Detection of the second mesiobuccal canal in mesiobuccal roots of maxillary molar teeth *ex vivo*

T. Yoshioka, I. Kikuchi, Y. Fukumoto, C. Kobayashi & H. Suda
Pulp Biology and Endodontics, Graduate School, Tokyo Medical and Dental University, Tokyo, Japan

Abstract

Yoshioka T, Kikuchi I, Fukumoto Y, Kobayashi C, Suda H. Detection of the second mesiobuccal canal in mesiobuccal roots of maxillary molar teeth *ex vivo*. *International Endodontic Journal*, **38**, 124–128, 2005.

Aim To assess the effectiveness of magnification and dentine removal (troughing) when locating the second mesiobuccal canal in mesiobuccal roots of maxillary molars.

Methodology A total of 208 extracted human maxillary molars were examined. After crown and pulp removal, the MB1 and 2 canals in the mesiobuccal root were located in three stages that were performed by two undergraduate dental students. Stage 1: canals were located with an endodontic explorer; stage 2: additional canals in the same teeth were located under magnification with a digital microscope (VH-8000, Keyence, Japan); stage 3: additional canals in the same teeth were located by removing dentine (troughing) from the pulp chamber floor within 3 mm from MB1 canal towards the palatal canal with an Enac ultrasonic tip (ST 21, Osada, Japan). In each group, the canals were prepared with Gates Glidden burs and K-files. The distal and palatal roots were then removed, and Indian ink was injected into the canal system within the mesio-buccal root. The root surfaces were washed with 6% NaOCl, and then rendered transparent to observe canal morphology. The root canal configurations were classified into five categories following the modified Weine's classification.

Results More than one canal in the mesio-buccal root was observed in 48% of specimens. Detection rates of multiple canals were 7, 18 and 42% following stages 1, 2 and 3, respectively. There was a significant difference between the stages for detecting the MB2 canal ($P < 0.05$, Friedman test).

Conclusions Both magnification (stage 2) and dentine removal under magnification (stage 3) were effective in detecting the presence of the MB2 canal. However, MB2 canals could not be detected in 13% of the teeth because of canal calcification or branching located more apically.

Keywords: canal detection, configuration of root canal systems, maxillary molars, mesio-lingual canal.

Received 25 May 2004; accepted 22 October 2004

Introduction

The incidence of second mesiobuccal canals (MB2) in the mesiobuccal root of maxillary first and second molars has been reported in the range between 33% (Kobayashi & Sunada 1987) and 96% (Carvalho & Zuolo 2000) *ex vivo* and 17% (Hartwell & Bellizzi 1982) and 65% (Stropko 1999) *in vivo*. In a laboratory study by Imura *et al.* (1998), graduate students treated MB2 canals in 52% of extracted maxillary first molar teeth, and 40% of extracted maxillary second molars. After rendering the same roots transparent, the incidence of MB2 canals rose to 81 and 67%, respectively. The detection of MB2 in maxillary molars *in vivo* has been lower than that of laboratory-based reports (Hess 1921, Pineda & Kuttler 1972, Vertucci 1984). Even when the modified access preparation by Weller & Hartwell (1989) was adopted, only 34% of maxillary molars had four canals identified and treated clinically.

Correspondence: Takatomo Yoshioka, Pulp Biology and Endodontics, Graduate School, Tokyo Medical and Dental University, 5-45 Yushima 1-chome, Bunkyo-Ku, Tokyo 113-8549, Japan (Tel.: +81-3-5803-5496; fax: +81-3-5803-5494; e-mail: yoshioka.endo@tmd.ac.jp).

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The detection rate of MB2 canals increases under magnification (Stropko 1999, Sempira & Hartwell 2000, Görduysus *et al.* 2001). Stropko (1999) reported that MB2 canals were located in 93% of first molars and 60% of second molars in a clinical setting when the operator used specific instruments adapted for micro-endodontics, whilst MB2 canals were found in 74% of first molars and 51% of second molars under conventional treatment. Sempira & Hartwell (2000) reported 33% of maxillary first molars and 24% of second molars had a negotiable MB2 canal as determined by use of an operating microscope *in vivo*. They mentioned that, although the microscope did not significantly increase the number of MB2 canals located, the enhanced visibility significantly increased confidence levels in using rotary burs and ultrasonic tips to remove calcific deposits covering many of the canal orifices.

