A SEM investigation of accessory foramina in the furcation areas of primary molars

Paulo Floriani Kramer* / Ítalo Medeiros Faraco Júnior** / Raquel Meira***

The purpose of this study was to determine the prevalence and anatomic characteristics of accessory foramina in the external and internal furcation areas of primary molars. Sixty human primary molars were divided into two equal groups. The teeth of the experimental group showed in previous radiographic examination the presence of a radiolucency area confined to the inter-radicular region, while the teeth of the control group had no sign of pulpal inflammation in the clinical and/or radiographic examination. The specimens were observed by scanning electron microscope (SEM). The external furcation area (EFA) showed a higher prevalence of accessory foramina than the internal furcation area (IFA) (P<0.05). However, the comparison between the two groups did not show statistically significant difference (P>0.05). The presence of accessory canals should not be considered the only reason for inter-radicular pathological bone resorption following pulpal necrosis in deciduous molars.
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INTRODUCTION

The furcation area of deciduous molars is of special significance due to its close anatomical relations with the follicle of the permanent successor. Moreover, in primary molars pathological bone changes following pulpal necrosis are not likely to be found at the apices, but rather in the interradicular region.[1-6]

A few investigators have studied the presence of accessory foramina that may connect the pulp and periodontal ligament. Accessory canals, defined as a communication between the pulp tissue and the periodontal ligament other than through the root apex, are the result of a localized failure in the formation of Hertwing´s sheath during embryonic stages of tooth formation.[7-8] This leads to a failure in odontoblastic differentiation and dentine formation and eventually to the formation of an accessory canal. Bacteria and toxins or products of the pulpal tissue decomposition may diffuse through them to the periodontal tissues.[7] Besides, from the level of the pulp-chamber floor to the apical foramen may have openings, the foramina, connecting with accessory or lateral canals. This relationship could therefore determine pathological consequences such as rarefaction areas caused by inter-radicular bone resorption following pulpal necrosis.[4,7,8]

A variety of techniques have been utilized to identify the existence of accessory canals, including dye perfusion,[1,2,4] serial histologic sections[8] and Scanning Electron Microscope (SEM) observations.[6,7,9] However, the results obtained from these studies are not in complete agreement, and usually originate in studies conducted on human permanent teeth.[10-14] Using dye perfusion technique, Winter[1] found that 23 percent of abscessed primary molars showed accessory canals leading from the pulp chamber floor to the furcation area. Associating dye perfusion technique and serial histological sections, another study demonstrated a 20 percent frequency of accessory canals and a higher permeability in the pulp-chamber floor of infected deciduous molars.[2] Yoshida *et al.,*[15] using serial histological sections, reported a frequency of 75 percent accessory canals that were localized principally in the central region of pulp chamber floor and were classified in true, blind, looping and unclosed.

An SEM study showed a prevalence of 36 percent of these openings. The shape of accessory canals was classified into three types: round (56%), oval (28%) and others (15%).[9] According to Morabito and DeFabianis,[7] 60 percent of specimens exhibited aberrant canals that, usually, were smooth-walled and with a round or oval

* Paulo Floriani Kramer, MDS, PhD, is director, Division of Pediatric Dentistry and professor of Pediatric Dentistry, Lutheran University of Brazil, Canoas, Brazil. Dr. Paulo Floriani Kramer 24 de Outubro Street, 435 / 307 - Porto Alegre - RS – Brazil – 90510-002
E-mail: paulokramer@hotlmail.com

** Ítalo Medeiros Faraco Júnior, MDS, PhD, is professor of Pediatric Dentistry, Lutheran University of Brazil, Canoas, Brazil. Dr. Ítalo Medeiros Faraco Júnior, Padre Chagas Street, 140/402 - Porto Alegre - RS – Brazil - 90570-080
E-mail: faraco@cpovo.net

*** Raquel Meira, DDS is postgraduate student of Pediatric Dentistry, Lutheran University of Brazil, Canoas, Brazil. Send all correspondence to Dr. Raquel Meira, Nossa Senhora de Copacabana Street, 1335/610 – Rio de Janeiro – RJ – Brazil
E-mail: raqmeira@terra.com.br

Table 1. Prevalence and the mean diameter of accessory foramina in the External (EFA) and Internal (IFA) Furcation Areas of deciduous molars.

