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The prevalence of furcation foramina in primary molars

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Abstract

Accessory canals in the furcation region of primary molars provide pulpal-periodontal communications which have important clinical implications. This study of 75 extracted primary molars using dye penetration under vacuum suction showed that 42.7% have foramina located within the furcation region. There were no significant differences in the prevalence between the first and second primary molars. However, in the second primary molar series most of these foramina were located on the root surfaces within the furcation region, rather than in the immediate area of root division. The high prevalence of accessory canals in the furcation region of primary teeth indicates the need for greater clinical consideration during endodontic and periodontal management.

The furcation area of a molar tooth, which encompasses the region around the division of the roots, is of special significance in the primary dentition due to its close anatomical relationship with the follicle of the succedaneous permanent molar. Accessory canals in the furcation area are clinically important for several reasons. Infection in the pulp can spread through these canals to affect the interradicular bone before involving perapical tissues (Winter 1962; Myers et al. 1987). In addition, medicaments placed in pulp can enter furcation bone through these canals. These accessory canals also provide communication of the pulp with periodontal tissues. often being the cause of deep periodontal pockets associated with nonvital teeth (Seltzer et al. 1963). Although the clinical implications of these communication canals are well recognized, there has been little research showing their existence or the anatomical location of these furcal foramina, particularly in primary teeth. This study was performed to determine the prevalence and location of accessory canals in the furcation region of extracted primary molars.

Materials and Methods

Selection of teeth

Seventy-five extracted primary molars, which had been stored previously in 2% formalin, were selected at random. Although the reasons for the extractions were unknown, they were carefully selected by the criteria that root resorption did not involve more than a third of the apical aspect of any root. In addition, teeth showing surface defects in the furcation region also were eliminated.

Preparation of teeth

The teeth were prepared according to the method of Gutmann (1978), with slight modifications. They were first placed in a solution of 2.5% sodium hypochlorite for surface cleansing for 20 min followed by rinsing with tap water. An occlusal endodontic access cavity was prepared in each tooth, followed by standard endodontic techniques of pulp tissue removal using spoon excavators and broaches. Care was taken not to scrape the floor of the pulp chamber. The teeth were stored in 3% hydrogen peroxide for 1 week, the solution being changed every two days. This technique destroys tissue attachment to the tooth, allowing for easy debridement but not causing decalcification (Hibbard and Ireland 1957). The teeth were rinsed in tap water for 20 min, then immersed in 95% alcohol for 24 hr to fix the tissues. Finally, they were dried thoroughly using compressed air before being placed in a vacuum suction system for dye penetration of the pulp system.

Dye penetration under vacuum suction

A tube was modified from a 3 cm by 1 cm rubber teat (Ansell International, Dandenong, Victoria, Australia). One end was placed around the crown of each tooth (Fig 1) to achieve a tight seal. The other end was sealed around a plastic tube modified from a 1 cm disposable pipette tip (Monoject Scientific, Sherwood, St. Louis, MO, USA), and the joint was secured using a piece of 0.18 mm wire tie (Fig 1). The plastic tube was located centrally in a 4 cm diameter rubber stopper designed to

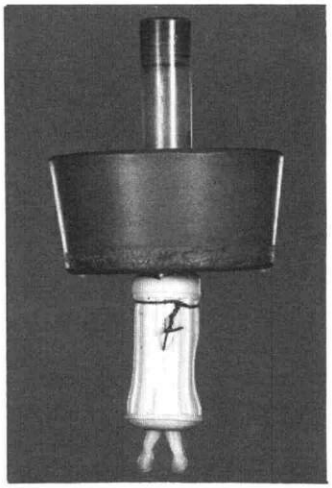

Fig 1. Primary molar tooth assembled for dye penetration of the root canals. A rubber teat holds securely at one end to achieve a tight seal. The other end of the teat is sealed around a plastic tube through which the dye is inserted. A wire tie is used to seal this section securely. Red sticky wax is applied to the apices of the tooth.

fit a 2 L flask attached to a vacuum pump (Fig 2). Red sticky wax was applied to the apical one-third of each root to seal the apical foramen (Fig 3). A drop of Safranin® dye (red) (Sigma Chemical Co., St. Louis, MO, USA) was intro-duced down the tube into the pulp chamber using a fine disposable glass pipette. Extreme care was taken to ensure that no spillage of dye occurred onto the external aspects of the tooth. A vacuum pressure of 550 mbar mercury was applied to the external root surfaces for a maximum of 5 min. As soon as the vacuum was applied, the furcation area of each tooth was observed carefully for the appearance of any red staining. As soon as red staining was noted, the tooth was removed so that markings on the cemental surfaces remained discrete.

