

# A SEM study of the orifices of the mesiobuccal root of the maxillary first permanent molar

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## SUMMARY

We performed a Scanning Electron Microscopy study of the pulp chamber floor in human maxillary first permanent molar teeth, making an initial observation of the floor of intact pulp chambers and a second exploration with the buccal and mesial walls shaped to facilitate the investigation. All the molars showed two orifices in the mesiobuccal root, these exhibiting differences in morphology and disposition. Seven point two percent of the cases displayed an infundibulum at the deepest part of the floor including two canals. In 21.4% of cases, these had two clearly separated orifices, while in 71.4% they displayed a groove at whose ends both orifices were located. The explicit findings concerning the mesiolingual canal indicate the need to detect this groove systematically and when its existence is confirmed it should be carefully explored. Detailed knowledge of the anatomical variations should facilitate identification of the orifices.

**Key words:** Mesiobuccal root – Mesiolingual orifice – Mesiobuccal groove – Scanning electron microscopy

## INTRODUCTION

The maxillary first permanent molar tooth has been studied by many authors but the

results are disparate, both as regards the number of canals found in the mesiobuccal (MB) root and in their disposition. In clinical work, the finding of a second canal –the mesiolingual (ML) canal- ranges between 18.6% (Hartwell and Bellizi, 1982) and 77.2% (Neaverth et al., 1987). This frequency is higher in work carried out at the laboratory, ranging from 36% (Green, 1973) to 96% (Kulild and Peters, 1990).

The possibilities to be gained from studies carried out in the laboratory are many, although the method most commonly used over the years has been the staining and clearing of molars (Okumura, 1927; Vertucci, 1984; Al Shalabi et al., 2000; Sert and Bayirli, 2004). Moreover, different methods of visual magnification have been used with a view to improving clinical (Sempira and Hartwell, 2000; Wolcott et al., 2005) and laboratory (Gilles and Reader, 1990; Rampado et al., 2004; Yoshioka et al., 2005) precision. As an example of the advantages of this exploratory technique, Buhrley et al. (2002) described that with no magnification they had found a second canal in 17.2% of cases; with a lens in 62.5%, and with a dental operating microscope in 71.1%.

It is known that failure to find and treat the second canal may modify the long-term prognosis of treatment (Weine et al., 1969; Slowey,

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1974; Wolcott et al., 2002). The many studies conducted on the maxillary first molar and the conflicting findings obtained clearly point to the difficulty involved in locating the ML canal; this is attributed to the irregular disposition of the entrances to the root canals (Acosta and Trugeda, 1978; Fogel et al., 1994).

Commonly, the location of the ML canal has been reported to be close to the mesiobuccal (MB) canal in the buccolingual direction (Neaverth et al., 1987; Pomeranz and Fishelberg, 1974), slightly mesial to a line joining the MB and P (palatine) canals (Johnson, 1985; Fogel et al., 1994; Stropko, 1999; Vertucci, 2005), at 1 to 4 mm from the mesiobuccal orifice (Slowey, 1974; Kulild and Peters, 1990; Gilles and Reader, 1990; Görduysus et al., 2001) and at some 4 mm from P (Harrán-Ponce and Vilar-Fernández, 2005). Nevertheless, there are few images available that facilitate clinical work and allow criteria to be unified and this, together with the important differences in the results reported in the literature, is what prompted us to explore the floor of the pulp chamber in maxillary first permanent molars.

## MATERIAL AND METHODS

We used maxillary first permanent molars that immediately after extraction were submerged in a 5.25% sodium hypochlorite solution, where they remained for varying times until use. We chose 34 pieces with minimum destruction of the crown, without taking into account their anatomical characteristics.

We performed a transverse cut on the crown 1mm towards the occlusal of the cervical line and a second cut across the middle third of the root. Several molars were rejected because they broke or because in the sculpting process they were seen to be highly calcified, and hence unsuitable for study. The pieces were placed in 5.25% sodium hypochlorite for two days, and the chambers and canals were brushed and irrigated with sodium hypochlorite at the same concentration to facilitate removal of pulp remains and detritus due to cutting.

Following this, the pieces were subjected to drying in an acetone series using the critical point method in a Polazon chamber from Bio-Rad. The surfaces of the open chamber were sputtered with gold in a Bio-Rad device (SEM coating system). The samples were then observed under a Zeiss DSM 940 scanning

electron microscope and the images thus taken were digitised on a Hewlett-Packard workstation XW 8000. Following this, the chambers were partially sculpted, removing the convexities of the mesial and buccal walls, which hindered observations. The chamber floor was not modified and the entry orifices of the canals were not dilated either. After the above procedure, the pieces were examined again under the microscope.

At the end of the study, the orifices were explored with files to confirm the existence of both canals.