	AEF	AIF
PREVALENCE	**53%•**	**25%**
DIAMETER	**65µm**	**80µm†**

• P < 0.05
† P > 0.05

Table 2. Prevalence and the mean diameter of accessory foramina in the External (EFA) and in the Internal (IFA) Furcation Areas in the control and experimental group.

	CONTROL		EXPERIMENTAL	
GROUP	**EFA**	**IFA**	**EFA**	**IFA**
PREVALENCE	47%	27%	60%	23%
DIAMETER	64µm	83µm	66µm	76µm

P > 0.05

aspect. Other SEM investigation found the presence of accessory foramina in 20 percent of internal furcation area (IFA) and in 50 percent of external furcation area (EFA).[6] Associating SEM with a perfusion technique of low viscosity latex under pressure, Paras *et al.* observed the absence of true canals running from internal to external furcation area.[16]

The documentation of accessory canals in furcation areas of primary molars is therefore scanty and the results are contradictory. The aim of this study was to determine, using SEM, the prevalence and anatomic characteristics of accessory foramina in the external and internal furcation areas of primary molars.

MATERIALS AND METHODS

Sixty primary molars, from children between the ages of four and ten years, were extracted for clinical or orthodontic indications. The molars selected had at least half of the root lengths, so that the furcation area could be clearly distinguished. Besides, the teeth with previous pulpal therapy were discarded and not included in either group.

Immediately after extraction, the teeth were immersed in 10 percent formol solution and divided into two equal groups. The thirty deciduous molars of the experimental group showed in previous radiographic examination the presence of a radiolucency area confined to the interradicular region, while the thirty primary molars of the control group did not show sign of pulpal inflammation in the clinical and/or radiographic examination. The teeth were sectioned transversely 5mm coronal to the floor of the pulpal chamber and 5 mm apical to the external furcation area and rotary instruments using profuse water spray were used to remove the roof of the chamber. The specimens were placed in a solution of 1 percent sodium hypochlorite for 20 minutes and underwent ultrasonic cleaning for 5 minutes to remove pulpal tissue remnants. Then they were rinsed under running tap water for 5 minutes and air-dried.

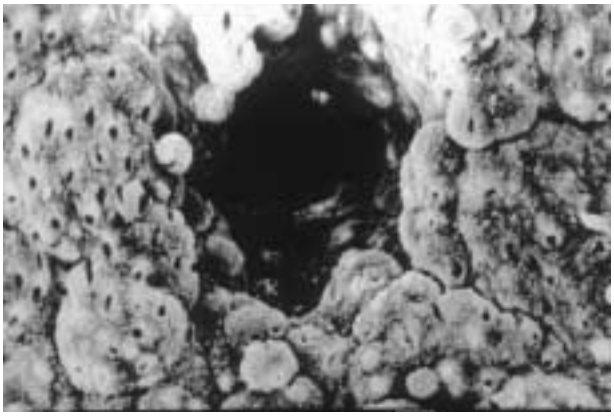

Figure 1. The internal furcation area aspect of a primary molar. Accessory foramina is indicated by arrow (Mag.X35).

The specimens were mounted on metallic stubs for SEM viewing, in which both the internal and external furcation surfaces faced upwards. They were sputter-coated with gold (Hummer Sputtering System-Anatec Ltd, Springfield, Virginia, USA) and examined with a scanning electron microscope (Jeol JSM-T330A - Jeol Ltd, Akishima, Japan). The SEM examination was conducted under blind conditions. Scanning micrographs were obtained in magnification of 15X, 35X, 750X and 1000X.

