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INFLUÊNCIA DO ALARGAMENTO DO FORAME E DA INSTRUMENTAÇÃO ALÉM ÁPICE NA DEFORMAÇÃO FORAMINAL E NO TRANSPORTE E CENTRALIZAÇÃO DO CANAL RADICULAR

Porto Alegre
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Trabalho de Conclusão de Curso apresentado ao Curso de Graduação em Odontologia da Universidade Federal do Rio Grande do Sul, como requisito parcial para obtenção do título de Cirurgiã-Dentista.

Orientadora: Profa. Dra. Fabiana Soares Grecca Vilella

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Porto Alegre, 17 de maio de 2021.

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RESUMO

Objetivo: Avaliar a deformação foraminal, o transporte e centralização de canais radiculares curvos após a utilização de diferentes instrumentos, 1 mm além do forame apical. **Métodos:** Trinta e três canais mésio-vestibulares de molares superiores foram divididos aleatoriamente em três grupos (n = 11) e preparados 1 mm além do forame apical de acordo com o instrumento utilizado: R-Pilot (RPG), ProDesign Logic (PDG) e ProGlider (PGG). Após, o instrumento #25/.05 ProDesign Logic® foi utilizado para preparar o canal em seu comprimento total. Imagens de Micro CT obtidas antes da instrumentação (momento 1), após a realização do alargamento foraminal (momento 2) e após o preparo final (momento 3) foram utilizadas para avaliar a deformação do forame de acordo com a área, razão dos diâmetros de Feret e circularidade. Também foram avaliados o transporte e centralização, nos 5 mm finais do terço apical. O programa Image J foi utilizado para a análise da deformação apical e o Adobe Photoshop para transporte e centralização. Os dados foram comparados entre os grupos em cada momento e entre os momentos em cada grupo ($\alpha = 5\%$). **Resultados:** Não houve diferenças significativas na razão dos diâmetros de Feret, circularidade e área (P> 0,05). Os canais foram transportados para mesial em todos os grupos, e o transporte aumentou significativamente após o preparo final nos grupos onde foram utilizados os instrumentos RPG e PGG (P <0,05). No grupo PDG, a centralização foi significativamente melhor no momento 3 do que 2 (P <0,05). **Conclusões:** Os instrumentos utilizados no alargamento foraminal, 1 mm além ápice combinados com o preparo final com instrumento #25/.05 não causaram deformação do forame apical. O instrumento ProDesign Logic seguido do preparo final apresentou melhor centralização, sem aumentar o transporte do canal.

Palavras-chave: Ápice dentário. Canal radicular. Endodontia. Tomografia micro-computadorizada.

ABSTRACT

Aims: To evaluate foraminal deformation, canal transportation and centering before and after curved canals were instrumented using different instruments used 1 mm beyond the apical foramen. **Methods:** Thirty-three mesiobuccal canals of maxillary molars were randomly divided into three groups (n=11) according to the instruments used 1 mm beyond the apical foramen: R-Pilot (RPG), ProDesign Logic (PDG) and ProGlider (PGG). After that, #25/.05 ProDesign Logic® files were used to prepare the canals to full length. Micro CT scans obtained before instrumentation (time point 1), after foraminal enlargement establishment (time point 2) and after final preparation (time point 3) were used to evaluate apical deformation according to area, ratio of Feret's diameters and circularity, transportation and centering in the final 5 mm of the apical third. Image J was used for the analysis of apical deformation, and Adobe Photoshop, for transportation and centering. Data were compared between groups at each time point and between time points in each group (α=5%). **Results:** There were no significant differences in ratio of Feret's diameters, circularity or area (P>.05). It was observed mesial transportation in all groups, and transportation increased significantly after final preparation in RPG and PGG groups (P<.05). In the PDG group, centering was significantly better at time point 3 than 2 (P<.05). **Conclusions:** Instruments used 1 mm beyond the apical foramen combined with #25/.05 final preparation did not lead to apical foramen deformation. ProDesign Logic® #25/.01 followed by #25/.05 improved centering without increasing transportation in root canals.

Keywords: Endodontics. Micro-computed tomography. Root canal. Tooth apex.

SUMÁRIO

1. INTRODUÇÃO

O principal objetivo do tratamento endodôntico é a reparação e/ou preservação dos tecidos periapicais. Para que o sucesso seja alcançado, é necessário um protocolo clínico rigoroso. A limpeza e modelagem do sistema de canais radiculares são etapas importantes do tratamento endodôntico, e fazem com que debris e microrganismos responsáveis por diversas patologias sejam removidos (Tomson; Simon, 2016).

