuccal root canals was not statistically significantly different from micro-CT. While periapical radiography was significantly less accurate than micro-CT. They evaluated CBCT and micro-CT as suitable methods to examine canal morphology [45].

In 2012, Han et al investigated the distobuccal canal orifice position of the maxillary second molar using CBCT in a Chinese population. They examined 816 second molars in 408 patients. They observed that 93.51% of second molars had three or four root canals. The distance between mesiobuccal and distobuccal orifice was between 0.7 and 4.8 mm. The distance between palatal and distobuccal orifice was between 0.8 and 6.7 mm. The angle between the three orifices was between 69.4 and 174.7 degrees [46].

They concluded that the position of the distobuccal canal of the maxillary second molar in the Chinese population has many variations that successful root canal treatment requires a complete knowledge of the anatomy of these teeth.

In 2012, Shenoi and Ghule investigated different mesiobuccal root shapes of maxillary first molar teeth in their study. They used 30 extracted first molar teeth. In order to measure their shape, they used CBCT imaging. They observed a variation in the mesiobuccal root in 80% of the teeth. Of these, 54.16% of extra canals were in the coronal third, 29.16% in the middle third, and 16.66% in the apical third. They concluded that more than half of the maxillary first molar teeth had MB2 and recommended further studies using a larger sample size [47].

In 2012, Kim and colleagues investigated the morphology of maxillary first and second molars using CBCT in a Korean population. They examined 814 first molars and 821 second molars in 415 Mongolian patients. One root was observed in 0.25% of first molars and 4.63% of second molars. The prevalence of attached roots was 0.73% in the first molar and 10.71% in the second molar [48].

In 802 three-rooted first molar teeth, extra canal was observed in 63.59% of mesiobuccal roots and 1.25% of distobuccal roots. Three or four roots were observed in 660 second molar teeth, in 34.39% of mesiobuccal roots, 0.3% of middle buccal roots, 0.3% of distobuccal roots and 1.82% of palatal roots. In 88.10% of first molars and 82.07% of second molars, the MB2 canal was present on both sides. They concluded that the use of CBCT is suitable for discovering additional channels.

Lee and colleagues in 2011 investigated the anatomy of the mesiobuccal canal in maxillary first and second molars in a Korean population using CBCT. They examined 458 first molars and 467 second molars. In 71.28% of the first molars and in 42.2% of the second molars, they identified the MB2 channel. The most common classification was based on Wein type III and II. MB2 channel prevalence decreased significantly with increasing age [49].

In a 2010 study by Lubbers et al., in a study entitled "Evaluation of the anatomy of impacted lower third molars by CT: Is there an indication for 3D imaging?" After examining 707 teeth, they concluded that due to the wide range of observed variations and the possibility of damage to the lower alveolar nerve, prescribing a 3D imaging is recommended in cases where a close connection between the nerve and the tooth is observed [50-52].

In a study titled "Mesiobuccal Root Canal Morphology of Maxillary First Molar by Micro CT" in 2010, Verma and Love investigated the morphology of this root in 20 cut roots. They used a CT scanner with a slice diameter of 11.6 microns. They examined the number and shape of channels, the presence of extra channels, communication between channels and the number of orifices. They observed that MB2 channels were present in 90% of the roots. Inter-channel communication was also observed in 55% of the channels. 15% of the roots had one apical foramen, 20% had two foramens, and 65% of the teeth had more than 3 foramens. In half of the roots, there were two orifices at the furca level, in 40% of the roots there was one orifice, and in 10% of the roots there were three orifices.

In 85% of the roots, a secondary channel was observed. Also, they observed that only 60% of roots in Wein's classification and 70% of teeth in Vertucci's classification could be divided. They concluded that the Micro CT method is an accurate and efficient method to examine the morphology of dental canals. In addition, the existing classifications to describe the root canal system do not adequately reflect the existing complexities [53].

