

# Middle Mesial Canals in Mandibular Molars: Incidence and Related Factors

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## Abstract

**Introduction:** Although the internal anatomy of mandibular molars has been extensively studied, information about middle mesial (MM) canals is limited. The primary aim of this retrospective study was to evaluate the incidence of MM canals in mandibular first and second molars. The secondary aim was to correlate the incidence of MM canals with variables of molar type, sex, age, ethnicity, and presence of a second distal canal. **Methods:** All mature permanent first and second mandibular molars treated from August 2012 to May 2014 were included in the analysis. After completion of root canal instrumentation in all main canals, the clinician inspected the isthmus area of the mesial root using the dental operating microscope. If there was a catch point in this area with a file or explorer, the operator spent more time attempting to negotiate an MM canal. **Results:** Seventy-five mandibular first and second molars were treated during the specified period. Fifteen (20%) teeth had negotiable MM canals. The incidence of MM canals was 32.1% in patients  $\leq 20$  years old, 23.8% in patients 21–40 years old, and 3.8% in patients  $>40$  years. Analysis of data revealed a significant difference in the distribution of MM canals among different age groups ( $P < .05$ ). The differences in the distribution of MM canals based on sex, ethnicity, molar type, and presence of a second distal canal were not significant. **Conclusions:** The incidence of negotiable MM canals overall and their frequency of identification in younger patients were higher than in previous reports. (*J Endod* 2015;41:28–32)

## Key Words

Dental operating microscope, isthmus, mandibular molar, middle mesial canal, root canal anatomy

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The aim of root canal therapy is to eliminate all irritants from the root canal system. These irritants include necrotic pulp tissue, microorganisms, and their byproducts. A detailed knowledge of the pulp canal anatomy is necessary to effectively clean and shape the root canal system. Mandibular molars are the most frequent tooth type to be endodontically treated (1). Traditionally, mandibular molars are described as 2-rooted teeth with 2 canals in the mesial root and 1 or 2 canals in the distal root (2). However, studies have shown several variations in the anatomy of mandibular molars that are thought to be determined by race and genetics (3). These variations include a separate distolingual root (4), C-shaped anatomy of the roots and/or canals (5), an isthmus between the mesiobuccal (MB) and mesiolingual (ML) canals (6), and a third canal in the mesial root known as the middle mesial (MM) canal (7).

The reported prevalence of the MM canal in mandibular molars varies among studies. Methods of detection include plastic casts (2), clearing (8), scanning electron microscopy (9), micro-computed tomographic ( $\mu$ CT) imaging (10), and use of a file under magnification (11).

Based on the method used, the prevalence of the MM canal ranged from 0% (2) to 36% (10). Clinical studies on negotiable MM canals show results different from studies involving extracted teeth. Two older clinical studies reported an incidence of 2.6% and 12% for negotiable MM canals (7, 12).

Pomeranz et al (7) described the anatomy of MM canals as follows: (1) fin: The file passes freely between the main mesial canal (ML or MB) and the MM canal (transverse anatomies), (2) confluent: The MM canal originates as a separate orifice but apically joins the MB or ML canal, and (3) independent: The MM canal originates as a separate orifice and terminates as a separate apical foramen.

Clinical studies show that magnification significantly increases the probability of locating and negotiating a second MB canal in maxillary molars (13–15). Compared with the dental operating microscope, there was no significant difference when loupes were used (13). In an attempt to locate and negotiate MM canals in mandibular molars, investigators showed *in vitro* that using the dental operating microscope can increase the number of located and negotiated canals (11). To date, there are no studies that report the incidence of negotiable MM canals in mandibular first and second molars using the dental operating microscope. The primary aim of this study was to evaluate the incidence of negotiable MM canals in mandibular first and second molars using the dental operating microscope for magnification. The secondary aim was to correlate the incidence of MM canals with variables including molar type (first or second mandibular molar), sex, age, ethnicity, and the presence of a second distal canal.

## Materials and Methods

The study period was from August 2012 to May 2014. All cases with mature first and second permanent mandibular molars referred to the first author for nonsurgical root canal treatment or retreatment and had treatment completed after informed consent were included. The data were extracted from the Maryland endodontic record under a protocol previously determined to be exempt by the Institutional Review Board at the University of Maryland.

