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Preparo dos canais radiculares utilizando o sistema rotatório: sua aplicação no ensino, seus efeitos sobre a biomecânica muscular do endodontista, e sobre a ocorrência de desvios

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Orientador: Prof. Dr. Ricardo Gariba Silva

Ribeirão Preto
2008

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Tese apresentada ao Programa de Pós-Graduação em Odontologia da Universidade de Ribeirão Preto como parte dos requisitos para obtenção do título de Doutor em Odontologia, área de concentração Endodontia.

Orientador: Prof. Dr. Ricardo Gariba Silva

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...não existem verdades definitivamente claras. O que hoje parece indiscutível, novas descobertas do pensamento poderão esclarecer ainda melhor.

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Os objetivos deste trabalho foram: 1) comparar os resultados obtidos entre acadêmicos com diferentes experiências na aprendizagem da endodontia, 2) avaliar os padrões cinemático, cinético e eletromiográfico (EMG) dos principais grupos musculares e 3) avaliar o desvio dos canais radiculares curvos variando o diâmetro cirúrgico, em relação ao preparo do canal radicular realizado com as técnicas rotatória e manual. Dez acadêmicos de quatro instituições de ensino superior (IES) com as seguintes características: A, experiência com a técnica manual no tratamento em molares; B, os alunos não realizavam endodontia em molares; C, os acadêmicos somente realizavam a técnica rotatória e na D, tinham experiência com as técnicas manual e rotatória participaram da primeira pesquisa, em que o método da plataforma com dupla exposição radiográfica foi utilizado para avaliar a direção original do canal e a perda do comprimento de trabalho. No segundo trabalho, para análise dos movimentos, foram fixadas marcas com LEDs no ombro, cotovelo e punho, capturadas por um sistema óptico. Eletrodos de superfície bipolar foram colocados nos músculos estudados. Os sinais da EMG foram normalizados e sincronizados pela contração isométrica voluntária máxima (CIVM) a partir do preparo de canais simulados com instrumentos rotatórios e manuais. Para o terceiro estudo, 27 molares superiores com raízes mésio-vestibulares curvas foram submetidos a três exames tomográficos com o aparelho Cone Beam, um inicial e outros dois após o preparo com os instrumentos 35.02 e 50.02 no CT. O transporte foi determinado pela mensuração da menor distância entre a porção não instrumentada do canal e os aspectos mesial e distal da raiz, comparadas com as mesmas medidas obtidas a partir das imagens após o preparo com o instrumento 35 e 50. Os resultados do primeiro trabalho demonstraram que nenhum desvio foi encontrado no preparo realizado com instrumentos rotatórios; na técnica manual, o índice foi de 78% ($p<0,0001$). A perda do comprimento de trabalho ocorreu em 58% e 22% dos canais instrumentados pela técnica manual e rotatória, respectivamente ($p>0,05$). Todos os alunos despenderam menor tempo de trabalho com os instrumentos rotatórios ($p<0,0001$). Na análise cinemática, os movimentos angulares do punho e cotovelo durante os preparos com ambas as técnicas foram classificados como sendo de risco baixo para o aparecimento dos DORT. Para o ombro, a classificação foi média. Não houve diferença estatisticamente significante quanto os registros cinéticos. Os resultados da EMG mostraram que no grupo muscular deltóide médio e trapézio, a instrumentação rotatória obteve maior índice CIVM do que a manual ($p<0,0001$). Os músculos extensor e flexor radial do carpo e braquiorradial mostraram maior valor percentual quando utilizado o método manual ($p<0,0001$). O índice médio de transporte após o instrumento 35 foi de 0,030 ±0,253 mm e após o 50, 0,057 ±0,317 mm, sem diferenças entre os grupos ($p>0,05$). Verificou-se que, em média, o índice de centralização após o uso do instrumento 35 foi de 0,42 ±0,32 mm e após o 50 os valores encontrados foram 0,54 ±0,29 mm, sem diferenças estatisticamente significantes entre os grupos ($p>0,05$). Diante do exposto, os instrumentos de NiTi obtiveram melhor aplicabilidade no ensino da endodontia, apresentaram maior uniformidade de movimentos e esforço mais homogêneo e não demonstraram desvios significativos com o aumento do diâmetro cirúrgico dos canais radiculares.