In a study entitled "Comparative evaluation of modified canal staining methods and differentiation technique, CBCT, peripheral quantitative computed tomography (PQCT), spiral computed tomography (SCT), and smooth and contrast medium-enhanced digital radiography in the study of canal morphology "Root" conducted in 2010 by Neelakantan et al. compared the accuracy of various methods of determining the morphology of the root canal with modified staining method and washing technique, 95 teeth were used. The results showed that the difference between flat and contrast digital radiography methods and SCT with staining method was significant. While no significant difference was observed between CBCT and PQCT with staining method. They concluded that the use of CBCT and PQCT have the same accuracy as the staining method and can be used to determine the morphology of dental canals.

In research titled "Mandibular first molar with abnormal mesial root morphology by CBCT: Case presentation" in 2010 by Krithikadatta et al. confirming this rare morphology, no correlation was observed between CBCT data and clinical and radiographic diagnosis. Based on this, they recommended the evaluation of clinical images along with the understanding of radiographic images.

In a study conducted by Blattner and his colleagues in 2010 under the title "Efficiency of CBCT as an accurate method in identifying the presence of mesiobuccal canals in the maxillary first and second molars: A pilot study", they investigated the presence of the MB2 canal in 20 first and second molar teeth. The second maxilla was paid. For this purpose, they used three different methods:

Periapical radiography, CBCT and clinical cutting of teeth, which is the gold standard for diagnosis of MB2. They observed that CBCT correctly recognized the presence or absence of this additional channel in 78.95% of the samples, which statistically did not show a significant difference between the ability of CBCT and the golden standard of examining the morphology of channels, i.e. the clinical cutting method. They concluded that CBCT is the gold standard for diagnosis of MB2 channel [54].

In a study titled "Prevalence and morphological classification of distolingual roots in mandibular molars in the Korean population" conducted by Song et al. in 2010, cross-sectional CT scans were collected from 1775 Korean patients of mongoloid origin and the percentage of root presence distolingual was determined in the first molar teeth.

In 2010, Zheng et al investigated canal morphology in maxillary first molars in a Chinese population using CBCT. They examined 775 CBCT images of patients, in 627 cases only one first molar tooth was suitable for examination and in 74 cases the first molar teeth were suitable bilaterally.

They examined the number of canals and roots, the presence of extra canals, and the presence of two-way MB2 canals. Roots attached to each other were present in 71.2% of unilateral molars. The prevalence of the number of channels was such that two channels were observed in 0.31%, three channels in 47.21%, four channels in 50.40%, five channels in 75.1% and six channels in 0.31%.

Additional canalels were observed in 52.24% of mesiobuccal roots, 1.12% of distobuccal roots and 1.76% of palatal roots. 71.11% of MB2 channels were symmetrical in bilateral cases. They concluded that CBCT is a suitable method for examining the internal morphology of teeth. In a study titled "Reliability of CBCT and other radiographic methods in the preoperative evaluation of mandibular third molars" conducted in 2010 by Suomalainen et al., 42 teeth were clinically evaluated by different methods and it was determined that CBCT method is more accurate than other methods in order to determine the position of the impacted third molar in relation to the lower alveolar nerve canal and also to determine the number of roots [55].

In 2009, Baratto Filho and his colleagues investigated the internal anatomy of maxillary first molars using three methods: Ex vivo, clinical and CBCT. In this study, they recorded the presence of sub-channels and their location, the number of foramen and the number of non-traceable channels. In the ex vivo method, 140 teeth were examined. In the clinical method, the files of 291 patients who underwent endodontic treatment in the last two years in the faculty were examined.

54 teeth were examined in the CBCT examination. They observed that in the ex vivo method, the fourth channel was observed in 67.14% of cases. 92.85% of the secondary canals were in the mesiobuccal root, which in 17.35% of the cases could not be traced only by using a microscope. A foramen was observed in 65.30% of secondary canals. In the clinical examination, 53.26%, 0.35% and 0.35% of the teeth had 4, 5 and 6 root canals, respectively [56].

