

## Third canal in the mesial root of permanent mandibular first molars: Review of the literature and presentation of 3 clinical reports and 2 in vitro studies

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### ABSTRACT

**Introduction.** Systematic anatomical studies corroborate the anatomical complexity of the root canal system. Deviations from the norm such as multiple orifices, apical deltas, accessory canals and other variations are frequent.

**Objectives.** To present clinical reports of mandibular molars with three canals in the mesial root and two in vitro studies of the morphology of these canals, together with a review of the literature.

**Materials and Methods.** Three clinical reports are presented of mandibular molars where three canals in the mesial roots were treated endodontically. Two in vitro studies were performed, one using computerized tomography and the other with scanning electron microscopy, to describe the morphology of the mesial root canals of permanent first molars. The scientific literature on this anatomical situation was also reviewed.

**Results.** The tomographic study found that the prevalence of a third mesial canal in the 27 teeth analysed was 14.81%; the microscopic study of 25 teeth found it to be 12%. The review of the literature encountered that the authors who report cases such as these found prevalences ranging from 1% to 15%.

**Conclusions.** From the teeth analysed in vitro, it is concluded that a third mesial canal may be present in a mandibular first molar in approximately 13% of cases. Clinically, the third canal is difficult to find and exhibits a very variable morphology, which may present anastomosis with the other canals.

**Key words:** Dental anatomy, root canals, mesial isthmus.

### INTRODUCTION

From early work by Hess and Zurcher (1) in 1925 through to more recent studies demonstrating the anatomical complexities of the root canal, roots with a conical channel and a single apical foramen have been known to be the exception rather than the rule. Researchers have shown multiple orifices, fins, deltas, loops, accessory canals and other variations in most teeth (2-4).

Although all teeth are anatomically complex, first lower molars are the first permanent posterior teeth to erupt and are those that most often suffer from caries, so they are highly

likely to require endodontic treatment. These molars normally have two roots, one mesial and one distal, and their usual canal distribution is two in the mesial root and one or two in the distal root. Nonetheless, other possibilities exist. A third root is found in between 5% and 40% of persons from mongoloid ethnic groups (5, 6); in the European population the frequency ranges between 3.4% and 4.2% (5, 7, 8). The probability of a mandibular first molar having a fifth canal is 1-15% (9). The purpose of this paper is to present clinical reports of mandibular molars with three canals in the mesial root and two in vitro studies of the morphology of these canals, together with a review of the literature.

## MATERIALS AND METHODS

### 1. Review of the literature

This review includes clinical articles and articles on studies of extracted teeth.

To identify the studies examined in this review, a thorough search was made of the following databases: PubMed and the journals index of the library of the Faculty of Medicine and Dentistry of the University of Valencia (Spain). No restriction was placed on the languages used in the studies reviewed. The search criteria included articles or books from 1920 to the present day. Articles that did not meet this criterion were excluded, as were those that contained information on mandibular molars but had no bearing on extra canals in the mesial and/or distal root of mandibular first molars.

### 2. Clinical reports

Three clinical reports on patients are presented. All the molars showed signs of acute irreversible pulpitis as a result of deep caries

### 3. In vitro studies

a. 27 mandibular first molars extracted for periodontal reasons and held in a 0.1% thymol solution were studied. The pulp chambers were opened and they were observed with computerised tomography (CT), as a method that makes it possible to study sections of teeth without destroying the sample.

b. A further study of 25 extracted mandibular first molars held in a thymol solution examined the morphology of the mesial canals. The canals were instrumented with rotary and manual instruments. Before instrumentation, the teeth were set in resin and cut at three levels (apical, middle and coronal third) with a hard tissue microtome (Accutom 2, Struers), dividing the length of the root into three equal portions, and images were obtained with a scanning electron microscope (Hitachi S-2500). The cross-sections were then reassembled, using a previously-prepared cylinder, and instrumented with the ProTaper system (Maillefer) following the manufacturer's recommended basic guidelines (irrigation with 2.5% sodium hypochlorite and 17% EDTA) before obtaining new images of the same sections. The images obtained recorded the canal system morphology.