The purpose of this study was to identify the MB2 canals in mesiobuccal roots of maxillary molar teeth using a three-stage technique: direct visualization and use of probe, magnification and dentine removal (troughing) and use of magnification.

Materials and methods

A total of 208 extracted human maxillary molars (98 first molars and 110 second molars) that had been stored in distilled water were used. No information was available regarding the reasons for their extraction. The crowns were removed at the level of the proximal enamel–cement junction and pulp tissue was removed. The floor of the pulp chamber was then explored in order to locate the MB1 and 2 canals in three stages that were performed by two undergraduate dental students. They were informed how to locate the MB1 and 2 canals and trained during a pilot study.

Stage 1: initially the canals were located with an endodontic explorer (Explorer single end No1; YDM, Tokyo, Japan). The canal was negotiated and confirmed by insertion of a size 10 K-file (Zipperer, Munich, Germany).

Stage 2: further efforts to locate canals were carried out under magnification using a digital microscope (×50, VH-8000; Keyence, Osaka, Japan) and canals negotiated with a size 10 K-file.

Stage 3: dentine on the chamber floor was removed (troughing) within 3 mm from the MB1 canal towards the palatal canal in a groove 2 mm deep using an Enac ultrasonic tip (ST 21, Osada, Japan) under magnification with a dental operating microscope (DOM; Opmi 99, Zeiss, Germany) to locate the MB2 canal.

The number of canals detected by stage was analysed statistically by the Friedman test at the 95% level of significance.

A coronal flare was made with Gates Glidden burs (size 1–4; Mani, Tochigi, Japan) for canals located in each stage. A size 35 K-file (Zipperer) was used as the master apical file and each canal was prepared in a step-back sequence with K-files (size 40–80; Zipperer). The distal and palatal roots were removed from the teeth. Gutta-percha master points adapted to the prepared canal were inserted to indicate the located canal, and Indian ink (Salis International, Inc., Golden, CO, USA) was injected into the root canal system with aspiration from the apical foramen. The root surfaces were washed with 6% NaOCl for 30 min. The teeth were demineralized with a 6% nitric acid solution for 24 h, dehydrated with ascending grades of alcohol, immersed in methyl salicylate, and rendered transparent.

The real number of canals in each mesiobuccal root was determined by observing the cleared root on the display of the digital microscope (VH-8000) at magnifications from 25× to 175×. The root canal configurations were classified into five categories (Yoshioka *et al.* 2004). Types I–IV followed Weine's (1996) classification. It was difficult to distinguish type III from type IV because dentine removal (troughing) under magnification prevented the determination of the level of canal division, so the number of these canals were aggregated. Type V was defined as a root canal configuration having more than two main canals. Any anatomical structures that branched off from the main canal more than 3 mm from the apex, with its egress located within 3 mm of the apex, was defined as another main canal. Those canals that did not meet this criteria were considered as accessory canals.

Results

The incidence of canal type is shown in Table 1. In the cleared specimens single canal (type I) was observed in

Table 1 Number of maxillary molars classified by root canal types

	Type I	Type II	Type III and IV	Type V	Total
First molar	32 (32.7)	35 (35.7)	30 (30.6)	1 (1.0)	98 (100.0)
Second molar	62 (56.4)	32 (29.1)	15 (13.6)	1 (0.9)	110 (100.0)
Total	94 (45.2)	67 (32.2)	45 (21.6)	2 (1.0)	208 (100.0)

Values in parentheses are in %.

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Table 2 Number of teeth classified by the number of MB canals confirmed in each stage

