

Analysis of the preparation obtained by three techniques of root canal instrumentation using computed tomography

Análise do preparo obtido por três técnicas de instrumentação do canal radicular através de tomografia computadorizada

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ABSTRACT

Objective

Use computed tomography to compare three methods of root canal instrumentation.

Methods

Thirty mandibular molar mesiobuccal canals were divided in three groups according to instrumentation technique: Group 1 - hand instrumentation with balanced force technique; Group 2 - Protaper Universal rotary system following manufacturer's instructions; and Group 3 - Protaper Universal rotary system and Gates-Glidden drills. Teeth were evaluated by computed tomography before and after preparation at three axial cuts: 3mm, 5mm, and 7mm from the root apex. Data were subjected to statistical analysis using the F, Chi-Square, Likelihood Ratio Chi-Square, and Mantel-Haenszel Chi-Square tests.

Results

Group 3 showed significantly greater dentin removal with no tendency towards mesial or distal canal transportation, compared with Groups 1 and 2. Also, Group 3 required the least amount of time for instrumentation.

Conclusion

Association of rotary instrumentation and Gates-Glidden drills is a safe and effective technique for root canal preparation.

Indexing terms: Dental instruments. Dental pulp cavity. Endodontics. Tomography, X-Ray Computed.

RESUMO

Objetivo

Comparar o preparo de canais radiculares através de tomografia computadorizada.

Métodos

Trinta canais méso-vestibulares de molares inferiores foram divididos em 3 grupos, de acordo com a técnica de instrumentação a ser utilizada: Grupo 1 - instrumentação manual, utilizando-se de movimentos de forças balanceadas; Grupo 2 - Sistema Protaper Universal de instrumentação rotatória, conforme protocolo do fabricante; Grupo 3 - Sistema Protaper Universal de instrumentação rotatória associada a brocas de Gates-Glidden para pré-alargamento cervical. Os dentes foram submetidos à tomografia computadorizada antes e após o preparo, e a análise das imagens foi feita através de cortes axiais a 3mm, 5mm e 7mm do ápice radicular. Os dados foram submetidos a análise estatística utilizando testes paramétricos (para as variáveis tempo e desgaste de dentina) e não-paramétricos (para a variável sentido do desvio).

Resultados

Os resultados mostraram uma tendência significativa do grupo 3 a desgastar mais dentina quando comparado aos grupos 1 e 2. O grupo 1 desgastou significativamente mais dentina para o sentido distal e o grupo 2 desgastou significativamente mais para o sentido mesial. O grupo 3 não apresentou tendência de sentido de desgaste. O tempo despendido foi menor no grupo 3, seguido pelo grupo 1 e 2.

Conclusão

Pôde-se concluir que a associação das brocas de Gates-Glidden ao Sistema Protaper Universal promoveu um preparo adequado de maneira segura e, a tomografia computadorizada foi um método adequado para a análise do preparo de canais radiculares.

Termos de indexação: Instrumentos odontológicos. Cavidade pulpar. Endodontia. Tomografia Computadorizada por Raios X.

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INTRODUCTION

There are a large number of rotary instrumentation systems available for endodontic practice, and there are great differences in design and clinical performance among them. The advantages these systems have brought endodontists deserve to be pointed out, however, many advancements in instrument design have been made to improve canal shaping and diminish clinical time. An example of this is the Protaper System (Dentsply Maillefer, Ballaigues, Switzerland) that was produced with progressive tapers with the intention of creating an ideal formatting in the shortest clinical time.

Cervical pre-widening with the use of Gates-Glidden burs in decreasing sizes releases interferences in the cervical and middle thirds of the root canal and allows the files to reach the apical third more easily and safely¹⁻⁴ in addition to reducing the rate of Protaper instrument fractures.

The complex dental internal anatomy sometimes makes it difficult to elaborate an appropriate cylindrical-conical modeling, demonstrates its limitations, and leaves areas without undergoing the action of instruments, and others with excessive dentinal wear. Taking into consideration that the majority of canals have a flattened anatomic shape, no matter how thin or small the rotary instrument diameter may be, its action on these flattened areas is unlikely to occur, preventing them from being well cleaned and shaped³⁻⁶.