## RESULTS

### 1. Clinical reports

#### Case 1:

A 44-year-old patient came to the clinic with spontaneous pain. The tooth was sensitive to percussion and did not present referred pain. In the access opening, a third canal was observed in the mesial root of the permanent mandibular first molar. The canals were prepared with hand files (K-File, Maillefer, Switzerland) using the step-back technique. To determine the working length, an apex locator was also used. The canals were filled with gutta-percha (Maillefer, Switzerland) and AH Plus (Dentsply, Germany) using the lateral condensation technique. The crown was restored with composite (Fig. 1).



**Fig. 1.** Case 1: X-ray of a mandibular molar with three obturated mesial canals.



**Fig. 2.** Case 2: pulp chamber opening with the entrance to the three mesial canals following instrumentation and final X-ray of the same case (the three obturated canals overlap each other).

#### Case 2:

The patient, aged 33, was referred by her dentist for endodontic treatment of the left mandibular first molar. Clinical examination showed very large caries that had invaded the pulp. The patient reported very acute pain, particularly at night and on drinking anything cold. The tooth responded to vitality tests. On opening the tooth, three mesial canals were found. All the canals were shaped with the basic series of Mtwo instruments (VDW, Germany) after preparation up to a no. 15 manual K-file. The canals were filled by the lateral condensation technique, using gutta-percha (Maillefer) combined with injected gutta-percha (BeeFill, VDW, Germany) and AH Plus cement (Dentsply, Germany). The patient was referred back to her dentist for crown reconstruction (Fig. 2).

Case 3:

A 45-year-old female patient presented very severe pain and clinical manifestations of acute pulpitis due to deep caries. Three canals were found in the mesial root and two in the distal root (5 canals in total). Obstructions were removed from the canals with no. 10 and no. 15 K-files. All the canals were prepared manually up to a no. 20 file and then instrumented with the Mtwo rotary system (VDW, Germany). All the canals were filled with gutta-percha and AH Plus using the lateral condensation technique. The patient was referred back to her dentist for reconstruction (Fig. 3).



Fig. 3. Case 3: X-ray showing the three obturated mesial canals.

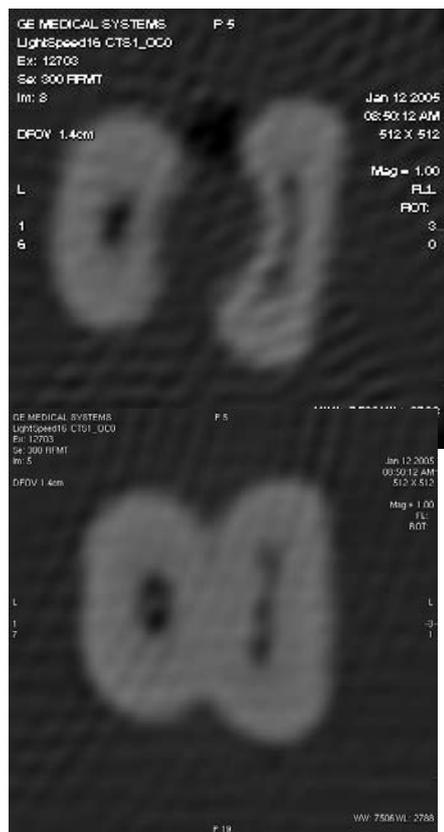


Fig. 4. CT of two mandibular first molars with three canals in the mesial root (cross-sections at middle and apical thirds).

2. In vitro studies

a. In the preliminary CT study of 27 mandibular first molars, 3 mesial root canals were only found in 4 molars (14.81%). In all of these, only two canals or one very broad canal were visible in the upper sections while in the more apical sections the third canal could be seen. The CT images show the presence of an isthmus joining the mesial canals (Fig. 4).  
 b. With the scanning electron microscope, 3 out of 25 mandibular molars (12%) were found to have three canals in the mesial root. This study also found that the canals encountered in the coronal third were types IV and V according to Von Arx (2005) (10) and the separation into three different canals occurred apically (Fig. 5).