## Root Canal Treatment Procedures

After local anesthesia and rubber dam isolation, carious dentin and all defective restorations were removed. If there were no caries visible clinically or in bitewing

radiographs, the access cavity was prepared through the intact restoration. Then, the main canals (ML, MB, distolingual, and distobuccal) were located under 8× magnification using a Global G6 microscope (Global Surgical Corporation, St Louis, MO). After negotiating these canals with a size #8 or #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland), coronal flaring was done with Gates Glidden drills (sizes 2, 3, and 4 [Dentsply Maillefer]). In retreatment cases, the previous root canal filling material was removed with Gates Glidden drills (sizes 4, 3, and 2) in the coronal third. The apical two thirds of the root canal filling material was removed using EndoSequence Rotary Files (Brasseler, Savannah, GA) operated at 1000 rpm. Then, the working length was determined with an electronic apex locator (Root ZX II; J Morita MFG Corp, Kyoto, Japan). Root canal preparation was followed by rotary instrumentation using EndoSequence files using a crown-down technique and ending with a master apical rotary size 35/04 in the mesial canals and 40/04 in the distal canal(s). The root canals were irrigated by flooding them with 2.5% sodium hypochlorite (NaOCl) between each file size. After completion of instrumentation of the main canals, they were dried with sterile paper points. The pulpal floor was thoroughly inspected under magnification and any isthmuses probed using either #8 or #10 size C-files (Dentsply Maillefer) or an endodontic explorer. If the tip of the C-file or explorer detected a catch in the isthmus area, the clinician attempted to negotiate the MM canal with a watch-winding motion and slight apical pressure. After reaching the working length, the MM canal was prepared to a slightly smaller size (usually 30/04) than the main canals. Before obturation, the working length in all canals was confirmed by taking a periapical radiograph with the corresponding gutta-percha points fitted to the working length. An appropriate horizontally angled radiograph was taken to visualize all mesial canals. Then, all canals were obturated using cold lateral compaction of gutta-percha in the apical third followed by vertical compaction of thermoplasticized gutta-percha (Calamus; Dentsply International, Johnson City, TN). Final radiographs from 2 different angles were taken.

The number of MM canals was recorded for sex, ethnicity, age of the patient at the time of treatment, molar type (first or second mandibular molar), and presence/absence of a second distal canal. The Pomeranz classification of MM canals and the location of the MM canal orifice were recorded also. Differences in the incidence of MM canals were compared using the chi-square and Fisher exact tests. Statistical analysis was performed using SPSS (Version 18; IBM, Armonk, NY). Statistical significance was set at  $P < .05$ .

**Results**

Seventy-five mandibular first and second molars were treated during the 21-month period of the study. Of these, 15 (20%) molars had negotiable MM canals. The distribution of MM canals based on sex, age, ethnicity, molar type, and presence/absence of a second distal canal is shown in Tables 1 and 2. The average age of the patients was 35 years.

There was a significant and progressive decrease in the incidence of MM canals with age (Table 1) ( $\chi^2$  test,  $P < .05$ ). There were no statistical differences in the incidence of MM canals based

on sex, ethnicity, or molar type ( $P > .05$ ). A second distal canal was present in 60% (9/15) of the teeth with an MM canal (9/15). Eight mandibular first molars with an MM canal had 2 distal canals. Only 1 mandibular second molar with an MM canal had 2 distal canals. Among teeth without an MM canal, 48.3% (29/60) had a second distal canal. There was no significant difference in the presence of a second distal canal between the teeth with an MM canal and those without an MM canal (Fisher exact test,  $P > .05$ ).

Among the 15 MM canals, 7 (46.7%) showed “confluent” anatomy, 3 (20%) showed “independent” anatomy, and 5 (33.3%) showed “fin” anatomy (no separate orifice). Figures 1–3 through A–D are representative of each of these anatomies. One mandibular second molar had 2 fins close to the ML and MB canals (Fig. 3). Among those with separate orifices (10 teeth with confluent or independent anatomy), 8 had an orifice close to the orifice of the ML canal, and 2 had an orifice close to the orifice of the MB canal. In those teeth with “confluent” anatomy, 3 joined the ML canal, and 4 joined the MB canal. Overall, 4% (2/50) of mandibular first molars had a second distal (distolingual) root, and 8% (2 of 25) of mandibular second molars had a C-shaped anatomy.