## RESULTS

The SEM study of the chambers revealed the presence of two orifices in the mesiobuccal root in all cases. However, variations were observed in the morphology and disposition of both of them.

In 71.4% of the molars, we detected a deep groove running from the mesiobuccal angle in the lingual direction at the confluence of the floor and mesial wall; this was broad in the buccolingual direction and narrowed in the mesiodistal sense. The groove displayed a large number of outgrowths that hindered appreciation of the exact morphology of the orifices (Figs. 1A, 3A). We observed a structure with a delicate aspect that delimited the true origin of the ML canal (Figs. 1B, 1C). In 60% of cases, the groove occupied approximately one third of the length of the mesial wall (Figs. 2A, 3A) and in 40% half of it (Fig. 1A). After shaping buccal and mesial walls (Fig. 1D), we observed the morphology of this deep cleft in better detail; two orifices were seen to be located at the end (Figs. 2B, 3C), separated by a small bridge of dentine whose origin was rounded at a level slightly lower than the pulp chamber floor (Figs. 2B, 3D). The diameters of the orifices were similar (Figs. 1E, 2B, 3C).

In 21.4% of the molars we observed two independent orifices at the confluence between the floor and the mesial wall. They were separated by a broad bridge of dentine at the level of the chamber floor. The distance between them varied; in 66.7% they filled the buccal third (Fig. 4A) and in 33% half of the mesial wall (Figs. 5A, 6B). The mesiobuccal (MB) orifice, which was largest, was located in the mesiobuccal angle of the chamber (Figs. 4B, 5B). Regardless of size and shape, the ori-

ifices were oriented on different planes (Figs. 4B, 4C, 5B).

Only in 7.2% of the molars was a broad infundibulum seen in the mesiobuccal angle (Fig. 7A). After the walls had been shaped, we observed the deep emergence of two separate canals separated by a small wall of sharpened dentine at a level lower than the chamber floor (Fig. 7B).

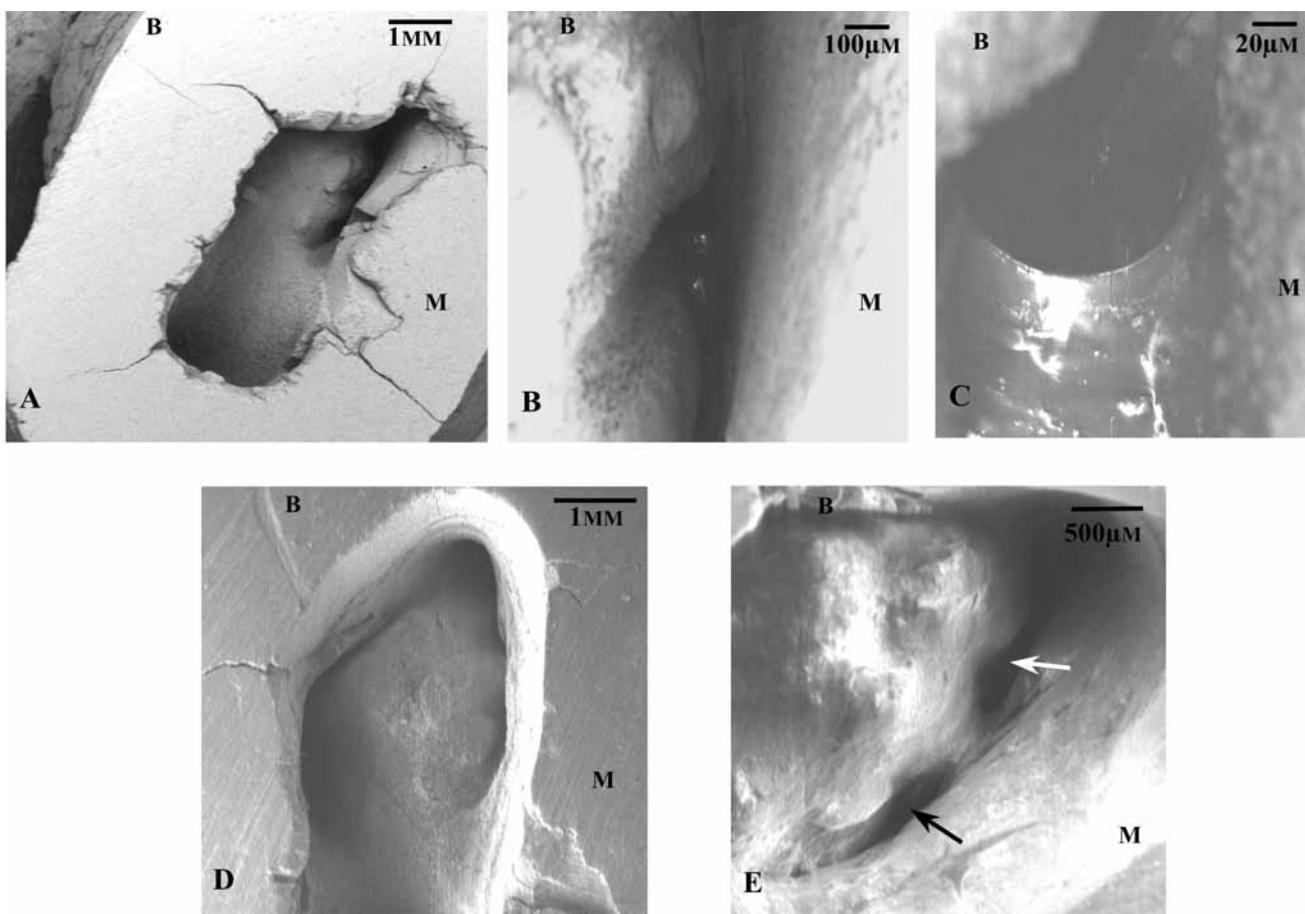
Exploration of the orifices with files confirmed the presence of both canals in 100% of the roots. In all cases, the floor of the pulp chamber showed outgrowths of dentine of very variable size; these hindered direct observation of the orifices, and they were sometimes so extended that they filled almost the whole of the pulp chamber (Fig. 6A). In some molars, smaller outgrowths were seen without difficulty (Figs. 5A, 7A) but sometimes they were so small that they could only be visualised with a microscope (Fig. 3B).

