

CLINICAL ARTICLES

Effect of Magnification on Locating the MB2 Canal in Maxillary Molars

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The purpose of this study was to determine if the surgical operating microscope and/or dental loupes could enhance the practitioner's ability to locate the second mesiobuccal canal (MB2) canal of maxillary molars in an in vivo, clinical setting. The participating endodontists documented 312 cases of root canal therapy on maxillary first and second molars. Participants that used the microscope or dental loupes located the MB2 canal with a frequency of 57.4% and 55.3%, respectively. Those using no magnification located the MB2 canal with a frequency of 18.2%. When no magnification was used, significantly fewer MB2 canals were located based by Chi-square analysis at $p < 0.01$. There was no significant difference between the use of the microscope and dental loupes in the frequency of locating the MB2 canal. When the maxillary first molars were considered separately, the frequency of MB2 canal detection for the microscope, dental loupes, and no magnification groups was 71.1%, 62.5%, and 17.2%, respectively. The results of this study show that the use of magnification in combined groups leads to a MB2 detection rate approximately three times that of the nonmagnification group and that the use of no magnification results in the location of significantly fewer MB2 canals. Based on these results, more emphasis should be placed on the importance of using magnification for locating the MB2 canal.

The objective of successful endodontic therapy is thorough mechanical and chemical cleansing of the entire root-canal system and its complete obturation with an inert filling material (1). Therefore, the ability to locate all the canals in this system is an important factor in determining the eventual success of the case. If a canal is

not detected, it cannot be cleansed and filled and is a potential cause of failure of endodontic therapy (2).

It has been known that maxillary molars often have two canals in the mesiobuccal root, since Hess and Zurcher (3) described this in 1925. Weine et al. (2), in 1969, suggested that the inability to locate, instrument, and obturate the second mesiobuccal canal (MB2) could lead to endodontic failure in these teeth. The challenge for the clinician in successfully treating maxillary molars is locating the MB2 canal.

Traditionally, most endodontic canal detection procedures have relied on the doctor's tactile dexterity and mental image of the canal system, because the ability to visualize the canal orifices was severely limited. This has changed with the utilization of enhanced vision systems in endodontics. The use of surgical headlamps and dental loupes has evolved into the use of the surgical operating microscope (SOM). The SOM provides the clinician with superior lighting and magnification and the ability to treat cases that previously may have been deemed untreatable or resulted in a compromised prognosis (4).

The magnification range of dental loupes is from $\times 2.0$ to $\times 6.0$. The SOM can be equipped with a range from $\times 4.0$ to $\times 30.0$, if desired. The fiber optic light of the SOM provides 2 to 3 times the light of a surgical headlamp (5).

The SOM has been advocated for use in all phases of endodontics, including locating calcified canals. Searching for calcified canals includes the use of the endodontic explorer, troughing with burs or ultrasonic tips, and close visual inspection of the root anatomy, which gives clues to the location of the hidden canal. One of the dangers in searching for calcified canals is the possibility of perforation. Using the SOM gives intimate detail of an area that otherwise would be under-illuminated and under-magnified, requiring guesswork and great caution (4). Many studies have reported on the incidence of the MB2 canal in maxillary molars (1, 2, 6, 7), and these studies have produced variable results. The incidence of the MB2 canal has been reported to be as low as 18.6% in an in vivo study conducted by Hartwell and Bellizzi (6) and as high as 95.2% in an in vitro study conducted by Kulild and Peters (8). It is difficult to compare the data of these reports, because each study had its own method of research. Some studies were conducted in vitro on extracted teeth, whereas others were performed in a clinical setting. Different methods for locating the

TABLE 1. No. and percentage of first and second molars treated by using three magnification methods

	Microscope: Group 1 (n = 94)		Dental Loupes: Group 2 (n = 130)		No Magnification: Group 3 (n = 88)		Combined Groups (n = 312)	
	n	%	n	%	n	%	n	%
First molar	59	63	91	70	58	66	269	67
Second molar	35	37	39	30	30	34	103	33