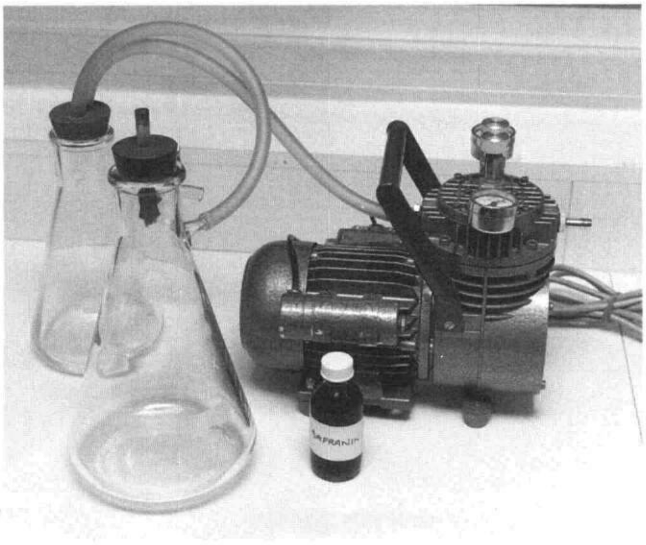

Fig 2. The vacuum suction apparatus for dye penetration of root canals.

Statistical Analysis

The Chi-square test was used for statistical analysis of the data.

Results

Prevalence of foramina in the furcation region

It is important to define the anatomical areas under study. The "furcation" has been defined as the area limited to the immediate region where the roots separate, while the "furcation region" encompasses the actual furcation of each tooth plus an area 4 mm down the internal aspect of the root surfaces (Gutmann 1978). Using these definitions, we first surveyed the prevalence of foramina in the furcation region of 75 primary molars. Overall, there were 32 teeth showing presence of foramina in the furcation region, giving a prevalence of 42.7% (Table 1). This prevalence varied slightly among the different teeth surveyed (Table 1). As shown in Table 1, the prevalence of foramina in the furcation region ranged from 33.3% in the mandibular first primary molar to 40.0% in the mandibular second molar, 48.0% in the maxillary second primary molar, and 50.0% in the maxillary first primary molar. The differences in prevalence among the different molars is not statistically significant ($P > 0.1$).

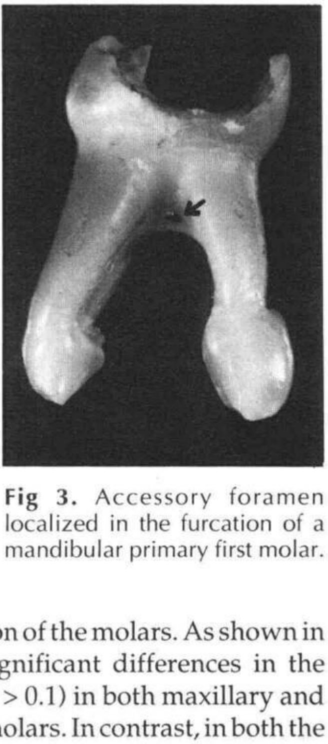

Fig 3. Accessory foramen localized in the furcation of a mandibular primary first molar.

Location of furcation foramina

It is of interest to analyze the location of the foramina. Table 2 (page 200) shows the distribution of the foramina in the furcation region of the molars. As shown in Table 2, there were no significant differences in the location of the foramina ($P > 0.1$) in both maxillary and mandibular first primary molars. In contrast, in both the

TABLE 1. Prevalence of Foramina in Furcation Region of Primary First and Second Molars

	First Primary Molar		*Second Primary Molar*		*Total*
	Max. (N = 10)	*Mand.* (N = 10)	*Max.* (N = 25)	*Mand.* (N = 30)	(N = 75)
No. with Furcal Foramina	5	3	12	12	32
Percentage	50.0%	33.3%	48.0%	40.0%	42.7%

The difference in prevalence of furcal foramina among the different molars is not statistically significant ($P > 0.01$)

TABLE 2. Analysis of Location of Foramina in Furcation Region in Primary Molars

Tooth	*Location of Foramina*		*P value*
	*Furcation**	*Furcation region*†	
First Primary Molar			
Max. (N = 5)	2 (40.0%)	3 (60.0%)	>0.1
Mand. (N = 3)	2 (66.7%)	1 (33.3%)	>0.1
Second Primary Molar			
Max. (N = 12)	3 (25.0%)	9 (75.0%)	<0.001
Mand. (N = 12)	2 (16.6%)	10 (83.4%)	<0.001

* Furcation encompasses the immediate root division region.
† Furcation region includes the internal aspect of the root from root division area down to approximately 4 mm of root length.

maxillary and mandibular second primary molars there were greater percentages of foramina located in the furcation regions compared to the furcation itself (75.0 vs. 25.0% in the case of the maxillary second primary molar, and 83.4 vs. 16.6% in the case of the mandibular second primary molar). These differences were statistically significant ($P < 0.001$). Figure 3 shows a primary mandibular first molar with a foramen in the furcation, as indicated by the discrete stained spot. In contrast, Figure 4 shows a foramen in the furcation region of a primary mandibular second molar.