The buccal and mesial walls of the pulp chamber displayed a convexity towards the

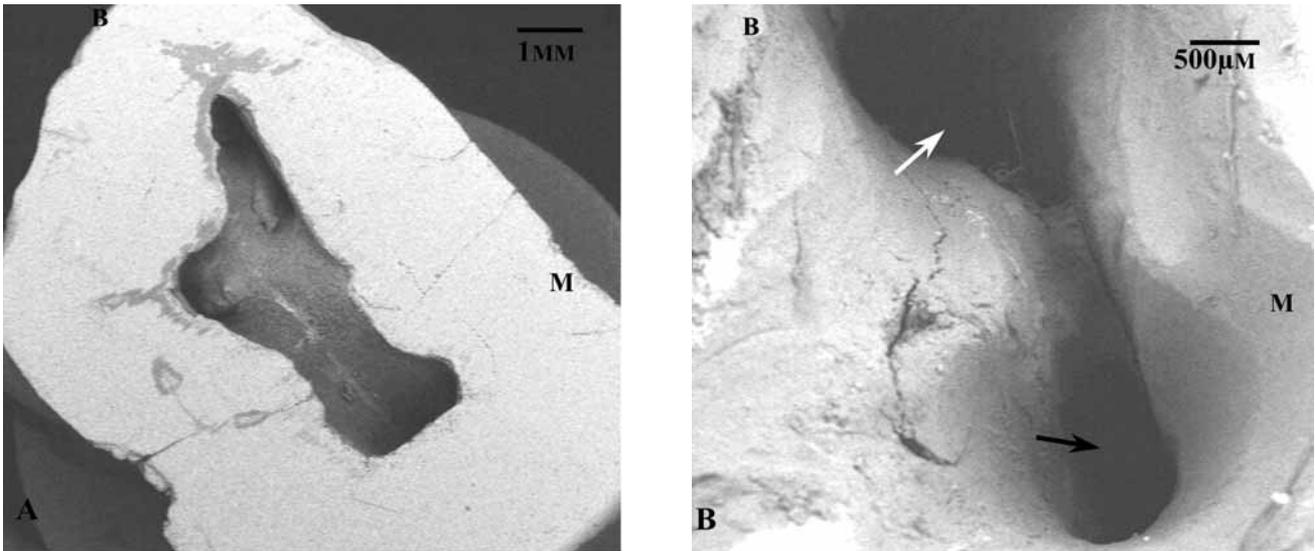
cavity that was often very pronounced on the mesial wall.

