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Root canal filling techniques for primary molars: an *in vitro* evaluation

Tecniche di sigillatura canalare in molari decidui: uno studio in vitro

KEYWORDS
Endodontics, Hand file, Lentulo spiral, Centrix syringe, Primary teeth, Root canal obturation.

PAROLE CHIAVE
Endodonzia, File manuali, Lentulo, Siringa Centrix, Denti decidui, otturazione canalare.

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Abstract

Aim: *This study evaluated the efficacy of three different techniques used in the root canal filling of primary teeth.*
Methodology: *Sixty artificial resin upper and lower primary molars were used. The quality of root canal filling was evaluated using standardized buccal/lingual radiographs, after the use of three different techniques: endodontic hand file, spiral Lentulo and Centrix syringe. Scores were attributed to the obturation length and the presence of voids. Data were statistically analysed and the comparison between groups was calculated using the chi-square test.*
Results: *The use of endodontic hand file demonstrated the best results regarding the endodontic filling length and density. The occurrence of material extrusion was greater when Lentulo spiral was used in palatine root canals of upper molars. The obturation density was similar among the lower molars and in mesio buccal and palatine canals of upper molars, while in the disto buccal canal of upper molars, the endodontic hand file was significantly more effective.*
Conclusions: *The quality of root canal filling was similar among the different groups. However, lentulo spiral allowed greater material extrusion in palatine root canals, and greater occurrence of voids in disto buccal canal of upper molars, in comparison with the other tested techniques.*

Obiettivi: *Questo studio ha valutato l'efficacia di tre differenti tecniche di sigilatura canalare in dentizione decidua.*
Metodologia: *60 molari artificiali decidui superiori e inferiori, in resina, sono stati usati: file endodontico a mano, lentulo spirale e siringa Centrix.*
La qualità della sigillatura canalare è stata valutata usando radiografie buccali/linguali standardizzate. I punteggi sono stati attributi riferendosi alla lunghezza della sigillatura e la presenza di vuoti. I dati sono stati analizzati statisticamente e la comparazione tra i gruppi è stata calcolata usando il test chi-quadro.
Risultati: *Il file endodontico a mano ha mostrato il miglior risultato relativamente alla lunghezza e alla densità della sigillatura canalare. L'evenienza di estrusione di materiale è stata maggiore durante l'uso del lentulo spirale nella radice palatina dei molari superiori. La densità dell'otturazione è stata simile tra i molari inferiori e i canali mesio buccali e palatali dei molari superiori, ma nei canali disto buccali dei molari superiori, il file endodontico è stato molto più efficiente.*
Conclusioni: *La qualità della sigillatura canalare è stata simile tra i differenti gruppi. Comunque, il lentulo spirale ha permesso una maggiore estrusione di materiale nel canale palatino strumentato e riempito con una pasta iodoformica da un unico operatore usando differenti canali radicolari ed una maggiore presenza di vuoti nel canale disto buccale dei molari superiori.*

Introduction

Endodontic treatment aims to eliminate the root canal infection and to retain the tooth functional until its physiological exfoliation. It outcome is influenced by various factors such as biochemical preparation, obturating material, and hermetic seal of root canal (1). Additionally, some particularities must be taken into consideration during the endodontic treatment of primary teeth: the complex primary molars anatomy, with secondary and accessories canals and physiological root resorption; also the child psychological maturity and the cooperation during the treatment may influ-

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ence in the effectiveness of mechanical instrumentation, irrigation of the canals and root canal obturation (2, 3).
In order to increase the success of the endodontic treatment, the properties of filling materials as well as the appropriate insertion into the root canal are crucial. Several methods have been indicated to insert the root canal filling materials into primary teeth (4-7), such as hand held lentulo spiral paste filler, engine driven lentulo spiral paste filler, endodontic plugger, endodontic pressure syringe, endodontic hand files, tuberculin syringes, paper points and other tips (4-8).
Lentulo spiral is a commonly used method, which creates a good distribution of paste in the root canal walls; however, some studies indicate the difficulty of achieving a dense root canal filling when this method is applied (1, 6, 9). The endodontic hand file seems to be effective to make the root canal filling material to achieve the the complete working length, nevertheless may not completely fill the root canal in laterality (10).
Centrix syringe is frequently used for post cementation, composite and glass ionomer insertion (11-14). It usually shows a material layer with few voids and imperfections. The use of this syringe-type applicator optimizes the material insertion due to the homogeneous dispersion of the material. However, the effectiveness of Centrix syringe to obturate primary root canals was not sufficiently investigated (15).
The literature presents few information regarding the most effective method to deliver iodoform paste in primary molars (5-7). Thus, the aim of this study was to compare in vitro the ability of three different techniques using endodontic hand files, spiral lentulo and Centrix syringe. The null hypothesis tested was that the quality of root canal filling is not affected by the different techniques used.

