Journal of Oral Science, Vol. 50, No. 1, 69-74, 2008

Original

Study of root canal accessibility in human primary molars

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(Received 29 August 2007 and accepted 6 February 2008)

Abstract: The aim of the present study was to provide a general scheme for pulpectomy of primary molars that may be useful for decision-making about negotiation of root canals and selection of appropriate instruments. A total of 160 vital primary molars in 85 patients (40 males, 45 females) aged 4-6 years were selected. After taking primary radiographs, local anesthesia was induced, and the teeth were isolated using a rubber dam. Canal accessibility index (CAI) and tooth accessibility index (TAI) were calculated according to initial file size. Mandibular first molars had either three canals (79.2%) or four canals (20.8%), and all second molars had four canals. Maxillary first molars had three canals and second molars had either three canals (70.9%) or four canals (29.1%). Lower accessibility of the mandibular first molar distobuccal root accounted for the lower accessibility of these teeth in comparison with mandibular second molars. While three-canal maxillary second molars were more accessible due to the lower accessibility of the distobuccal canal of the maxillary first molar, poor accessibility of the distal canal in four-canal second molars was responsible for the difficult accessibility of these teeth. In conclusion, it seems that the accessibility of a single canal in each tooth determines the difficulty of accessibility for any given tooth. Moreover, while primary second molars are more accessible than first molars, all of them are negotiable. (J. Oral Sci. 50, 69-74, 2008)

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Keywords: pulpectomy; primary molar; canal accessibility.

Introduction

Primary teeth exhibit anatomical differences from permanent teeth in terms of size, and external and internal morphology. In comparison with permanent teeth, the relatively thin layer of hard mineralized tissue between the external and internal surfaces leads to rapid involvement of the dental pulp by advancing caries. Nonetheless, conservation of primary teeth is deemed advantageous for maintenance of arch length and harmonized temporal and spatial development of permanent teeth. Pulpectomy of primary teeth is indicated when the dental pulp is non-vital or irreversibly inflamed. However, as primary teeth may show bizarre internal geometry of the pulpal cavity, with features not commonly observed in permanent teeth, such as connections involving furcation and horizontal anastomoses, endodontic treatment of primary teeth is considered highly complicated. This is especially true for primary first molars; some authors have suggested that clinical indications for such treatment are limited (1), whereas others have ignored the issue (2) or totally rejected it (3).

Even in contemporary dental practice, the prevailing notion that bizarre and tortuous canals of primary teeth may not be adequately negotiated, cleaned, shaped, or filled, has brought about needless sacrifice of primary teeth with carious pulp. However, clinical studies have shown that the prognosis for primary teeth after pulpectomy is reasonable (4). In a retrospective study, Coll and Sadrian reported an overall success rate of 77.7% for pulpectomy of primary teeth with no difference between molars and incisors (5). They suggested that the most important

preoperative predictor of success was the amount of root resorption; root resorption exceeding 1 mm resulted in a success rate of only 23.1%. In another retrospective study, Moskovitz et al. proposed that coronal microleakage rather than other factors affected the prognosis of pulpectomy (6). The existing disagreement between the hard-to-negotiate concept of primary molar root canals and the relatively high success rate reported in retrospective studies of pulpectomy highlights a potential concern: have teeth diagnosed as non-negotiable and eventually extracted, been merely overlooked? Furthermore, although there have been several paraclinical investigations of primary tooth root canal anatomy (7,8), there have been no attempts to determine the clinical accessibility of these canals, which would be of genuine significance for clinical decision-making.

An objective overview of this issue requires a large-scale prospective study that is independent of any pre-existing bias. Moreover, the extant dental literature suggests that pulpectomy for primary molars has been simply overlooked, and that stringent clinical guidelines related to this issue are lacking. The aim of the present study was to investigate the feasibility of pulpectomy for primary molars by assessing the primary stage of root canal negotiation and accessibility. Moreover, we sought to determine whether a general scheme could be devised for assisting clinicians in decision-making about selection of proper instruments for each type of trait and for individual root canals.

