Brazilian Research in Pediatric Dentistry and Integrated Clinic 2016, 16(1):299-305
DOI: http://dx.doi.org/10.4034/PBOCI.2016.161.31
ISSN 1519-0501

Original Article

Morphological Assessment and Cleaning Capacity of a Reciprocating System in Root Canals of Deciduous Teeth

Sérgio Luiz Pinheiro,[1] Caroline Miki Ota,[2] Fabiola Mara Galvan Romitti,[2] Fátima Gabriela Aquino Barret,[2] Tânia Sanches Pato,[2] José Carlos Pettorossi Imparato[3]

[1]Professor, Master's Program in Health Sciences, Department of Pediatric Dentistry, Pontifícia Universidade Católica de Campinas, Campinas, SP, Brazil.
[2]MSc, Dental Research Center, São Leopoldo Mandic, Campinas, SP, Brazil.
[3]Coordinator, MSc Program, Dental Research Center, São Leopoldo Mandic, Campinas, SP, Brazil.

Author to whom correspondence should be addressed: Sérgio Luiz Pinheiro, Rua Raul Gasparini, 525, Vinhedo, SP, Brazil. 13280-000. Phone: +55-11-99245-0090. E-mail: slpinho@puc-campinas.edu.br.

Academic Editors: Alessandro Leite Cavalcanti and Wilton Wilney Nascimento Padilha

Received: 09 November 2015 / Accepted: 09 August 2016 / Published: 27 September 2016

Abstract

Objective: To assess root canal morphological results and cleaning capacity in deciduous teeth instrumented with a reciprocating system. **Material and Methods:** 15 deciduous molars and a total of 24 canals were selected for the study. Nine teeth (13 canals) were selected at random for microbiological analysis and 6 teeth (11 canals) were used for tomographic analysis of morphology. The roots used for the microbiological assessment were contaminated with standard strains of Enterococcus faecalis. All roots were instrumented using the WaveOne System with a Small (21:06) 21 mm file and an X-Smart plus motor. Tomography was conducted with an I-CAT machine before and after instrumentation with the objective of analyzing the WaveOne System's shaping capacity. Statistics: Biostat 4.0 software was used to analyze results. The microbiological results (log_{10}) and tomographic results (pixels) were analyzed using descriptive statistics and the Wilcoxon test. **Results:** There was a significant reduction in Enterococcus faecalis colony-forming units after instrumentation of the root canal systems of deciduous molars using the WaveOne system ($p=0.0033$) and significant enlargement of the root canal systems was observed after instrumentation ($p=0.047$), while morphology was maintained. **Conclusion:** The WaveOne System, using the Small file was effective for disinfection of the root canal systems of deciduous molars.

Keywords: Endodontics; Instrumentation; Deciduous Teeth; Tomography.

Introduction

Premature loss of deciduous teeth can result in changes to the timing and sequence of eruption of the permanent teeth. Maintenance of deciduous teeth up to the physiological point of shedding contributes to mastication, phonation and esthetics and helps to prevent children from acquiring unhealthy habits [1]. Traumatic events or caries processes involving deciduous teeth can cause infections that lead to pulp necrosis or irreversible pulpitis that will require endodontic treatment.

The success of endodontic treatment is dependent on reducing the number of microorganisms in root canals [2] by means of chemomechanical preparation involving removal of vital tissues, necrotic remnants and microorganisms. In pediatric dentistry, cleaning and maintenance of the anatomic shape of the root canal system of deciduous teeth can be made difficult by the anatomic complexity of deciduous teeth and by the behavior of the child [3].

Disinfection of the root canals of deciduous teeth can be accomplished by mechanical preparation with k-files, hybrid techniques, rotary systems [4] or reciprocating systems [5].

Employing reciprocating instrumentation was recently proposed as an alternative to continuous rotation as an option for instrumentation of curved canals using a single file [6]. This system shapes the root canal safely [7]. The system also allows for greater irrigant flow, removing lower quantities of dentin from the canal walls [8] and reducing the tendency to damage or fracture the instrument [9]. The WaveOne system uses a reciprocating action and is designed to employ just one file, with 3 size options (Small 21:06; Primary 25:08 or Large 25:08) chosen according to the width of the canal that is being instrumented.

There are few reports in the literature from studies that have employed reciprocating systems to prepare root canals in deciduous teeth. In view of this, the objective of this study was to compare the morphological results and capacity for cleaning root canals using the reciprocating technique in deciduous molars.