Materials and Methods

Root canal preparation. Sixty artificial resin primary teeth with standardized internal anatomy (Tecnodon, Belo Horizonte, Belo Horizonte, MG, Brazil) was used in this study. The overall sample consisted in 30 upper molars (90 canals) and 30 lower molars (90 canals).
All canals were checked radiographically for apical patency and root canal conditions by inserting a #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland). Each toth was identified by a code, and then assembled in a mannequin (Prodens, Belo Horizonte, MG, Brasil), which was coupled to a head in a dental unit, simulating the clinical conditions. Access to the pulp chamber was obtained with #4 diamond burs (KG Sorensen, Cotia, SP, Brazil) with a high-speed hand piece under water-cooling. A#15 K-file was inserted into each canal until its tip was just visible at the apical foramen, and the length was measured. The working length (WL) was established by subtracting 1 mm from the full length of the tooth.
A previously trained Endodontist performed all the endodontic procedures. Root canals were instrumented manually with K-file (Dentsply, Tulsa, OK, USA). In lower molars the preparation was up to file #25-30 for mesiobuccal and mesiolingual canals and up to #30-35 for distal canals; and in upper molars the enlargement was up to #25-30 in mesiobuccal and distobuccal canals, and #30-35 for palatal canals. After each instrument, the irrigation of root canals was performed using 2 mL of 1% sodium hypochlorite (Asfer Indústria Química Ltd., São Caetano do Sul, SP, Brazil), 5 mL of distilled water was used as final irrigation. The root canals were dried using absorbent paper points (Dentsply, Tulsa, OK, USA).
Root canal filling. Teeth were randomly divided into three groups (n=20, 10 upper molars and 10 lower molars), and the root canals were filled with a iodoform paste using different delivery methods: Group I endodontic hand file (Dentsply, Tulsa, OK, USA); Group II pressure syringe (Centrix, DFL, Taquara, RJ, Brazil); Group III Lentulo spiral (Dentsply, Tulsa, OK, USA). All primary molars were obtured using a single filling material to obtain the same radiopacity and consistency.
In **group I**, a #25 K file (Dentsply, Tulsa,

OK, USA) was used to deliver the obturation paste into the root canal. A rubber stopper was used to keep the file 1 mm short of the apex. The file was smeared with the iodoform-based paste, inserted into the canal and rotated in counter clockwise direction. Subsequently it was driven up and down, with a wiping motion against the canal walls, and then removed from the canal. This process was repeated until the canal orifice appeared to be filled with the paste.

In **group II** a Centrix syringe (DFL, Rio de Janeiro, RJ, Brazil) was used to fill the root canal with the iodoform-based paste. The paste was inserted into the syringe-type applicator and the tip (Centrix Accudose tip, DFL, Rio de Janeiro, RJ, Brazil) was positioned in the Centix syringe. Then, the cement was placed in the coronal portion of the root canal, and the application was performed in the apical-cervical direction. The material was inserted until the canal orifice appeared to be filled with the paste.

In **Group III** #4 lentulo spiral (Dentsply, Tulsa, OK, USA) was passively placed to the working length before the paste was applied, thus reduction the risk of fracture. A rubber stop was placed around the thicker part of the spiral filler to reduce displacement during the filling procedures. Then, the lentulo was mounted on slow speed handpiece, coated with the iodoform paste, inserted into the canal, and withdrew gently while still rotating. The procedure was repeated until the canal orifice appeared to be filled with the paste.

Cotton pliers holding a cotton pellet were used to lightly press the material inside the canal. After the root canal obturation, the pulp chamber of each tooth was sealed with Zinc Oxide Eugenol cement (ZOE).