The literature has shown that the qualitative analysis of root canal instrumentation has been performed by some methodologies in canals simulated in resin blocks and in natural teeth. Analysis in natural teeth has been performed by means of radiographic assessments, system of muffles, moldings or by tomography. Compute tomography was recently suggested for this type of analysis, with good results, mainly because of being a non-destructive resource that allows evaluation of the quantity of dentin removed from the root canal walls^{5,7}.

The aim of this study was to evaluate, by means of computed tomography, the direction of the root canal deviation, quantity of dentin removed in the mesio-vestibular canal of mesial roots of mandibular molars after the use of three instrumentation techniques and the total time spent on each technique.

METHODS

Thirty extracted first or second permanent mandibular molars were selected for this study. The teeth had completely formed roots, were stored in physiological solution and the mesio-vestibular roots presented curvatures between 25 and 45 degrees. The use of the teeth for research purposes was approved by the Research Ethics Committee of São Leopoldo Mandic, under Protocol No.06/025.

After coronal opening, the mesial roots were separate from the distal roots at the furca level, using a diamond-coated disc (KG Sorensen, Brazil). Part of the tooth crowns was cut in order to standardize the working length to 19 mm. The roots were randomly divided into 3 equal groups, with the aim of providing the homogeneity of the samples. The roots were then positioned and fixed by the cervical portion in an acrylic resin base, five at a time, at all times with the vestibular surface, which was marked with a scratch, facing the external surface of the tomograph.

In order to obtain the pre-instrumentation images, in three cuts for analysis: 3, 5 and 7 mm from the root apex, the tomograph, 3DX Accuitomo (J. Morita®, Japan) was used.

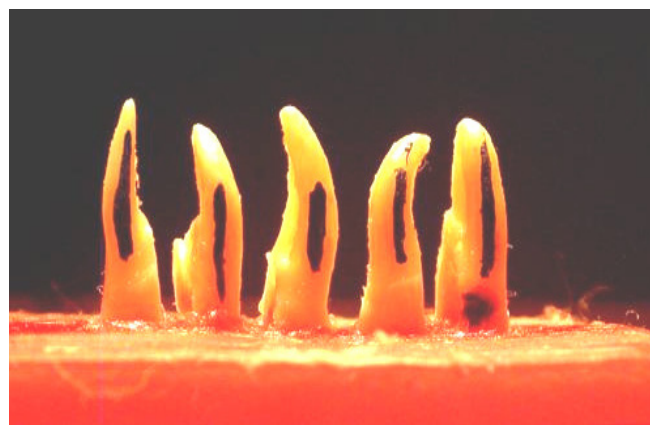


Figure 1. The teeth were positioned and the vestibular surfaces marked. Group 1 - roots numbered from 1 to 10; Group 2 - roots numbered from 11 to 20; Group 3 - roots numbered from 21 to 30.

For each of the groups, a technical sequence of root canal preparation was formed, as shown in Table 1.

Table 1. Division of the groups according to technique used.

Groups	n	Instrumentation technique
Group 1	10	Manual - balanced forces
Group 2	10	Universal Protaper in accordance with manufacturer's protocol
Group 3	10	Cervical pre-widening with Gates-Glidden + Universal Protaper

Detailed description of the techniques used considering the groups:

Group 1: Roots 1 to 10 - two-stage manual instrumentation technique using the Balanced Forces concept

Instrumentation performed by this technique was divided into two stages: Preparation of the cervical and middle thirds, and apical preparation.

Preparation of the cervical and middle thirds: a) initial catheterization with Kerr type file #10 up to the real working length (RWL); b) widening of the cervical and middle thirds (up to the beginning of the curvature) with K-flexofile type files using balanced force movements up to the diameter corresponding to KFlexofile type file #35; c) using Gates Glidden #3 and #2 burs, respectively with "brush-stroke" movements in the direction towards the "safety zone".

Preparation of the apical third: a) preparation of the apical third up to the diameter corresponding to file K-flexofile #25; b) step-back with programmed withdrawal of 1 mm at a time, up to the diameter corresponding to file K-flexofile #40.