O preparo de canais radiculares além forame, com ou sem alargamento foraminal, vem sendo investigado (Kustarci *et al.,* 2008; Frota *et al.,* 2018; González Sanchez *et al.,* 2012; Yammine *et al.,* 2017). A constrição apical sempre foi o limite ideal da conformação e obturação do canal (Wu, Wesselink & Walton, 2000), nesse sentido, o forame apical não é alterado pela instrumentação. Uma vez que a constrição apical nem sempre pode estar presente ou detectável (Dummer, McGinn & Rees, 1984; Simon, 1993; Nekoofar *et al.*, 2006), estudos têm demonstrado a tendência em usar o forame apical principal como limite para a instrumentação (Wu, Wesselink & Walton, 2000; Alothmani, Chandler & Friedlander, 2013; Jafarzadeh, Beyrami & Forghani, 2017), ou mesmo além do forame com o objetivo de promover uma desinfecção eficiente em casos de periodontite apical (Silva *et al.,* 2016). Embora não consolidada, essa prática poderia permitir a irrigação da região apical e promover um debridamento mecânico mais eficiente da porção apical, incluindo o forame, otimizando a desinfecção do canal radicular e favorecendo seu reparo (Rodrigues *et al.,* 2017; Souza, 2006)

O alargamento do forame apical parte do pressuposto de que a passagem de um instrumento compatível com a anatomia do forame não é suficiente para promover uma limpeza efetiva, o que requer instrumentação ativa do forame apical (Perez *et al.*, 2018), possibilitando melhor irrigação e modelagem da região apical e resultando em melhor desinfecção do canal. Além disso, o alargamento do forame apical também está associado a maiores percentuais de cicatrização periapical, principalmente quando há presença de lesões periapicais crônicas (Brandão *et al.*, 2019).

Embora exista preocupação em relação à dor pós-operatória, estudos mostraram que o alargamento foraminal não foi o responsável para maiores taxas de dor pós-operatória (Silva *et al.*, 2013; Cruz *et al.,* 2016). Por outro lado, quando esse alargamento é realizado com instrumentos de maior calibre, existe a preocupação na manutenção da anatomia, essa manobra pode levar a deformação foraminal e o transporte do canal radicular, especialmente em canais com curvatura (Duran-Sindreu *et al.*, 2012; González Sanchez *et al.,* 2012).

Diferentes instrumentos de níquel-titânio (NiTi) estão sendo desenvolvidos e que podem ser utilizados na realização dessa manobra. O ProGlider (Dentsply Maillefer, Ballaigues, Switzerland) é um instrumento de secção transversal quadrada de NiTi com tratamento térmico *M-wire*, ISO #16 taper variável de 0.02 a 0.08 ao longo da ponta ativa (Uslu, Ozyurek & Inan, 2016). O R-Pilot (VDW, Munich, Germany) utilizado com a mesma finalidade, apresentado como instrumento único de movimento reciprocante, secção transversal em forma de S produzido em NiTi com tratamento térmico *M-Wire*, ISO #12.5 taper 0.04. A Easy equipamentos odontológicos, que conta com o sistema ProDesign Logic (Easy Equipamentos Odontologicos, Belo Horizonte, MG, Brazil), apresenta um instrumento de secção transversal hélice dupla e tripla composta de liga de NiTi com tratamento térmico de controle de memória. O instrumento tem diâmetro ISO #25 taper 0.01.

Desta forma, há necessidade de avaliar a influência de diferentes instrumentos utilizados além do forame apical na deformação foraminal, transporte e centralização do canal radicular. Para comparar e avaliar o preparo promovido pelos diferentes tipos de instrumentos, a microtomografia computadorizada foi utilizada.

2. OBJETIVOS

2.1 Objetivo geral

O objetivo do estudo foi avaliar a deformação foraminal, o transporte e centralização de canais curvos após a utilização de instrumentos 1 mm além do forame apical e após o preparo final do canal radicular

2.2 Objetivos específicos

Avaliar através de microtomografia computadorizada:

- Deformação foraminal, após a realização do preparo apical com diferentes instrumentos, 1mm além do forame, através da medida da área, diâmetro de Feret e circularidade;

- Transporte apical, após a realização do preparo apical com diferentes instrumentos, 1mm além do forame e após o preparo completo do canal radicular;

- Centralização do preparo, após a realização do preparo apical com diferentes instrumentos, 1mm além do forame e após o preparo completo do canal radicular.

3. ARTIGO CIENTÍFICO

O presente estudo foi submetido à apreciação e aprovação no Comitê de Ética em Pesquisa da Universidade Federal do Rio Grande do Sul (UFRGS) (Anexo A).

O artigo gerado no trabalho de conclusão de curso foi traduzido para o idioma inglês (Anexo B) e submetido à publicação no periódico *Brazilian Dental Journal*, eISSN 1806-4760.

Deformation of the apical foramen, canal transportation, and centering ability after over instrumentation with different instruments

SUMMARY

Aim: To evaluate foraminal deformation and enlargement, canal transportation and centering before and after curved canals were instrumented using different instruments 1 mm beyond the apical foramen. Methodology: Thirty-three mesiobuccal canals of molars were divided into three groups according to the instrument used 1 mm beyond the apical foramen: R-Pilot® #12.5/.04 (RPG), ProDesign Logic® #25/.01 (PDG), and ProGlider® #16/.02 (PGG). After that, #25/.05 ProDesign Logic® files were used to prepare the canals until the apical foramen. Micro CT scans obtained before instrumentation (time point 1), after foraminal enlargement establishment (time point 2) and after final preparation (time point 3) were used to evaluate apical deformation according to area, ratio of Feret's diameters and circularity, transportation and centering. Data were compared between groups at each time point and between time points in each group (α=5%). Results: There were no significant differences in ratio of Feret's diameters or circularity (P>.05). The direction of transportation was mesial in all groups, and transportation increased significantly after final preparation in RPG and PGG groups (P<.05). In the PDG group, centering was significantly better at time point 3 than 2 (P<.05). Conclusions: Instruments used 1 mm beyond the apical foramen combined with #25/.05 final preparation did not lead to apical foramen deformation. ProDesign Logic® #25/.01 followed by #25/.05 improved centering without increasing transportation in root canals.

