Evaluation of the cleaning ability of two rotatory nickel-titanium systems: ProTaper Universal and heat-treated ProDesign S

Ana Grasiela da Silva **LIMOEIRO**[1]
Antônio Henrique **BRAITT**[2]
Evaldo Almeida **RODRIGUES**[3]
Gladyvan Rabelo **BRAITT**[4]
Carlos Eduardo da Silveira **BUENO**[5]

doi: http://dx.doi.org/10.1590/2178-3713.4.2.034-039.oar

ABSTRACT

Introduction: The purpose of endodontic instrumentation is to promote cleaning and shaping of the root canal, preparing it for final filling. **Objective:** The objective of this study was to evaluate, *in vitro*, the cleaning quality of simulated canal blocks instrumented by two nickel-titanium rotary systems. **Methods:** Twenty acrylic blocks (simulated canals) were used and separated into two groups of ten each. India ink was injected into the simulated canals which were wrapped up with foil to avoid influencing during instrumentation. The blocks in Group 1 were instrumented by means of the original sequence of ProTaper Universal system up to file F3. 5 ml of saline solution were used for irrigation at each change of instrument. The blocks of Group 2 were instrumented by heat-treated ProDesign S system up to file #30.05; 5ml of saline solution were also used for irrigation. After instrumentation, the blocks were photographed and analyzed in terms of cleanliness by three Masters in Endodontics. **Conclusion:** Within the experimental conditions of this research, it was reasonable to conclude that no statistical differences were found between the cleaning ability of both systems studied.

Keywords: Dental instruments. Root canal preparation. Endodontics.

How to cite this article: Limoeiro AGS, Braitt AH, Rodrigues EA, Braitt GR, Bueno CES. Evaluation of the cleaning ability of two rotatory nickel-titanium systems: ProTaper Universal and heat-treated ProDesign S. Dental Press Endod. 2014 May-Aug;4(2):34-9. doi: http://dx.doi.org/10.1590/2178-3713.4.2.034-039.oar

[1]Master's student in Endodontics, School of Dentistry — São Leopoldo Mandic.
[2]Chair of the Postgraduate Program, FUNORTE.
[3]Assistant professor, State University of Feira de Santana (UEFS).
[4]Professor, FUNORTE.
[5]Full professor, Postgraduate Program, School of Dentistry — São Leopoldo Mandic.

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Submitted: February 10, 2014. Revised and accepted: February 14, 2014.

Contact address: Ana Grasiela Limoeiro
Rua Ezequiel Batista, 266 – Centro – Iguai/BA — Brazil
CEP 45.280-000 – E-mail: grasielalimoeiro@gmail.com

Introduction

The purpose of root canal preparation is to promote cleaning and shaping of the root canal system without creating iatrogenic events such as compaction of debris, step formation, transport, perforation or fracture of instruments.[1] The concepts of cleaning and shaping introduced by Schilder,[1] who gave special attention to initial root canal anatomy while seeking conical preparation without changing the position of the apical foramen, represented a major breakthrough in endodontic therapy . In addition to mechanical objectives, the author also emphasized biological treatment goals: Avoid pushing material, whether necrotic or not, beyond the apical foramen during instrumentation; perform biomechanical preparation of single root canals within a single session; create enough space for intracanal dressing.

Endodontic treatment success relies on several factors; however, cleaning and shaping are essential for periapical tissues repair. These procedures are performed by the action of instruments and endodontic irrigants and are considered as an important phase of endodontic treatment.[2]

Endodontic success derives from final and hermetic root canal filling made possible by proper root canal preparation aimed at maximum cleaning and consequent better shaping. However, on certain occasions, the root canal is noticeably curved, an anatomical detail that hinder instrument adaptation to the dentin wall. Hurdling such barrier depends on knowledge, technical domain, professional training, clinical experience and on the physical-mechanical properties of instruments. Solving this problem is a major concern evinced by the diversity of techniques.[3]

Some studies have reported that rotary nickel-titanium instruments perform unsatisfactory cleaning of root canal walls, particularly in the apical surface of curved canals.[4]

Several rotary systems comprising nickel-titanium instruments have been released on the market. Therefore, the advent of new instrumentation techniques and the arising of new instruments create the need to study which system proves to be more effective in removing any organic or inorganic tissue of the root canals. This study evaluated the cleaning ability of two rotary systems: heat-treated ProDesign S and ProTaper Universal.

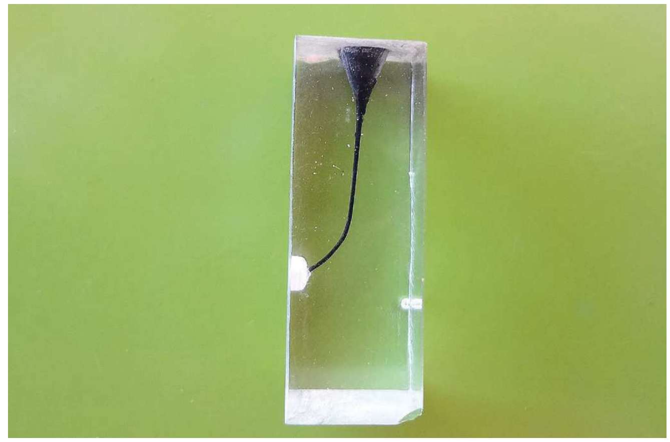

Figure 1. Acrylic block dyed with Indian ink.