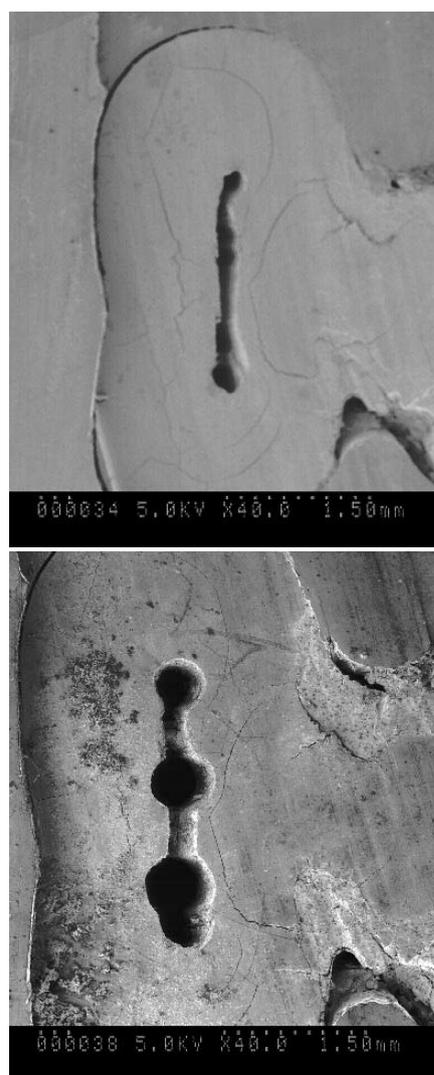


Fig. 5. Scanning electron microscope image of a cross-section before (A) and after (B) instrumenting the mesial root of a mandibular first molar (by courtesy of Dr. Areso).

## DISCUSSION

In a study of 760 mandibular molars, Fabra (11) found that 20 (2.6%) had three canals in the mesial root. In 13 of these (65%) the third canal joined the mesiobuccal canal in the apical third of the root and in 6 (30%) they converged with the mesiolingual canal, also in the apical third; the third canal ended as an independent canal in only 1 case.

Many authors agree on the presence of three foramina in the mesial root but few report three independent canals, which presents itself as a rare anatomical variant (12-15). Walker (16) cites 3 canals in the mesial root of the mandibular first molars as an infrequent occurrence. Goel (17) notes that the mesial root of permanent mandibular first molars presented two foramina in 60% of the specimens they examined, 6.7% had three and 3.3% even had four. In early studies by Hess (1), only 1 out of 55 teeth presented 2 distal roots and 5 canals did not appear in any of the teeth. However, many other authors confirm the hypothesis of a third canal in the mesial root of the permanent mandibular first molars

According to Mortman (18), the third mesial canal is not an extra canal but rather the sequelae of instrumenting the isthmus between the mesiobuccal and mesiolingual canals. The isthmus is a narrow connection between two root canals that contains pulp tissue (19). In clinical practice, this isthmus is important in the conventional treatment of canals and in periapical surgery. In both cases it can lead to failure because it makes the canals very difficult to shape. An isthmus is located in between 54% and 89% of cases, most frequently between 4 mm and 6 mm from the apical foramen (19, 20).

The studies that examine series of cross-sections taken at different distances from the apex observe that isthmuses mainly occur at 3-5 mm from the apex (19-21).

The prevalence and types of isthmus that can be identified in first molars by endoscopic examination during periapical surgery (10) are as follows for the mesial root of the mandibular first molar: in a sample of 52 mesial roots, a canal with no isthmus was found in 3 cases (6%), two canals with no isthmus in 6 (11%) and two canals with isthmus in 43 (83%).