Key Words: tooth apex, endodontics, root canal, micro-computed tomography.

INTRODUCTION

Cleaning and shaping of curved root canals remain the greatest challenges in Endodontics. Successful treatment is linked to numerous factors, such as the correct instrumentation and debridement of the root canal and the preservation of its original anatomical trajectory (1).

Controversies exist regarding the selection of the ideal limit of root canal therapy in teeth with vital or infected pulps. Attention on extended root canal preparation techniques, by over instrumentation with or without enlarging the foramina are being investigated (2,3,4,5). This maneuver could promote a more efficient mechanical debridement and efficient disinfection (6,7). Apart from favoring repair, mainly in cases of apical periodontitis (8).

One of the major concerns regarding apical foramen enlargement is the possibility of postoperative pain. Studies suggested that apical enlargement and non-enlargement techniques resulted in the same response for postoperative pain (9,10).

On the other hand, the effects of over instrumentation with NiTi rotary systems on foramen might promote deformation of the apical foramen, especially when curved canals are cleaned. Reciprocating and continuous rotary systems to realize this maneuver are available, with different designs, structures and materials manufactured using different types of heat treatment. ProGlider® rotary files (Dentsply-Maillefer Instruments S.A., Ballaigues, Switzerland), manufactured from M-wire, have a square cross-section, tip size 16 and taper .02 to .08. ProDesign Logic® (Easy Dental Equipment, Belo Horizonte, Brazil) files, also continuous rotary files, are manufactured from the control memory alloy (CM) and have a helix-shaped cross-section, a tip size 25 and a continuous taper .01. The reciprocating systems available on the market include the M-wire R-Pilot® (VDW, Munich, Germany) files, which have an S-shaped cross-section, a tip size 12.5 and a continuous taper .04.

This study compared foraminal deformation, canal transportation, and centering after instrumentation using three types of instruments 1 mm beyond the apical foramen previously curved root canal shaping. Micro-computed tomography images obtained before and after the preparation were used for analyses. The null hypothesis was that the use of different instruments 1 mm beyond the apical foramen will not lead anatomical changes in the root canal.

MATERIAL AND METODS

Sample selection

Thirty-three extracted human permanent maxillary molars with fully formed roots and no history of endodontic treatment were included in the study. Mesiobuccal canals with curvatures between 25° and 35° degrees and a radius of less than 10 mm were selected, as described by Schneider (11) and Schafer et al. (12). After examination of the teeth under micro-computed tomography (Micro-CT) (time point 1), only those whose mesiobuccal canals had an apical foramen diameter of 150 µm to 200 µm were included. The selected teeth were distributed randomly into three test groups according to the type of instrument used (n=11) (Table 1).

Table 1. Test groups and treatment time points.

Groups	n	Time point of analysis under micro-CT according to file used		
		Time point 1	**Time point 2**	**Time point 3**
R-Pilot® (RPG)	11	Without endodontic preparation	After the use of #12.5/.04 RPG	Final Preparation (#25/.05 ProDesign Logic®)
ProDesign Logic® (PDG)	11	Without endodontic preparation	After the use of #25/.01 PDG	Final Preparation (#25/.05 ProDesign Logic®)
ProGlider® (PGG)	11	Without endodontic preparation	After the use of #16/.02 PGG	Final Preparation (#25/.05 ProDesign Logic®)

Endodontic procedures

Access cavities were realized and the pulp chamber roof was completely removed using a 1012 spherical diamond tip (KG Sorensen, Barueri, Brazil) and an Endo Z tip (Dentsply/Maillefer Instruments S.A., Ballaigues, Switzerland).

Initially, the mesiobuccal canals were explored using a #08 K-type file (Dentsply/Maillefer Instruments S.A., Ballaigues, Switzerland) until its tip reached the foramen. The length measured on the file was defined as the working length (WL).

After that, an instrumentation was established in the mesiobuccal canal 1 mm beyond the WL according to the test group:

- RPG: #12.5/.04 R-Pilot® file in reciprocating motion;
- PDG: #25/.01 ProDesign Logic® file in rotary motion at 350 rpm and torque of 1N;
- PGG: #16/.02 ProGlider® file in rotary motion at 300 rpm and torque of 2N.

Next, a #25/.05 ProDesign Logic® file in rotary motion at 950 rpm and torque of 4N was used to prepare the entire length canals (WL), until the apical foramen (final preparation).

All files were used in a slow, in-and-out pecking motion, according to the manufacturer's instructions. An endodontic VDW Silver engine (VDW, Munich, Germany) operated with a 16:1 contra-angle was used for all files. The same trained operator performed all endodontic procedures. Each set of files was used for to prepare four canals.

Canals were irrigated with 2.5% sodium hypochlorite (NaOCl) (Iodontosul - Industrial Odontológica do Sul LTDA, Porto Alegre, Brazil) at a total of 2 mL at each instrument change, using a conventional disposable syringe and a 29-gauge side-vented Endo-Eze irrigation needle (Ultradent, South Jordan, UT).