Material and Methods

Twenty acrylic blocks (simulated canals) were filled with Indian ink (Nankin Acrilex) and divided into two groups of ten each (Fig 1).

Working length was previously determined by introducing a #10 K-file (Dentsply/Maillefer) within the canals until its tip could be seen at the apical foramen.

The blocks were numbered from 1 to 20 and wrapped up with foil to avoid influence on instrumentation. Subsequently, they were positioned in a bench vise with the curvature towards the left.

The acrylic blocks in Group 1 (even-numbered blocks) were prepared with the rotary NiTi ProTaper Universal system up to file F3, following the manufacturer's instructions. This system innovated by presenting some features in its morphology, such as multiple tapers in the same instrument. Consequently, due to having an active tip of high flexibility and because it caused a great wear in the cervical and middle thirds as a result of multiple tapers, the system made preparation of the root canals safer and more effective.[5,6,7] The system was operated at 350 rpm with a torque of 3 N.

The blocks in Group 2 (odd-numbered blocks) were instrumented by heat-treated ProDesign S system up to file #30.05. Speed and torque values are shown in Table 1.

Both groups were driven by X-Smart endodontic motor (Dentsply/Maillefer), and each instrument remained in the canal for 5 seconds. The rotary files were used five times and then discarded.

Table 1. Speed and torque used by heat-treated ProDesign S.

File	Length	Motion	Speed and torque
30.10	2/3 of the canal	Anticurvature brushing	800 rpm/4 N
25.08	+2 mm	Anticurvature brushing	800 rpm/4 N
25.01	1 mm beyond the foramen	Back and forth or pecking movement	350 rpm/0.6 N
20.06	WL	Back and forth or pecking movement	350 rpm/1.6 N
30.05	WL	Back and forth or pecking movement	350 rpm/1.6 N

A total of 5 ml of a 0.9% saline solution was used for irrigation at each change of instruments. Endo-eze hypodermic needle was used for application. After instrumentation, the blocks were positioned with the curvature facing left (Fig 2) and photographed by a digital Sony Cyber-shot WX7 camera within the same focal distance.

Images of the middle and apical thirds of the simulated canals were analyzed by three Masters in Endodontics who were unaware of which blocks comprised Groups 1 and 2. Data were sent for statistical analysis carried out on the basis of Cohen's Kappa coefficient — a statistical measure of inter-rater agreement. The present study used a classification of standard data as presented in the literature (Table 2).

Calculations were performed by means of the GLIMMIX procedure of SAS system for statistic analysis. Significance level was set at 5% in all statistical tests.

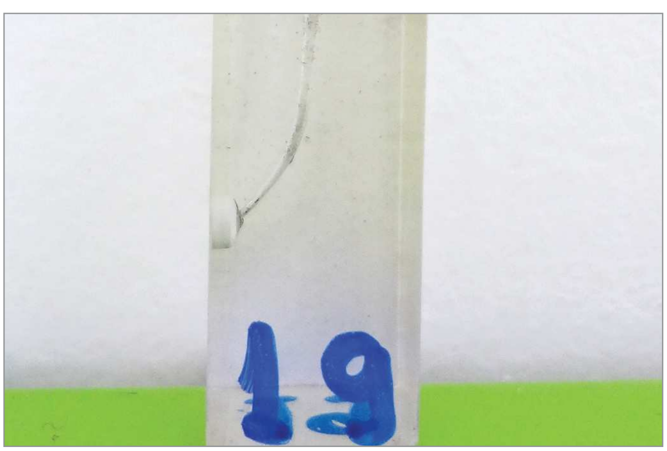

Figure 2. Instrumented acrylic block.

Results

Inter-rater agreement was assessed by Cohen's Kappa coefficient. The results of multivariate analysis of variance are presented in Table 3.

No evidence ($P > 0.05$) of diverging criteria was found between observes, which proved the assessments to be reliable in terms of apical third cleanliness.

In addition to absence of differences, Cohen's Kappa coefficient was also statistically relevant. It allowed researchers to infer the degree of adhesion of assessments carried out by observers.

Kappa coefficient values are presented in Table 4. They evince highly satisfactory concordance rates, with observers 2 and 3 achieving the highest agreement. Table 5 shows the results yielded by McNemar's test applied to pairs of raters with regard to the middle third.

Strong evidence of differences of criteria between observers 1 and 3 ($p < 0.01$) and reviewers 1 and 2 ($p < 0.05$) were observed.

Observer 1 showed consistently different results in comparison to the outcomes mentioned by other reviewers (Table 6).

Agreement between observers 2 and 3 was the only one considered as satisfactory and rated as substantial. The other variables were only fair or moderate, which could put the validity of agreement between observers into question.