According to Von Arx (10), isthmuses in the mesial root of mandibular first molars may be classified into 5 types: type I is two separate canals, type II is two separate canals joined by an isthmus, type III is three canals joined by an isthmus, type IV is two elongated canals that join in the centre and type V is a single, very broad and elongated canal. The mesial root of the mandibular first molar is most frequently of type IV or V.

In a study employing micro-computed tomography ( $\mu$ -CT), Mannocci et al. (22) found isthmuses at all levels with prevalence figures between 17.25% and 50.25%. In this study, more isthmuses than expected were encountered three millimetres from the apex. Many calcifications were found in them, as well as some lateral canals that originated from the central part of the isthmuses. The authors conclude that clinical procedures and endodontic surgery in the mesial root of mandibular molars may be affected by this aspect of root canal anatomy.

In view of the information provided by the research in this field, greater attention should be paid to searching for any spaces where a glide path may be established in the mesial root in order to clean, shape and fill such an isthmus or possible third canal.

It must not be forgotten that an additional canal in the mesial root of a mandibular molar is a possibility and if it is not sealed the endodontic treatment can result in failure, even though it is very difficult to clean an isthmus, especially when it is 3-5 mm from the apex.

If preparing a 'canal' in an isthmus can assist in cleaning and reshaping it, as many canals as necessary (without damaging the root structure) may be prepared so as to divide the isthmus and make it easier for the disinfectants to penetrate the spaces that cannot be reached with a file.

The prevalence of third canals cited in the literature is shown in Table 1.

Authors	Year	No. of teeth	Method	Three canals (%)
Skidmore and Bjorndol <sup>(23)</sup>	1971	45	Vitro	0
Pineda & Kuttler <sup>(24)</sup>	1972	300	Vitro	0
Vertucci <sup>(25)</sup>	1974	100	Vitro	1
Pomeranz <sup>(26)</sup>	1981	100	Vivo	12
Martinez-Berna & Badanelli <sup>(27)</sup>	1983	1418	Vivo	1.5
Fabra-Campos <sup>(10)</sup>	1985	145	Vivo	2.1
Fabra-Campos <sup>(28)</sup>	1989	760	Vivo	2.6
Goel <sup>(16)</sup>	1991	60	Vivo	15

**Table 1.** Prevalence of a third canal in the mesial root of mandibular first molars according to different authors.

Even though anatomical variations in mandibular first molars are documented in the literature, variations in the anatomy of these teeth are not recognised by a great many dentists (29). While a third canal in the mesial root of mandibular first molars may not be a very frequent discovery, a review of the literature indicates that its prevalence is 0-15% (Table 1). In this study, the percentages encountered in the preliminary studies are similar to the prevalence found by other authors (17, 26).

Variation in the mesial root of mandibular first molars can be identified through very careful observation of angled radiographs. Buccolingual views, 20° from mesial and 20° from distal, reveal the basic information on the tooth's anatomy and root canal system required for endodontic treatment (30). Successful endodontic treatment depends on entering

the pulp chamber and cleaning, shaping and obturating the canal system. Each of these procedures is very important, but any anatomical variation that is present in any of the teeth needs to be detected in order to avoid failure of the canal treatment; if this occurs, periapical surgical treatment can be attempted, although the percentage of cures attained by these methods is lower for mandibular molars than for those of the maxilla (31).

The present study confirms that the third canal in the mesial root of mandibular first molars is a reality and can be encountered in almost 15% of these roots. To find it, it must be sought along the line between the two mesial canals after thorough removal of the pulp chamber roof and of any cervical stenosis in this zone that might cover the opening of the canals, using burs or ultra-sound.

## CONCLUSIONS

Difficulties in cleaning and shaping the mesial root canal system during conventional root canal treatment can result in failure. The high prevalence of isthmuses that is known to exist in the mesial roots of mandibular molars indicates the need for careful examination of the root anatomy to find every pathway and its possible portal of exit in this complicated system.

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