

In Vitro Stereomicroscopic Study of the Incidence and Position of Root Canal Isthmuses in Mandibular First Molars

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Background: Accessibility to all sites of root canal and its mechanical and chemical cleaning is mandatory for successful root canal therapy. The presence of isthmus is a major hindrance to complete root canal accessibility.

Objectives: The purpose of the present study was to determine the relative frequency and type of isthmuses in the apical region of mesial root of the first mandibular molar extracted in Yazd.

Materials and Methods: In this descriptive-laboratory study, 100 mandibular first molar teeth were collected. The mesial roots were excised at the cervical region and three horizontal sections perpendicular to the longitudinal axis of the root were secured with 1-, 3-, and 5-mm distances upwards from apex region of the roots. The incised surfaces were stained using India ink and viewed under stereomicroscope with a magnifying power of $\times 60$ and photographed. The obtained images were studied regarding the presence or absence of isthmuses and the various anatomical forms of isthmuses were recorded based on Hsu and Kim taxonomy.

Results: Isthmus was present in 54% of teeth. The greatest frequency of isthmuses was observed in the 5 mm from the apex. The type V isthmus was the most prevalent isthmuses between all levels of roots.

Conclusions: The frequency of isthmuses in the mesial root of mandibular first molars was high. The results of clinical and surgical endodontic procedures may be affected by this aspect of root canal anatomy.

Keywords: Endodontic Treatment; Root Canals; Taxonomy; Tomography

1. Background

A successful endodontic therapy is based on removal of all vital or necrotic tissue, microorganisms, and microbial byproducts. The success rate of surgical and nonsurgical endodontic procedures may be reduced due to intricate nature of root canal anatomy such as webs, fins, and isthmuses, or other irregularities, which can act as bacterial reservoirs (1). One study concluded that bacteria are able to survive in difficult situation, even more than a decade in isthmuses. An isthmus has been defined as a narrow, ribbon-shaped communication between two root canals that contains pulp tissue. Isthmuses have been found to be present in all types of root in which two canals are normally found (2, 3). The incidence of canal isthmuses varies for each type of tooth and the level within a given root (4) but also appears to be age related (5).

Hsu and Kim classified the isthmuses into five types (6):

1. Two or three root canals with no notable communication
2. Two root canals with definite connection between the two main root canals
3. The presence of three root canals instead of two incomplete e-shaped canals with three canals

4. Canals extending to the isthmuses

5. A trace connection or corridor throughout (Figures 1-3).

The prevalence of isthmuses in the mesial root of mandibular molars have been observed in previous studies (7-9) with observation through different methods and at varying distances from the apex (8, 9). The reported prevalence of isthmus in mandibular molars ranges from 58% to 89% (10, 11).

2. Objectives

The aim of this study was to investigate the incidence and type of isthmuses in mesial root of mandibular molars in an Iranian population.

3. Materials and Methods

In this study, 100 freshly removed first molars of lower jaw with separate mesial and distal roots and fully formed apices were collected from general practitioners, then they were transferred into 10% formalin for preservation. Mesial roots were separated from cervical area using diamond disks (Tizkavan, Iran). In order to reduce the chances of contamination with foreign material,