Micro-computed tomography (micro-CT)

Images were acquired using a SKYSCAN (Bruker Micro-CT, Kontich, Belgium) scanner at 70 kV, 100 µA, 13.3 mm FOV (XY), 7.0 mm FOV (Z) and 0.013 mm/Pix voxel size.

Teeth were scanned at three time points: (1) before instrumentation, (2) after the use of instruments 1mm beyond foramen, and (3) after final preparation. A support model made from ExpressTM XT Putty Soft (3M ESPE, St. Paul, MN) addition silicone was used to standardize the individual positioning of each tooth for micro-CT scanning.

Reconstructed axial slices (2D) and volumes (3D) were visualized using the DataViewer software (Extron, Anaheim, CA), which was used to process images for volume registration, matching and cutting plane selection.

The apical third were examined. The root canal section orthogonal to the canal axis was defined on the first apical section where the apical foramen was visible. The number used to identify the position of the selected section was the same at the three time points.

Analysis of area, ratio of Feret's diameters and circularity of the apical foramen

The area, ratio of Feret's diameters and circularity of the apical foramen at the three time points were calculated using the Image J software (National Institute of Health, Bethesda, MD). The axial images of the apical foramen were analyzed by one trained evaluator blinded to the groups. The boundary of the apical foramen was traced manually using the *Draw* tool for each specimen (Figure 1), and the area, Feret's diameters and circularity were calculated using the *Set Measurements* tool. Feret's diameters were defined as the longest distance between two parallel straight lines that are tangent to the shape. Ratio of Feret's diameters was calculated as the ratio of maximum to minimum Feret's diameters (Figure 2). Circularity was determined based on a perfect circle, which tends towards 1.0, in contrast with a straight line, which is 0.0.

Figure 1. Images illustrating the boundary of the apical foramen anatomical changes after the use of instruments 1mm beyond foramen (time point 2) and final preparation (time point 3) in comparison with baseline images (time point 1) in PDG group.

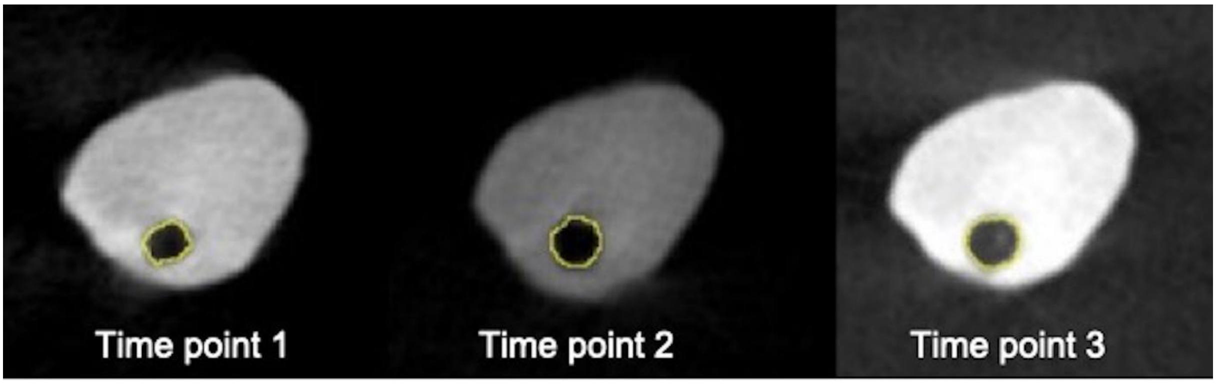
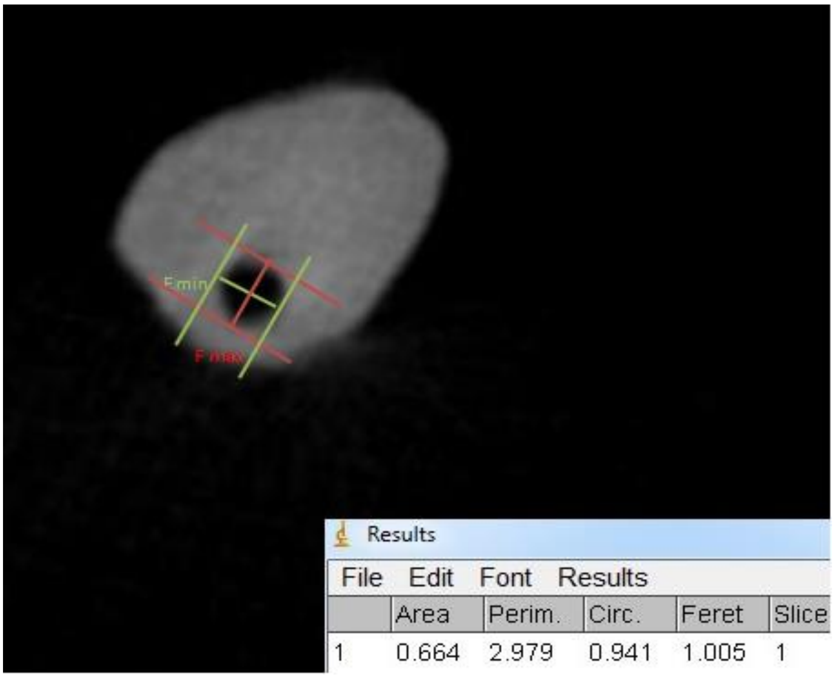


Figure 2. Specimen of PDG Group. The maximum (Fmax) and minimum (Fmin) Feret's diameters are defined as the furthest and shortest distances, respectively, between two parallel tangents on the boundary of a shape.