The aims of the present work were to: 1) compare the results achieved by graduate students with different levels of experience in endodontic learning, 2) evaluate kinematic, kinetic, and electromyographic (EMG) patterns of the main muscular groups, and 3) assess the deviation of curved root canals with varying surgical diameters in relation to the root canal preparation accomplished with the rotary NiTi and the manual techniques. Ten students from four HE institutions (Higher Education Institution) with the following characteristics were selected: A, students who had experience in manual techniques for the treatment of molars: B, students who had not performed molar endodontic treatments; C, students who had executed only the rotary techniques; and D, students who had experience in the manual and rotary techniques, as they had participated in the first experiment, where the platform method with double radiographic exposure was employed to evaluate the original direction of the root canal and the loss in working length. For the second study, LED marks captured in an optical system were attached to the shoulder, elbow and fist for the analysis of movements. Bipolar surface electrodes were then placed along the muscles under study. The EMG signals were normalized and synchronized through maximum voluntary isometric contraction (MVIC) starting from the preparation of simulated root canals with rotary and manual instruments. For the third study, 27 upper molars with curved mesiovestibular roots were submitted to three computed tomography tests using Cone Beam, one at the beginning, and two more after the preparation with instruments #35.02 and #50.02. The results obtained from the first work asserted that no deviation was found in the preparation executed with rotary instruments; in the manual technique, the deviation was 78% ($p<0,0001$). A loss of working length occurred in 58% and 52% of the root canals instrumented with the manual and the rotary techniques, respectively ($p<0,05$). All students spent less working time utilizing rotary instruments ($p<0,0001$). In the kinematic analysis, the fist and elbow angular movements using both manual and rotary techniques were considered as low risk to cause Lesion from Repetitive Effort (LRE). As to the shoulder, the displacement was classified as medium risk. There were no statistically significant differences regarding the kinetic registrations. The EMG results showed in the medium deltoid and trapeze muscular group the rotary instrumentation produced a LRE rate higher than that occurring with the use of manual instruments ($p<0,0001$). The carpal radial flexor and extensor, and brachioradial muscles showed a higher percent value when the manual method was utilized ($p<0,0001$). The average transportation index after using instrument # 35 was 0,030±0,253mm and after instrument # 50, 0,057±0,29mm, without statistically significant differences. Considering the above results, the rotary NiTi instruments had more applicability in endodontic teaching, provided greater uniformity of movements, and a more homogeneous effort, and did not show significant deviations with the increase in the surgical diameter.

A endodontia, a exemplo das demais ciências, passou por transformações nos últimos tempos, relacionadas ao seu aspecto tecnológico, que se fazem perceptíveis e têm o objetivo de acréscimo qualitativo nos procedimentos endodônticos. Como exemplo, observe-se o advento da instrumentação rotatória dos canais radiculares, com o uso de instrumentos de níquel-titânio (NiTi), que são mais flexíveis, possuem efeito memória de forma e são mais resistentes à torção que aqueles de aço-inoxidável (WALIA et al., 1988).

Com isso, houve diminuição dos principais acidentes encontrados em endodontia durante a instrumentação dos canais radiculares, tais como a redução do desvio, da formação de degrau, da perfuração e do *zip* apical, ou seja, mantêm-se a direção original do canal radicular, principalmente quando se compara a instrumentação rotatória à manual, realizada com instrumentos de aço-inoxidável (THOMPSON; DUMMER, 1997ABCDEF; COLEMAN; SVEC, 1997; KUM et al., 2000; BERGMANS et al., 2002; SCHÄFER, FLOREK, 2003; SOONTAG et al., 2003; SCHÄFER; SCHLINGEMANN, 2003; SHORT et al., 1997; BERTRAND et al., 2001; GARIP; GÜNDAY et al., 2001; PETERS et al., 2001A; PETERS et al., 2001B; TASDEMIR et al., 2005; PERU et al., 2006; SCHIRRMEISTER et al., 2006; LOIZIDES et al., 2006; HARTMANN et al., 2007).

Contudo, é desejável que a ação mecânica dos instrumentos se dê em todas as paredes do canal radicular (SIDNEY; ESTRELA, 1996; SIQUEIRA-JUNIOR et al., 1999; RODIG et al., 2002; TAN; MESSER, 2002). Para isso, é de fundamental importância o alargamento cervical prévio, procedimento que contribui para a determinação do diâmetro anatômico (WU et al., 2002; BARROSO et al., 2005; VANNI et al., 2005), visando a limpeza da porção apical do canal (SIQUEIRA-JÚNIOR, 2005; PÉCORA; CAPELLI, 2006), acesso retilíneo do instrumento até o terço apical, reduzindo as possibilidades de acidentes durante as manobras do preparo biomecânico

(TORABINEJAD, 1994) e permite estabelecer, com maior segurança, o instrumento adequado para o diâmetro cirúrgico (SOUZA; RIBEIRO, 2002).

