ASSESSMENT OF THE SHAPING ABILITY OF DIFFERENT RECIPROCATING SYSTEMS IN SIMULATED CURVED ROOT CANALS USING MICRO-COMPUTED TOMOGRAPHY

ANÁLISE DO PREPARO DE CANAIS CURVOS SIMULADOS PROMOVIDO POR SISTEMAS RECIPROCANTES: ANÁLISE POR MICROTOMOGRAFIA COMPUTADORIZADA

Aline Keller dos SANTOS[1]; Marco Antônio Húngaro DUARTE[2]; Melissa Esther RIVERA-PEÑA[1]; Murilo Priori ALCALDE[3]; Rodrigo Ricci VIVAN[2]

1 – DDS - Department of Operative Dentistry, Endodontics and Dental Materials, Bauru School of Dentistry, University of São Paulo, Bauru, SP, Brazil;

2 – PhD - Department of Operative Dentistry, Endodontics and Dental Materials, Bauru School of Dentistry, University of São Paulo, Bauru, SP, Brazil;

3 – MSc - Department of Operative Dentistry, Endodontics and Dental Materials, Bauru School of Dentistry, University of São Paulo, Bauru, SP, Brazil.

ABSTRACT

Aim: To analyze the shaping ability of Unicone (Medin), Wave One (Dentsply Maillefer) and Reciproc (VDW) reciprocating systems through the use of micro-computed tomography (MCT) in simulated curved canals. Methods: The shaping time, the centering ability and the changes in canal volumes of these systems were measured. Sixty artificial root canals with a curvature range of 30^0 in resin blocks, were scanned pre and postoperatively by MCT. The resin blocks were divided into four groups (n=15) and the root canals were shaped using three reciprocating systems and Ni-Ti Flex files (Dentsply Maillefer) for the control group. The data were analized using the software CTAnalyser and the Shapiro-Wilks test with $p<0.05$ indicating a statistically significant difference. Results: The results showed statistically significant difference ($p<0.05$) between the reciprocating and manual instruments regarding the shaping time. There was not statistically significant difference between the reciprocating systems used in this study. In the cervical portion of the canal, the Unicone system showed the highest volume increase of the reciprocating systems. No statistically significant differences regarding the centering ability of the reciprocating systems were found. Conclusions: In comparison to the manual preparation technique, the reciprocating instruments provided a faster shaping of the simulated root canals and similar centering ability. Lastly, concerning the volume increase of the root canal portions, statistically significant differences in the cervical portion of the root canals were observed, identifying the highest values for the Unicone group within the reciprocating systems. Lastly, the reciprocating systems provided an adequate centering ability.

KEYWORDS: Endodontics; Dental Instruments; X-Ray Microtomography.

INTRODUCTION

The maintenance of the original shape of the canal and the position of the apical foramen are essential factors during biomechanical preparation[1]. The mechanized instrumentation with nickel-titanium (Ni-Ti) instruments is widely used in the preparation of root canals. These instruments produce fast, tapered, centralized preparations with a lower rate of procedural errors[2,3]. These systems are currently being improved with new alloys, reducing the number of files in the instrumentation sequence as well as the working time, while maintaining quality and safety of preparation[4]. Nowadays, systems with a single instrument, using a modified nickel-titanium (Ni-Ti) alloy, have been developed[5]. These instruments have provided greater agility in the preparation of root canals due to the simplification of the instrumentation technique[5].

In 2008, the preparation of root canals using only a ProTaper F2 instrument (Dentsply Maillefer, Switzerland) in reciprocating motion was proposed, presenting a new perspective in relation to Ni-Ti files[5]. This movement comes with the prerogative of reducing the risk of fracture by the cyclical fatigue of the instruments[5-8], favoring greater safety in the instrumentation of curved canals[9]. Among the instruments available in the market that are indicated to be used in the reciprocating movement, Wave One (Dentsply Maillefer, Ballaigues, Switzerland) and Reciproc (VDW GmbH, München, Germany) are the most studied and have already been evaluated regarding the safety and quality of the preparation of curved root canals[10-13].