Analysis of apical transportation and centering

Apical transportation and centering ability of the files were analyzed in a linear mesiodistal direction. The images were transferred to and measured with the Adobe Photoshop software CS6 (v. 13.0x32, Adobe Systems, San Jose, CA). Transportation and centering were evaluated after instrumentation 1 mm beyond foramen was established, comparing micro-CT images at time points 1 and 2; and after final preparation, comparing the micro-CT images at time points 2 and 3, using the formula suggested by Gambill et al. (13). Apical transportation was calculated as follows: $(X1 - X2) - (Y1 - Y2)$, where X1 was the shortest distance from the distal portion of the root to the periphery of the unprepared canal; X2, the shortest distance from the distal portion of the root to the periphery of the prepared canal; Y1, the shortest distance from the mesial portion of the root to the periphery of the unprepared canal; and Y2, the shortest distance from the mesial portion of the root to the periphery of the prepared canal. A result of zero indicated no canal transportation; a positive result indicated transportation toward the distal region of the root; and a negative result indicated transportation toward the mesial region of the root.

Centering was calculated using the following formula: $(X1 - X2)/(Y1 - Y2)$ or $(Y1 - Y2)/(X1 - X2)$. The numerator of the formula was the lowest number found when the values were unequal. A value close to 1 indicated a better centering, and a value close to 0, a poorer centering.

Statistical analysis

The Shapiro Wilk test was used to evaluate data normality. Repeated-measures analysis of variance (ANOVA), followed by the Tukey test for multiple comparisons, was used to compare the area and ratio of Feret's diameters at the three time points in the same group. One-way ANOVA was used to compare different groups at the same time point. As circularity data did not have a normal distribution, time points in the same group were compared using the Friedman non-parametric test, and the Kruskal-Wallis test was used to compare groups at the same time point. The data about apical transportation and centering at the same time point were compared between groups using one-way ANOVA, and data for the same group at time points 2 and 3 were compared using a dependent *t* test. The level of significance was set at 5% ($P \leq .05$). Statistical analyses were performed using the GraphPad Prism 7 software (GraphPad Software Inc., San Diego, CA).

RESULTS

Figure 1 show the anatomical changes of the apical foramen after over instrumentation was established and after preparation was complete in PDG group. Although there was an increase in apical foramen area at these time points for all types of files, this increase was statistically significant only in PDG when time point 1 (before preparation) was compared with time point 3 (after final preparation) ($P < .05$). No significant differences were found between the three time points for all groups when comparing the results of ratio of Feret's diameters ($P > .05$). Circularity did not change significantly after over instrumentation was established or after preparation was complete ($P > .05$). The comparison of foramen area, ratio of Feret's diameters and circularity between groups at the same time point revealed no significant differences ($P > .05$) (Table 2).

Table 2. Mean and standard deviation (±) of root canal area (mm^2), ratio of Feret's diameters (mm/mm) and median value (maximum value; minimum value) of canal circularity (mm^2/mm^2) in the test groups at time points 1 (no preparation), 2 (after the use of instruments 1mm beyond foramen) and 3 (after final preparation) ($p > 0.05$).

		RPG	PDG	PGG
Area	Time point 1	0.52 ± 0.37	0.46 ± 0.24^A	0.51 ± 0.29
	Time point 2	0.71 ± 0.31	0.66 ± 0.26	0.63 ± 0.36
	Time point 3	0.92 ± 0.39	0.83 ± 0.26^A	0.81 ± 0.27
Ratio of Feret's diameters	Time point 1	0.51 ± 0.29	0.72 ± 0.16	1.19 ± 0.44
	Time point 2	0.63 ± 0.36	0.75 ± 0.14	1.23 ± 0.45
	Time point 3	0.81 ± 0.27	0.78 ± 0.12	1.31 ± 0.38
Circularity	Time point 1	0.82 (0.93; 0.44)	0.84 (0.94; 0.43)	0.74 (0.90; 0.53)
	Time point 2	0.82 (0.93; 0.47)	0.88 (0.94; 0.52)	0.74 (0.92; 0.54)
	Time point 3	0.85 (0.93; 0.51)	0.87 (0.98; 0.47)	0.78 (0.93; 0.57)

*Equal capital letters indicate significant differences in the same column ($P < .05$)

Table 3 shows data about apical transportation and centering. There was a tendency to transportation in the mesial direction of the canal after over instrumentation and final preparation in all file groups. There were no significant differences between groups at the same time point ($P > .05$), and transportation increased significantly after final preparation in RPG and PGG ($P < .05$). There were significant differences in centering among RPG and PDG groups at the time point 3 (P<.05), but centering was significantly better at time point 3 than at time point 2 in PDG (P<.05).

Table 3. Mean and standard deviation (±) of apical transportation (mm) and centering (mm) in the test groups after the use of instruments 1mm beyond foramen (time point 2) and final preparation (time point 3).