A literatura demonstra que o preparo biomecânico em canais curvos deve ser realizado com instrumentos rotatórios de Ni-Ti com grande *taper* e mínimo diâmetro cirúrgico apical (ISO *size* 20, 25 ou 30), permitindo a compactação do material obturador com menor chance de extrusão (YOUNG et al., 2007). Apesar de vantagens na fase de obturação, biologicamente, os objetivos podem não ser alcançados, pois, em canais infectados, o preparo apical é ponto crítico e deve ser direcionado para o máximo controle da desinfecção; assim, a literatura também suporta a filosofia de preparos apicais maiores com moderado *taper* (SPÅNGBERG, 2001).

Alguns estudos demonstraram que preparos apicais com limas de diâmetros maiores que 30 reduzem significativamente o número de microrganismos e aumentam os efeitos antissépticos dos irrigantes (SHUPING et al., 2000; KHADEMI et al., 2006). Ou então, que a remoção de 100 à 150 micrometros de dentina das paredes proporcionam a limpeza do canal com a formação do batente apical (WEINE et al., 1972). WU; WESSELINK (1995) recomendaram alargar os canais até o diâmetro 40 para remover maior quantidade de *debris* e promover maior limpeza do terço apical, em função da remoção de maior porção de dentina contaminada.

Entretanto, os limites de segurança para o aumento do diâmetro cirúrgico em canais curvos, quanto às possíveis alterações morfológicas nos canais radiculares, pelos instrumentos rotatórios de NiTi, ainda não foram demonstrados.

Apesar das vantagens comprovadas da instrumentação rotatória mediante o uso de instrumentos de NiTi, a instrumentação manual é ainda o método mais utilizado. Alguns autores responsabilizaram o ensino em relação à adoção ou não da técnica rotatória, sendo de competência do educador o convencimento da eficiência e os benefícios do procedimento mecanizado (PARASHOS; MESSER, 2006). As escolas européias, que adotaram a instrumentação rotatória, concluíram que a incorporação da técnica foi fácil e os estudantes apreciaram ter opção para realizar o preparo biomecânico dos canais radiculares, ao invés de assumir que somente uma técnica manual resolveria todas as situações clínicas. Quando estudantes de graduação prepararam canais curvos com os instrumentos rotatórios de NiTi, foram obtidos resultados com menor formação de desvios e maior conservação de estrutura dentária, comparativamente à instrumentação manual (GLUSKIN et al., 2001; SONNTAG et al., 2003; KFIR et al., 2004; PERU et al., 2006).

A tecnologia, além de melhorar a qualidade do tratamento, deveria proporcionar menor esforço e tempo de trabalho para o profissional, e conseqüente qualidade de vida melhor. Com os instrumentos rotatórios, o tempo despendido torna-se menor para a execução do preparo biomecânico do canal quando comparado ao tempo gasto na instrumentação manual, o que pode demandar menor esforço físico, fato este a que muitos autores referem-se como menor estresse ou fadiga operatória (GLOSSEN et al., 1995; SHORT et al., 1997; GLUSKIN et al., 2001; TASDEMIR et al., 2005). Uma das maneiras para melhorar a qualidade de vida é evitar e/ou prevenir os Distúrbios Osteomusculares Relativos ao Trabalho (DORT), que aumentaram nas últimas décadas e são causas comuns de desqualificações profissionais, com conseqüências financeiras e médicas (ANDERSSON, 1999). Adequar as posições de trabalho e o *design* dos equipamentos e dos instrumentais às regras da ergonomia podem contribuir significativamente para a prevenção dos distúrbios apontados (RÉGIS-FILHO, 1997; GUAY, 1998; PARCELL et al., 2000; OZAWA et al., 2001; SIMMER-BECK et al., 2006).

O avanço da tecnologia com o uso dos instrumentos rotatórios de NiTi permite preparar mecanicamente canais radiculares com menor número de acidentes e melhor centralização do que com o uso de limas manuais de aço-inoxidável (YOUNG et al., 2007). Entretanto, algumas questões relacionadas à técnica de aplicação desta tecnologia, associada aos métodos de ensino, merecem reflexão científica a fim de que o processo educacional seja o mais eficiente possível. Outro aspecto a ser esclarecido é a repercussão do uso dessas técnicas sobre o padrão muscular dos profissionais que a realizam, bem como sobre eventuais desvios do leito original do canal radicular.

O presente estudo teve por objetivo:

1- Comparar os resultados obtidos entre acadêmicos com diferentes experiências na aprendizagem da endodontia, em relação à eficiência do preparo do canal radicular realizado com as técnicas rotatória e manual em canais curvos de molares inferiores, analisando eventuais desvios de instrumentação, perda do comprimento de trabalho e o tempo do preparo.

2- Verificar, *in vivo,* os padrões cinemáticos (ângulos de trabalho das articulações), cinéticos (torque muscular) e eletromiográficos (registro da atividade muscular) em endodontistas durante a realização de preparo de canais simulados empregando técnica de instrumentação rotatória e manual.