Material and Methods

This project was approved by the Research Ethics Committee at the Faculdade de Odontologia e Medicina São Leopoldo Mandic (Protocol 626681).

The study was conducted using a sample of 15 deciduous molars donated by the human teeth bank at the São Leopoldo Mandic dental research center (Table 1). The following parameters for the sample size were determined from test t: minimum detectable difference between means equal to 4.94, coefficient of variation equal to 5.0, probability level α=0.05 and statistical power equal to 0.8. Thus, the estimated minimum sample was found to be 10.

The criteria for inclusion in the sample were: deciduous molars with a maximum of one third of the root reabsorbed (with 11.0 +/- 1.0 mm working length); free from pathological internal or external root resorption; free from internal and/or external drilling in the furcation area; and with a

moderate root angle [10]. Nine teeth (13 canals) were selected at random for microbiological analysis and 6 teeth (11 canals) were selected for tomographic analysis.

Table 1. Description of the sample: distribution of the roots between teeth.

	1°UM	2°UM	1°LM	2°LM
MV	3	2	3	4
ML	0	0	3	4
D	0	0	0	0
DV	3	2	0	0
P	0	0	0	0

1°UM: first upper molar; 2°UM: second upper molar; 1°LM: first lower molar; 2°LM: second lower molar; MV: MV canal; ML: ML canal; D: distal canal; DV: DV canal; P: palatine canal.

The teeth were washed under running water and then immersed in saline solution (LBS Laborasa Ind. Farm. Ltda, São Paulo, SP, Brazil) until the experiments were started. Odontometry was conducted using the visual method [4]. The working length was determined visually by inserting a size 10 Kerr file (Dentsply Maillefer, Ballaigues, Switzerland) until the tip of the file could be seen at the apical foramen. A silicone stop was fitted to the reference cuspid corresponding to the canal and the working length was determined by subtracting 1 mm from the length of the canal [11]. Endodontic access was achieved using a sterile spherical carbide bur (KG Sorensen, São Paulo, SP, Brazil) and after the canals had been located, access was completed using a number 3082 diamond bur (KG Sorensen, São Paulo, SP, Brazil). Teeth were then sterilized in an autoclave (Brasidérmica, São Paulo, SP, Brazil).

The roots to be used for microbiological assessment were contaminated with strains of Enterococcus faecalis ATCC 29212 (LabCentulo, Campinas, SP, Brazil) and inoculated in 200 ml of BHI (Labcenter, Campinas, São Paulo, Brazil) for 5 days at 37°C in an atmosphere of 85% nitrogen (N_2), 10% carbon dioxide (CO_2) and 5% hydrogen (H_2), created using an anaerobiosis sachet (Oxoid Ltd., Basingstoke, United Kingdom). All teeth were instrumented using the WaveOne system using the Small CRT 21:06 file with a length of 21 mm, coupled to an X-Smart plus motor (Dentsply Maillefer, Ballaigues, Switzerland).

Microbiological analysis (n=13): 9 deciduous molars (13 root canals). Initially the canals were irrigated with 1 ml of saline solution (LBS Laborasa Ind. Farm. LTDA, São Paulo, Brazil); then initial collection was performed with a sterile number 15 paper cone (Dentsply Maillefer, Petrópolis, RJ, Brazil) for 1 minute; followed by instrumentation with the WaveOne system using the Small CRT 21:06 file with a length of 21 mm, coupled to an X-Smart plus motor (Dentsply Maillefer, Ballaigues, Switzerland), followed by irrigation with 1 ml of 1% sodium hypochlorite solution (Asfer Indústria Química Ltda, São Caetano do Sul, SP, Brazil). After instrumentation was complete, a second bacterial sample was collected for 1 minute using sterile paper points (Dentsply Maillefer, Ballaigues, Switzerland) of a diameter compatible with the canal anatomy and immediately transferred to the BHI medium. All samples were then diluted at 10-5 and seeded onto blood agar plates (Labcenter, Campinas, SP, Brazil) for counting of viable bacteria. Samples were then mixed in a solution agitator AP56 (Phoenix Luferco Ind. Com. Equipamentos Científicos, Araraquara, SP,

Brazil) for 1 minute and then diluted, before three 25 ul aliquots were seeded onto blood agar plates using the micropipette technique [12]. After seeding, the cultures were incubated in anaerobiosis at 37°C for 5 days in an atmosphere of 85% N_2, 10% CO_2 and 5% H_2, created using the sachet system. Once this period had elapsed, the total number of colony-forming units per millimeter (CFU/ML) was counted.