		RPG	PDG	PGG
Apical transportation	Time point 2	$- 0.27^{a} \pm 0.18$	$- 0.57^{a} \pm 0.36$	$- 0.25^{a} \pm 0.27$
	Time point 3	$- 0.89^{b} \pm 0.61$	$- 0.41^{a} \pm 0.38$	$- 1.04^{b} \pm 1.04$
Centering ability	Time point 2	$0.27^{a} \pm 0.33$	$0.05^{a} \pm 0.17$	$0.25^{a} \pm 0.24$
	Time point 3	$0.10^{aA} \pm 0.15$	$0.52^{bB} \pm 0.34$	$0.22^{a} \pm 0.22$

*Different lowercase letters indicate significant differences in the same column (P<.05)
*Different uppercase letters indicate significant differences in the same line (P<.05)

DISCUSSION

This study analyzed the shaping ability of three types of instruments used for instrumentation 1 mm beyond the apical foramen followed by final preparation to entire canal length, that is, to the apical foramen, using a #25/.05 rotary file. The preservation of the original shape of the canal is associated with better endodontic treatment results. The determination of the apical instrumentation limit and the apical diameter are still crucial points in canal treatments. The analyzes were measured using a micro-CT scanner. Data obtained with micro-CT scans enable the identification of morphologic changes associated with different biomechanical preparations including canal transportation, dentin removal, and final canal preparation (14).

A major advantage of micro-CT scanning is the ability to obtain highly accurate evaluation of root canal shape by the superimposition and measurement of preoperative and postoperative 3-dimensional renderings. Zheng et al. (15) also used this feature in their analysis.

The use of a file with a caliber smaller than that of the apical foramen may not clean the canal efficiently. Correct foraminal enlargement is achieved using larger caliber instruments. Souza (7) suggests that when the canal is instrumented past the apical foramen, there is better bacterial removal, which promotes healing. Foraminal enlargement creates conditions for the growth of connective tissue in the space of the unfilled apical portion during the repair process after treatment (16).

However, enlargement may promote deformation of the apical foramen, especially in curved canals, and lead to unsatisfactory filling (17).

Each instrument analyzed in this study has a distinct cross-section, taper and tip diameter. ProDesign Logic® has a double helix cross-section, tip 25 and taper .01 (1) ProGlider® has a square cross-section, tip 16 and a variable taper beginning at .02 in the first millimeter (18). R-Pilot® has an S-shaped cross-section, tip #12.5 and taper .04 (19). Therefore, as there was a 1-mm overlap in the preparation, the apical diameter of the canals after preparation should be 26 for ProDesign Logic®, 18 for ProGlider® and #16.5 for R-Pilot®.

Regarding apical enlargement, the initial null hypothesis was accepted. R-Pilot®, ProDesign Logic®, and ProGlider® files did not change the circularity and ratio of Feret's diameters after use, thus preserving the anatomical features of the foramen. Following instrumentation beyond apex and after preparation using #25/.05 rotary file, few changes from circular to oval shape were observed in all groups, although they increased the foraminal surface area. Similar results were observed for Vieira et al. (20) using Reciproc Blue R25 instrument in the apical foramen and beyond apex and Daou et al. (21), using Reciproc Blue and XP-endo Shaper instrumented at the apical foramen limit.

The foramen ovalization has been reported following canal over instrumentation. The major foramen was photographed before and after overinstrumentation with ProTaper Universal and ProFile Vortex instruments, the results showed that the instruments did not maintain the original position of the foramen (4). Frota et al. (3), who used a digital microscope for analyses, found foramen deformation after using Reciproc (#25/.08), WaveOne (#25/.08) and ProDesign R (#25/.06) files in two different working lengths, 0.00 mm and 1.0 mm beyond the foramen. Silva Santos et al. (17) also found foraminal deformation after the use of #25/.08 files, 1 mm beyond the foramen. Our results may be correlated with prior instrumentation with small diameter and taper instruments 1 mm beyond the foramen.

The analysis of canal transportation revealed that all files under test led to transportation towards the external (mesial) wall in the apical third, results which are similar to those found in other study (4,22). Transportation in this direction might be explained by the fact that the distal wall pushes the file, particularly if the file has a larger taper, in a direction against the mesial wall, opposed to the curvature (23). Despite the absence of significant differences between groups, apical transportation was significantly greater in RPG and PGG after final preparation (time point 3). In PDG, however, transportation did not change significantly after the final preparation, which may be associated with the fact that the #25.05 ProDesign Logic® files worked with a free tip at the apical foramen during final preparation. However, according to Fan et al. (24), apical transportation becomes clinically relevant when it exceeds 300 µm, which occurred in all groups after final preparation and in PDG also after the use 1mm beyond foramen file was used. This may be explained by the fact that the tip diameter of the #25.01 ProDesign Logic® files is greater than that the other two instruments under study.

At time point 3, PDG showed better centering ability than RPG. The analysis of the centering ability also revealed that in PDG canal centering was significantly better after final preparation (time point 3) than after over instrumentation (time point 2). As seen above, at PDG the apical foramen was enlarged during the use of #25/.01 ProDesign Logic®, leaving the #25/.05 ProDesign Logic® tip work freely during final preparation, which might have contributed to our results.