Statistical analysis was performed using the proportions test and analysis of variance with a level of significance of 5%.

RESULTS

Table 1 shows the prevalence of accessory foramina in the furcation areas. The prevalence of these openings in the external furcation area (EFA) was 53 percent, while 25 percent of the specimens demonstrated accessory foramina in the internal furcation area (IFA). The difference in prevalence between the EFA and IFA was statistically significant ($P<0.05$). On the other hand, there were no statistically significant differences in the diameter of the foramina between the furcation areas ($P>0.05$), as shown in Table 1.

Forty-seven percent of the molars of the control group exhibited accessory foramina in the EFA, while in the experimental group, SEM revealed eighteen of the thirty teeth (60%) with accessory foramina in this furcation area. The control group showed accessory foramina 20-200 µm in diameter, with average diameter of 64µm and in the experimental group the diameters

Figure 2. The external furcation area aspect of a primary molar. Accessory foramina is indicated by arrow (Mag.X15).

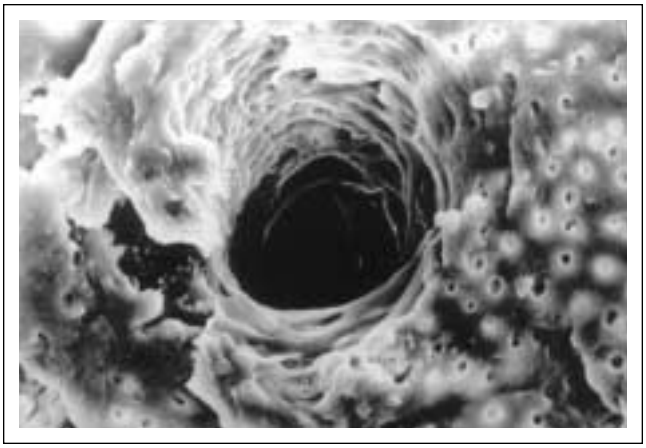

Figure 3. Photomicrograph of an accessory foramina located on the IFA. The accessory canal appears to become narrower in diameter as it extends deeper into the dentin (Mag. X1000).

Figure 4. Photomicrograph of an accessory foramina located on the EFA. The cementum surface appears to extend into the accessory canal (Mag. X750).

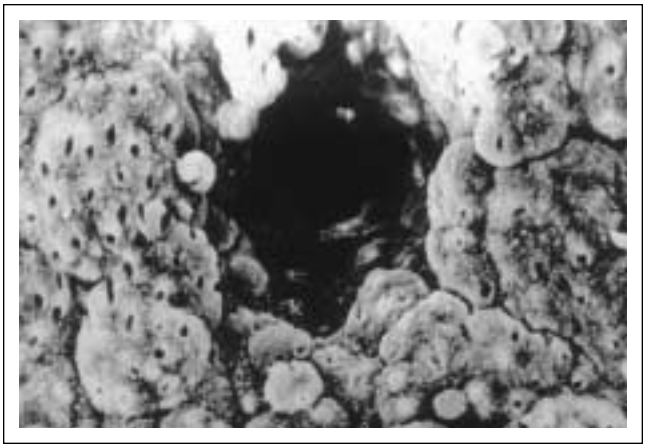

Figure 5. Photomicrograph of an accessory foramina located on the IFA. The dentin surface appears to extend into the accessory canal (Mag. X750).

ranged from 15-200µm, with average diameter of 66µm (Table 2).

The SEM observations on IFA demonstrated accessory foramina in 27 percent and 23 percent of primary molars in the control and experimental groups, respectively. The diameters ranged from 22-222µm with average diameter of 83µm in the control group and from 20-160µm with average diameter of 76µm in the experimental group (Table 2).

The statistical analysis of the data revealed that there were no statistically significant differences neither in the prevalence nor diameter of accessory foramina between the control and experimental group in both furcation areas ($P>0.05$), as shown in table 2.