3- Avaliar, *ex vivo*, o índice de transporte, o sentido do transporte e o índice de centralização de canais mésio-vestibulares curvos de molares superiores após o preparo biomecânico com instrumentos rotatórios de diferentes diâmetros apicais (35 e 50), por meio da tomografia computadorizada.

[1] Esta tese foi dividida em capítulos, na forma de artigos, que apresentam os resultados obtidos em cada etapa do experimento. Cada capítulo foi formatado de acordo com a revista à qual foi submetido.

CAPÍTULO 1

Rotary instrumentation teaching techniques to graduate students with different learning experiences in endodontics

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Rotary instrumentation teaching techniques to graduate students with different learning experiences in endodontics

Running Title: Rotary instrumentation in graduate students.

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Rotary instrumentation teaching techniques to graduate students with different learning experiences in endodontics

Abstract

The purpose of the present study was to compare the results obtained by students of dentistry from four different higher education institutions (HE) with different learning experiences in endodontics in relation to the efficiency of curved low molar root canal preparation accomplished with mechanical and rotary techniques, assessing occasional instrument deviations, loss of working length, and preparation time. Each student treated two canals, one through the mechanical technique, using GG drills followed by FlexoFile files, and the other, using Endo-Flare files and Hero 642 instruments. The radiographic platform was utilized to assess the maintenance of the original canal direction, possibility of instrument fractures, and loss of working length. No deviation was found in the preparation accomplished with rotary instruments, while a deviation rate of 78% ($p<0,0001$) was encountered when using mechanical instruments. As to the working length, losses of 58% and 22% occurred in the root canals prepared with mechanical and rotary techniques, respectively, without statistically significant differences ($p=0,0014$). During the study, two manual and one rotary files were fractured. All students spent less working time with rotary than with manual instruments ($p<0,0001$).

The instrumentation of root canals with Nickel-Titanium (NiTi) rotary instruments is a resource at professionals’ disposal, since Walia et al. (1) demonstrated that these instruments are more flexible and more resistant to deformation than those made of stainless steel. Various rotary systems have been introduced in the last recent years with advantages over the mechanical methods, in that they present less possibility of deviations, better shaping, reduced instrumentation time, and adequate cleaning of root canals (2).

Scientific evidence led various researchers from different countries to propose the use of rotary instruments in the teaching of dentistry in graduation courses. Parashos, Messer (3) described that the majority of the followers of this new technology learn how to use rotary techniques through dentistry commercial guides. This statement may cause a negative impression when error occurs, thus justifying that teaching is of the utmost importance for the divulgence of rotary instruments safe usage.

In the 1990’s, only one fourth of the schools in Western Europe and Scandinavia and 12% of the North American schools taught rotary instrumentation techniques in graduation courses (4). In France (5), the students of all sixteen dentistry schools were submitted to talks and laboratory courses on rotary systems. 100% of the schools showed interest in implementing such techniques and in 13 of them the students were allowed to apply such techniques under the supervision of qualified professors.

Gluskin et al. (6) compare the effects of root canal preparations of human extracted teeth accomplished by students utilizing both rotary and manual techniques through tomographic superpositions. The students were able to prepare curved canals with NiTi rotary instruments with less transportation, greater preservation of the dental structure, and less working time. Peru et al. (7), achieved similar results through computer microtomography, however, the students selected for the experiment did not have any experience in endodontics.

Hänni et al. (8) assessed the final quality of the treatments, possibility of fractures, and the teaching of rotary techniques to graduation students of the University of Zurich School of Dentistry during the endodontic preclinical and clinical periods. The majority of the students classified the utilization of rotary instruments as positive, considering that the fractures occurred only in their preclinical period, but were not detected in the clinical period.

The intent of this study was to compare the results obtained among the students of dentistry from four Higher Education (HE) institutions in Brazil, who had different experiences in endodontics regarding the efficiency of the preparation of curved, lower molar root canals accomplished with the use of rotary and manual techniques, assessing instrument deformation, loss of working length, and preparation time.

Materials and Methods

The present study utilized 80 extracted human lower molars belonging to the database from four Brazilian Higher Education Institutions (HE), which were stored in a solution of distilled water and 0,1% timol at the time of use. After being washed in running water for 24 hours to remove any trace of the solution, the teeth were radiographed for the assessmente of the curvature extent and radius according to Schneider (9) and Pruett et al. (10), respectively. Mesial roots with curvatures between 20 and 49° and radius between 4 and 10 mm with two distinct mesial canals ending in distinct foramens were selected. The working length (WL) was determined at 1mm beneath the real tooth. After access, the roots were immersed in condensation silicone (Zetaplus, Zhermack, Germany), and mounted on a radiographic platform, which allowed for the samples multiple radiographic exposure.