In 95.63% of the mesiobuccal roots, there was an additional canal, which was not detectable in 27.50%. In 59.38% cases, there was an extra canal of a foramen. In CBCT examination, 2, 4 and 5 root canals were observed in 1.85%, 37.05% and 1.85% of teeth, respectively. A foramen was observed in 90.90% of the studied teeth. They concluded that the use of microscope and CBCT are very necessary to trace additional canals and CBCT is a suitable method to start identifying the morphology of canals in the maxillary first molar.

In a study titled "Search for the root canal shape of the mandibular first molar in Chinese Taiwanese population" conducted in 2009 by Chen et al., 183 collected teeth were examined by a cutting microscope. In this study, the type of morphology was determined by Vertucci classification and it was found that 20% of the teeth had extra distal roots.

A study entitled "Morphology of the root canal of the first and second permanent mandibular molar teeth in the Ugandan population" was conducted in 2009 by Rwenyonyi et al. In this study, 224 first molar teeth and 223 second molar teeth of the mandible were used. Then, through Indian ink staining, it was determined that most of the mesial roots were of type IV of Vertucci's division and most of the distal roots were of type I. Also, the adhesion of the roots in the second molar was significantly higher than in the first molar.

A study titled "Morphology of the root canal of permanent mandibular first and second molars in the Jordanian population" conducted by Al-Qudah and Awawdeh in 2009, used 685 extracted first and second molar teeth. After applying the access cavity, the pulp tissue was dissolved by sodium hypochlorite and then Indian ink was injected into the canals. After decalcifying and dehydrating the teeth, the number of canals of each root, the number of canals of each tooth, the shape of canals, the number and location of sub-canals, and the presence of inter-canal communication were determined. Most of the teeth were 3-channel (48%) and 4-channel (46%). Also, the mesial roots were mostly type IV and the distal roots were type I. In addition, 10% of teeth had C-shaped roots.

Study population

In this study, 45 extracted humans first and second molar teeth were used.

Collecting teeth

In this study, first and second molar teeth were collected from 5 different geographical areas and before performing CBCT, all teeth were checked by a restorative specialist to ensure the type of molar teeth (first or second).

Preparation of CBCT stereotypes

CBCT was used in this study to determine the morphology of molar teeth canals. First, the teeth were mounted inside the putty in the form of an arch. 7 molar teeth were placed in each arch. Then, the teeth were scanned using the CBCT scanner of the Faculty of Dentistry (Pro max 3D and Planmeca models) with conditions of 72 KVP and 8 mA.

Determination of tooth morphology

Evaluation of the number and condition of roots (adhesion of roots to each other) in each tooth was done visually. In this case, the roots were considered to be attached to each other if this adhesion was observed in at least two-thirds of the length of the root. In order to determine the morphology of dental canals after preparing CBCT stereotypes, the images in all three axial, sagittal, and coronal sections were morphologically evaluated with the help of Romexis software. To evaluate the total number of canals in each tooth, the number of canals in each root and the morphology of the canals in one root were determined. Vertucci's classification and Gulabivala's supplementary classification were used to determine the morphology of the root canal. All evaluations were done by 2 calibrated endodontists.

Sampling method

In the current research, a two-stage cluster sampling method was used, in the first stage, one city was selected from each geographical region, and then teeth were collected from each city in different regions.

Data collection

The method of data collection in this study was laboratory and field. The data collection tool was also observation.

Data analysis method

The data was entered into SPSS software version 11.5 and the frequency percentage of each type of root morphology was described using frequency distribution tables and mean, median and standard deviation indices.

Result

In the present study, 253 maxillaries first and second molar teeth were used, 2 first molar teeth and one molar tooth were excluded from the study due to severe calcification and lack of recognition of the dental canal system.