Morphological analysis (n=11): 6 deciduous molars (11 root canals). Computed tomography scans were conducted before and after instrumentation with the WaveOne system using an I-CAT machine (Imaging Sciences International, Hatfield, United States), model 9140-0000-0000R, series ICU071080. It should be pointed out that for this assessment there was no contamination with Enterococcus faecalis. The scan results for the canal area were obtained in pixels using tpsDig software to outline the canal lumen and determine its area.

Statistical analysis

The results were analyzed with the aid of Biostat 4.0 software. For the microbiological analysis, the results in CFU/ML were transformed into $\log_{10}$ and for the tomographic analysis the results were analyzed in pixels. Results were analyzed with descriptive statistics and the Wilcoxon test.

Results

There was a significant reduction in Enterococcus faecalis bacteria after instrumentation of the root canal systems of deciduous molars using the WaveOne system with the Small CRT 21:06 file with a length of 21 mm (p=0.0033) (Table 2). Significant enlargement of the root canal systems was observed after instrumentation (p=0.047) (Table 3) and morphology was maintained.

Table 2. Arithmetic means, medians, standard deviations, interquartile deviation and Wilcoxon test results for Enterococcus faecalis colony-forming units (log-transformed) before and after instrumentation of the root canal systems.

Log_{10}	Mean	Standard deviation	Median	Interquartile deviation
Before	5.23[a]	0.27	5.35	0.42
After	0.29[b]	0.65	0.00	0.00

a,b: Results followed by different letters are significantly different (p=0.0033).

Table 3. Arithmetic means, medians, standard deviations, interquartile deviation and Wilcoxon test results for canal area before and after instrumentation of the root canal systems.

Pixels	Mean	Standard deviation	Median	Interquartile deviation
Before	1155.7[a]	1173.92	809.7[a]	1301.04
After	1618.88[b]	1505.45	1229.25[b]	1353.34

a,b: Results followed by different letters are significantly different (p=0.047).

Discussion

One important cause of endodontic treatment failure in deciduous molars is the presence of polymicrobial infection with a predominance of anaerobic microorganisms such as Streptococcus and Enterococcus faecalis, which are members of a microbiota that is resistant to conventional

instrumentation [13]. Siqueira et al. used scanning electron microscopy to demonstrate that Enterococcus faecalis colonize root canal walls, forming biofilm structures [14]. Other causes of failure are presence of accessory foramina around root bifurcations and ectopic resorptions which compromise effective cleaning of the canal [15]. Chemomechanical preparation has an important part to play in disinfection of root canal systems [14].

Ineffective instrumentation can lead to incomplete cleaning of the root canal system with the result that irrigants will be unlikely to be effective in non-instrumented regions of the canal. Over the last 10 years, many rotary nickel-titanium (Ni-Ti) instruments have been developed in attempts to overcome these problems [3].

In our study we used a Small CRT 21:06 file with a length of 21 mm, which is the preferred file indicated for atresic canals and which has a cutting face angled to cut in the counterclockwise direction. The reciprocating movement cuts when rotating in the counterclockwise direction, while the clockwise component reduces the risk of cyclic instrument fatigue [16,17].

Using just one instrument with an alternating movement can reduce the risk of fracture during torsion, eliminating cyclic fatigue [18]. Furthermore, the instrumentation technique requiring just one file can also reduce stress to the professional performing the work [16].

In the present study a significant reduction in Enterococcus faecalis was observed after instrumentation of the root canal systems of deciduous molars using the WaveOne system, in agreement with others authors who observed similar canal cleaning capacity when different rotary and reciprocating systems were compared (WaveOne, Reciproc and MTwo) [19]. The WaveOne and Reciproc system exhibited similar efficacy for cleaning root canals in a previous study [20].

A study showed that the WaveOne and Reciproc reciprocating systems exhibited better performance in terms of maintenance of the original curvature of the canal, when compared with rotary systems, in agreement with the results of the present study [21]. As was the case in our study, some authors assessed permanent teeth using cone-beam tomography and concluded that the reciprocating system can be used with confidence, offering good safety, and that instrumentation with WaveOne resulted in satisfactory conservation of original canal morphology [22]. A computed tomography study showed that the reciprocating systems Reciproc and WaveOne caused minimum dislocation of apical substrate and remained centralized within the root canal [23].