Ten graduate students of dentistry from four Higher Education Institutions (HE), who were attending endodontics clinic classes and presented the following characteristics were ramdonly selected: in HE A, the selected students had experience only in manual techniques for molars treatment; in HE B, the students did not perform molar endodontic treatments; in HE C, the students performed only rotary techniques; in D, the students had experience in both techniques. The forty students received previous theoretical training in the techniques employed and then, each one instrumented two canals: the first, using the manual technique, in which the crown down preparation was done with Gates-Glidden drills in the cervical third utilizing drill nr. 1 up to the beginning of the curvature, and Nr. 2, 2 cm beneath that level. After this procedure, a 40 FlexoFile file (Dentsply-Maillefer, Ballaigues, Switzerland) juxtaposed to the canal entry was utilized to initiate the manual preparation with oscillatory movements, and in sequential order up to the first file that reached the working length, in accordance with the technique described by Cohen (11). Thereafter, starting from the first file that had reached the working length, and now with filing movements, the apical stop was sequentially enlarged up to #35 file.

The second canal was instrumented, at first with Endoflare (Micro-Mega, Besançon, France) mounted upon an electric motor (Driller ENDO PLUS, Sao Paulo, Brazil) and Dabi Atlante counter-angle (Dabi Atlante, Ribeirao Preto, Brazil) for the cervical preparation. After, Hero 642 #30.06 instrument (Micro-Mega, Besançon, France) was utilized in the 2/3 of the total length up to the beginning of the curvature, followed by 25.05 instrument up to the working length. Instrument 25.05 was also used in or up to 2mm beneath WL. The preparation was finalized with instruments 30.02 and 35.02. A motor torque of 5N and speed of 250 rpm was selected.

Each specimen was previously radiographed on the adjustable platform with a #15 file (Dentsply-Maillefer, Ballaigues, Switzerland), stabilized in the working length. The working length was measured with a digital chronometer (NexxTech, Orbyx Electronics, CA, USA) since the first used instrument, which initiated the preparation up to its end, which was done with instrument # 35. Thereafter, a second radiographic exposure was carried out using the same radiographic film, now with the last instrument utilized in the WL. The irrigating solution utilized was sodium hypochlorite 1% (Dermus Manipulação, Florianopolis, Brazil) and 2ml of that solution was flowed between each instrument utilized.

The platform that allowed for double radiographic exposure of the samples studied was applied to evaluate the maintenance of the original direction of the canal and the loss of working length. After processing, the radiographs were assessed with the aid of the Image Tool program version 3.00 (University of Texas Health Science Center, San Antonio, TX), to investigate the presence or absence of deviations in the root canals original shape, as well as the loss of working length. When present, the angle between instruments 15 and 35 deriving from the apical deviation was assessed with *Angle* tool. As to the loss of working length, if present, the *Distance* tool was used to measure the distance (mm) between the 15 and 35 instrument tips.

The occurrence of instrument fractures and deformations was reported. The instruments with whatever morphological alterations were promptly replaced.

The Variance Analysis for experiments totally casualized with factorial arrangements of the HE Institutions factor levels and Method was conducted in accordance with the research delimitation and the variable type. The significance level established was 5%.

A fracture analysis was not carried out due to the small number of occurrences.

Results

Preliminary results were obtained prior to the experimental procedure, aiming at investigating the homogeneity of the sample regarding root canals angle and radius of curvature.

The average curvature angle of the specimens varied between 32.65 ± 3.85^o, while the average curvature radius varied between 8.81 ± 0.71mm. With regard to the Turkey-Kramer multiple comparison test, the average differences among the groups were considered statistically non significant ($p<0,05$).

Deviations

Deviations were found in 78% of the root canals prepared with the manual method. Average deviations were between 8.938^o ± 8.750^o. No deviations were found in root canals prepared with the rotary method (n=40). The average deviations in the manual group were 7.000° ± 4.876° in HE A, 7.000° ± 4.876° in HE B, 14.900^o ±13.453^o in C, and 6.150^o ±6,028^o in D. (Table 1). There was no statistically significant difference between the rotary and manual methods in all HE institutions ($p<0,001$) when comparing average deviations independent of the methods. There was a statistically significant difference between the rotary and the manual methods in all HE institutions ($p<0,001$) and between the manual method in C and D HE institutions ($p<0,05$).

Loss in working length

Fifty percent of the root canals prepared with the manual method presented WL loss. In the rotary technique, the loss occurred in only 22% of the canals shaped. There was no significant difference among the HE institutions and between the instrumentation methods. The total average loss in working length with the rotary method was -0.275mm ± 0.751mm and -0.700 ± 1.137mm with the manual method (Table 1).

