The prevalence of furcation foramina in primary molars
D. Ringelstein, BDSc  W. Kim Seow, BDS, MDSc, PhD, FRACDS

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.

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
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 introduced 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.

**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 pri-

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

<table>
<thead>
<tr>
<th></th>
<th>First Primary Molar</th>
<th>Second Primary Molar</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. with Furcal Foramina</td>
<td>5</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Percentage</td>
<td>50.0%</td>
<td>33.3%</td>
<td>48.0%</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Tooth</th>
<th>Location of Foramina</th>
<th>Furcation*</th>
<th>Furcation region*</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Primary Molar</td>
<td></td>
<td>Max. (N = 5)</td>
<td>2 (40.0%)</td>
<td>3 (60.0%)</td>
</tr>
<tr>
<td>First Primary Molar</td>
<td></td>
<td>Mand. (N = 3)</td>
<td>2 (66.7%)</td>
<td>1 (33.3%)</td>
</tr>
<tr>
<td>Second Primary Molar</td>
<td></td>
<td>Max. (N = 12)</td>
<td>3 (25.0%)</td>
<td>9 (75.0%)</td>
</tr>
<tr>
<td>Second Primary Molar</td>
<td></td>
<td>Mand. (N = 12)</td>
<td>2 (16.6%)</td>
<td>10 (83.4%)</td>
</tr>
</tbody>
</table>

* Furcation encompasses the immediate root division region.

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* 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.

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

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

Mr. D. Ringelstein was a final-year undergraduate dental student at the time of the study. Dr. W. Kim Seow is senior lecturer in pediatric dentistry, Department of Social and Preventive Dentistry, Dental School, University of Queensland, Turbot Street, Brisbane, Queensland, Australia 4000, Telephone: (07) 233 8044. All correspondence should be sent to Dr. Seow. Reprint requests should be sent to: Dr. W. Kim Seow, Dept. of Pediatric Dentistry, University of Queensland Dental School, Turbot St., Brisbane, Queensland 4000 Australia.


**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