The accessory foramina in the present investigation were smooth-walled and mainly located in the central part of the furcation area. Most of them were round or oval in shape (Figures 1 and 2) and were observed to cluster around the larger accessory canal. Many of the accessory foramina found in this study led to canals which appeared to become narrower in diameter as they traveled deeper into the dentin (Figure 3). Some canals seemed to be occluded, partial or totally, by cementum. SEM examination of the EFA revealed an appearance typical of cemental surface (Figure 4), while the IFA demonstrated an appearance typical of dentin surface with openings of dentinal tubules in the pulp-chamber floor (Figure 5).

DISCUSSION

A SEM study allows enhanced observations of the furcation areas of deciduous molars. However, SEM observations can reveal the presence of accessory foramina that can potentially lead to true canals, as well as can lead to blind and looping canals.[15]

The present SEM study demonstrated a higher prevalence of accessory foramina in the external furcation area, agreeing with the results obtained in an SEM study carried out by Paras *et al.*[6] and in histological-section study by Wrbas *et al.*[17] Most of the detected

foramina in this study were smooth-walled with an oval and round aspect and located in the central portion of the external and internal furcation area. Goto *et al.*[9], Morabito and DeFabianis[7] and Paras *et al.*[6] also observed this finding in their studies.

The openings in both areas appeared to lead to accessory canals that became narrower in diameter as they traveled deeper into the dentin, as also demonstrated by Paras *et al.*[6], who disclosed concentric distribution of the canals, which suggests a circular arrangement of collagen fibers during the embryonic period.

According to Fanning,[18] Obersztyn[19] and Haralabakis *et al.*,[20] the root resorption of deciduous teeth is accelerated by the presence of inflammatory process in the surrounding tissues. Moss *et al.*[2] observed histopathology alterations by the presence of decalcification and premature loss of the protecting layer of cementum. The present study also verified resorption areas more advanced in the teeth of the experimental group. Winter[1] related that areas with advanced resorption could represent primary sites of accessory canals that could induce a resorption process more advanced in this area

Partial or total obliteration of accessory foramina by a mineralized structure, characterizing blind accessory canals, was verified as described by Yoshida *et al.*[15] Henderson[21] reported that physiological root resorption process occurs with phases of resorption and repair. The deposition of mineralized tissue could be induce by the process of repair, which could be orientated by the casual presence of accessory foramina in the external furcation area.[1,6,7] Appelbaum[22] reported that physiological root resorption process may initiate in the walls of accessory canals.

Although some authors have reported that the interradicular bone resorption may be caused by the presence of accessory canals in the furcation area, the present study suggests that the presence does not necessarily imply a direct communication between pulp and periodontal tissue, as also described by Paras *et al.*[16] Yoshida[15] reported a frequency of 75 percent accessory canals, however, most of them were blind or looping. Winter[1], Moss *et al.*[2] and Wrbas *et al.*[17] also agree that the presence of accessory canals should not be considered the only reason for interradicular pathological bone resorption following pulpal necrosis in deciduous molars.

Therefore, other factors may facilitate the diffusion of infected material and toxin toward the interradicular region in deciduous molars. The small thickness of dentin, physiological root resorption with dentin tubule exposition in the external furcation area, and the presence of true accessory canals could increase the permeability of the region, thus causing pathological alterations in the interradicular region of primary molars.

CONCLUSIONS

Based on the methodology and results of this study, the following conclusions may be drawn:

1. The external furcation area of deciduous molars showed a higher prevalence of accessory foramina than the internal furcation area in the control and experimental group.
2. The presence of inflammatory lesion in the interradicular region has not determined statistically significant difference in the prevalence or anatomic characteristics of foramina in the external and internal furcation area of deciduous molars.
3. The presence of accessory canals should not be considered the only reason for interradicular pathological bone resorption following pulpal necrosis in deciduous molars.
4. More research to investigate other factors that could increase the permeability of interradicular region and cause bone resorption in this region are indicated.

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