Roots showing foramina in furcation region

It may be clinically relevant to identify the roots in furcation region showing foramina in the primary molars. Table 3 shows the roots involved in the mandibular primary molars. The most commonly involved root in these teeth was the distal root (45.5%), followed by the mesial root (36.3%), and the involvement of both mesial and distal roots (18.2%). However, these differences were not statistically significant ($P > 0.1$). Table 4 shows a similar analysis of the roots involved in the maxillary molars. The mesiobuccal root is most involved frequently (41.7%), with another 41.7% showing the presence of foramina in both mesiobuccal and palatal roots. Only 16.6% showed the presence of foramina in the distobuccal root alone, and no teeth had foramina on the palatal root alone.

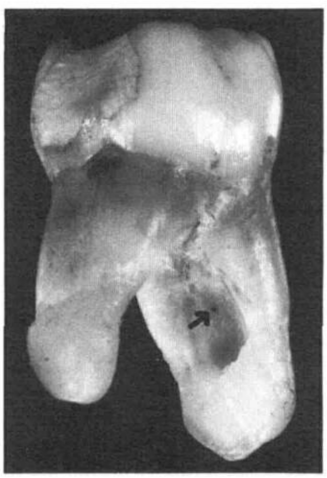

Fig 4. Accessory foramen noted in the furcation region of a mandibular primary second molar.

It is of interest to note that all the foramina appeared as discrete areas of staining. Diffusion of the dye through dentinal tubules was not a problem.

Discussion

Accessory canals on root surfaces may be considered developmental aberrations caused by the persistence of abnormally placed blood vessels that leave gaps in the Hertwig's sheath (Scott and Symons 1982). Although accessory canals may occur anywhere along the root surface, those in the furcation areas of molars pose the most difficult complications in clinical dentistry. Most of the previous work investigating the furcation region of teeth has centered on permanent molars. In these teeth, a wide range of prevalence figures have been noted, probably due to differing sensitivity of the techniques employed. Using dye penetration method similar to that of the present study, Gutmann found that 24.5% of 102 permanent molars showed patent accessory canals leading from the floor of the pulp channels to the furcation (Gutmann 1978). However, a higher prevalence of 40% was noted by Vertucci and Williams (1974) in their visual examination of 100 mandibular first permanent molars using a dissecting microscope. The highest prevalence (59%) was noted by Lowman et al. in 1973 using a combination of radiopaque dye system and radiography on 46 permanent molars.

In sharp contrast, other investigators employing chiefly radiographic methods have found no lateral

TABLE 3. Type of Root Showing Foramina in Furcation Region* in Mandibular Primary Molars

Root	*No. of teeth with Foramina (N = 11)*
Distal Alone	5 (45.5%)
Mesial Alone	4 (36.3%)
Distal and Mesial	2 (18.2%)

* These foramina are located on the internal aspect of the root within 4 mm from the center of the true furcation area.
The differences in the results are not statistically significant ($P > 0.1$).

TABLE 4. Type of Root Showing Foramina in Furcation Region* in Maxillary Primary Molars

Root Surface	*No. of Teeth With Foramina (N = 12)*
Mesiobuccal Alone	5 (41.7%)
Distobuccal Alone	2 (16.6%)
Palatal Alone	0
Mesiobuccal and Palatal	5 (41.7%)

* These foramina are located on the internal aspects of the root within 4 mm from the center of the true furcation area.

canals coming from the pulp chamber of multirooted teeth (Pineda and Kuttler 1972; De Deus 1975; Hession 1977). This probably is due to low sensitivity of the technique employed in these studies for the detection of accessory canals.

Although permanent molars have been well investigated, there is a paucity of information regarding the presence of accessory canals in the furcation region of primary molars. Interest in this anatomical part of the tooth was aroused first from clinical observations that many necrotic primary molars show bone loss in the furcation area (Winter 1962; Myers et al. 1987), suggesting possible channels of communication between the pulp and periodontal bone in this region of the root. To demonstrate this, Winter (1962) used a dye perfusion system to study by direct observation the prevalence of patent accessory canals in the furcation region. He reported that 29% of 100 primary molars possessed accessory canals leading to the interradicular root surface, with the opening of these canals found principally on the middle third of the root surface. The above results were confirmed by Moss et al. (1965) in a histological study which found that 20% had accessory canals entering the pulp chamber in the region of the furcation of the roots. However, both these studies were done on primary molars which were extracted for interradicular abscesses diagnosed from radiographs, so the results may be biased.