TABLE 2. No. of MB2 canals found and percentage of total no. of teeth they were found in before and after use of additional techniques

	Microscope: Group 1	Dental Loupes: Group 2	No Magnification: Group 3
MB2-% located	19.1% (18 of 94)	23.8% (31 of 130)	8.0% (7 of 88)
After use of additional techniques	22.3% (21 of 94)	31.5% (41 of 130)	10.2% (9 of 88)
Total before increasing magnification	41.4% (39 of 94)	55.3% (72 of 130)	18.2% (16 of 88)

Additional techniques included explorer, bur, ultrasonics, NaOCl, dyes, or other.

mesiolingual canal result in differing conclusions as to its incidence. Seidberg et al. (9) in 1973 and Pomeranz and Fishelberg (10) in 1974 published results of both in vitro and in vivo studies. The Seidberg et al. (9) in vitro study found that out of 100 teeth, 62% had an MB2 canal. Their in vivo study, however, reported that out of 201 teeth, only 33.3% had an MB2 canal. Pomeranz and Fishelberg's (10) in vitro study found that out of 100 teeth, 69% had an MB2 canal. The in vivo study (9) reported that out of 100 teeth, 31% had two canals. In a clinical setting, limited access and visibility as well as the risk of perforation may explain the lower incidence of MB2 canals found when compared with in vitro studies. It is possible that if one had a greatly enhanced view of the operating field via the SOM or loupes, the ability to locate the MB2 canal would increase.

Clinical studies to date have not reported the use of enhanced vision. It is very possible that magnification and illumination will increase one's ability to locate the second mesiobuccal canal in maxillary molars. The purpose of this study was to determine if the surgical operating microscope or dental loupes significantly enhanced the practitioner's ability to locate the MB2 canal in an in vivo, clinical setting.

MATERIALS AND METHODS

A letter was sent to 153 practicing endodontists. Each specialist was asked if they would be willing to participate in a study in which they would document 20 successive cases of root-canal therapy on maxillary first or second molars. They were asked to return a postcard indicating whether or not they would participate. They were also asked to note what type of magnification they used: SOM, dental loupes, or no magnification. Thirty-three endodontists agreed to participate in the study. Each received 20 documentation forms with instructions for completing them. They were instructed to perform the search for all possible canals exactly as they normally would and to complete the form immediately after the appointment in which the root canals were located. The forms were to be returned as soon as the 20 cases were completed. The forms were filled out in the following manner: the endodontist indicated the initial magnification used (SOM, loupes, or none) and the canals that were located after the initial access (MB1, MB2, DB, P). It was noted if additional techniques were used in locating the canals (explorer, bur, ultrasonics, NaOCl, dyes, or other). If additional canals were located after using the additional techniques (MB1, MB2, DB, P), it was recorded. The endodontist then noted

a third step, which was if an additional increase in magnification was used in searching for hidden canals (SOM or loupes). If an increase in magnification resulted in locating a canal, that canal was specified. (MB1, MB2, DB, P). The endodontist noted if the process of locating all the canals resulted in a procedural error (perforation, instrument separation, other). The final information documented was age of patient, access through crown, MB2 negotiated to working length, and presence of pulp stones. The endodontist was then allowed to make any additional comments. Of the 660 documentation forms that were sent out, 353 were returned. Of the 353, 41 were not included in the study for one of three reasons: incomplete data, improper tooth selection, or return of an improper (unofficial) form. The remaining 312 documentation forms, representing 312 maxillary molar root canal theories, were statistically analyzed using the Statistical Analysis System (SAS, Cary, North Carolina).

RESULTS

Group 1 refers to cases where the microscope was used as the initial magnification. Group 2 refers to cases where dental loupes were used as the initial magnification. Group 3 refers to cases where no magnification was used, initially. Table 1 shows the number and percentage of first and second molars that were treated in each group. Of the 312 total cases, group 1 treated 94, group 2 treated 130, and group 3 treated 88 teeth. Table 2 shows the number and percentage of the MB2 canals located under different conditions after the initial access. After the initial access and before the use of additional techniques, endodontists in group 2 located a higher percentage of MB2 canals, 23.8%. Group 1 was next at 19.1%, followed by group 3 at 8.0%.