Investigation of root morphology

In the examination of root morphology in the maxillary first molar, the highest prevalence in terms of the number of roots was observed in the form of three-rooted first molar. 40 teeth had three roots and 2 teeth had four roots. Also, one or two roots were not seen in any of the investigated teeth. In the examination of root attachment in Mulravel's teeth, in cases where the teeth had three roots, only one case of mesio-buccal root attachment to the palatal root was observed, and the other 35 teeth had three separate roots (Figure 4). In both teeth with four roots, two mesial roots were fused to each other. In the examination of the root morphology in the maxillary second molar tooth, similar to the first molar tooth, the highest frequency in terms of the number of roots was observed in the second molar tooth with three roots.

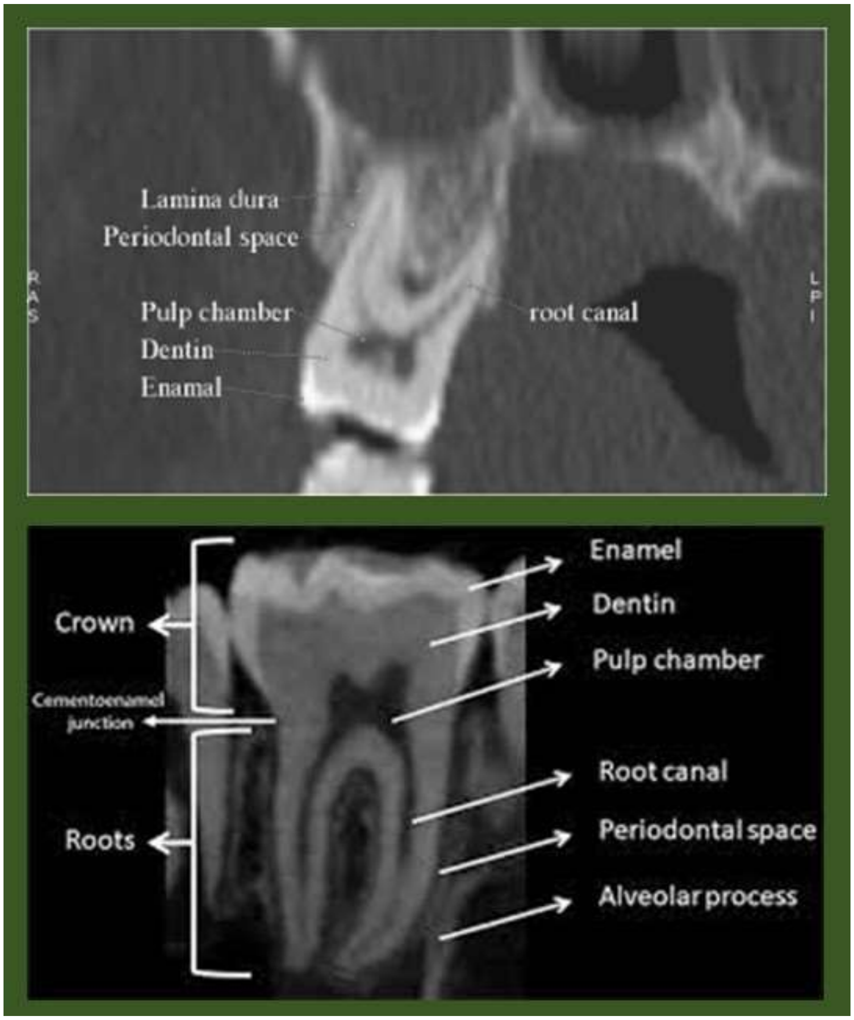

Figure 4. Investigation of root morphology

In the examination of root attachment in the second molar tooth, in cases where the teeth had three roots, 45 teeth had three separate roots. 9 teeth with two attached roots (7 cases of adhesion of mesiobuccal and distobuccal roots and 2 cases of adhesion of distobuccal and palatal roots) and only one case of adhesion of all three mesiobuccal, distobuccal and palatal roots were observed. Four roots were observed in second molar teeth, four separate roots in one case and two roots attached together in one case. Also, only in the case of a tooth with two roots, two buccal and palatal roots were separated from each other.