Recently, the Unicone reciprocating instrument (Medin, Nové Město, Czech Republic) was introduced on the market. This instrument has a triangular section, diameters of 20, 25 and 40, with a fixed taper value of 0.06. There is little data supporting the quality of preparation and safety when using this system for the preparation of root canals. Therefore, the objective of the present study was to analyze the quality of the Unicone reciprocating system, comparing it with the Wave one and Reciproc systems, by analyzing the volume change, centering ability and also the time spent in preparing simulated curved canals. The null hypothesis is that all systems require the same time to prepare simulated curved canals. There is no difference in the quality and safety of the preparation with the different reciprocating systems.

METHODOLOGY

The evaluation of the preparation of artificial canals with reciprocating instruments was done by micro-computed tomography (MCT). Sixty acrylic blocks with artificial canals, 30º of curvature and working length of 17mm were used in this study. Each specimen was scanned twice (pre and post instrumentation) using a high-definition MCT scanner (SkyScan 1174v2; Bruker-microCT, Kontich, Belgium). The parameters used were 50 kV, 800 mA, 180º of rotation with a step size of 1.0 and an isotropic resolution of 22.86 μm. Bidimensional images of all samples were reconstructed in different angular projections by means of a modified Feldkamp conic beam reconstruction algorithm, which is computer-processed and controlled by the NRecon v.1.6.4.8 software (Bruker-microCT).

Sample preparation

The acrylic blocks were divided into 4 groups (n = 15): Group I - Wave One 25/08 (Dentsply Maillefer, Ballaigues, Switzerland); Group II – Reciproc 25/08 (VDW GmbH, München, Germany); Group III - Unicone 25/06 (Medin, Nové Město, Czech Republic); Group IV - Manual instrumentation. For this purpose, NiTi Flex files (Dentsply Maillefer, Ballaigues, Switzerland) and Gates Glidden #3 (Dentsply Maillefer, Ballaigues, Switzerland) were used in a crown-down manner up to a 25 instrument. In all the experimental groups a 10 and 15 K file were used to initially explore the canals. Afterwards, all different reciprocating instruments were used to prepare the canals following the manufacturer's instructions, and recommended torques and speeds using an electric motor VDW Silver (VDW GmbH, München, Germany). The Unicone file was used in the "Wave One all" preset program as recommended by the manufacturer. Saline solution was used to irrigate the simulated root canals using a 29-gauge needle (NaviTip, Ultradent, Brazil). After the instrumentation, all blocks were scanned again using the same previous parameters. Also, the time taken to prepare each sample was recorded for all the experimental groups by the means of a digital chronometer (KIKOS CR100, São Paulo, Brazil).

Evaluation of the centering ability

The evaluation of the results was performed using two-dimensional and three-dimensional cross-sectional images, which were analyzed (apical, middle and cervical portions of the root canal) with the CTAnalyser software (CTan, version 1.8.1.5, Skyscan, Aartselaar, Belgium) using the 2D tool and 3D analysis, respectively. In addition, the centering ability measurement was performed by 2D images in the simulated canals sections obtained by micro-computed tomography, comparing the initial distance with the final distance of the canal wall to the outer surface of the block in the mesio-distal direction[14].

Statistical evaluation

The data obtained in each test were submitted to the Shapiro-Wilks normality test and due to the normality of the data, the Anova and Tukey tests were used for the comparisons between the groups. The level of significance was 5%. All values were processed using Prism 6.0 (GraphPad Software, Inc., La Jolla, CA, USA).

RESULTS

Table 1 - Presents the mean and standard deviation of the time spent for the preparation of the simulated curved canals. There was statistically significant difference (P <0.05) between reciprocating and manual instruments in relation to the preparation time. Among the reciprocating systems there were no statistically significant differences (P> 0.05).

Table 2 - Shows the mean and standard deviation of the canal volumes. All groups significantly increased the volume of the root canals in the three portions evaluated in this study (P <0.05). The Unicone group had a significant volume increase in the cervical region when compared to the Reciproc and WaveOne groups (P <0.05). Finally, the volume increase of the Manual group was significantly larger (P <0.05) than the rest of the groups.