In searching for additional canals, the explorer was used in 88.6% of the cases; the bur in 76.9% of the cases; ultrasonics in 7.1% of the cases; NaOCl bubble test in 49.0% of the cases; dyes in 2.6% of the cases; and in 1.9% of the cases, other methods were used. The number of MB2 canals located after use of additional techniques is shown in Table 2.

The use of additional techniques resulted in the location of 21 additional MB2 canals in group 1 (22.3%), 41 additional MB2 canals in group 2 (31.5%), and 9 additional MB2 canals in group 3 (10.2%). Table 2 shows the total number of MB2 canals located before increasing magnification (initial access plus additional techniques). Combining the number of canals located upon initial access with those found after the use of additional techniques,

TABLE 3. No. of additional canals located after use of microscope for an increase in magnification

	Microscope (Original Mag.)	Dental Loupes (Original Mag.)	None (Original Mag.)	Combined Groups
Microscope (increased mag.)	75% (15 of 20)	25% (3 of 12)	60% (9 of 15)	57.4% (27 of 47)
Dental loupes (increased mag.)	NA	NA	36.6% (11 of 30)	36.6% (11 of 30)

Percentage is the number of times a canal was found for the number of times the microscope was used.

TABLE 4. Overall no. of additional canals located and percentage of total teeth in which they were located for each group

	Group 1: Microscope	Group 2: Dental Loupes	Group 3: No Magnification
MB2-% Located	57.4% (54 of 94)	55.3% (72 of 130)	18.2% (16 of 88)

TABLE 5. No. and percentage of MB2 canals located in first and second molars

	Group 1: Microscope	Group 2: Dental Loupes	Group 3: No Magnification
% MB2, 1st molars ($p < 0.00$)	71.1% (41 of 58)	62.5% (55 of 88)	17.2% (10 of 58)
% MB2, 2nd molars ($p < 0.006$)	36.1% (13 of 36)	40.5% (17 of 42)	20.0% (6 of 30)

results in the total number of MB2 canals located before magnification. The total for groups 1, 2, and 3 was 41.4%, 55.3%, and 18.2%, respectively.

There were 47 instances when an increase in magnification involved the microscope. Twenty of the 47 instances involved group 1. In this situation, the dentist initiated treatment with the microscope but increased the magnification after utilizing other techniques. Twelve of the 47 instances involved group 2. In this situation, the dentist initiated treatment with the dental loupes but switched to the microscope after utilizing other techniques. Fifteen of the 47 instances involved group 3. In this situation, the dentist initiated treatment with no magnification and switched to the microscope after utilizing other techniques. There were 30 instances when an increase in magnification involved the dental loupes. All 30 cases were initiated in the group without magnification. Table 3 shows the number of additional canals located after an increase in magnification. When an increase in magnification involved the microscope, the MB2 canal was located in 27 out of 47 instances (57.4%). These cases originated in group 1, group 2, or group 3. When an increase in magnification involved dental loupes, the MB2 canal was located in 11 out of 30 instances (36.7%). These cases originated in group 3. At $p < 0.05$, Chi-square analysis revealed no significant relationship between the type of magnification increase (microscope or dental loupes) and the number of MB2 canals located. As stated previously, of the 47 times that the microscope was utilized to increase magnification, 20 were from group 1. In this situation, the microscope was used initially and the magnification was increased after trying additional techniques. In 15 of the 20 cases, the MB2 canal was found for a frequency of 75%. When additional locating of the MB2 canal was added to group 1, the final number of MB2 canals found was 54 in 94 teeth (57.4%). The MB2 canals located when an increase in magnification involved dental loupes were not added to group 2, because these cases originated in group 3.