**Discussion**

Failure of root canal treatment is related to the presence of bacterial biofilm in the root canal system (16). If 1 aim of root canal treatment is to remove all irritants from the root canal system, a missed canal or an unclean root canal system can be a cause for treatment failure. Persistent endodontic infection can be attributed to difficulties in removing a bacterial biofilm from root canal ramifications, including isthmuses (17).

The presence of isthmuses in the mesial root of mandibular molars has been studied using different techniques. One *in vitro* study examined the apical 6 mm of the mesial root of 50 mandibular molars (18). These roots showed isthmuses in 33% of the specimens at 3–5 mm from the apex (18). However, none of the sections showed more than the 2 main canals. Using  $\mu$ CT reconstructions, Fan et al (19) investigated isthmuses in the apical 5 mm of 126 mesial roots of mandibular first and second molars. Isthmuses with different anatomies were present in 107 of 126 (85%) specimens. Some specimens had more than 1 isthmus in the apical 5 mm. Harris et al (10) studied the internal anatomy of 22 mandibular molars using  $\mu$ CT reconstructions. An isthmus was present in 100% of the specimens, and 36% had more than 2 canals. A systematic review, which included both *in vitro* and *in vivo* studies of the internal anatomy of mandibular first molars, showed isthmuses present in 54.8% of the mesial roots (20). Fifteen studies were included in this review with a collective sample size of 1615 teeth. However, none of these studies reported whether isthmuses were clinically negotiable. Nevertheless, they provide sufficient evidence to show that there is a high probability of having uncleaned areas in the mesial root of mandibular molars after root canal treatment.

Using an endoscope to examine resected root ends, von Arx et al (21) studied 144 failed root canal–treated teeth that subsequently

**TABLE 1.** The Frequency Distribution (%) of Middle Mesial Canals (MMCs) in Mandibular Molars ( $N = 75$ ) Based on Sex, Age, and Ethnicity

	Sex, n (%)		Age, n (%)			Ethnicity, n (%)		
	M	F	<20	21–40	>40	Black	White	Hispanic
With MMC	8 (23.5)	7 (17.1)	9 (32.1)	5 (23.8)	1 (3.8)	8 (27.6)	5 (12.2)	2 (40)
Without MMC	26 (76.5)	34 (82.9)	19 (67.9)	16 (76.2)	25 (96.2)	21 (72.4)	36 (87.8)	3 (60)
Total	34	41	28	21	26	29	41	5

F, female; M, male.

## Clinical Research

**TABLE 2.** The Frequency Distribution (%) of Middle Mesial Canals (MMCs) in Mandibular Molars ( $N = 75$ ) Based on Molar Type and Presence/Absence of a Second Distal Canal

	Second distal canal, $n$ (%)		Molar type, $n$ (%)	
	With	Without	First molar	Second Molar
With MMC	9 (60)	6 (40)	11 (22)	4 (16)
Without MMC	29 (48.3)	31 (51.7)	39 (78)	21 (84)
Total	38	37	50	25