## DISCUSSION

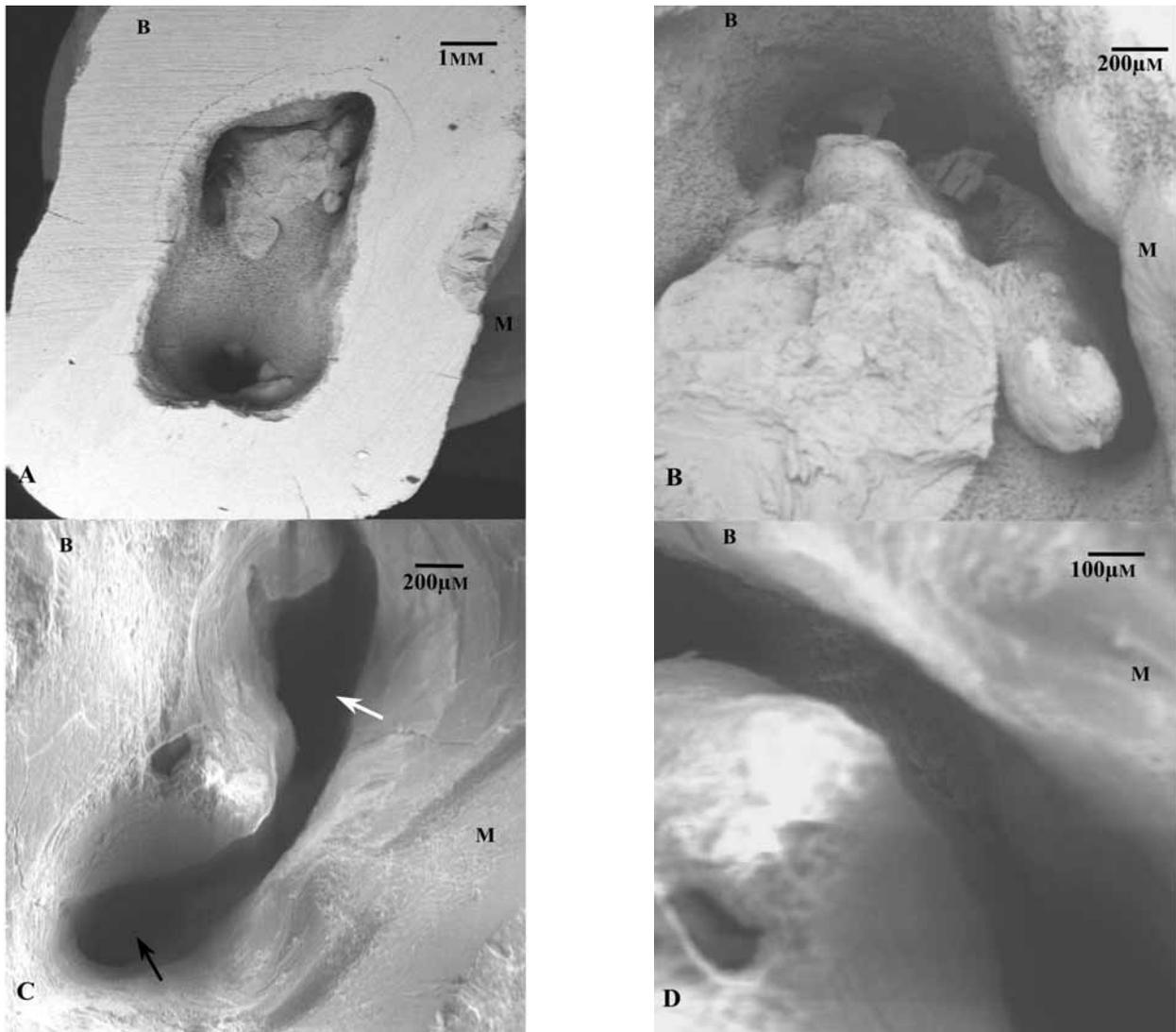
The results obtained on detecting two canals in 100% of the MB roots studied here reveal the constant presence of a ML canal. Nearly all previous investigations on this root have offered a paucity of results concerning its determination both in clinical practice (18.6%, Hartwell and Bellizi, 1982; 31%, Pomeranz and Fishelberg, 1974; 39%, Weller and Hartwell 1989) and at the laboratory (36%, Green, 1973; 51.5% Weine et al., 1969; 55% Vertucci, 1984). The most recent clinical publications report better efficacy, citing percentages above 60% and varying between the 73.2% of Stropko (1999) and the 61% of Wolcott et al. (2002). Although studies on extracted molars usually report higher percentages of success, ranging between 60% and 70% (Seidberg et al., 1973; Çalişkan et