Confidence limits predict the variability of Kappa coefficient in the study population with a significance level of 95 %. For observer 1, confidence limits were 0 (zero), which also suggested assessment fragility.

After assessing observers reliability, observer 1 was dismissed from analysis of the middle third. Subsequently, analysis of variance was performed as previously described. Analysis of variance outcomes are presented in Table 7.

Table 2. Criteria for interpretation of Kappa coefficient.

Kappa	Description	Concept
____ - 0.00	Chance agreement	Poor
0.00 - 0.20	Very low agreement, possibly chance agreement	Slight
0.20 - 0.40	Low agreement, acceptable with little rigor	Reasonable
0.40 - 0.60	Intermediate agreement, neither strong nor weak	Moderate
0.60 - 0.80	High agreement, probably not by chance	Substantial
0.80 - 1.00	Very high agreement, extremely reliable	Near perfection
1.00	Perfect agreement	Perfect

Source: Vieira et al.[16]

Table 3. McNemar's test for uniformity of criteria among observers evaluating the apical third.

Observers		McNemar's test		
		Statistics	DF	P-value
1	2	3.0000	1	0.0833
1	3	2.0000	1	0.1573
2	3	1.0000	1	0.3173

Table 4. Cohen's Kappa coefficient for uniform criteria among observers evaluating the apical third.

Observers	Cohen's kappa coefficient				
	Kappa	ASE	LCL (95%)	UCL (95%)	Criterion
1 and 2	0.7059	0.1496	0.4126	0.9992	Substantial
1 and 3	0.8020	0.1302	0.5468	1.0000	Near perfection
2 and 3	0.8990	0.0989	0.7040	1.0000	Near perfection

ASE: asymptomatic standard error - LCL: lower confidence limit - UCL: upper confidence limit.

Table 5. McNemar's test for uniformity of criteria among observers evaluating the middle third.

Observers	McNemar's test		
	Statistics	DF	P-value
1 and 2	5.0000	1	0.0253
1 and 3	8.0000	1	0.0047
2 and 3	3.0000	1	0.0833

Table 6. Cohen's Kappa coefficient for uniform criteria among observers evaluating the middle third.

Observers	Cohen's kappa coefficient				
	Kappa	ASE	LCL (95%)	UCL (95%)	Criterion
1 and 2	0.3421	0.1919	-0.0340	0.7182	Reasonable
1 and 3	0.2000	0.1315	-0.0576	0.4576	Slight
2 and 3	0.7000	0.1523	0.9886	1.0000	Substantial

ASE: asymptomatic standard error - LCL: lower confidence limit - UCL: upper confidence limit.

Table 7. Analysis of variance to test the effects of the system and third on dirt.

	Degrees of freedom			
	Numerator	Denominator	Statistics	P-value
System	1	96	0.00	0.9486
Third	1	96	1.10	0.2978
System * third	1	96	0.31	0.5763

Analysis did not reveal strong evidence ($p > 0.10$) of differences between the true mean of dirt at different levels of the main factors (system and root canal third). Additionally, there was no evidence of significant interaction.

Discussion

One of the most important objectives of root canal instrumentation is to remove pulp tissue, whether vital or necrotic, as well as infected dentin and debris in order to eliminate most microorganisms from the root canal system.[8,9]

Root canal cleaning is the physical action of endodontic instruments on the walls of the canal. It relies on the effects of endodontic irrigants responsible for removing the largest possible amount of debris so as to create ideal conditions that enable tissue recovery and regeneration as well as subsequent hermetic filling. Nevertheless, occasional inefficiency in root canal cleaning might also be due to the shape of instruments unable to adapt to anatomic variations of the root canal.[10]

Among the different instrumentation methods available, we chose two rotary systems which have been extensively used in Brazil: ProTaper Universal and heat-treated ProDesign S.

This study did not aim at assessing the irrigating solution ability of promoting cleaning. Therefore, the same irrigant (0.9% saline solution) was used throughout the experiment.

Importantly, instruments were reused for five times during biomechanical preparation. Afterwards, they were discarded. Previous studies show that the more an instrument is used, the lower its cutting ability and, as a result, cleaning.[11] Furthermore, the probability of fracture is increased, which in fact occurred during biomechanical preparation of the last block carried out by means of ProTaper Universal and file F1.

The advent of nickel-titanium instruments, as a result of superelasticity and new design, improved cleaning rates. These instruments increased the apical surgical diameter and, as a result, enabled a larger area of the root canal to be endodontically accessed. Despite scientific advances in terms of new endodontic instruments, equipment and techniques, studies have concluded that biomechanical preparation is not effective in completely removing organic and inorganic remnants from the root canal.[12,13,14]

The results of this study reveal that neither one of the two instrumentation techniques completely cleaned the surfaces of the acrylic blocks walls. Thus, the present findings are in agreement with Schäfer and Schlingemann.[15]

Therefore, the ongoing search for instruments that promote proper sanitation of the root canal system is important because the more improvements are obtained, the higher the quality of cleaning and the success rate of endodontic therapy.

Conclusion

Within the experimental conditions of this research, it was reasonable to conclude that no statistical differences were found between the cleaning ability of both systems studied.

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