At the completion of the experiment, standardized buccal/lingual radiographs were taken for each tooth (Spectro 70x, Dabi Atlante, Ribeirão Preto, SP, Brazil) to simulate the clinical conditions.

Radiographic Evaluation. The quality of root canal filling using the different techniques was radiographically accessed by two knowledgeable pediatric dentists. Each radiograph was mounted in a 35 mm slide frame and projected onto screen. Both evaluators were blinded to the filling technique. When disagreement occurred during evaluation, the case was discussed with a third observer until a final agreement was reached.

In order to test the intra- and inter-examiner variability, Kappa coefficient was obtained using a sample of 50 periapical radiographs of teeth presenting different root canal obturation status. The Kappa values for intra-examiner variability was 0.91 and the value for inter-examiner concordance was 0.85, showing excellent agreement.

The quality of the root canal filling was defined as follows (6):

1) Underfilling – when the root canal filling was more than 2 mm short of the apex.

2) Adequate – if the root canal filling was within 0 and 2 mm of the apex

3) Overfilling – if the filling material extruding from the apex.

The density of the root canal filling was defined using modified criteria used by Sigurdsson et al. (16):

1) Good – optimal filling, with no voids.

2) Acceptable – good filling, in which the voids were rarely observed.

3) Unacceptable – presence of large numer of voids in different areas of root canal.

Data analysis. Data were analysed statistically and group differences calculated using SPSS statistical software (version 17.0, SPSS, Inc., Chicago, IL, USA). The results were compared between groups using the chi-square test ($P<0.05$).

Results

A total of 180 posterior root canals of primary teeth were filled using hand files, lentulo spiral and Centrix syringe methods. From these, twelve root canals were excluded from the study due to failures during the root canal preparation, thus, a total of 168 root canals were evaluated.

The obturation techniques included in this study demonstrated similar results regarding the root canal filling length ($p=0.312$). The obturation length was con-