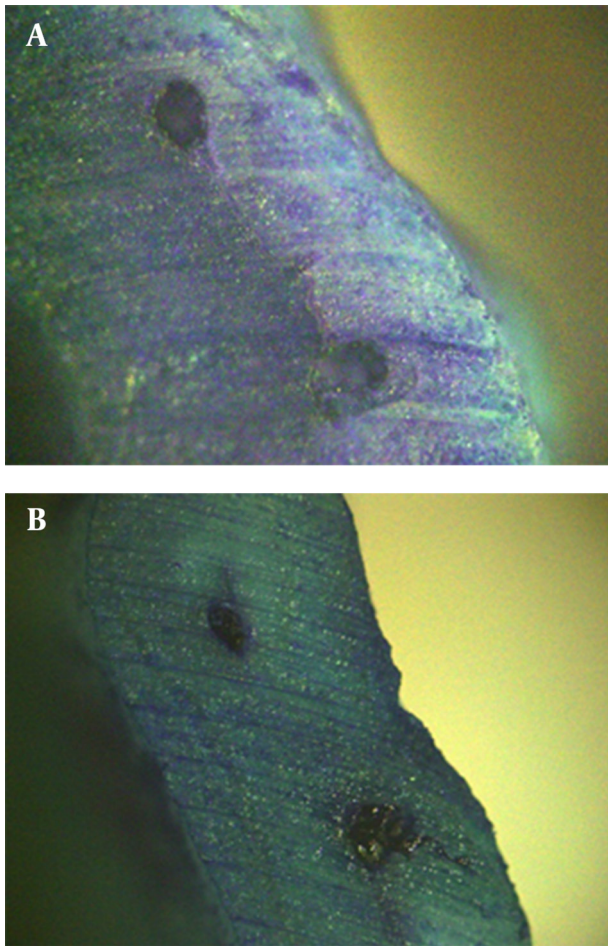


Figure 1. Isthmuse, Type I and II

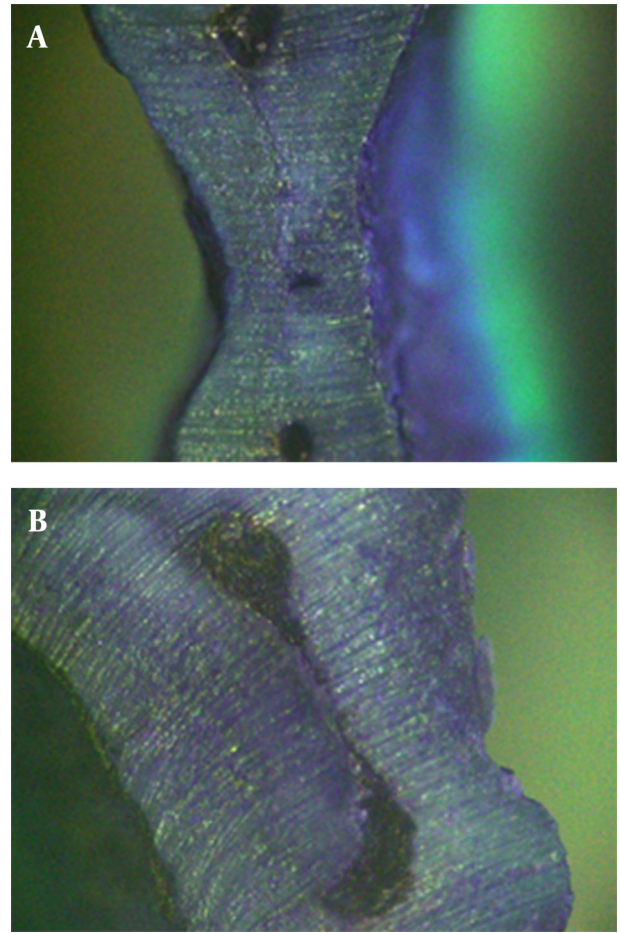


Figure 2. Isthmuse, Type III and IV

the roots were covered with wax and each root was separately kept in clear resin. Then three horizontal cut perpendicular to long axis of tooth at distances of 1, 3, and 5 mm from root apex were measured with the help of a caliper and were prepared with a diamond disk. In order to dissolve any remaining organic material, each specimen was kept in 5.25% sodium hypochlorite solution (Paksan, Iran). When hard tissue sections were prepared, their thickness varied considerably (250-1000 mm). When examining histopathologic sections of teeth, a high resolution of fine structures is required, which can be achieved by staining the sections (12). Therefore, all sections were subsequently washed by water, colored with India ink (Indiamart, India), viewed with the magnification of $\times 60$ under stereomicroscope (Carl Zeiss, Germany), and photographed. Photos were analyzed based on Hsu and Kim taxonomy using high resolution screen.

4. Results

In this study, 100 human lower mesial roots of molar teeth were analyzed for the presence of isthmuses via



Figure 3. Isthmuse, Type V

Hsu and Kim taxonomy (6). This study reveals that 35% of studied roots had one canal and 65% had two canals in the 5-mm apical root section. At the 3-mm apical section, the number of two root canals reached 50% and at

1-mm apical section they were reduced to 24%; therefore, the highest prevalence of isthmuses was found at 5-mm section and the lowest was found at 1-mm apical root sections. Based on Hsu and Kim classification, the highest frequent isthmuses in different sections was type four and the lowest frequency belonged to type three (Figure 4)(Table 1).