Table 3 - Shows the thickness of the mesial and distal walls of the pre and post instrumentation samples for all the experimental groups. Regarding the centering ability of the reciprocating systems considered in this study, no statistically significant diferences were found. The reciprocating instruments as well as the manual operated instruments showed a greater tendency of wear to the mesial aspect of the root (p < 0.05).

Figure 1 - Shows samples of the instrumentation promoted by the different systems used in this study.

Figure 1 - A) Reciproc B) Wave One C) Unicone D) Manual

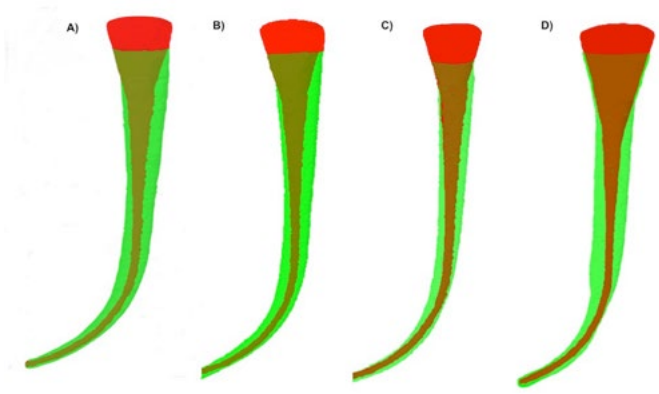

Table 1 - Mean and standard deviation of the time needed for the instrumentation of the simulated root canals.

Reciprocating systems	Preparation time (min)
Reciproc	2.01±0.41[a]
Wave One	1.73±0.71[a]
Unicone	1.61±0.27[a]
Manual	7.31±1.31[b]

A different letter in each column indicates statistically significant differences (p < 0.05).

Table 2 - Mean and standard deviation of the volume of the simulated root canals after instrumentation.

	0-3mm	3-6mm	6-9mm
Reciproc	68.73±10.22[a]	80.87±5.59[a]	73.80±3.59[a]
Wave One	67.27±9.65[a]	79.80±5.49[a]	74.80±3.74[a]
Unicone	73.47±7.58[a]	83.07±5.05[a]	80.07±3.10[b]
Manual	68.47±18.65[a]	83.53±6.01[a]	87.20±1.69[c]

A different letter in each column indicates statistically significant differences (p < 0.05).

Table 3 - Results for the thickness of the mesial and distal walls of the pre and post instrumentation samples for all the experimental groups.

	Level	Wall	Before	After	Mesial vs Distal
Reciproc	1mm	Mesial	6.85±0[a]	6.61±0.13[b]	P < 0.05
		Distal	1.76±0[a]	1.28±0.11[b]	
	3mm	Mesial	5.40±0[a]	5.20±0.12[b]	P < 0.05
		Distal	4.62±0[a]	3.95±0.20[b]	
	5mm	Mesial	4.92±0[a]	4.66±0.12[b]	P < 0.05
		Distal	4.82±0[a]	4.42±0.13[b]	
Wave One	1mm	Mesial	6.85±0[a]	6.39±0.21[b]	P < 0.05
		Distal	1.76±0[a]	1.56±0.12[b]	
	3mm	Mesial	5.40±0[a]	4.99±0.11[b]	NS
		Distal	4.62±0[a]	4.24±0.16[b]	
	5mm	Mesial	4.92±0[a]	4.68±0.29[b]	NS
		Distal	4.82±0[a]	4.49±0.10[b]	
Unicone	1mm	Mesial	6.85±0[a]	6.56±0.19[b]	NS
		Distal	1.76±0[a]	1.44±0.17[b]	
	3mm	Mesial	5.40±0[a]	5.14±0.15[b]	P < 0.05
		Distal	4.62±0[a]	4.13±0.12[b]	
	5mm	Mesial	4.92±0[a]	4.69±0.09[b]	NS
		Distal	4.82±0[a]	4.51±0.15[b]	
Manual	1mm	Mesial	6.85±0[a]	6.44±0.32[b]	NS
		Distal	1.76±0[a]	1.46±0.20[b]	
	3mm	Mesial	5.40±0[a]	5.12±0.12[b]	P < 0.05
		Distal	4.62±0[a]	4.17±0.11[b]	
	5mm	Mesial	4.92±0[a]	4.63±0.15[b]	P < 0.05
		Distal	4.82±0[a]	4.40±0.03[b]	

A different letter in each column indicates statistically significant differences (p < 0.05). NS: Non-significant.