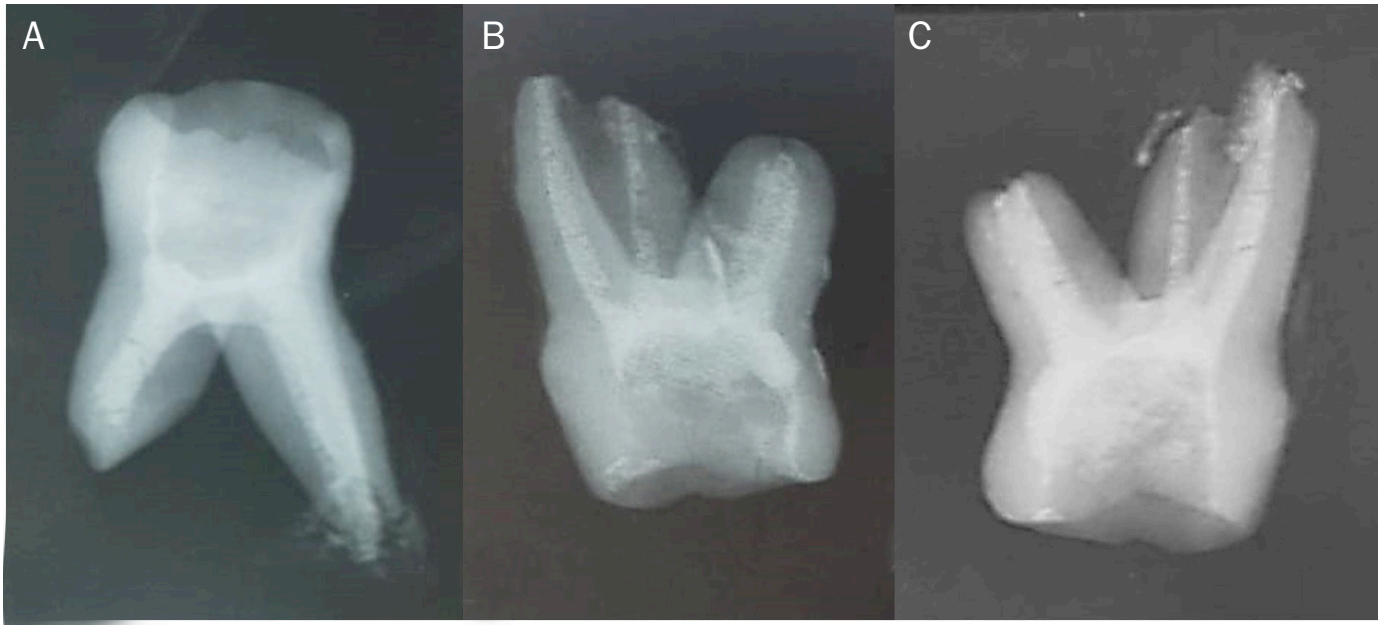

Figure 1
***A** Lower molar filled with Centrix seringe. Adequate root canal filling length and good filling density; **B** Upper molar filled with hand files, presence of voids and adequate root canal filling length; **C** Upper molar filled with lentulo spiral, overfilling and presence of voids.*

sidered adequate in 72.9% of canals filled with hand files; 75.8% of canals filled with centrix syringe and 65.8% of obturations made with lentulo spiral. Regarding the obturation density, 91.2% of canals filled with the endodontic hand file were considered good or acceptable, while the lentulo spiral technique showed the worst scores of obturation density. This results, however, were not significantly different among the obturation techniques (p=0.653) (table 1). In figure 1 it is possible to observe examples from the filling techniques tested and from the evaluated parameters. The filling length were similar, despite the different techniques used in the root canals of lower molars and in the MB (mesio buccal) and DB (disto buccal) canals of upper molars (p>0.05).
However, in the palatine canal of upper molars, Lentulo spiral allowed greater extrusion in comparison with other groups (p= 0.014) (table 2).
The scores attributed to obturation density in the different root canals are described in table 2. There was no difference in the obturation density among the root canals of lower molars and in the MB and palatine canals of upper molars (p >0.05). In the DB of upper molars, the Lentulo technique showed the highest occurrence of unacceptable fillings (p=0.007).

Discussion

The adequate delivery of filling materials to the root canal walls and the complete root canal obturation throughout its length, avoiding gaps and voids, are the ultimate goals of endodontic filling in

Table 1

Distribution frequency of root canal filling methods according to the length and quality of obturation (n=168)

Methods	Root canal filling length				Density of root canal filling			
	Adequate	Underfilling	Overfilling	P value	Good	Acceptable	Unacceptable	P value
Endodontic hand file	44 (72.5)	8 (14.0)	5 (8.8)		41 (71.9)	11 (19.3)	5 (8.8)	
Lentulo spiral	32 (65.3)	11 (22.4)	6 (12.2)	0.312	34 (69.4)	7 (14.3)	8 (16.3)	0.653
Pressure syringe	47 (75.8)	13 (21.0)	2 (3.2)		40 (64.5)	14 (22.6)	8 (12.9)	

Table 2

Distribution frequency of root canal filling methods according to the length and quality of obturation, within the different root canals (n=168)

	Root canal	Methods	Root canal filling length				Density of root canal filling			
			Adequate	Underfilling	Overfilling	P value	Good	Accetable	Unacceptable	P value
Upper Molar	MB	Endodontic hand file	8	1	0	0,412	8	0	1	0,399
		Lentulo spiral	10	0	0		10	0	0	
		Centrix syringe	9	1	0		8	1	1	
	DB	Endodontic hand file	9	0	0	0,810	9	0	0	0,007
		Lentulo spiral	7	2	1		7	0	3	
		Centrix syringe	6	4	0		5	4	1	
	P	Endodontic hand file	6	0	3	0,014	8	0	1	0,253
		Lentulo spiral	3	2	5		6	2	2	
		Centrix syringe	8	2	0		5	3	2	
Lower Molar	MBi	Endodontic hand file	7	3	0	0,222	4	5	1	0,350
		Lentulo spiral	2	3	0		2	1	2	
		Centrix syringe	6	2	2		7	2	1	
	ML	Endodontic hand file	7	1	2	0,184	7	3	0	0,365
		Lentulo spiral	4	3	0		4	2	1	
		Centrix syringe	8	3	0		8	1	2	
	D	Endodontic hand file	7	3	0	0,446	5	3	2	0,640
		Lentulo spiral	6	1	0		5	2	0	
		Centrix syringe	10	1	0		7	3	1	

MB=mesio-buccal, DB=disto-buccal, P=palatal, MBi=mesio-buccalinferior, ML=mesio-lingual, D=distal

primary teeth (4, 17, 18). The method used to take the material into the root canal is one of the factors that imply in the occurrence of failures in the obturation length and density (4). Few studies, however, have been carried out to evaluate the different methods of root canal filling of primary teeth. The present study aims to fill this gap, since it is still necessary to point out the best method of root canal obturation in primary teeth, particularly in molars.