Group 2: Roots 11 to 20 - Rotary instrumentation with Universal Protaper System - technique suggested by the manufacturer.

To perform the preparation of teeth in the Groups with the Universal Protaper rotary system, an X-Smart electric motor (Dentstply-Maillefer) with a constant speed of 300 rpm and torque control suggested by the manufacturer was used in the following manner: a) Shaping files (Sx, S1 and S2) - torque 3Ncm; b) Finishing files (F1, F2) - torque 1Ncm and 2Ncm respectively.

Sequence used: a) initial catheterization with K-file #10 up to RWL;

b) the use of file S1, until small resistance was offered; c) file Sx, until small resistance was offered; d) file S1, up to RWL; e) file S2, up to RWL; f) file F1, up to RWL; g) file F2, up to RWL.

For each tooth a new rotary instrument was used.

Group 3 - Roots 21 to 30 - Rotary instrumentation with Universal Protaper System with pre-widening using Gates Glidden burs. a) initial catheterization with Kerr type file #10 and #15, up to RWL; b) use of file S1, until small resistance was offered; c) file Sx, until small resistance was offered; d) Gates-Glidden bur #3 at low speed, (10.000 rpm); e) Gates Glidden bur #2 at low speed, (10.000 rpm); f) pre-widening with K-flexofile type file # 15 and 20 up to RWL; g) file S1, if possible, up to RWL; h) file S2, if possible, up to RWL; i) file F1, up to RWL; j) pre-widening with K-flexofile type file #25; k) file F2, up to RWL.

In the same way as in Group 2, the manual files and Gates-Glidden burs were used twice and for each tooth a new rotary file was used.

For all the groups the same irrigation protocol was used; that is to say, 5ml of 2.5% sodium hypochlorite at each change of file, 5ml of 17% EDTA (ethylenodiamino tetraacetic acid) for 3 minutes and final irrigation with 2 ml of 2.5% sodium hypochlorite. For maintenance of foraminal patency a Kerr type file #10 was used at each change of file. The manual and rotary files, and Gates-Glidden burs were used only once. A new tomograph was taken after instrumentation, and cuts were made at 3, 5 and 7mm from the root apex.

To measure the areas of the canals, the software program ImageTool (ImageTool Software Development Kit Source Code Version 3.0) was used, and the area corresponding to the root canal before and after instrumentation was demarcated for 3, 5 and 7 mm. This procedure was performed by two evaluators at different times, to provide greater reliability of the measures, and a mean was calculated. Afterwards, the means of the measurements obtained of the area of each root post-instrumentation were subtracted from the pre-instrumentation area, thus calculating the area of dentin removed.

For measurement of the direction of deviation, the differences in measurements between pre-and post-instrumentation were analyzed in a similar manner to that suggested by Gambill et al.⁶, however, the sign of that difference was not removed, because a negative difference would mean a deviation in the Distal (D) direction; a positive difference, deviation in the Mesial (M) direction and a null difference, centralized canal (C). The measurements were made with the aid of the program 3D Tomox (version 1.0.51), associated with the tomograph itself, which allowed the measurements to be calculated in millimeters, make cuts in the direction of X, Y and Z and

visualize images in three dimensions. The time spent on the preparation of each root was calculated (in minutes).

To evaluate the time spent a stopwatch (Cronobio. CIAL, São Paulo, Brazil) was used.

The data were submitted to statistical analysis by means of parametric tests, such as the F test for the analysis of variance of the variables time and dentin wear, and non parametric tests, such as the Chi-Square, Likelihood Ratio Chi-Square and Mantel-Haenszel Chi-Square tests for the variable direction of deviation.