DISCUSSION

The aim of this study was to measure the centering ability, the shaping time and the changes in canal volume of simulated root canals prepared with three different reciprocating systems. An adequate shaping should be based on the ability of endodontic instruments to follow and maintain the anatomy of the root canals, removing a suitable amount of dentin in the inner and outer walls of the root canal while avoiding the displacement of the apical foramen[15]. The preparation of the canal using a single instrument in reciprocating motion has the purpose of favoring canal enlargement with adequate taper and less time of preparation[4]. The results of this study showed that reciprocating instruments were able to speed up the preparation of the root canal in relation to manual instrumentation, being in agreement with other studies that verified the greater speed of reciprocating instruments for the preparation of root canals[11,16]. Consequently, the null hypothesis concerning the preparation time of the simulated root canals was rejected, since every group had a different shaping time.

In order to verify and measure the shaping ability promoted by different instrumentation systems, micro-computed tomography (MCT) has been proposed as a suitable method for this purpose[17]. Micro-computed tomography (MCT) is a high-resolution research technology that allows the development of accurate three-dimensional models and the acquisition of quantitative data[18,19]. This technology has been described as a non-invasive and reproducible method that favors different evaluations without destruction of the samples[20, 21].

In several studies, acrylic blocks have been used to analyze the quality and safety of different instrumentation systems[10-13]. The use of resin blocks in this study enabled standardization of root canal anatomy, such as angle, curvature radius, diameter and length of the root canal [15]. Therefore, this technique allows a reduction of variations during the instrumentation procedures[22]. However, resin blocks present different properties when compared to human teeth, as they do not provide information about remaining dentin thickness after root canal preparation[15,23]. As a result, other studies are needed to analyze the shaping ability of these reciprocating systems in human teeth[23].

The shaping ability of an endodontic file has been associated to the number of flutes, cross-section, helical and rake angle, tip design, metallurgical properties and surface treatment[4]. Few studies have tested the shaping ability, cyclic and torsional resistance of the Unicone system[15,24-26]. In a study by Maia-Filho et al.[15] (2015), the Unicone system presented the best proportion of shaping between the inner and outer walls along the whole length of the root canal. However, there was not statistically significant difference between Reciproc, Unicone and Protaper Universal associated to the modification of the root canal curvature. Concerning the results of this study, no statistically significant difference related to the centering ability of the reciprocating systems considered in this study was found. Therefore, the null hypothesis referring to the quality and safety of the reciprocating systems was accepted.

When comparing the volume increase in the apical, middle and cervical thirds of the root canals, it was found that the apical and middle portions showed statistically similar values. Nonetheless, in the cervical portion, the manual group favored a significantly larger volume increase in relation to the reciprocating systems, possibly due to the use of Gates Glidden drills. A larger cervical preparation favors a greater escape of debris and a greater space for the irrigating solution to flow back into the pulp chamber[27]. Furthermore, in relation to the reciprocating systems, the Unicone system favored a significantly larger volume increase in relation to the other two systems, possibly because of its constant taper, while the others systems present a taper decrease after the initial 3mm of the instrument.

CONCLUSIONS

Within the limitations of this study, all reciprocating instruments provided faster preparations in simulated curved canals compared to manual operated instruments. In addition, no statistically significant differences related to the centering ability of the endodontic systems used in this study were found. Finally, concerning the volume increase in the different levels of the simulated root canals, statistically significant differences in the cervical portion were observed, identifying the highest values for the Unicone group within the reciprocating systems.