Figure 4. Different Type of Isthmuses, Schematic View

Table 1. Incidence and Type of Isthmus^a

Isthmus	One Canal		Two canal				
			Type I	Type II	Type III	Type IV	Type V
1-mm Root Section	76 (76)	24 (24)	-	-	-	-	-
3-mm Root Section	50 (50)	34 (34)	13 (13)	1 (1)	-	-	2 (2)
5-mm Root Section	35 (35)	11 (11)	18 (18)	-	8 (8)	28 (28)	-

^a Data are presented as No. (%).

5. Discussion

In our study, similar to most of previous studies including studies by Weller, Kerekes and Bidar et al. (3, 13, 14), teeth were kept in clear resin and then parallel longitudinal sections were prepared; however, in another study, sections were prepared perpendicular to longitudinal axis of root (15). In some studies computerized tomography (CT) was used (7, 11, 16, 17). The presence of isthmus changes regarding kind of the tooth and section surface (18). In present study, 54 isthmuses were seen at 5-mm apical sections of mesial roots; however, this frequency was 16% at 3-mm apical root sections. Mannocci et al. reported that the prevalence of isthmuses at the 5-mm apical root sections of lower mandibular teeth was 17% to 50% and the highest number of isthmuses was seen at the 3-mm apical root sections. These findings can be due to the small sample size (17). In a similar study performed by Endal et al. using micro-CT, highest number of isthmuses were seen at 4-mm to 6-mm apical root sections. The problem with using CT is visualizing only hard tissue debris and filling materials (18). In 1984, Vertucci reported that isthmuses were seen in 52% of two canaled roots, he added that 75 percent of anastomose were seen at one-third of coronal root sections and 15% at apical root sections (5). Bidar reported that the frequency of isthmuses was 16% in distal roots of molars (14). von Arx used surgical endoscope and found that the frequency of isthmuses in distal roots and mesi-

al roots was 36% and 83%, respectively (4). Fan's study (11) showed that the frequency of isthmuses at 5-mm apical root sections of mesial roots in the first and the second lower molars was 86% and 84%, respectively, which were similar to the results of von Arx (4). Choudary (16) used a spiral CT to diagnose isthmuses and showed the frequency of 81% at 5-mm apical root sections, which was almost the same as the frequency of 83% in von Arx study (4). In Mannocci study, using CT showed a frequency of 17% to 50% for isthmuses, which would be due to their small sample size (17). In a study, 59% of roots had isthmuses, 22% of them were complete isthmuses and 37% were incomplete isthmuses, which show the high prevalence of isthmuses at apical root sections (9). Using CT, Endal showed that isthmus area had changed after cleaning. The most important isthmuses in molars is the existence of strap like connection between canals (18). This study revealed that although isthmuses were cleaned by EDTA and NaOCl and the needle penetrated into one-third of apices of canal, ivory debris still remained in isthmuses. Even using ultrasonic equipment to activate the cleaning material failed to clean the debris thoroughly. According to Hsu and Kim, one of the reasons that increased the success rate of endodontic surgery was the diagnosis of isthmuses (6). It was shown that dentinal debris are produced during canal instrumentation and its penetration of sealers and filling materials into isthmuses despite continuous irrigation during and after instrumentation (18). Some in vitro studies have shown that none of the isthmuses in the root canals can be completely obturated with root filling materials during conventional endodontic treatment (18, 19). Therefore proper management of isthmuses requires newer strategies and further studies to verify their efficiencies. A recent study done on the cleaning efficacy of laser activated irrigation of root canals showed that the use of this technique is more efficient in improving apical third of root canal compared to passive ultrasonic irrigation and hand irrigation techniques (20-22). Because researchers around the globe have reported different frequency of isthmuses in mesial roots of lower molars, it seems that variety of genetic features and geographical distribution have a significant effect on teeth anatomic features (23). Therefore, clinicians of each area should have enough familiarity with population anatomy of the area in order to have a more successful therapy.

Authors' Contributions

Study concept and design: Dr. Mahdi Tabrizzadeh; acquisition of data: Dr. Yousef Khalil Sefat; analysis and interpretation of data: Dr. Yousef Khalil Sefat; drafting of the manuscript: Mahdi Hakimian; critical revision of the manuscript for important intellectual content: Dr. Mahdi Tabrizzadeh; administrative, technical, and material support: Dr. Mahdi Tabrizzadeh; and study supervision: Dr. Mahdi Tabrizzadeh.

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