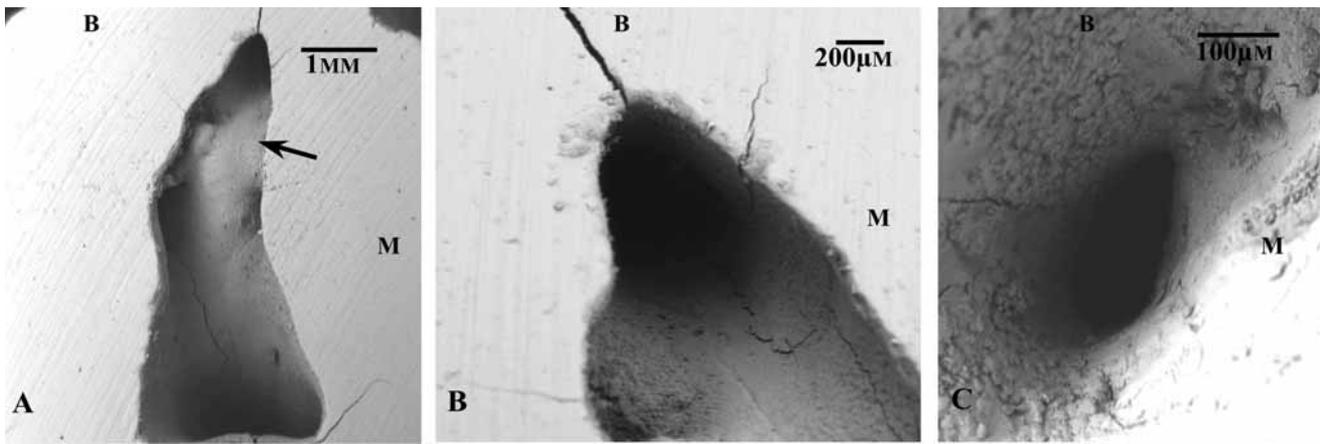
**Fig. 1.** (A) SEM view of the pulp chamber, showing a marked convexity in the mesial (m) wall and a large, deep cleavage filling the buccal (b) half from the mesiobuccal angle in the lingual direction. (B) At the very bottom of the depression there is a smooth shiny structure delimiting a dark circle. (C) Greater magnification of the previous image, showing the ML orifice measuring some 140 µm in diameter, surrounded by a thin layer with a polished aspect that contrasts with the adjacent tissue. (D) Image of the deep groove located between the floor and the mesial wall after shaping the walls. (E) At greater magnification, the groove shows two elongated comma-shaped orifices of similar size, the MB (white arrow) and ML (black arrow), separated by a bridge of dentine.



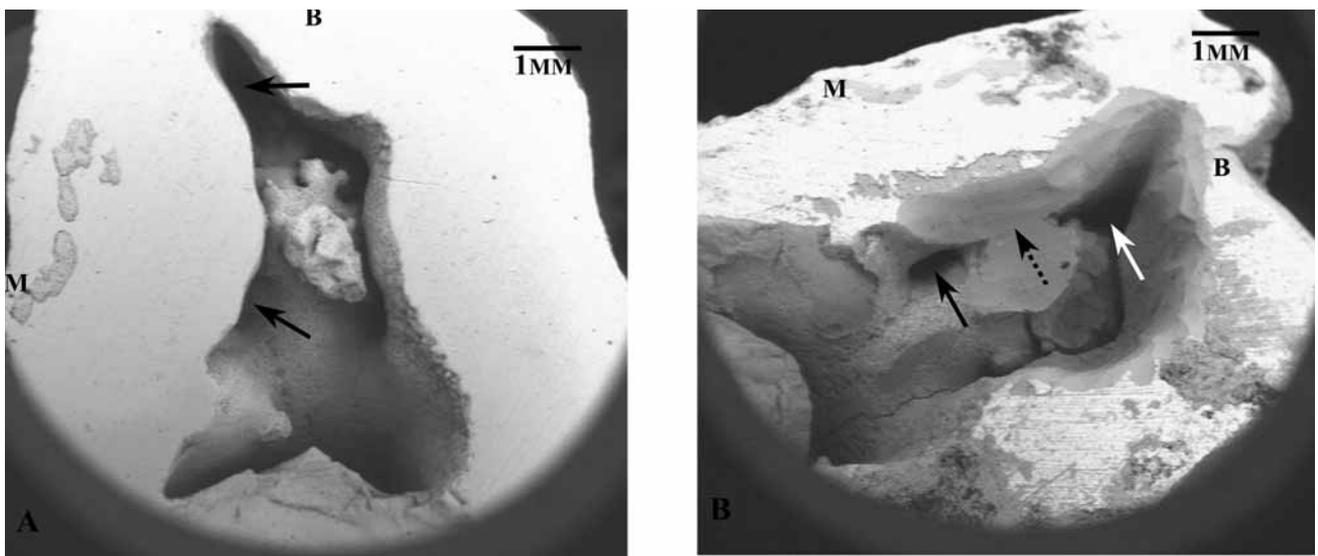
**Fig. 2.** SEM view of the pulp chamber. (A) At the confluence of the mesial wall (slightly convex) and the chamber wall a deep cleavage elongated in the buccolingual direction and narrow in the mesiodistal sense filling the buccal third may be seen. (B) A magnified image of the chamber floor after shaping the mesial and bucal walls, showing in the depths of the groove the true origin of the canals, the MB (white arrow), greater than the ML (black arrow), separated by a bridge of dentine located at a lower level of the chamber floor.