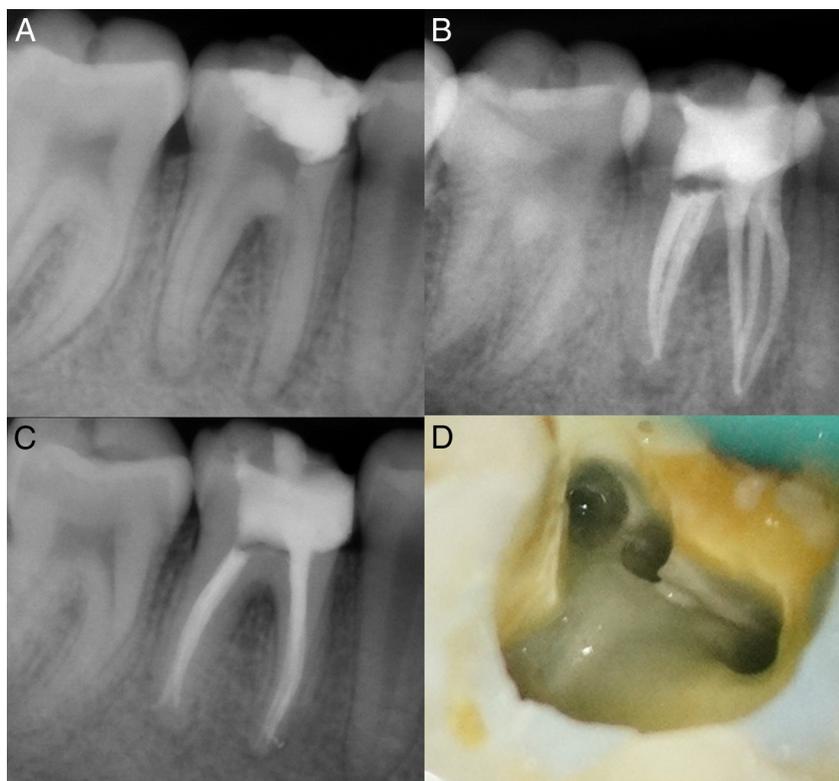
underwent root end surgery. They observed the highest percentage of isthmuses in the mesial root of mandibular molars (88.5%). Toure et al (22) showed that more mandibular molars were extracted after root canal treatment than any other tooth type. In addition, the second most common reason (20%) for extraction of mandibular molars was failure of endodontic treatment. It is possible that the identification, followed by the cleaning and shaping of MM canals, could lead to a reduction in irritants emanating from the complex root canal anatomy of mesial roots of mandibular molars. Thus, the number of failures of nonsurgical root canal treatment in these teeth might be reduced.

A clinically significant finding in our study was a higher incidence of negotiable MM canals in younger patients. Patients aged 20 years or younger showed an incidence of 32.1% for negotiable MM canals in mandibular molars. Gu et al (6) studied the isthmus anatomy of 36 mandibular first molars *in vitro* using  $\mu$ CT reconstructions. They showed a significantly higher prevalence (50%) of isthmuses in patients aged 20–39 years compared with 24% in patients older than 60. They

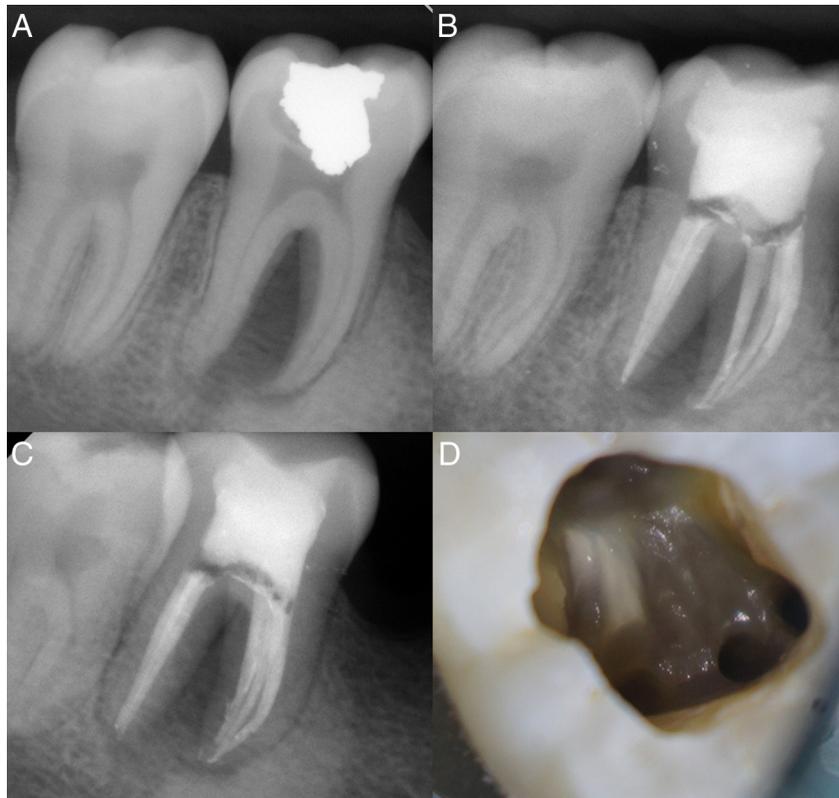
also showed that the average ratio of a partial isthmus to a complete isthmus increased with age (6). These findings are consistent with the results of our study. These findings indicate that clinicians should spend more time evaluating the pulp chamber floor area between the MB and ML canals to search for an isthmus when treating mandibular first and second molars of younger patients.