Materials and Methods

Study population

This clinical trial was performed at the Department of Pediatrics, Tabriz University of Medical Sciences. A total of 160 primary molars in 85 patients (40 males, 45 females) aged 4-6 years without any confounding past medical history were included in the present study. The subjects had been referred for treatment of carious primary molars, and the selected children were categorized as cooperative (Frankel's class IV). The selected carious molars were vital and suitable for partial pulpectomy. Moreover, the selected teeth did not pose a serious challenge for crown restoration. The presence of the following signs and symptoms was ruled out by clinical and radiographic examinations:

1. Internal or external pathology, root resorption, or a thickened periodontal ligament
2. Periapical pathoses
3. Pain on percussion
4. Presence of a fistula or sinus tract
5. Suppuration from the root canals
6. Evidence of pulpal derangement such as pulp stones

The aforementioned criteria were considered to indicate that partial pulpectomy was feasible. However, hemorrhage that was not controllable within 5 min of pulpal extirpation during partial pulpectomy was considered to indicate a shift of therapeutic protocol to full root canal therapy.

Narrowing of the selection criteria minimizes the risk of internal pathologic modulation of the root canals, e.g. internal resorption. This is because any alteration of the structure affects endodontic file selection, leading to seriously biased conclusions. Moreover, the selected teeth do not pose a serious challenge for crown restoration.

The study procedure, probable discomfort, and risks as well as benefits were explained to the parents of the children, and all of them provided written informed consent. This study was approved by the ethical and research committees of Tabriz University of Medical Sciences.

Therapeutic protocol

The study procedure was performed by a single pediatric dentist. Initially, periapical radiographs of the selected teeth were taken using the standard parallel technique. Local anesthesia was induced using inferior alveolar nerve/lingual nerve block for mandibular primary molars and infiltration anesthesia (palatal/buccal) for maxillary primary molars (Xylocaine® 2%, Epinephrine 1/100000, Dentsply, York, USA). Isolation of the operation site was accomplished by placement of a rubber dam. During access cavity preparation and prior to pulpal exposure, all remaining dental caries as well as undermined enamel pieces were eliminated. The entire roof of the pulp chamber and dentinal remnants overhanging the pulp horns were removed. A funnel-shaped access to the entrance of the root canals was prepared. After amputation and extirpation of the coronal pulp at its entry level to the root canals, the pulp chamber was irrigated with a light flow of sterile 0.9% NaCl-solution.

An estimated working length 2 mm short of the primary diagnostic radiographic length was measured. After negotiation of the root canals, an initial endodontic K-file (MANI®, Utsunomiya, Japan) was introduced to the estimated working length, and a second radiograph was taken. The endodontic file that could be passed along the estimated working length while fitting snugly into the canal was used as the initial endodontic file. Subsequently, the corrected working length (CWL) was determined. Cleaning of the canals was started from the initial file for the CWL with a filing motion, and the canals were enlarged three sizes beyond the initial file to eliminate any organic remnants. Copious irrigation was implemented throughout the procedure. Thereafter, the canals were dried using paper points. Using a pressure syringe and starting at 1 mm from the apex, the canals were then filled with ZOE and the orifice areas were packed with a stiffer mix of ZOE.

The remainder of the pulp chamber was filled with restorative glass ionomer (Dentsply®, Weybridge, UK) and a stainless steel crown was placed.

Information about the number and location of canal orifices and the initial files was registered for each tooth and any individual canal. On a random basis, some procedures were performed twice at regular time intervals to allow for estimation of intra-examiner data agreement. The canal accessibility index (CAI) was calculated according to the following formula:

$CAI = (\sum n \times F_s) / n_t$

For any canal, n represents the number of canals associated with a certain file size (F_s) and n_t is the total number of cases with that specific canal.

For example, for a canal that is initially negotiated with a no. 25 file (10 molars) and a no.30 file (15 molars), the CAI is calculated as:

$CAI = [(25 \times 10) + (30 \times 15)] / (10 + 15) = 28$

Tooth accessibility index (TAI) was calculated according to the following formula:

$TAI = (\sum CAI) / n_c$

where n_c represents the number of canals for each tooth.

Statistical analysis

All quantitative data are presented as mean ± standard deviation (SD). Intra-examiner agreement for initial file selection was evaluated by Spearman's correlation coefficient. Analysis of variance (ANOVA) was used to analyze the significance of differences in initial file size between various canals. Multiple post-hoc comparisons were conducted based on the Scheffé test to find individual differences. In the present study $P < 0.05$ was considered to indicate statistical significance.

Results

A total of 160 primary molars in 85 patients (40 males, 45 females) aged 4-6 years were selected. Of these, 76 were maxillary molars (first molar: 40, second molar: 36) and 84 were mandibular molars (first molar: 46, second molar: 38).

Intra-examiner data agreement

The intra-examiner agreement of data for initial file selection was excellent (Spearman correlation coefficient = 0.91).