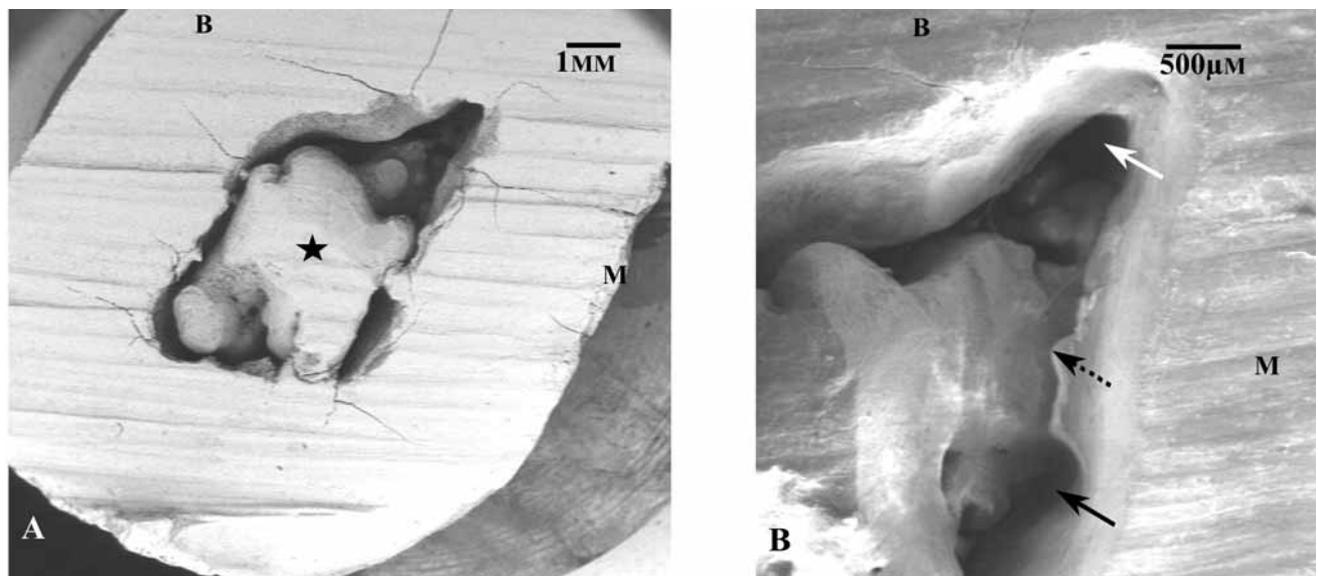
**Fig. 3.** SEM view of the pulp chamber. (A) A cleavage, narrow in the mesiodistal direction, starts out from the mesiobuccal angle in the lingual direction. Note its very irregular distal edge. (B) In the mesiobuccal angle it exhibits large numbers of dentine outgrowths. (C) After shaping the mesial and buccal walls, it is possible to note a cleavage showing a large prominence of the internal wall that delimits the two orifices: the MB (white arrow), with a slightly irregular contour, and the ML with an oval shape (black arrow). (D) In the stenosed zone, note the clear bridge of dentine, rounded at its origin.