Table 1. Morphology of the roots of maxillary first molar teeth

Number of teeth (%)	Root morphology
0	Four distinct roots
2 (1.6)	Four roots and two roots stuck together
4 (597.6)	Three distinct roots
1 (0.8)	Three roots and two roots stuck together
0	Three roots stuck together
0	Two separate roots
0	Two roots stuck together

0	A root

Table 2. Morphology of the roots of maxillary second molar teeth

Number of teeth (%)	Root morphology
1 (0.8)	Four distinct roots
1 (0.8)	Four roots and two roots stuck together
45 (89.6)	Three distinct roots
9 (7.2)	Three roots and two roots stuck together
1 (0.8)	Three roots stuck together
1 (0.8)	Two separate roots
0	Two roots stuck together
0	A root

Examining the morphology of channels

The prevalence of the fourth canal in the mesiobuccal root (MB2) of the first molar tooth was 52.8%. (26 teeth out of 45 maxillaries first molars had a fourth mesiobuccal canal.) In the examination of the root canal morphology in the mesiobuccal root of the first molar, type I (a single canal from the pulp chamber to the apex) had the highest prevalence. In cases where the mesio-buccal root contained two canals, respectively, type VI (two separate canals left the pulp chamber and united in the root trunk and finally separated and ended in two apical foramen), type II (two separate channels leave the pulp chamber and connect near the apex) and type III (one channel leaves the pulp chamber and becomes two channels that finally connect) were the most common. In the distobuccal root of the first molar, the most type of canal morphology was type I.

Also, in 4 teeth, the fourth canal was observed in the buccal dysnoe root, and in three cases, the morphology of the canal was type III and in one case it was type II. In the palatal root of the first molar, the most type of canal morphology was typing I. Also, in 2 teeth, the fourth canal in the palatal root was observed, in one case, the morphology of the canal was type IV and in one case it was type II. In the examination of the morphology of the canals in the permanent first molar teeth, two new anatomical variations were observed. In one case of the first molar, the distobuccal and mesiobuccal canals were connected, and in the case of the other tooth canals, the mesiobuccal root was in the form of MB: 1-3-2-1. In examining the morphology of the molar root canals in the second maxilla, the prevalence of the fourth canal in the mesiobuccal root (MB2) of this tooth was 16.84%.

(19 teeth out of 45 maxillaries second molars had the fourth mesiobuccal canal.) In the examination of the root canal morphology in the mesiobuccal root of the second molar type I had the highest prevalence. In cases where the mesio-buccal root contained two canals, type III, type IV, and type VI and II were the most prevalent. In the distobuccal root of Mollerdum, the most type of canal morphology was type I (119 teeth). Also, in one case, a fourth canal was observed in the buccal disno root, whose morphology was type III. In the palatal root of the second molar, the most type of canal morphology was type I. In the examination of the morphology of the canals in the permanent second molar tooth, five new anatomical variations were observed. Meanwhile, in one of the second molar teeth, the dental canals were in the form of 3-2-1-2-3-4-3, first the distobuccal and palatal canals are connected to each other, then they join the mesiobuccal canal. Then they are separated from each other in the same way. In another case, the canals were 2-3-4, where there were two mesial and distal canals first, and then the palatal canal was separated from them. In another second molar tooth, the mesiobuccal and distobuccal canals were separated at first, then connected and finally separated from each other.