REFERENCES

01. Lopes HP, Elias CN, Estrela C, Siqueira F. Assessment of the apical transportation of root canals using the method of the curvature radius. Braz Dent J.1998; 9(1): 39-45.

02. Schäfer E, Erler M, Dammaschke KE. Comparative study on the shaping ability and cleaning efficiency of rotary mtwo instruments. Part 2. Cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth. Int Endod J. 2006; 39(3): 203-12.

03. Sonntag D, Ott M, Kook K, Stachniss V. Root canal preparation with the niti systems k3, mtwo and protaper. Aust Endod J. 2007; 33(2): 73-81.

04. Plotino G, Ahmed HMA, Grande NM, Cohen S, Bukiet F. Current assessment of reciprocation in endodontic preparation: a comprehensive review—part II: properties and effectiveness. J Endod. 2015; 41(12): 1939–1950.

05. Yared G. Canal preparation using only one ni-ti rotary instrument: preliminary observations. Int Endod J. 2008; 41(4): 339–44.

06. De-Deus G, Moreira EJL, Lopes HP, Elias CN. Extended cyclic fatigue life of f2 pro-taper instrument used in reciprocating movement. Int Endod J. 2010; 43(12): 1063–8.

07. Rubini AG, Sannino G, Pongione G, Testarelli L, Al Sudani D, Jantarat J, et al. Influence of file motion on cyclic fatigue of new nickel titanium instruments. Ann Stomatol. 2013; 4(1): 149-51.

08. Varela-Patiño 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.

09. Plotino G, Costanzo A, Grande NM, Petrovic R, Testarelli L, Gambarini G. Experimental evaluation on the influence of autoclave sterilization on the cyclic fatigue of new nickel-titanium rotary instruments. J Endod. 2012; 38(2): 222-5.

10. Ruddle CJ. Canal preparation: single-file shaping technique. Dent Today. 2012; 31(1): 124,126-9.

11. Bürklein S, Hinschitza K, Dammaschke T, Schäfer E. Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: reciproc and waveone versus mtwo and protaper. Int Endod J. 2012; 45(5): 449-61.

12. Berutti E, Paolino DS, Chiandussi G, Alovisi M, Cantatore G, Castellucci A, et al. Root canal anatomy preservation of WaveOne reciprocating files with or without glide path. J Endod. 2012; 38(1): 101-4.

13. Berutti E, Chiandussi G, Paolino DS, Scotti N, Cantatore G, Castellucci A, et al. Canal shaping with waveone Primary reciprocating files and protaper system: a comparative study. J Endod. 2012; 38(4): 505-9.

14. Gambill JM, Alder M, Del Rio CE. Comparison of nickel-titanum and stainless steel hand-file instrumentation using computed tomography. J Endod. 1996; 22(7): 369-375.

15. Maia-Filho EM, Rizzi CC, Coelho MB, Santos SF, Costa LMO, Carvalho CC, et al. Shaping ability of reciproc, unicone, and protaper universal in simulated root canals. Scientific World J. 2015; 2015:1-6.

16. Zuolo AS, Mello Jr. JE, Cunha RS, Zuolo ML, Bueno CES. Efficacy of reciprocating and rotaty techniques for removing filling material during root canal retreatment. Int Endod J. 2013; 46(10): 947-953.

17. Versiani MA, Leoni GB, Steier L, De-Deus G, Tassani S, Pécora JD, et al. Micro–computed tomography study of oval-shaped canals prepared with the self-adjusting file, reciproc, waveone, and protaper universal systems. J Endod. 2013; 39(8): 1060–1066.

18. Versiani MA, Ordinola-Zapata R, Keleş, A, Alcin H, Bramante CM, Pécora JD, et al. Middle canals in mandibular first molars: a micro ct study in different populations. Arch Oral Biol. 2016; 61: 130-7.

19. Rossi-Fedele G, Ahmed HMA. Assessment of root canal filling removal effectiveness using micro–computed tomography: a systematic review. J Endod. 2017; 43(4): 520–526.