The degree of curvature of the mesiobuccal roots of the upper molars ranged from 25º to 35º (11), and their radius was shorter than 10 mm (9), in agreement with studies that used these same anatomical characteristics (12). Roots with these degrees of curvature were selected because teeth with this type of curvature may be at a greater risk of canal transportation. Moreover, selecting only teeth whose mesiobuccal canals had an apical foramen diameter measuring 150 µm to 200 µm ensured that at least one of the files that was used to prepare the canal would reach the foramen.

Axial sections of the apical third of the canals were selected for the analyses because this region is the most critical for endodontic treatment. Correct cleaning and shaping of this region are directly associated with treatment success (25). Procedural accidents, such as apical transportation, may prevent the removal of all microorganisms and organic tissue from the dentin walls, compromising the disinfection and sealing of the canal system (23). Apical transportation and centering were analyzed using micro-CT images, which ensured good precision, validity, and data reproducibility (26). Other methods of analysis, such as serial cuts, clearing, and scanning electron microscopy, result in structural changes. In this study, such changes would preclude the analysis of transportation and centering at the three time points selected. Apical transportation was evaluated only on the mesiodistal axial sections, as the canal along this direction was narrower than in the buccopalatal direction. According to Wu et al. (27), the diameter of the mesiobuccal canal of a molar at a point more than 1 mm from the apex is about 0.20 mm in the mesiodistal direction and 0.43 mm in the buccopalatal direction.

Despite the *in vitro* study limitations, the present results highlighted that the combined R-Pilot®, ProDesign Logic®, or ProGlider® files establishment 1mm beyond apical foramen

with with #25/.05 final preparation until the apical foramen did not lead to apical foramen deformation. ProDesign Logic files followed by a final preparation improved canal centering without increasing canal transportation.

RESUMO

Objetivo: Avaliar a deformação foraminal, o transporte e centralização de canais radiculares curvos após a utilização de diferentes instrumentos, 1 mm além do forame apical. **Métodos:** Trinta e três canais mésio-vestibulares de molares superiores foram divididos aleatoriamente em três grupos (n = 11) e preparados 1 mm além do forame apical de acordo com o instrumento utilizado: R-Pilot (RPG), ProDesign Logic (PDG) e ProGlider (PGG). Após, o instrumento #25/.05 ProDesign Logic® foi utilizado para preparar o canal em seu comprimento total. Imagens de Micro CT obtidas antes da instrumentação (momento 1), após a realização do alargamento foraminal (momento 2) e após o preparo final (momento 3) foram utilizadas para avaliar a deformação do forame de acordo com a área, razão dos diâmetros de Feret e circularidade. Também foram avaliados o transporte e centralização, nos 5 mm finais do terço apical. O programa Image J foi utilizado para a análise da deformação apical e o Adobe Photoshop para transporte e centralização. Os dados foram comparados entre os grupos em cada momento e entre os momentos em cada grupo ($\alpha = 5\%$). **Resultados:** Não houve diferenças significativas na razão dos diâmetros de Feret, circularidade e área ($P > 0,05$). Os canais foram transportados para mesial em todos os grupos, e o transporte aumentou significativamente após o preparo final com ProDesign Logic 25/.05 nos grupos onde foram utilizados os instrumentos RPG e PGG 1 mm além do forame ($P < 0,05$). No grupo PDG, a centralização foi significativamente melhor no momento 3 do que 2 ($P < 0,05$). **Conclusões:** Os instrumentos utilizados no alargamento foraminal, 1 mm além ápice combinados com o preparo final com instrumento #25/.05 não causaram deformação do forame apical. A combinação do PDG 1 mm além do forame e o preparo final com o instrumento do mesmo fabricante, ProDesign Logic 25/.05, apresentou melhor centralização, sem aumentar o transporte do canal.

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4. CONSIDERAÇÕES FINAIS

A determinação do limite de instrumentação apical e do diâmetro apical ainda são pontos cruciais no tratamento do canal, além disso, a preservação da forma original do canal está associada a melhores resultados do tratamento endodôntico. Este estudo avaliou a influência de três instrumentos com diâmetros e conicidades diferentes utilizados 1 mm além do forame apical, seguido do preparo final em todo o comprimento do canal na deformação foraminal, centralização e transporte em canais radiculares curvos por meio de imagens obtidas por microtomógrafo computadorizado. Os instrumentos utilizados no alargamento foraminal, PDG, RPG e PGG, combinados com o preparo final com o instrumento #25/.05 ProDesign Logic não causaram deformação do forame apical. O instrumento #25/.01 ProDesign Logic seguido do preparo final com o instrumento #25/.05 ProDesign Logic apresentou melhor centralização, sem aumentar o transporte do canal.

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ANEXOS

ANEXO A - Carta de aprovação do Comitê de Ética em Pesquisa.