Time taken for preparation

A statistically significant difference was observed with respect to the time spent in the preparation of root canals among the HE institutions, as well as between the instrumentation methods applied. The students from HE B presented a higher time average with both rotary and manual methods. The rotary method presented a total average time (8.012 ± 3.036 minutes) lower than the manual (13.361 ± 5.24 minutes) in all HE institutions assessed with statistically significant differences ($p<0.0001$). There was no statistically significant differences among the HEs with regard to rotary methods. However, as to the manual method, there was a difference between HE B group and the others ($p<0.001$). In He B and C, no statistically significant difference between the application of the rotary and the manual methods was found (Table l). Figure 1 represents the preparation average time (in minutes) spent with the rotary and manual methods at each of the HE institutions evaluated. Two manual files and one rotary instrument were fractured during the experiment.

TABLE 1. Sample distribution based on the deviation of root canals, loss of WL, and instrumentation time (Average values ±standard deviation).

HE	Method	N	Deviation (degrees)	WL loss (mm)	Time (minutes)
A	Manual	10	7.000 ± 4.876	-0.300 ± 0.483	11.16 ± 1.54
	Rotary	10	0.000 ± 0.000	-0.200 ± 0.422	8.05 ± 2.09
B	Manual	10	7.700 ± 6.056	-1.000 ± 1.054	19.32 ± 6.37*

	Rotary	10	0.000 ± 0.000	-0.100 ± 0.568	11.33 ± 4.11
C	Manual	10	14.900 ± 13.453**	-0.800 ± 1.476	9.31 ± 2.48
	Rotary	10	0.000 ± 0.000	-0.700 ± 1.252	6.37 ± 1.36
D	Manual	10	6.150 ± 6.028**	-0.700 ± 1.337	14 ± 4.59
	Rotary	10	0.000 ± 0.000	-0.100 ± 0.316	7.26 ± 2.04
Total	Manual	40	8.938 ± 8.750*	-0.700 ± 1.137	13.361 ± 5.24***
	Rotary	40	0.000 ± 0.000*	-0.275 ± 0.751	8.012 ± 3.036***

* p<0.001; ** p<0.05; *** p<0.0001

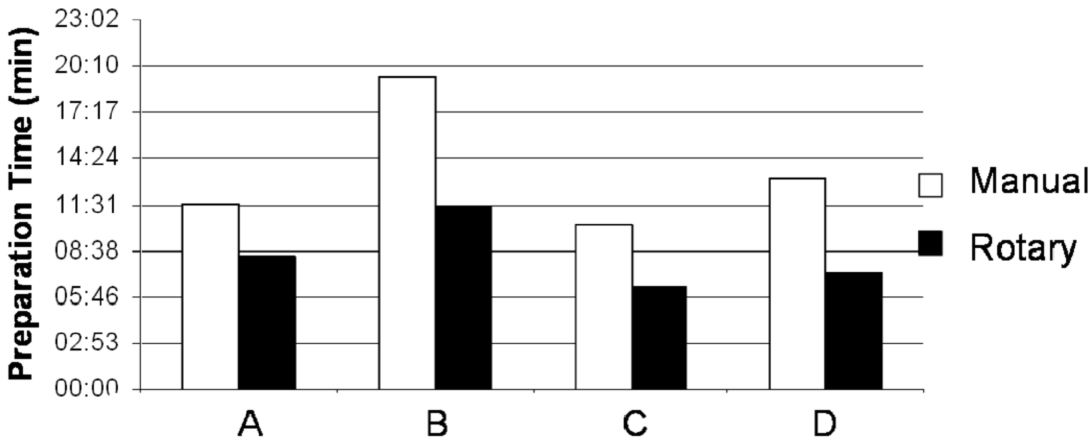

Fig. 1. Interaction graph among the variables: Teaching characteristics in HE institutions A, B, C, and D, concerning root canal preparation time.

Discussion

The utilization of mechanized devices by graduate students during the root canal preparation is still limited, as substantiated through a questionnaire sent to the professors responsible for endodontics teaching in HE institutions all over the country, whereby it was verified that 84.61% of them do not utilize rotary instruments in graduation courses, versus15.38% that do (12).

Nevertheless, various authors from different countries have reported positive experiences owed to the implementation of rotary instruments in graduation teaching courses, and showed upper root canal treatment success rates higher than with the use of stainless-steel manual instrumentation, especially regarding root canals final shape and working time (4-8,13), thus leading us to think about how this technology can be introduced in graduation teaching through actions to obtain effective pedagogical projects. One aspect that should be taken into consideration is whether the graduation student, who has not developed psychomotor ability, can perform good quality biomechanical preparation.