Microcomputed tomography is a technology with a number of different promising applications in several different areas of dentistry [24] and it can often be used to assess the anatomy of root canals and their morphology before and after instrumentation [25]. The main advantage of this assessment method is the possibility of analyzing instrumentation of root canals in three dimensions [26]. Cone-beam tomography is more precise than other routine techniques, it is highly reproducible and several images of the canals can be captured [27]. Prior knowledge of the root and the canal anatomy and knowledge of the post- instrumentation morphology allows for a global 3D analysis of the external and internal morphology of the root and canal system using tomography [28], which is the methodology that was used in the present study.

Some researchers conducted a study using 60 extracted permanent upper first molars and concluded that the Reciproc, Wave-One and OneShape instruments were safe during use and respected the original curvature of the canal, in agreement with the results of the present study, in which we observed on tomography that the WaveOne system increased the canal diameter [29]. In this context it can be stated that the WaveOne system offers the capability for cleaning the root canal because its cutting surfaces are angled to cut when rotated in the counterclockwise direction during the cutting movement.

Conclusion

The WaveOne System, using the Small CRT 21:06 file with a length of 21 mm was effective for disinfection and shaping of the root canal systems of deciduous molars.

References

1. Bodur H, Odabaş M, Tulunoğlu O, Tinaz AC. Accuracy of two different apex locators in primary teeth with and without root resorption. Clin Oral Investig 2008; 12(2):137-41.
2. Nunes MR, Mello I, Franco GC, de Medeiros JM, Dos Santos SS, Habitante SM, Lage-Marques JL, Raldi DP. Effectiveness of photodynamic therapy against Enterococcus faecalis, with and without the use of an intracanal optical fiber: an in vitro study. Photomed Laser Surg 2011; 29(12):803-8.
3. Vincenzi V, Plotino G, Giansiracusa A, Pietrangeli E, Sudani DA, Grande NM, Milana V. A SEM study of canal cleanliness after a new nickel-titanium rotary instrumentation technique. Ann Stomatol 2011; 2(1-2):19-22.
4. Pinheiro SL, Araujo G, Bincelli I, Cunha R, Bueno C. Evaluation of cleaning capacity and instrumentation time of manual, hybrid and rotary instrumentation techniques in primary molars. Int Endod J 2012; 45(4):379-85.
5. Berutti E, Chiandussi G, Paolino DS, Scotti N, Cantatore G, Castellucci A, Pasqualini D. Effect of canal length and curvature on working length alteration with WaveOne reciprocating files. J Endod 2011; 37(12):1687-90.
6. Kim HC, Kwak SW, Cheung GS, Ko DH, Chung SM, Lee W. Cyclic fatigue and torsional resistance of two new nickel-titanium instruments used in reciprocation motion: Reciproc versus WaveOne. J Endod 2012; 38(4):541-4.
7. Berutti E, Chiandussi G, Paolino DS, Scotti N, Cantatore G, Castellucci A, Pasqualini D. Canal shaping with WaveOne Primary reciprocating files and ProTaper system: a comparative study. J Endod 2012; 38(4):505-9.
8. Metzger Z, Teperovich E, Zary R, Cohen R, Hof R. The self-adjusting file (SAF). Part 1: respecting the root canal anatomy--a new concept of endodontic files and its implementation. J Endod 2010; 36(4):679-90.
9. Plotino G, Grande NM, Testarelli L, Gambarini G. Cyclic fatigue of Reciproc and WaveOne reciprocating instruments. Int Endod J 2012; 45(7):614-8.
10. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol 1971; 32(2):271-5.
11. Bernardes RA, Duarte MA, Vasconcelos BC, Moraes IG, Bernardineli N, Garcia RB, Baldi JV, Victorino FR, Bramante CM. Evaluation of precision of length determination with 3 electronic apex locators: Root ZX, Elements Diagnostic Unit and Apex Locator, and RomiAPEX D-30. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007; 104(4):e91-94.
12. Le Goff A, Bunetel L, Mouton C, Bonnaure-Mallet M. Evaluation of root canal bacteria and their antimicrobial susceptibility in teeth with necrotic pulp. Oral Microbiol Immunol 1997; 12(5):318-22.
13. da Silva LA, Nelson-Filho P, Faria G, de Souza-Gugelmin MC, Ito IY. Bacterial profile in primary teeth with necrotic pulp and periapical lesions. Braz Dent J 2006; 17(2):144-8.
14. Siqueira JF, Jr., Alves FR, Versiani MA, Rôças IN, Almeida BM, Neves MA, Sousa-Neto MD. Correlative bacteriologic and micro-computed tomographic analysis of mandibular molar mesial canals prepared by self-adjusting file, reciproc, and twisted file systems. J Endod 2013; 39(8):1044-50.