Discussion

Since the main goal of root canal treatment is the complete debridement of the root canal and the complete removal of microorganisms and their by-products from the root canal system and the effective flooding of the canal system, knowledge of the morphology of the root canal is essential. As a result, one of the common causes of root canal treatment failure is the inability to effectively treat all root canals [57].
Therefore, examining the morphology of the root canal, especially in teeth with a high probability of having additional canals, such as the first and second molars of the maxilla, is of great importance for endodontists and general dentists who want to perform root canal treatments.
In the present study, CBCT was used to investigate the formation of dental canals. Also, similar to the present study, Kim et al. and Lee et al. used CBCT to examine the internal morphology of the first and second molar teeth. Also, Zheng and his colleagues used this technique in examining the morphology of the maxillary first molar. Ghule and Shenoi used CBCT to study the mesiobuccal root of maxillary first molar. In addition, Han and his colleagues used the CBCT technique in their study to investigate the position of the orifice of the distobuccal canal of the second molar. Meanwhile, Verma and Love used micro-CT to examine the mesiobuccal root morphology of the maxillary first molar. In the studies conducted by Khraisat and Smadi, Sadeghi and Sadr Lahijani, Alavi et al., Ng et al., and Al Shalabi et al., staining with India ink or fuchsia and then clarifying using demineralization to examine the formation of the Müller canals first or second maxilla were used [58].
Ashfote Yazdi and Hasani used tooth cutting. In their study, Eghbal and colleagues used two periapical radiographs in two different directions. Also, Wein and his colleagues used periapical radiographs after placing the file inside the canals to examine the mesiobuccal root of the maxillary first molar. It has been shown in various studies that CBCT (Figure 5) has a much higher accuracy than periapical radiography [59].
On the other hand, unlike CBCT, in coloring and clarifying or cutting teeth, dental samples are lost and we will no longer be able to carry out further investigations on the accuracy of determining the shape. Also, CBCT can be used at the bedside, which none of the mentioned methods have this capability. In this regard, Kim and his colleagues and Zheng and his colleagues investigated the morphology of the dental canal in patients using CBCT. In this situation, it will be possible to examine the morphology of a tooth bilaterally, which is not common in any laboratory study.

Raw	Study	Year	Severe COVID-19		non- Severe COVID-19			Proportion Wight 98%		Weight %
			Yes	No	Yes	No				
1	Wang et al.	2021						0.85	[0.39 – 1.02]	6.02
2	Kragholm et al.	2021						0.83	[0.42 – 1.01]	5.92
3	Papadopoulos et al	2021						0.74	[0.55 – 1.02]	5.65
4	Team	2020						0.91	[0.48 – 1.08]	6.03
Heterogeneity τ^2=0.00, I^2= 0.00, H^2=1.00								0.98	[0.20 – 1.08]	
Test of θ= θ, Q (4) =3.99, P= 0.66										
1	Hafeez et al.	2020						0.68	[0.52 – 1.06]	6.02
2	Wang et al.	2020						0.74	[0.31 – 1.08]	5.92
3	Guan et al	2020						0.89	[0.19 – 1.01]	5.65
4	Zhang et al	2020						0.90	[0.29 – 1.02]	6.03
Heterogeneity τ^2=0.00, I^2= 0.00, H^2=1.00								0.98	[0.20 – 1.06]	
Test of θ= θ, Q (4) =4.44, P= 0.71										
1	Piva et al.	2020						0.92	[0.39 – 1.06]	5.03
2	Zhang et al.	2020						0.87	[0.54 – 1.02]	6.02
3	Haghighi et al.	2020						0.88	[0.63 – 1.01]	5.57
4	Jebril	2019						0.60	[0.25 – 1.08]	6.13
Heterogeneity τ^2=0.02, I^2= 0.00, H^2=1.00								0.95	[0.22 – 1.07]	
Test of θ= θ, Q (4) =5.55, P= 0.74										

Figure 5. Forest plot showed Tooth Root Erosion Using CT scan and Radiation after Receiving Orthodontic Treatment

In their study, Abuabara and his colleagues, by evaluating and comparing the accuracy of CBCT in registering sub-canals compared to periapical radiography, microscope and ultrasound, observed that CBCT had a very high accuracy and there was no difference between its use compared to microscope and ultrasound. Also, by comparing periapical radiography, CBCT and micro-CT, Domark and his colleagues stated that CBCT is an efficient method in examining the shape of canals. In the study of Neelakantan and his colleagues, CBCT had an acceptable accuracy in determining the shape of dental canals compared to the techniques of clarification and staining, PQCT and SCT. Also, Blattner and his colleagues compared CBCT with the gold standard method of determining the morphology of dental canals or clinical cutting of teeth, and found that in about 80% of cases, CBCT with the gold standard had the same diagnosis of MB2 [60].