Our data showed no significant difference in the incidence of MM canals among different ethnic groups. Larger populations of known ethnic backgrounds are needed to show whether there is a level at which any differences become statistically significant. However, there was a considerable difference in the number of MM canals between whites and nonwhites. The incidence of MM canals in the white population was 12.2% (5 of 41), which is consistent with the findings of Pomeranz et al (7). The incidence of MM canals in nonwhites (blacks and Hispanics) was 29.4% (10/34).

Susin et al (23) showed that cleaning of isthmuses and intercommunications between root canals in 1 root is clinically challenging. They showed that negative apical pressure using EndoVac (SybronEndo, Orange, CA) removed considerably more debris from the isthmuses than manual dynamic irrigation with NaOCl and EDTA 17% (23). The effect of active ultrasonic irrigation, using NaOCl as an irrigant, on the cleanliness of the isthmus area in mandibular molars *in vivo* has been reported (24, 25). When active ultrasonic irrigation was added to conventional hand/rotary instrumentation during canal cleaning and shaping, both histologic and microbiological assessment showed significantly cleaner isthmus areas in the apical 1–3 mm (24, 25). Although these studies used noninvasive techniques to clean the isthmus area, none of them evaluated the amount of bacterial reduction in the complex root canal system. In an *in vitro* study on the effectiveness of Self Adjusting Files (ReDent Nova Ltd, Ra'anana,



**Figure 1.** (A) A preoperative view of tooth #30 in a 20-year-old black man. (B) A distal angle radiograph after obturation. The orifice of the MM canal is located close to the MB canal orifice. The MM canal showed “confluent” anatomy and joined the ML canal in the apical third. (C) A straight-on view of the tooth after obturation. (D) A magnified view ( $\times 8$ ) of the 3 mesial canals.



**Figure 2.** (A) A preoperative radiograph of tooth #30 in a 16-year-old black man. (B) A distal angle radiograph after obturation. The MM canal orifice is located close to the orifice of the MB canal. The MM canal showed a separate apical foramen (“independent” anatomy). (C) A mesial angle radiograph after obturation. (D) A magnified view ( $\times 8$ ) of the 3 mesial canals.

Israel) in removing bacterial biofilm from the mesial root of mandibular molars, no difference between Self Adjusting Files and other rotary files was found (26).

The negotiation of MM canals with hand/rotary files provides access for irrigating solutions into the otherwise inaccessible isthmus. We hypothesize that negotiation and chemomechanical preparation of the isthmus area can substantially reduce the bacterial biofilm and bacterial load. We also hypothesize that this reduction in bacterial biofilm may improve the outcome of nonsurgical root canal treatment in mandibular molars. Clinical outcomes studies with long-term follow-ups are needed to test these hypotheses.