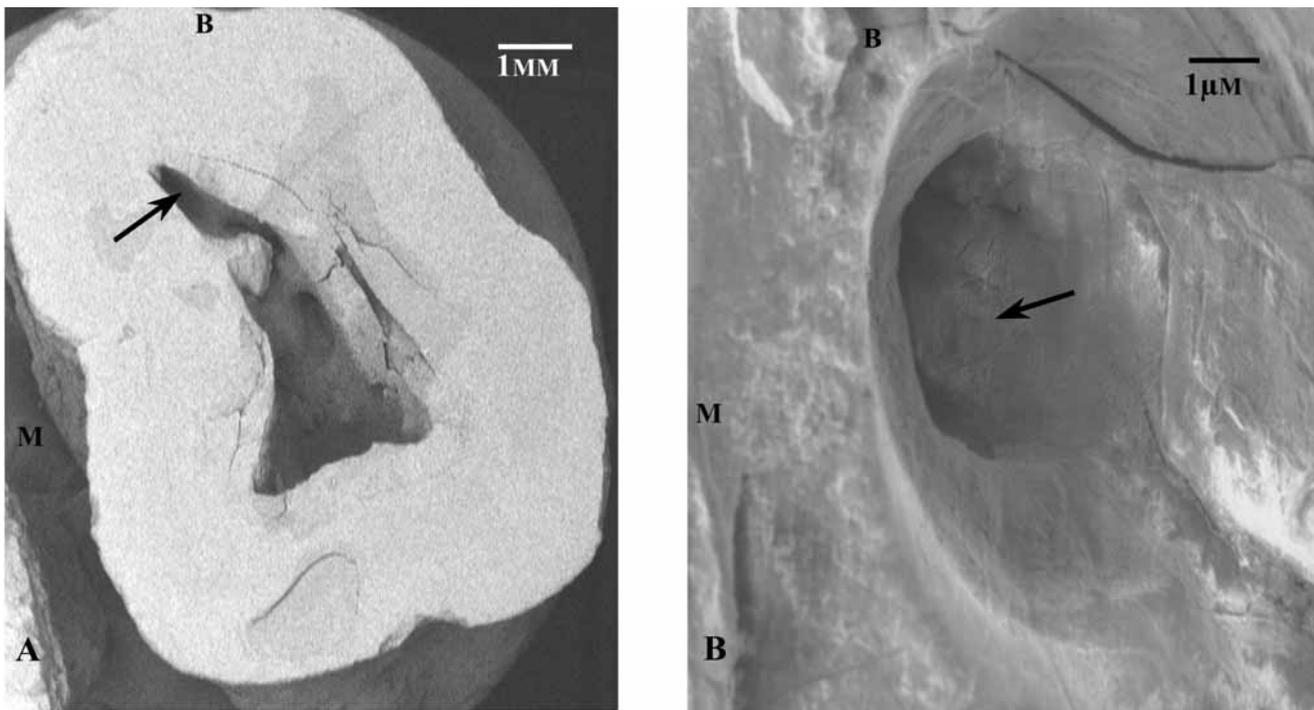
**Fig. 4.** SEM view of the pulp chamber. (A) At the confluence of the floor and the mesial wall there are two orifices clearly separated by a thick dentine septum (arrow) at the level of the floor of the chamber. (B) MB orifice in the mesiobuccal angle of the chamber. (C) ML orifice, smaller in size than the MB. Note that the orifices are oriented differently.



**Fig. 5.** SEM view of the pulp chamber. (A) At the confluence between the floor and the mesial wall, partially hidden by the strong convexity of this latter, it is difficult to see two orifices (arrows) located in the buccal half. (B) After shaping the walls and once the outgrowth of the floor has been eliminated the two orifices are clearly seen. In the mesiobuccal angle, note the start of the MB orifice, with the shape of an infundibulum (white arrow) separated from the ML orifice (black arrow) by a thick bridge of dentine at the level of the floor (dotted arrow), located at the confluence of the floor and the mesial wall. The ML orifice is located at the confluence of the floor and the mesial wall.



**Fig. 6.** SEM view of the pulp chamber. (A) In the buccal area many outgrowths hinder the localisation of the root orifice(s); a pulp stone (star) fills almost the whole of the chamber. (B) After shaping the mesial and buccal walls and after partial removal of the pulpar calculus, visualisation of the entry of the MB (white arrow) and ML (black arrow) canals, which occupy more than the vestibular half of the chamber, is not hindered by a small tongue of dentine (dotted arrow).



**Fig. 7.** SEM view of the pulp chamber. (A) The highly convex mesial wall shows an outgrowth of dentine that hinders the view of the floor. Note orifice (arrow) in the MB angle (B). After shaping the walls, in the mesiobuccal angle it is possible to observe a broad infundibulum with a greater buccolingual diameter and, at depth, the start of a dentine bridge (arrow).

al., 1995; Ng et al., 2001), in more recent work figures closer to 80% have been obtained (Al Shalabi et al., 2000, Jung et al., 2005), and some authors have even reported canal duplication at percentages between 90% and 96% (Gilles and Reader, 1990; Kulild and Peters, 1990).

The discrepancies in the results could have been due to the different methods of study employed, which as reported by some authors (Seidberg et al., 1973; Pomeranz and Fishelberg, 1974; Imura et al., 1998) entail greater complication and are more conservative in clinical practice than at the laboratory; this exacerbates the difficulties involved in the localisation of the ML canal. The dentinal structure that we observed delimiting the origin of the mesiolingual canal may also prevent its visualisation.

One of the causes of this has been that its diameter is usually small (Kulild and Peters, 1990; Martínez-Berna, 1989; Stropko, 1999; Pineda, 1973). Although this problem was not the most crucial one in our study, and the size of the canal may even be equal or similar to that of the MB, it is possible that in earlier works only the orifices that were easiest to see were visualized. To overcome this drawback, lenses or microscopes have been used. Although some authors (Yoshioka et al., 2002;

Rampado et al., 2004) have recognised the benefits of this, they reported fewer findings than those discussed here. Nevertheless, knowledge of the situation and conformation of the orifices may solve this problem.