The methodology utilized for the assessment of deviation and loss of WL was the radiographic platform, with the superposition of digital radiographs taken before and after the root canal preparation (14). Although the canal visualization is two-dimensional, the radiographic method is applied for the interpretation of deviations deriving from the instrumentation and is of easy execution (15-18).

There was a concern about the sample selection with regard to the choice of teeth that possessed a root canal with a given angle pattern and radius of curvature that were equally distributed among the experimental groups, which, after a statistical analysis, revealed to be similar. The angle pattern and radius selected are considered severe, given that greater deviations occur in teeth with such characteristics (9,19).

In the present study, no deviation was found when using the rotary technique in root canals, however, this casualty was evidenced in 78% of the root canals prepared with the manual method. Those findings were similar to the ones encountered by Veltry et al. (18) and Iqbal et al. (20), who found deviations derived from the use of NiTi rotary instruments, which were considered irrelevant.

The students with learning characteristics including only the usage of rotary instruments for the preparation of root canals (HE C) produced higher deviation rates when using manual instruments, with statistically significant differences in comparison with the students that received manual training at first, and after rotary training (HE D). This evidence may be justified by the non-development of sufficient ability to perform with manual instrumentation. It is suggested that the learning of the rotary technique does not require previous experience. Nevertheless, Parashos; Messer (3) emphazise that it is important that educators have experience and command of the technique, so as to provide good examples, and are also familiar with instrumentation techniques for a better effectiveness of teaching.

Sonntag et al. (13) corroborate the above information as they reached the conclusion that previous experience in manual preparation did not reflected a higher quality improvement with the use of rotary instruments after the analysis of the final shape of simulated root canals accomplished by graduation students. Nonetheless, a greater number of fractures was found when mechanical tools were utilized, which did not happen with the present work, perhaps due to the usage of simulated root canals, which despite allowing for a high level of reproducibility and standardization, hardly reflect the clinical behavior of the instruments tested (21).

In this research, statistically significant differences between the rotary and manual techniques with regard to the working length were not found. One of the factors for the loss of working length during the preparation of root canals is the occurrence of deviations from the original course. In the present study, this endodontic casualty occurred only with root canals prepared with the manual technique, without influence on the working length. As to the rotary techniques, literature shows evidence of loss or gain of 0.5mm in the working length (22, 23), thus, corroborating the findings of the present study.

Time variation is influenced by the selection of the technique utilized, as well as by the operator and anatomic complexity of the root canal (21). The results of the current study ascertain that the rotary instrumentation required less time than the manual for the execution of the preparations in all HE institutions. However, the students, who did not have endodontic experience in the biomechanical preparation of the molar root canals (HE B), showed a time average higher than the others in their accomplishment with manual techniques. This can be explained by the fact that this was the first contact of the students of that institution with this dental group which, for their anatomic characteristics, tend to hinder all stages of the endodontic treatment. It has also been reported that the decrease in working length by the use of rotary instruments may reduce professionals' fatigue (6).

Conclusion

In the present work, the students from the four HE institutions with different experiences in endodontics teaching showed better results in relation to the parameters evaluated when the rotary technique was applied, i.e., they were able to prepare curved root canals with lesser deviation occurrences and faster than when utilizing the manual technique. Endodontics teaching should comprise the innovations in techniques of root canal instrumentation and be adapted to teach rotary techniques to graduate students, provided that they have qualified human resources and an adequate teaching infrastructure.

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CAPÍTULO 2

Analysis of kinematics, kinetic and electromyographic patterns during the preparation of the root canal with rotary and manual instruments

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Analysis of kinematics, kinetic and electromyographic patterns during the preparation of the root canal with rotary and manual instruments

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Key words: kinematics, kinetics, electromyography, endodontics, manual instruments, rotary instruments.

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Analysis of kinematic, kinetic, and electromyographic patterns during the preparation of the root canal with rotary and manual instruments

Abstract

Purpose This study assessed the muscular activity of eight endodontists during the preparation of simulated root canals applying rotary and manual instrumentation techniques through kinematics, kinetics, and electromyography (EMG).

Methodology The operators prepared one canal with RaCe rotary instruments and another with Flexo-File files. For the analysis of movements, marks with LEDs were fastened to the skull-mandibular articulation, shoulder, elbow, fist, and hand. Bipolar surface electrodes were placed over carpal radial flexor, carpal radial extensor, brachioradial, biceps, triceps, medium deltoid, and upper trapeze muscles. The EMG signals were normalized and calculated to Maximum Voluntary Isometric Contraction (MVIC).