Table 4 shows the total number of MB2 canals located in the study (initial access plus additional techniques plus increased magnification of group 1). Combining the MB2 canals located upon initial access, after additional techniques, and after increased magnification results in the total number of MB2 canals located in the study. The percentage of total teeth in which a MB2 canal was found for groups 1, 2, and 3 were 57.4%, 55.3%, and 18.2%, respectively. At $p < 0.01$, Chi-square analysis revealed that sig-

nificantly fewer MB2 canals were located when no magnification was used (group 3). The difference between groups 1 and 2 in the frequency of locating MB2 canals was not statistically significant. Table 5 shows the frequency of MB2 canals located in first molars versus second molars. Maxillary first and second molars were then considered separately. At $p < 0.01$ (first molars), and $p < 0.006$ (second molars), Chi-square analysis revealed that significantly fewer MB2 canals were located when no magnification was used (group 3). No statistically significant difference was found between groups 1 and 2 for the frequency of locating MB2 canals.

Procedural errors and additional information were not determined for each group, but for the 312 total cases, a perforation occurred in only one case (0.3%), and instrument separation occurred in only two cases (0.6%). The mean patient age was 44 yr old; the oldest was 88 yr old, and the youngest was 8 yr old. Of the 312 cases, 81 (26%) were accessed through a crown. The MB2 canal was located in 165 out of 312 cases (52.8%). Of the 165 cases, it was negotiated to working length in 143 (86.6%). The presence of pulp stones was indicated in 71 cases (22.8%).

DISCUSSION

When located, the MB2 canal was negotiated to working length in the majority of cases (86.6%). This is significant when considering the frequency of two MB canals with two separate foramina. Kulild and Peters (8) found this to occur 45.8% of the time, whereas Neaverth et al. (11) demonstrated an even higher rate of 61.8%.

Also of significance were the additional techniques that the participating endodontists used for searching for hidden canals. The explorer and bur were used the majority of the time, 88.6% and 76.9%, whereas the use of ultrasonics was low, 7.1%. The limited use of ultrasonics was somewhat unexpected considering the precision it affords in troughing for calcified canals. Previous in vivo studies have investigated the incidence of the MB2 canal in maxillary molars. However, none of the studies indicated whether or not any form of magnification was used. The majority of in vivo studies showed an incidence of the MB2 canal from 18% to 36% (9, 10, 12–14). Three studies showed an incidence of 64.6%, 77.2%, and 52% (11, 15, 16). Two of these, however, did not indicate how the cases were selected. It is not known if successive

cases were submitted or if they were chosen at random (11, 15). The groups that used magnification in this study showed an incidence of the MB2 canal almost twice that of the majority of previous *in vivo* studies and are similar to the findings of Nosonowitz and Brenner (15), Neaverth et al. (11), and Vande Voorde et al. (16).

There are some inherent problems with a clinical study of this kind. One is the variability of the teeth. Some teeth are more difficult to treat than others for various reasons, and these differences cannot be sorted out beforehand to create a level playing field for each magnification group. Another problem is that some participants may be less determined to locate a hidden canal than others. It is possible that, in some instances, the most important factor in locating the MB2 canal is not the magnification but the persistence of the operator. One of the reasons for having many participants was to balance the influence that one participant might have on the overall results. The results of this study show that the use of magnification leads to a MB2 detection rate three times that of the nonmagnification group. The use of no magnification results in the detection of significantly fewer MB2 canals. Of particular interest is that there was no significant difference between locating the MB2 with the use of the microscope or the use of loupes. In fact, practitioners using loupes, initially, found far fewer MB2 canals when switching to higher magnification with the SOM than those who initially used the SOM and then switched to higher power did.

Based on these results, more emphasis should be placed on the importance of using magnification in locating the MB2 canal and not on which type of magnification is used. If cost is a factor, entry level SOMs tend to cost up to four times as much as loupes. Whether the SOM can prove to be more beneficial in other areas of endodontics, such as surgery or broken instrument retrieval, may be the deciding factor between investing in loupes or the SOM.

In conclusion, it seems that the magnification of the operating field provided by the microscope and dental loupes is an important factor in successfully locating the MB2 canal.

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