	No. of root canals				
	0	1	2	3	Total
First molar					
Stage 1	0 (0.0)	96 (98.0)	2 (2.0)	0 (0.0)	98 (100.0)
Stage 2	0 (0.0)	73 (74.5)	25 (25.5)	0 (0.0)	98 (100.0)
Stage 3	0 (0.0)	48 (49.0)	50 (51.0)	0 (0.0)	98 (100.0)
Cleared tooth	0 (0.0)	32 (32.7)	65 (66.3)	1 (1.0)	98 (100.0)
Second molar					
Stage 1	2 (1.8)	96 (87.3)	12 (10.9)	0 (0.0)	110 (100.0)
Stage 2	2 (1.8)	96 (87.3)	12 (10.9)	0 (0.0)	110 (100.0)
Stage 3	2 (1.8)	70 (63.6)	38 (34.6)	0 (0.0)	110 (100.0)
Cleared tooth	0 (0.0)	62 (56.4)	47 (42.7)	1 (0.9)	110 (100.0)
Total					
Stage 1	2 (1.0)	192 (92.3)	14 (6.7)	0 (0.0)	208 (100.0)
Stage 2	2 (1.0)	169 (81.2)	37 (17.8)	0 (0.0)	208 (100.0)
Stage 3	2 (1.0)	118 (56.7)	88 (42.3)	0 (0.0)	208 (100.0)
Cleared tooth	0 (0.0)	94 (45.2)	112 (53.8)	2 (1.0)	208 (100.0)

Values in parentheses are in %.

33% of maxillary first molars and 56% of second molars. Table 2 shows the detection rate of canals in maxillary molars for each stage. MB2 canals (type II, III, IV and V) in maxillary molars were observed in 55% of the cleared roots. Detection rates of MB2 canals in stages 1, 2 and 3, were 7, 18 and 42%, respectively. There was a significant difference between the methods to detect the MB2 canal ($P < 0.05$). No perforations were noted on the root surfaces. In stage 3, MB2 canals were detected in 51% of first maxillary molars and 35% of second maxillary molars. After clearing the same roots, the detection of MB2 canals rose to 69 and 44%, respectively.

Tables 3 and 4 show the number of canal orifices confirmed at stage 3 in the cleared teeth in maxillary first and second molars, respectively. The effectiveness

Table 3 Distribution of maxillary first molars with respect to the confirmed number of MB canals in stage 3 and true number of MB canals

True number of MB canals (cleared tooth)	Confirmed number of MB canals in stage 3			
	0	1	2	Total
1	0 (0.0)	32 (32.7)	0 (0.0)	32 (32.7)
2	0 (0.0)	16 (16.3)	49 (50.0)	65 (66.3)
3	0 (0.0)	0 (0.0)	1 (1.0)	1 (1.0)
Total	0 (0.0)	48 (49.0)	50 (51.0)	98 (100.0)

Values in parentheses are in %.

Table 4 Distribution of maxillary second molars with respect to the confirmed number of MB canals in stage 3 and true number of MB canals

True number of MB canals (cleared tooth)	Confirmed number of MB canals in stage 3			
	0	1	2	Total
1	1 (0.9)	61 (55.5)	0 (0.0)	62 (56.4)
2	1 (0.9)	9 (8.1)	37 (33.7)	47 (42.7)
3	0 (0.0)	0 (0.0)	1 (0.9)	1 (0.9)
Total	2 (1.8)	70 (63.6)	38 (34.6)	110 (100.0)

Values in parentheses are in %.

Table 5 Number of maxillary molars with undetected MB2 classified by root canal types and causes of undetection

	Type II		Type III and IV		
	Calcification	Lower diversion	Calcification	Lower diversion	Total
First molar	6	2	1	7	16
Second molar	3	0	0	7	10
Total	9	2	1	14	26

Values in parentheses are in %.

of MB2 location, defined as the ratio of total detected canal numbers in stage 3 to total true canal numbers in each tooth type, was 83% in first molars and 89% in second molars.

Table 5 explains the reasons why MB2 canals were not detected for each canal type. Root canal configurations with undetected canals were observed in eight type II canals and in eight type III and IV canals in maxillary first molars, in three type II canals and six type III and IV canals in second molars; MB2 canals could not be detected in 13% of the teeth. The reasons why canals could not be detected included orifice calcification (Fig. 1a) and lower division (Fig. 1b). The major cause of not detecting type II canals was orifice calcification, and that for types III and IV were branching located more apically.