Our present study using randomly selected primary molars shows a much higher prevalence (42.7%) of accessory canals in the furcation region of primary molars. Although some of the canals may not be patent in the healthy in vivo state due to connective tissue seals, they represent potential channels which may be opened during pathological changes in the pulp.

There is important clinical significance of these canals. First, infection of the pulp can spread easily to the interradicular bone via these furcation communications. This problem was addressed by Seltzer and co-workers in 1963, as well as by Winter in 1962 who located furcation accessory canals in 29% of primary molar teeth showing interradicular abscesses. These interradicular abscesses tend to drain through the periodontal ligament and are an important cause of periodontal pockets in the primary dentition.

Second, during the pulpotomy procedure it is possible that excess medicament solutions placed in the pulp chamber may enter these accessory canals and involve the alveolar bone. Many of these medicaments, such as formocresol, possess strong inflammatory potential (Seow and Thong 1986) and if allowed to contact bone, may cause painful osteitis. Therefore, it is advisable to localize pulpotomy medicaments to the amputated root stump rather than spreading it over the entire pulpal floor, where there is a high possibility of diffusion of the medicaments through accessory canals into the bone.

Third, the communication of the periodontal tissues with the pulp affected by furcation canals may suggest that infections originating from the periodontal tissues theoretically could reach the pulp. Although periodontal abscesses are uncommon in children, they may be observed around ill-fitting stainless steel crowns, orthodontic bands, and impacted foreign bodies. However, the incidence of pulpal necrosis resulting from such periodontal infections is unknown.

In conclusion, the high prevalence of accessory canals in the furcation region of primary molars suggests that communications of the pulp with interradicular bone and periodontal tissues are highly possible.

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De Deus QD: Frequency, location and direction of lateral secondary and accessory canals. J Endo 1:361-66, 1975.

Gutmann JL: Prevalence, location and patency of accessory canals in the furcation region of permanent molars. J Periodontol 49:21-26, 1978.

Hession RW: Endodontic morphology: A radiographic analysis. Oral Surg 44:610-20, 1977.

Hibbard ED, Ireland RL: Morphology of the root canals of the primary molar teeth. ASDC J Dent Child 24:250-61, 1957.

Lowman JV, Burke RS, Pellan GB: Patent accessory canals: incidence of molar furcation region. Oral Surg 36:580-84, 1973.

Moss SJ, Addelston H, Goldsmith ED: Histologic study of pulpal floor of deciduous molars. J Am Dent Assoc 70:372-79, 1965.

Myers DR, Battenhouse MR, Barenia JT, McKinney RV, Singh B. Histopathology of furcation lesions associated with pulp degeneration in primary molars. Pediatr Dent 9:279-82, 1987.

Pineda F, Kuttler Y: Mesiodistal and buccolingual roentgenographic investigation of 7,275 root canals. Oral Surg 33:101-10, 1972.

Scott JH, Symons NB: Introduction to dental anatomy. Edinburgh: Churchill Livingstone, 1982.

Seltzer J, Bender IB, Ziontz M: The interrelationship of pulp and periodontal disease. Oral Surg 16:1474-90, 1963.

Seow WK, Thong YH: Modulation of polymorphonuclear leukocyte adherence by pulpotomy medicaments: effects of formocresol, glutaraldehyde, eugenol and calcium hydroxide. Pediatr Dent 8:16-21, 1986.

Vertucci TJ, Williams RG: Furcation canals in the human mandibular first molar. Oral Surg 38:308-14, 1974.

Winter GB: Abscess formation in connection with deciduous molar teeth. Arch Oral Biol 7:373-79, 1962.

Nutritional deficiency – oral manifestations

Many developmental and systemic conditions have oral manifestations, some of which are early indicators of disease. The following chart pinpoints oral conditions that may be symptoms of nutritional deficiencies. In many instances, early detection can increase patient comfort and well being.

Oral manifestations related to nutritional deficiency

Vitamin A
- Hyperplasia of the gingiva
- Gingivitis
- Periodontitis

Vitamin B12 (pernicious anemia)
- Spongy red-blue (very hemorrhagic) gingiva
- Detachment of periodontal fibers
- Bone loss
- Halitosis
- Angular cheilosis

Vitamin D (rickets)
- Enamel hypoplasia
- Absence of lamina dura
- Abnormal alveolar bone patterns

Vitamin K
- Gingival bleeding (caused by decreased formation of prothrombin)

Thiamin
- Satinlike appearance of tongue and gingiva (caused by atrophy of filiform papillae—beri-beri
- Angular cheilosis

Niacin
- Fiery red glossitis (devoid of papillae)
- Ulcerative gingivitis
- Angular cheilosis

Iron
- Red painful tongue (atrophy of filiform papillae)
- Angular cheilosis
- Dysphagia