Differently from previous studies, in which the sample consisted in anterior teeth (5, 6); our study assessed the quality of root canal obturation using primary upper and lower molars. To appraise the quality of root canal filling, it is important to consider the anatomic diversity of the root canals instead of a unique tooth, once the techinique difficulties are clearly more frequent in narrow and curved root canals in comparison to large and straight canals. The quality of obturation may also be influenced by the tooth position in the oral cavity, as well as by the management of children's behavior. In this study, before the instrumentation and filling, each tooth was assembled in a mannequin (Prodens, Belo Horizonte, MG, Brasil), which was coupled to a head in a dental unit. Due to the ethical difficulty in achieve natural teeth with standardized anatomy; this study used standardized resin artificial teeth. Although the limitations of this method, which does not reflect properly the in vivo conditions, with the absence of alveolar bone, and physiological root resorption, the use of artificial teeth represents an adequate model to in vitro studies, especially due

to the standardized internal anatomy and root canal wall thickness, very similar to natural teeth.

Different authors advocate that the lentulo spiral is an effective technique for obturation of primary teeth (5, 7). However, in the present study, the lentulo spiral technique demonstrated the worst results regarding both root canal filling length and density.

Around 16.3% of root canal fillings performed with lentulo spiral were considered inadequate, presenting voids, specially in DB canal of upper molars. The obturations performed with endodontic hand file, though, were considered good or acceptable in 91.3% of cases.

These results are in agreement with previous studies which had also reported poor results regarding obturation density when using lentulo spiral (4, 6, 9). In the palatine canal of upper molars, which presents a straight and large anatomy, the lentulo spiral tended to allow the material extrusion beyond the apex. Contrarily, others studies found less extrusion by lentulo technique (9, 19), mainly in curved canals (15). These controverse results may be explained mostly due to the viscosity and consistency of the filling material used in the evaluation. Moreover, the operator skills and the previous experience with the method should also be considered as a bias in results (4). The discrepancies between the outcomes may be justified by differences in the applied methodology: different teeth anatomy, different sample size and evaluation parameters (20). Clinically, the voids mean material leakage, with consequent microorganisms reinfection, and failure of the endodontic treatment (7). However, the material extrusion through the apex probably represents more important role in the endodontic treatment outcome than the presence of voids within the obturation mass (19).

This aspect is particularly important in the root canal treatment of primary teeth, when materials containing zinc oxide and eugenol are used. ZO has low absorption capacity, leaving particles in the periap-

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ical tissues when extravasation occurs (21). Furthermore, due its hardness, it may occur deflection of eruption of permanent teeth (22). However, with the use of iodoform-based or calcium hydroxide-based pastes for the primary teeth root canal filling, the concerns regarding the material extrusion had decreased (23), once these materials are more biocompatible and resorbable (23, 24).

Our results also demonstrated an influence of the root canal anatomy in the quality and in the length of root canal obturation. A statistically significant difference regarding the filling length was noticed in the palatine canal of upper. Also, the results of root canal filling density were statistically different depending on the filling method in the disto-buccal canal of upper molars. There results indicated that large and straight root canals, such as the palatine canal, have a major tendency to be overfilled, and in this case, an endodontic hand file, with a better control of material insertion can be indicated. Otherwise, the mesio-buccal and disto-buccal canals present an atresic and curved anatomy, being positioned in the maxilla which makes the adequate material insertion more difficult to be achieved.

Conclusions

In conclusion, the quality of root canal filling was similar among the different groups. However, lentulo spiral allowed greater material extrusion in palatine root canals, and greater occurrence of voids in disto buccal canal of upper molars.

Conflict of Interest

The authors declare that they have no conflict of interest.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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