As a further difficulty, reports have also been made that the ML canal shows a marked mesial slant at its emergence (Stropko, 1999; Görduysus et al., 2001), although sometimes we observed different slants with respect to the MB orifice, which we were able to appreciate better by exploration with files, and hence inclination was not an important parameter in this study. We believe that the presence of a marked slant is a more serious problem in later steps of canal treatment than its actual presence.

The dentine outgrowths hindered direct observation of the orifices, in agreement with the findings of Kulild and Peters (1990), Fogel et al. (1994) and Ibarrola et al. (1997). 82.5% of professionals consulted by Selden (1991) consider that the presence of pulp stones may hinder conventional treatment of roots. Although we agree with this, we believe that small microscopic irregularities are more important since they may pass overlooked in clinical practice, masking the orifices. Indeed, this was one of the greatest problems in our explorations. These morphological alterations of the chamber are probably the result of a bio-

logical process of successive appositions of secondary dentine (Philippas, 1961; Kawasaki et al., 1980; Deutsch and Musikant, 2004), which mainly occur on the chamber floor (Kuttler, 1980; Vertucci, 2005). The process of mineralisation may also be the result of aggression over long periods, such as that due to caries (Seltzer and Bender, 1987) or to restoration work (Chandler et al., 2003). We believe that these arguments may account for the high incidence observed by us in the molars studied, which were extracted because they had pulp pathology and/or periodontal disease. Probably, in the work reported by other authors (Neaverth et al., 1989; Stropko, 1999; Yoshio-ka et al., 2005) searching for the mesiolingual orifice, involving opening a groove between the MB and P canals, the unknown outgrowths were removed in the process.

Another of the serious difficulties was the presence of convexities on the chamber walls, and especially the curvature of the mesial wall, which to different extents were seen in all the molars studied, only allowing clear appreciation of the morphology of the orifices after shaping of the buccal and mesial walls. In the treatment of the canals of these molars, some authors have recommended that the chamber should be opened in the shape of a heart or a rhomboid (Neaverth et al., 1987; Stropko, 1999). On the basis of our own observations, we believe that this would be correct since it facilitates removal of the mesial convexity and the location of the canals.

The orifices were always found at the junction of the floor and the chamber walls, confirming the results of Krasner and Rankow (2004), who reported that this is one orientation with which to look for them. The ML orifice has usually been described mesial to an imaginary line between the MB and P canals at a distance 1-4 mm from the former (Slowey, 1974; Johnson, 1985; Gilles and Reader, 1990; Vertucci, 2005). Although these data are of great interest and confirm to our own findings, they offer few references as to the configuration of the orifices. In light of the present findings, we believe that the situation is more complex, since variable morphology and disposition were observed in the orifices of the mesiobuccal root.

The paucity of studies that have described the initial conformation of the orifices makes the comparison of results difficult, and this is exacerbated by a relative absence of images published, although Martínez-Berna (1989)

stated that the ML orifice appears as a depression or a groove, sometimes bleeding. Our observations revealed a common infundibulum in the MB angle with a frequency of 7.2%. Only Stropko (1999) reported such a possibility. In 21.4% of the molars we observed two orifices separated by a broad bridge of dentine at the level of the chamber floor. This is consistent with the descriptions of Acosta and Trugeda (1978) and Thomas et al. (1993), who reported a frequency of 11.2% and 3.7% respectively. However, those authors described that in 34.3% and 19.6% of cases they were joined by the trace of a groove. We believe that all of them would correspond to the same form. Gilles and Reader (1990) clearly showed that the orifices entering the canals were separated in 18% of cases. In the highest percentage of cases (71.4%) they detected a deep groove at whose ends the orifices were located and this could correspond to the schematic representation offered by Neaverth et al. (1987) or to the subpulpal groove described by Görduysus et al. (2001) and Kulild and Peters (1990) as an exploration site. From these analyses, the need to unify criteria with descriptions and images that will facilitate their systematization should be stressed.

It has been reported that variations in the results may be due to true differences in the samples investigated (Alavi et al., 2002; Wasti et al., 2001; Çalışkan et al., 1995). We agree that there may be differences among the sampling groups although some authors have reported very close percentages (Kulild and Peters, 1990; Görduysus et al., 2001). The differences between our results and the latter findings could be due to the fact that we rejected highly calcified chambers.

We believe that the differences possibly stem from the fact that when the orifices are included in a groove, this is not explored adequately owing to the difficulties involved. We propose that if a groove is detected it should be explored in detail because even under magnifying devices it is difficult, if not impossible, to visualise orifices with a diameter of about 140µm, as discussed here. The evidence concerning the ML canal reported here makes it essential to attempt to detect its presence systematically. We believe that more attention should be focused on the morphological variations adopted by both orifices in the chamber floor with a view to facilitating the localisation of the elusive ML canal.

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