RESULTS

Table 2. Orthogonal Contrast for effect of Group, Height of Cut and Interaction between Group and Height of Cut, for the variables deviation and Area (pixel)

Contrasts	Variance		Variance	
	Transport	Pr > F	Area	Pr > F
Height of Cut				
3 mm vs. 5 mm, 7 mm	0.00355556	0.6626	6679.51250	0.0005
5 mm vs. 7 mm	0.01666667	0.3459	9741.00417	<.0001
Group	-	-	-	-
Group 1 vs. Group 2, Group 3	0.06805556	0.0589	2289.80000	0.0376
Group 2 vs. Group 3	0.00016667	0.9247	6552.15000	0.0006
Interação	-	-	-	-
G1 [3 mm vs. 5 mm, 7 mm]	0.00016667	0.9247	1701.33750	0.0722
G1 [5 mm vs. 7 mm]	0.00050000	0.8700	1209.01250	0.1285
G2 [3 mm vs. 5 mm, 7 mm]	0.01666667	0.3459	2982.15000	0.0181
G2 [5 mm vs. 7 mm]	0.09800000	0.0241	5281.25000	0.0019
G3 [3 mm vs. 5 mm, 7 mm]	0.00150000	0.7768	2088.60000	0.0469
G3 [5 mm vs. 7 mm]	0.00450000	0.6236	4032.80000	0.0063
3 mm[Group 1 vs. Group 2, Group 3]	0.01666667	0.3459	470.40000	0.3410
3 mm[Group 2 vs. Group 3]	0.00800000	0.5132	2691.20000	0.0246
5 mm[Group 1 vs. Group 2, Group 3]	0.06016667	0.0754	129.06667	0.6172
5 mm[Group 2 vs. Group 3]	0.06050000	0.0746	2376.20000	0.0343
7 mm[Group 1 vs. Group 2, Group 3]	0.00600000	0.5710	2483.26667	0.0306
7 mm[Group 2 vs. Group 3]	0.01800000	0.3274	1566.45000	0.0843

For the variable area there was statistical difference among the three groups, with the largest quantity of dentin being removed in Group 3, followed by Group 2 and 1, respectively. Whereas with regard to height of cuts, the results showed that in Groups 2 and 3, the conicity of the canals was maintained to a greater extent, and in Group 1 there was greater rectification of the canal, and there was no statistical difference for area as regards the heights of cuts before and after preparation. Moreover, at the height of cut at 7 mm only Group 1 presented significant difference among the other groups, with a lower value for dentin removal.

Table 3. No parametric analysis to verify the association between the direction of deviation and groups, using the Chi-Square, Likelihood Ratio Chi-Square and Mantel-Haenszel Chi-Square tests.

Direction	Groups			
	Group 1	Group 2	Group 3	Total
Frequency				
Expected				
Cell Chi-Square				
Percent				
Distal	18 12 3 20.00	7 12 2.0833 7.78	11 12 0.0833 12.22	36 40.00
Mesial	6 13.333 4.0333 6.67	19 13.333 2.4083 21.11	15 13.333 0.2083 16.67	40 44.44
Central	6 4.6667 0.381 6.67	4 4.6667 0.0952 4.44	4 4.6667 0.0952 4.44	14 15.56
Total	30 33.33	30 33.33	30 33.33	90 100.00
	Non parametric Tests			Prob
	Chi-Square			0.0147
	Likelihood Ratio Chi-Square			0.0108
	Mantel-Haenszel Chi-Square			0.3620

With the purpose of verifying the direction of deviation, categories were established for this variable according to the sign and magnitude observed, in the following manner: negative difference deviation in the Distal direction (D); positive difference deviation in the Mesial direction (M); and Null value observed, revealed the absence of deviation; that is to say, a centralized canal (C). This new variable was analyzed by non parametric statistics using the Chi-Square, Likelihood Ratio Chi-Square and

Mantel-Haenszel Chi-Square tests.

For the association between groups (instrumentation procedures) and direction of deviation, a significant effect was observed, of Group 1 in deviating more towards the Distal direction, and Group 2, deviating more towards the Mesial direction. Group 3 presented no tendency between the different directions of deviation.

Table 4. Orthogonal contrast for effect of group, for variable time (seconds).

Contrasts	Variance	
Group	Transportation	Pr > F
Group 1 vs. Group 2, Group 3	3511.35000	0.3088
Group 2 vs. Group 3	68328.05000	<.0001

When observing the time of instrumentation of each group, it was verified that Group 3 presented the shortest preparation time, followed by Group 1 and lastly Group 2.