They found CBCT to be a reliable and suitable method for evaluating and diagnosing MB2. In this regard, Baratto Filho and his colleagues also recommended the use of CBCT to examine the internal anatomy of maxillary first molar teeth. As a result, the use of CBCT technique can be a suitable, accurate and non-invasive method for examining the internal morphology of teeth.

Conclusion

In the present study, it was observed that the prevalence of three-rooted first and second molars was 98.4% and 97.6%, respectively. Also, the prevalence of four-rooted first and second molars in both cases was 1.6%. In 0.8% of the second molar teeth, the teeth had two roots. Similar to the present study, in the study of Neelakantan and his colleagues, in the maxillary first and second molars, the prevalence of three roots was 96.8% and 93.1%, respectively. They observed four roots in only 0.9% of first molar teeth. Unlike the present study, they reported a higher percentage of the prevalence of two-rooted first molar teeth (1.3%) and second molar teeth (5.8%). Also, they observed a root in 0.9% of first and second molars, which was different from the results of the present study.

In the present study, it was observed that in the first molar, the root adhesion was 2.4% and in the second molar, it was 8.8%. This result is somewhat consistent with the result of Kim et al.'s study on the Mongolian race. They found the prevalence of bonded roots in the first molar was 0.73% and in the second molar was 2.71%. Zheng and his colleagues also reported the prevalence of attached roots in Chinese maxillary first molars of 71.2%, which was similar to the present study.

Meanwhile, Ng and his colleagues reported that all maxillary first and second molars in the Burmese population had three separate roots. In contrast to the results of the present study, al Shalabi and his colleagues in the Irish race observed attached roots in 11% of maxillary first molars and 43% of second molars, which is a relatively higher percentage of attached roots compared to other studies and the present study. This difference can be due to how the roots stick to each other. In the present study, only roots that are fused to each other in their entire length or at least two thirds of the coronal root have been identified as attached. If in the above study, the roots that were attached to each other in one third or half coronal were also considered as attached roots.

In the current study, in 46.4% of the cases, the mesiobuccal canal was type I, and in one case, this root was united with the distobuccal root. Unlike the present study, in the disturbed studies of Yazdi and Hasani, as well as Sadeghi and Sadr Lahijani, about 20-25% of mesiobuccal canals were type I. Meanwhile, similar to the present study, Abuaraba and his colleagues assessed mesiobuccal roots as type I in 48% of first molars.

In this study, distobuccal and palatal first molar canals were type I in 96% and 98.4% of cases, respectively. Similar to Hazez's study, Kim and colleagues observed only one canal in 98.75% of distobuccal roots and 100% of palatal roots. Also, Zheng and colleagues reported only one canal in 98.88% of distobuccal canals and 98.24% of palatal canals. Ashfote Yazdi and Hasani, as well as Alavi and his colleagues, found type I distobuccal and palatal canals in all first molars. Ng et al reported type I dental canal in 96% of distobuccal roots and 100% of palatal roots. Contrary to the present study and the aforementioned studies, in the study of Sadeghi and Sadr Lahijani, the prevalence of type I canal was lower than other studies, and the distobuccal root was 90% and the palatal root was 92%.

In the present study, it was determined that the shape of the mesiobuccal root of the second molar in 84.16% of the cases where this root was separate, had a type I shape. Therefore, additional channels were observed in 16.84%. Similar to the present study, Sadeghi and Sadr Lahijani reported in their study that 74% of mesiobuccal roots of second molars had type I formation. Meanwhile, in their study, Kim and his colleagues observed MB2 canal in 34.39% of the mesiobuccal roots of the second molar. While Lee and colleagues observed the prevalence of MB2 in 42.2%. Also, Alavi et al. and Ng et al. reported that in 56% and 49% of second molar teeth, there was an additional canal in the mesiobuccal root. This rate was 58% in the study of al Shalabi and his colleagues.

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