Mandibular primary first molar

Two separate mesiobuccal and mesiolingual canals were negotiated in all cases (Table 1). The distal root contained two separate negotiable canals in 19.6% of first molars (9 molars) and the remaining cases (37 molars) had a single distal canal. The data regarding the CAI for each canal are presented in Table 1. The CAI for the mesiobuccal canal, which was the most accessible root canal, was 29.38. In both three- and four-canal mandibular primary molars, the mesiolingual canal was the least accessible root canal (CAI = 12.92). The TAI for the mandibular primary first molar was 22.21 for three-canal teeth and 19.08 for four-canal teeth.

Mandibular primary second molar

In all of the studied cases, both the mesial and the distal roots demonstrated two negotiable buccal and lingual canals. The accessibility of mandibular primary second molars, in descending order, was: mesiobuccal, distobuccal, distolingual, and mesiolingual (Table 1). The major accessibility difference between mandibular primary first

Table 1 CAI values and prevalence of individual root canals

Mandibular first molar (n = 46)	Mesiobuccal	Mesiolingual	Distal	Distobuccal & Distolingual
CAI	29.38	12.92	24.21	17
Prevalence	100% (n = 46)	100% (n = 46)	79.2% (n = 37)	19.6% (n = 9)
Mandibular second molar (n = 38)	Mesiobuccal	Mesiolingual	Distobuccal	Distolingual
CAI	29.38	27.08	28.33	28.13
Prevalence	100% (n = 38)	100% (n = 38)	100% (n = 38)	100% (n = 38)
Maxillary first molar (n = 40)	Mesiobuccal	Distobuccal	Palatal	
CAI	26.88	13.54	30.62	
Prevalence	100% (n = 40)	100% (n = 40)	100% (n = 40)	
Maxillary second molar (n = 36)	Mesiobuccal	Distobuccal	Palatal	Distal
CAI	27.08	23.33	32.20	11.43
Prevalence	100% (n = 36)	100% (n = 36)	100% (n = 36)	29.1% (n = 10)

CAI: Canal accessibility index

and second molars was observed in the mesiolingual canal. The TAI for the mandibular primary second molar was 28.23.

Maxillary primary first molar

The general scheme for these teeth was three separate mesiobuccual, distobuccal, and palatal root canals. Palatal canals were the most accessible (CAI = 30.62) and distobuccal canals were the least accessible (CAI = 13.54). The accessibility of mesiobuccal and palatal canals was similar. The TAI for the maxillary primary first molar was 23.68.

Maxillary primary second molar

Mesiobuccal, distobuccal, and palatal canals were found in all of the studied cases. However, a separate negotiable distal canal was encountered in 29.1% of cases (10 molars). While palatal canals exhibited maximum accessibility (CAI = 32.30), the distal canal was the least accessible canal (CAI = 11.43). The TAI for the maxillary primary second molar was 27.57 for three-canal teeth and 23.53 for four-canal teeth.

Bivariate between-group comparisons

There was no significant difference in initial file size between the mesiobuccal and distal canals (both one- and two-canal categories) ($P > 0.05$) in mandibular primary molars (Table 2). However, the initial file size (IFS) for the mesiolingual canal was significantly less than for the other canals ($P < 0.05$). The IFS for the mesiobuccal, mesiolingual, distobuccal and distolingual canals was not significantly different in mandibular secondary molars ($P > 0.05$).

The distobuccal canal showed a lower IFS than the mesiobuccal and palatal canals in maxillary primary molars ($P < 0.05$). However, there was no significant difference between mesiobuccal and palatal canals ($P > 0.05$). For the maxillary second molar, while the IFS for the mesiobuccal and palatal canals was not significantly different ($P > 0.05$), both the distobuccal and distal canals exhibited a lower IFS than these canals ($P < 0.05$). Moreover, the IFS for the distal canal was significantly less than for the distobuccal canal ($P < 0.05$).

Bivariate within-group comparisons

Comparison of the IFS demonstrated that only the distobuccal canal of the mandibular first molar had lower values than the canals of mandibular second molars ($P < 0.05$). Comparison of the maxillary first and second molars showed that the primary molar distobuccal canal had a lower IFS than the mesiobuccal, distobuccal, and palatal canals of the second molar ($P < 0.05$) and a higher IFS than the distal canal ($P < 0.05$). Both the distobuccal and distal canals of the second molar had lower IFS values than the mesiobuccal and palatal canals of the first molar ($P < 0.05$). There was no significant difference between the mesiobuccal and palatal canals of the maxillary first and second molars ($P > 0.05$).