CEP UFRGS

UFRGS - PRÓ-REITORIA DE PESQUISA DA UNIVERSIDADE FEDERAL DO RIO GRANDE DO

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: INFLUÊNCIA DE DIFERENTES INSTRUMENTOS DE PATENCIA NO TRANSPORTE E CENTRALIZAÇÃO DO CANAL RADICULAR E NA DEFORMAÇAO FORAMINAL

Pesquisador: Fabiana Soares Grecca

Área Temática:

Versão: 2

CAAE: 78641417.7.0000.5347

Instituição Proponente: UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 2.473.857

Apresentação do Projeto:

O grande objetivo do tratamento endodôntico é a reparação e/ou preservação dos tecidos periapicais. Para que o sucesso seja alcançado, é necessário um protocolo clínico rigoroso. A limpeza e modelagem do sistema de canais radiculares são etapas importantes do tratamento endodôntico, e fazem com que debris e microrganismos responsáveis por diversas patologias sejam removidos. Durante o tratamento, são produzidas raspas de dentina que tendem a ser compactadas no forame apical, sendo uma fonte de tecido contaminado no interior do canal dentário que necessita ser removido pela desobstrução do forame apical, através da manobra de patência.

Objetivo da Pesquisa:

O objetivo do estudo será avaliar a influência de diferentes instrumentos de patência no transporte e centralização do canal radicular e na deformação foraminal.

Avaliação dos Riscos e Benefícios:

Riscos e benefícios foram modificados a fim de atender às recomendações do CEP e ao que dispões a regulação vigente. (PENDÊNCIA ATENDIDA)

Comentários e Considerações sobre a Pesquisa:

Serão selecionados 33 molares permanentes superiores humanos extraídos, doados por pacientes previamente triados, que tiveram exodontia como indicação. Os pacientes serão informados do

Endereço: Av. Paulo Gama, 110 - Sala 317 do Prédio Anexo 1 da Reitoria - Campus Centro
Bairro: Farroupilha **CEP:** 90.040-060
UF: RS **Município:** PORTO ALEGRE
Telefone: (51)3308-3738 **Fax:** (51)3308-4085 **E-mail:** etica@propesq.ufrgs.br

procedimento que o dente será submetido e assinarão um termo livre e esclarecido e um termo de doação do órgão em prol da pesquisa. A coleta destas amostras será realizada nos atendimentos realizados pelos graduandos nas disciplinas de: Exodontia, Cirurgia e Traumatologia Buco-Maxilo-Faciais II e Anestesiologia e Introdução a Exodontia. Os dentes serão seccionados, separando a raiz mesial da raiz distal e palatina. A raiz mesial será radiografada com auxílio de um aparelho de Rx, e os canais radiculares mésio-vestibulares serão selecionados de acordo com ângulo e raio de curvatura das raízes segundo metodologia proposta por Schäfer et al (2002). Aqueles com ângulo entre 20 e 40 graus e raio menor que 10 mm serão incluídos no estudo. A amostra será randomizada de acordo com o software random.org em 3 grupos experimentais com n=11, de acordo com o sistema de instrumentação.

Considerações sobre os Termos de apresentação obrigatória:

ORÇAMENTO: Os pesquisadores fizeram as modificações solicitadas e no projeto agora consta:

"O presente projeto será encaminhado para agências de fomento após aprovação pelos comitês, caso não seja contemplado, o pesquisador responsável se responsabilizará pelos custos." (PENDÊNCIA ATENDIDA)

CARTAS DE ANUÊNCIA: - As cartas de anuência dos ambulatórios de Cirurgia, Anestesiologia e Exodontia, bem como do LABIM com os nomes e assinaturas dos responsáveis foram incluídas (PENDÊNCIA ATENDIDA)

TCLE: O telefone do CEP (3308.3738) foi corrigido. (PENDÊNCIA ATENDIDA)

CÁLCULO DE TAMANHO AMOSTRAL: apresentado e em condições de aprovação.

CRONOGRAMA E PARECER DA COMPESQ: apresentados e em condições de aprovação.

TERMO DE DOAÇÃO DE DENTES: apresentado e em condições de aprovação.

Conclusões ou Pendências e Lista de Inadequações:

O parecer é pela aprovação.

Considerações Finais a critério do CEP:

Aprovado.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1002472.pdf	22/11/2017 10:33:01		Aceito

Projeto Detalhado / Brochura Investigador	Projeto.pdf	22/11/2017 10:32:28	Fabiana Soares Grecca	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TERMOS.pdf	22/11/2017 10:30:22	Fabiana Soares Grecca	Aceito
Declaração de Instituição e Infraestrutura	LABIM.pdf	22/11/2017 10:28:54	Fabiana Soares Grecca	Aceito
Declaração de Instituição e Infraestrutura	Cirurgia1.pdf	22/11/2017 10:28:31	Fabiana Soares Grecca	Aceito
Declaração de Instituição e Infraestrutura	PUC.pdf	09/10/2017 15:39:51	Fabiana Soares Grecca	Aceito
Declaração de Instituição e Infraestrutura	Endodontia.pdf	09/10/2017 15:39:08	Fabiana Soares Grecca	Aceito
Folha de Rosto	Plataforma.pdf	09/10/2017 15:33:40	Fabiana Soares Grecca	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

PORTO ALEGRE, 25 de Janeiro de 2018

Assinado por:
MARIA DA GRAÇA CORSO DA MOTTA
(Coordenador)

Endereço: Av. Paulo Gama, 110 - Sala 317 do Prédio Anexo 1 da Reitoria - Campus Centro
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ANEXO B - Certificado da tradução do artigo científico para o idioma inglês.