20. Rhodes JS, Ford TR, Lynch JA, Liepins PJ, Curtis RV. Micro-computed tomography: a new tool for experimental endodontology. Int Endod J. 1999; 32(3): 165-70.

21. Peters OA, Laib A, Rüegsegger P, Barbakow F. Three-dimensional analysis of root canal geometry by high-resolution computed tomography. J Dent Res. 2000; 79(6): 1405-9.

22. Yared G, Kulkarni GK. An in vitro study of the torsional properties of new and used rotary nickel-titanium files in plastic blocks. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003; 96(4): 466-71.

23. Yun H, Kim SK. A comparison of the shaping abilities of 4 nickel-titanium rotary instruments in simulated root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003; 95(2): 228-33.

24. Alcalde MP, Tanomaru-Filho M, Bramante CM, Duarte MAH, Guerreiro-Tanomaru JM, Camilo-Pinto J, et al. Cyclic and torsional fatigue resistence of reciprocating single files manufactured by different nickel-titanium alloys. J Endod. 2017; 43(7): 1186–1191.

25. Almeida-Gomes F, de Matos HRM, Nunes RFLA, Arrais AM, Ferreira-Maniglia C, Vitoriano MM. Cyclic fatigue resistence of different continuous rotation and reciprocating endodontic systems. Indian J Den Res. 2016: 27(3): 278-282.

26. Silva EJNL, Villarino LS, Vieira VTL, Accorsi-Mendonça T, Antunes HS, De-Deus G, et al. Bending resistance and cyclic fatigue life of reciproc, unicone, and waveone reciprocating instruments. J Endod. 2016; 42(12): 1789–1793.

27. Pécora JD, Capelli A, Guerisoli DMZ, Spanó JCE, Estrela C. Influence of cervical preflaring on apical file size determination. Int Endod J. 2005; 38(7): 430–435.

RESUMO

Objetivos: Analisar por meio do micro tomógrafo computadorizado (MTC), a qualidade do preparo promovido pelos sistemas reciprocantes Unicone (Medin), Wave one (Dentsply Maillefer) e Reciproc (VDW). Material e Métodos: Foi feita uma avaliação da alteração do volume, centralização e tempo de preparo de canais curvos simulados. Foram utilizados sessenta blocos de acrílico com canal artificial com curvatura de 30^0. Cada espécime foi escaneado 2 vezes (pré e pós-instrumentação) por meio do (MTC). Os blocos foram divididos em 4 grupos (n=15) e os canais foram preparados com os sistemas reciprocantes, sendo o grupo controle preparado com limas NiTi Flex (Dentsply Maillefer). A alteração do volume, centralização e tempo de preparo dos 3 sistemas foram medidos e comparados com os dados obtidos previamente. Os dados foram analisados utilizando o software CTAnalyser e submetidos ao teste de normalidade de Shapiro-Wilks, sendo o nível de significância de 5%. Resultados: Houve diferença estatisticamente significante ($P<0.05$) entre os instrumentos reciprocantes e os manuais em relação ao tempo dispendido para o preparo. Na porção cervical do canal, o volume promovido pelo sistema Unicone foi maior do que nos outros, sendo o grupo manual significantemente maior em relação a todos os grupos. Não observou-se diferença estatística significante na centralização do preparo entre os sistemas reciprocantes. Conclusão: Em relação à técnica manual, os instrumentos reciprocantes proporcionaram uma agilidade maior no preparo dos canais e apresentaram semelhanças no aumento do volume das porções do canal radicular. Finalmente, os sistemas reciprocantes promoveram um preparo centralizado.

PALAVRAS-CHAVE: Endodontia; Instrumentos Odontológicos; Microtomografia por Raio-X.

CORRESPONDING AUTHOR
Rodrigo Ricci Vivan
Address: Faculdade de Odontologia de Bauru-USP. Al. Octavio Pinheiro Brisolla, 9-75, CEP 17012-901, Bauru, São Paulo, Brazil.
Telephone: +55-14-3235-8344.
E-mail: rodrigo.vivan@fob.usp.br