Discussion

The aim of the present study was to investigate the accessibility of human primary molars and proper instrument selection during pulpectomy. The results showed that primary first molars are generally less accessible than

Table 2 Comparison of initial file sizes used for primary molars

Tooth	Canal	File number					
		10	15	20	25	30	35
Mandibular first molar	Mesiobuccal				20.8%	70.8%	8.4%
	Mesiolingual	50%	42%	8%			
	Distal			16.6%	58.8%	5%	
	Distobuccal		12.5%	7.1%			
	Distolingual		12.5%	7.1%			
Mandibular second molar	Mesiobuccal				20.8%	70.8%	8.4%
	Mesiolingual				58.3%	41.7%	
	Distobuccal				33.4%	66.6%	
	Distolingual				42%	53%	5%
Maxillary first molar	Mesiobuccal				62.5%	37.5%	
	Distobuccal				45.8%	37.5%	16.6%
	Palatal				87.5%	12.5%	
	Distal						
Maxillary second molar	Mesiobuccal				33.3%	58.4%	8.3%
	Distobuccal		5%	34%	54.2%	6.8%	
	Palatal					58.4%	41.6%
	Distal	71.4%	28.6%				

primary second molars. However, a single canal in the entire root canal system which has significantly lower accessibility than the other canals determines the accessibility of primary molars.

Different methods have been used to investigate the anatomy of root canals. These include direct observation with the aid of a microscope (9), macroscopic sections (10), filling of canals with inert materials followed by decalcification (11), and filling of canals and clearing (12). However, all of these methods have serious limitations, as most of the relationship of the external structure to the pulp is lost during sample preparation (13). A significant constraint of conventional radiography is the super-imposition of overlying structures, which obscure the object of interest. Furthermore, extrapolation of the results of these studies to real clinical situations and using them as a guideline for clinical decision-making is extremely difficult if not impossible.

Several *in vitro* studies have evaluated the root canal morphology of human primary molars (14,15). Zoremchhingi et al. investigated the root canal morphology of human primary molars using computed tomography (14). There are some discrepancies between their findings and ours. For example, Zoremchhingi et al. reported that the distal root of the mandibular primary molar had two canals in 40% of cases, which was a higher prevalence than what we found clinically (20%). There are several explanations for this disagreement, one of which may be the ethnicity of the study subjects, and another may be the difference in the techniques used for the assessment of root canal accessibility, i.e. computed tomography versus clinical evaluation. Also, the classification of the canals may have differed between the two studies. For instance, we found a distal canal in 29% of maxillary primary second molars and a distobuccal canal in all cases. The 26.6% incidence of two-canal distobuccal roots reported by Zoremchhingi et al. may be in accordance with the same scenario, namely categorization of a distal and a distobuccal canal as a two-canal distobuccal root.

A method of grading complexity in restorative dentistry has been described in the Index of Restorative Dental Treatment Need or RIOTN (16). The RIOTN complexity index for root canal treatment is the major factor determining the complexity of treatment. Our findings indicate that accessibility of both three- and four-canal mandibular primary first molars is significantly lower than that of primary second molars. However, surprisingly, the mesiolingual canal was found to be the only indicator of difficulty for mandibular primary molars. In agreement with our findings, Zoremchhingi et al. reported that the mesiolingual canal showed the smallest diameter (mean: 0.4 mm) (14). In our study, the mesiobuccal canal of the mandibular first molar had the highest canal accessibility index, whereas Zoremchhingi et al. observed the maximum diameter in the distal canal (14). The CAI for mandibular second molars was nearly the same for all canals, and Zoremchhingi et al. reported a similar finding with reference to canal diameter (14).

The scenario for maxillary primary molars differed completely; in three-canal molars, low accessibility of the distobuccal canal substantially decreases the accessibility of the maxillary first molar compared to the second molar. In line with our findings, Zoremchhingi et al. demonstrated that the distobuccal canal has the smallest diameter in the middle and apical thirds (14). However, the TAI for four-canal maxillary second molars was nearly the same as that for first molars due to lower accessibility of the extra distal canal.

In conclusion, it seems that the accessibility of a single canal in each tooth determines the difficulty of tooth accessibility. Moreover, while the accessibility of primary second molars is higher than for first molars, both of these tooth types have accessible canals that would not compromise endodontic treatment.

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