15. Pinheiro SL, Schenka AA, Neto AA, de Souza CP, Rodriguez HM, Ribeiro MC. Photodynamic therapy in endodontic treatment of deciduous teeth. Lasers Med Sci 2009; 24(4):521-6.
16. De-Deus G, Brandão MC, Barino B, Di Giorgi K, Fidel RA, Luna AS. Assessment of apically extruded debris produced by the single-file ProTaper F2 technique under reciprocating movement. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010; 110(3):390-4.
17. Varela-Patino P, Ibañez-Párraga A, Rivas-Mundiña B, Cantatore G, Otero XL, Martin-Biedma B. Alternating versus continuous rotation: a comparative study of the effect on instrument life. J Endod 2010; 36(1):157-9.
18. Pirani C, Paolucci A, Ruggeri O, Bossù M, Polimeni A, Gatto MR, Gandolfi MG, Prati C. Wear and metallographic analysis of WaveOne and reciproc NiTi instruments before and after three uses in root canals. Scanning 2014; 36(5):517-25.
19. Amaral P, Forner L, Llena C. Smear layer removal in canals shaped with reciprocating rotary systems. J Clin Exp Dent 2013; 5(5):e227-30.
20. Carvalho MS, Junior EC, Bitencourt Garrido AD, Roberti Garcia LF, Franco Marques AA. Histological evaluation of the cleaning effectiveness of two reciprocating single-file systems in severely curved root canals: Reciproc versus WaveOne. Eur J Dent 2015; 9(1):80-6.
21. Yoo YS, Cho YB. A comparison of the shaping ability of reciprocating NiTi instruments in simulated curved canals. Restor Dent Endod 2012; 37(4):220-7.
22. Marzouk AM, Ghoneim AG. Computed tomographic evaluation of canal shape instrumented by different kinematics rotary nickel-titanium systems. J Endod 2013; 39(7):906-9.
23. de Meireles DA, de Brito TC, Marques AA, Garrido AD, Garcia LF, Sponchiado EC Jr.. Retracted: Micro-computed tomography evaluation of apical transportation and centring ability of Reciproc and WaveOne systems in severely curved root canals. Int Endod J 2015; 48(8):814.
24. Endal U, Shen Y, Knut A, Gao Y, Haapasalo M. A high-resolution computed tomographic study of changes in root canal isthmus area by instrumentation and root filling. J Endod 2011; 37(2):223-7.
25. Moore J, Fitz-Walter P, Parashos P. A micro-computed tomographic evaluation of apical root canal preparation using three instrumentation techniques. Int Endod J 2009; 42(12):1057-64.
26. Bergmans L, Van Cleynenbreugel J, Wevers M, Lambrechts P. Mechanical root canal preparation with NiTi rotary instruments: rationale, performance and safety. Status report for the American Journal of Dentistry. Am J Dent 2001; 14(5):324-33.
27. Hartmann MS, Fontanella VR, Vanni JR, Fornari VJ, Barletta FB. CT evaluation of apical canal transportation associated with stainless steel hand files, oscillatory technique and pro taper rotary system. Braz Dent J 2011; 22(4):288-93.
28. Demirbuga S, Sekerci AE, Dinçer AN, Cayabatmaz M, Zorba YO. Use of cone-beam computed tomography to evaluate root and canal morphology of mandibular first and second molars in Turkish individuals. Med Oral Patol Oral Cir Bucal 2013; 18(4):e737-44.
29. Saber SE, Nagy MM, Schäfer E. Comparative evaluation of the shaping ability of WaveOne, Reciproc and OneShape single-file systems in severely curved root canals of extracted teeth. Int Endod J 2015; 48(1):109-14.