DISCUSSION

Various methodologies have been used to evaluate the action of instruments and techniques in root canal shaping, such as the radiographic method^{1,7-12}, muffles¹³⁻¹⁵, artificial canals¹⁶⁻¹⁷ and computed tomography, which has been to be superior for this type of analysis^{4-6,18-25}.

The mesio-vestibular roots of extracted mandibular molars were used, as they frequently present accentuated curvatures and accentuated concavity in the distal region, making them more susceptible to the risks of instrumentation²¹.

Taking into consideration that the majority of canals have a flattened anatomic shape, no matter how thin or small the rotary instrument diameter may be, its action on these flattened areas is unlikely to occur, preventing them from being well cleaned and shaped³⁻⁶. Thus, the hybridization of instruments may be an efficient combination both for practicality and for diminishing the time and weariness of the operator. Berutti et al.²⁶ studied the influence of manual pre-widening and torque on the failure of the Protaper system, and concluded that pre-widening is the main determinant factor in the reduction of failures in this system.

As regards dentin removal, Group 1 was the one in which the last removal was promoted, and even between

the three levels of cut in this group, there was no statistical difference with reference to area. This may be explained by the low conicity of the manual instruments, which do not promote such a conical preparation as that provided by rotary instruments with increasing tapers. It was observed that although the pre-widening with Gates-Glidden burs had been performed, at the height of the cut at 7 mm, more dentin was not removed in this Group than in Group 2, instrumented only with the Protaper rotary system¹⁸. Probably the little conicity of these manual instruments, even in a crown-apex preparation, did not open sufficient space to enable the Gates-Glidden burs to work more freely and at greater depth, without being forced into the apical direction, as happened in Group 3. Results contrary to these were shown by Gluskin et al.⁵, Gambill et al.⁶ and Peru et al.²⁰.

In the most apical cut (3 mm) there was statistical difference between Groups 2 and 3 with regard to dentin removal. In Group 3 the apical third was widened more than it was in the Group in which the Protaper system was used as recommended by the manufacturer, probably because the instrument may have come into greater contact with the apical region, free of interferences from the cervical and middle thirds. This allows us to say that the apical preparation with rotary instruments does not necessarily have a smaller diameter in comparison with manual preparations, and a hybrid technique would be a good solution to enable these instruments to work freely within the canal and promote a larger widening of the apical and middle thirds, because the same was also observed in the cut at 5 mm from the apex.

In the more cervical cut at 7 mm from the root apex, Group 1 differed statistically from the others. In Group 1 less removal of dentin was promoted at 7 mm followed by Group 2 and lastly, with the greatest wear, Group 3. These same results were found by Garip & Gunday¹⁸, and they contradict the report made by Gluskin et al.⁵.

There was no difference in the direction of deviation between the heights of cuts, but there was difference between the groups and direction of deviation. Group 1 had a greater tendency to transport towards the distal direction. This is due to the fact that the stainless steel files are rigid, and have difficulty in working in large curvatures, and thus tend to wear more towards the region inside the curvature, rectifying the canal. Group 2 had a greater tendency to transport towards the mesial direction. This is owing to the fact that the NiTi files have a tendency to return to the initial position because of their superelasticity and in the curvature of mandibular molars,

they wear more toward the mesial direction; that is to say, outside of the curvature.

Group 3 showed no tendency towards deviation, conserving the canal in a more centralized form, probably as a result of associating the use of Gates-Glidden burs.

Group 3 was the one in which the preparation was performed in the fastest manner, followed by Group 1, without however, presenting statistical differences between them. Group 2 differed statistically from Group 3 as regards time, thus being the slowest group.

CONCLUSION

According to the methodology used, and based on the results obtained in the present study, it was possible to conclude that the Group in which there was the association

of nickel-titanium rotary instruments with Gates-Glidden burs (pre-widening) the largest quantity of dentin removed and least deviation (transport) was promoted, and the procedure was the fastest.

Collaborators

SCG AMAEDEU was responsible for elaborating the project, conducting the research and writing the article. RS CUNHA was responsible for the statistical analysis, and writing the article. CES BUENO was responsible for preparing the samples, and writing the article. FC ABE was responsible for the bibliographic survey, and writing the article. AS MARTIN guided the research and participated in writing the article.

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