Discussion

The effectiveness of using a dental operating microscope for detection of MB2 canal orifices in extracted maxillary molars compared with unaided vision (without loupes or head-lamps) has been evaluated (Baldassari-Cruz *et al.* 2002). The result of that study indicated that a dental operating microscope increased detection of MB2 canals from 51 to 82%. Buhrley *et al.* (2002)

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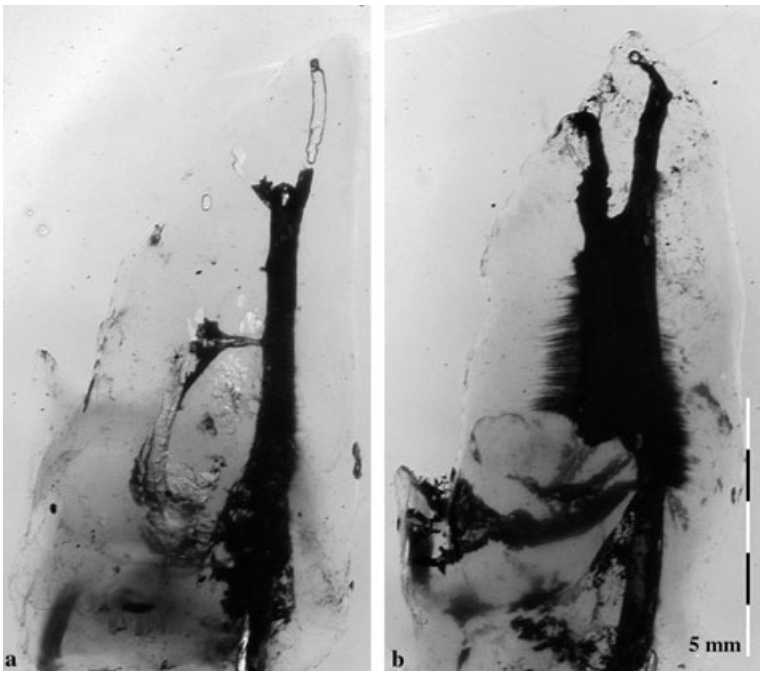

Figure 1 Samples of missing MB2 canals: (a) orifice calcification. (b) lower diversion.

reported the frequency of MB2 canals *in vivo* in maxillary first molar teeth using microscopes, dental loupes, or no magnification was 71, 63 and 17%, respectively. In a previous study (Yoshioka *et al.* 2002) a significantly higher detection rate of root canal orifices under a microscope *in vitro* than detected with the naked eye was reported. The use of surgical loupes was also shown to be relatively ineffective compared to the microscopic method (Yoshioka *et al.* 2002).

The MB2 canal is often located anteriorly to line from the MB1 and palatal canals. Troughing the chamber floor within 3 mm from the MB1 canal towards the palatal canal with an ultrasonic tip under the microscope (stage 3) made detection of the MB2 canal more successful. Because the orifices of the MB2 canals were calcified or located more apically than the pulp chamber floor, dentine removal exposed them effectively. These findings supported previous research that non-negotiable factors of MB2 canal location were diffuse calcification and pulp stones, debris in type II canals and non-detected type IV canals (Ibbarrola *et al.* 1997).

Efficiency in confirming the number of canals was lower in first molars (83%) than that in second molars (89%), because first molars have more MB2 canals than second molars. Görduysus *et al.* (2001) selectively removed dentine from the pulp chamber floor and at the mesial-axial line of the cavity, along the mesiobuccal subpulpal groove until a perforation occurred or it was considered too dangerous to remove dentine further apically. One perforation occurred in one of the 15 teeth *in vitro* when an MB2 canal was pursued. The detection rate of MB2 would not increase even by trying to remove dentine until a perforation occurred. Perforations may ultimately compromise the prognosis of root filled teeth (Benenati *et al.* 1986, Ruddle 2002). It is thus recommended that negotiation of the MB2 should be performed carefully within a safety limit.

Wolcott *et al.* (2002) reported that there were significant differences in the location of the MB2 canal between initial treatment and retreatment protocols. The incidence of MB2 canals in first molar retreatments was 67% compared with a 59% incidence in initial treatments, whereas in second molars, the retreatment incidence was 44% compared with 35% in initial treatments. These researches concluded that failure to find and treat existing MB2 canals would decrease the long-term prognosis. If the initial treatment was completed by the same operator, it would be very challenging to detect a missed MB2 canal in retreatment without new technology.

Conclusions

Both magnification and dentine removal under magnification were more effective in detecting the MB2 than direct visualization. However, 13% of

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MB2 canals could not be detected because of the canal calcification or branching located more apically.

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