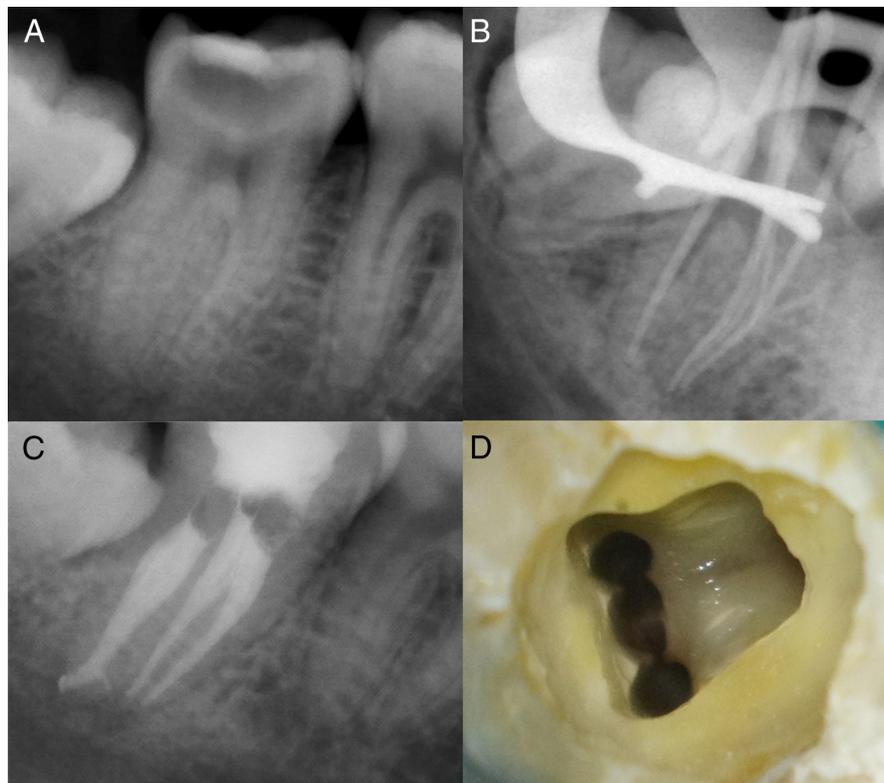
Anatomic variations of mandibular molars such as the distolingual root/canal and C-shaped root/canal anatomy are well recognized by endodontic clinicians. Studies have shown an overall prevalence of 13% for distolingual root in mandibular first molars (20) with a higher prevalence of 22% (4) to 28.5% (27) in Asian ethnic groups. Studies have shown a prevalence of 10%–31.5% for C-shaped anatomy in mandibular second molars in different Asian populations (5, 28). However, in this study, the prevalence of a distolingual root and C-shaped anatomy was less than other reports. This may be related to the fact that no patients of Asian heritage were included in the patient sample.

In contrast, data on the incidence/prevalence of MM canals are limited. Clinical studies on the incidence of negotiable MM canals are limited to those performed in the 1980s without using magnification (7, 12). Pomeranz et al (7) reported the highest incidence (12%). It is now well documented that using magnification enhances the clinician’s ability to visualize the anatomy of the pulp chamber (11, 14). Our study is the first *in vivo* evaluation of the incidence of MM

canals using the dental operating microscope. The high incidence (20%) of MM canals in this study is likely attributable to the use of the microscope.

Several of our anatomic findings regarding MM canals are consistent with other studies. Pomeranz et al (7) reported that the orifice of the MM canal was always located close to the ML canal. Our findings were similar for the majority of teeth with a separate MM orifice (8/10). Only 2 of 10 (20%) of teeth had the orifice of the MM canal located near the MB canal (Figs. 1 and 2). Our findings were also consistent with the observations made under magnification in a recent *ex vivo* study on extracted mandibular molars (11). A separate apical foramen for an MM canal was a rare finding (7, 11, 12). Nevertheless, in the present study, 20% (3/15) of the MM canals had a separate apical foramen (“independent” anatomy). Pomeranz et al (7) reported that the most prevalent anatomy was a “fin” (67%). Karapinar-Kazandag et al (11) found that all MM canals showed a “confluent” anatomy. No “independent” or “fin” anatomy was found. In our study, the most prevalent (46.7%) anatomy was “confluent.”

In conclusion, using magnification and careful tactile search techniques, the incidence of MM canals in mandibular molars was found to be higher than previously reported. The probability of finding and negotiating an MM canal in younger patients is significantly higher than in older individuals. Using the operating microscope is key to locating and negotiating MM canals. Clinical studies with long-term follow-ups are needed to determine the effect of preparation of MM canals on the outcome of nonsurgical endodontic treatment in mandibular first and second molars.



**Figure 3.** (A) A preoperative view of tooth #31 in an 18-year-old white man. (B) A distal angle view of the gutta-percha cone fit. There are 2 “fins” in the mesial root adjacent to the MB and ML canals. (C) A mesial angle radiograph after obturation. (D) A magnified view ( $\times 8$ ) of the access cavity. Note the presence of fins adjacent to the MB and ML canals.

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*The authors deny any conflict of interest related to this study.*

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