Results In the kinematic analysis, the fist and elbow angular movements during the preparation with both techniques were classified as low risk factors for Work-Related Musculoskeletal Disorders (WMSD). As to the shoulder, the classification was medium-risk. There was no statistically significant difference revealed by the kinetic reports. EMG results showed that the rotary instrumentation in the medium deltoid and trapeze muscular group achieved a MVIC higher than the manual instrumentation (6.14 against 5.44% and 23.20 against 17.79%0, respectively (p<0,0001). The carpal radial flexor and carpal radial extensor, as well as the brachioradial muscles showed a higher percent value with the utilization of the manual method (31.15%, 12.73%, and 16.38%0, respectively (p<0,0001). **Conclusions** The muscle recruitment for the execution of articular movements during the preparation of root canals with the rotary and manual technique is distinct for each one, however, the rotary instrumentation presented a greater uniformity of movements with a more homogeneous effort.

Introduction

The purpose of ergonomics applied to dentistry is to obtain means and systems do decrease physical and mental stress, as well as prevent from diseases related to the practice of dentistry (Djerassi 1971).

Nonetheless, the Work-Related Musculoskeletal Disorders (WMSDs) have been increasing in the last decades and are usual factors for professional disqualifications with financial and medical consequences (Andersson 1999). In surgeon dentists, incorrect postures are one cause of cervical column, neck, and shoulders disorders, besides hands neuropathies, due to the inadequate use of odontological instruments and tools (Szymanska, 2002, Akesson et al. 1995). Alexopoulos et al. (2004) observed that 52% of the Greek dentists, who participated in a research, reported at least one osteomuscular disorder.

Adapting the working positions to the ergonomic rules is one of the measures to prevent WMSD, which can significantly contribute to physical effort reduction, thereby bringing benefits to the daily routine of professional activities (Régis-Filho 1997, Guay 1998).

Another aspect is related to the equipment and instrumental design that are also extremely important for the decrease of muscular fatigue and, consequently, for the reduction of physical and mental stress, as corroborated by Parcell et al. (2000) Posture-comfort stools with arm supports brought better muscle-skeletal benefits when cavitary preparations were accomplished by surgeon-dentists. Simmer-Beck et al. (2006) reported that it is possible to reduce WMSD with ergonomic adaptations to the clinical mirrors. Morse et al. (2003) also disclosed an association between the increase in hours of use of the ultrasound and the increase of tendonitis in the upper extremities during dental hygiene procedures.

Régis-Filho (1997) demonstrated, through the muscular biomechanics expressed by kinematic registrations (articulations working angles), kinetic (muscular torque) and electromyographic (neuromuscular activity graphically represented by the electric activity of the muscle), that endodontics, and more specifically the root canal preparation, is one of the odontological practices that can largely cause some type of WMSD, surpassing exodontic, scratching and curettage, as well as amalgam condensation clinical procedures.

Ozawa et al. (1998) disclosed that in a group of 192 dentists 79.2% had fatigue and pain in the hands and forearms, which occurred with larger intensity during or after the preparation of the root canals. With the intention of reducing those symptoms, endodontic instrument handles manufactured according to ergonomic principles were praised, owing to the fact that larger diameters facilitate the catch of instruments and reduce muscular electromyographic activity (Ozawa et al. 2001).

As many other medical and odontological specializations, endodontics has developed in the last years, thus bringing more precision, smaller possibility of mistakes and casualties, less discomfort to the patients and more speed in the conclusion of the procedures (Young et al. 2007). Some authors have suggested that, besides the foregoing facts, the preparation of root canals using nickel-titanium (NiTi) instruments is associated with the least stress and operating fatigue, especially due to the decrease in working time when compared with manual instrumentation (Short et al., 1997, Gluskin et al., 2001, Tasdemir et al., 2005).

The objective of the present study was to verify, *in vivo*, the results obtained from the kinematic standard records (articulations working angles), kinetics (muscular torque), and electromyographic (muscular activity records) in endodontists during the accomplishment of preparation of simulated root canals applying rotary and manual instrumentation techniques.

Material and Methods

Eight healthy, skillful subjects, four females and four males, with ages between 23 and 39 years participated in this study. All of them were endodontists with clinical experience accumulated during at least two years.

To participate in this experiment, before the collection of data all of them read and signed the term of consent approved by the Research Ethics Committee of the University of Ribeirão Preto - UNAERP.

Each endodontist, seating on odontological stools and in the 12 o'clock position, prepared two simulated canals in resin blocks with diameter corresponding to an instrument 20 and curvatures of 40° (Crinodont o Produtos Odontológicos, Curitiba, Brazil). RaCe 25 rotary Ni-Ti instruments were used (FKG, La Chaux-of-

Fonds, Switzerland), in one of them, and in the other, Flexo-File manual files 25 (Dentsply-Maillefer, Ballaigues, Switzerland). At the moment of use of the above-described instruments, the resin blocks had already been attached to a lathe machine and prepared; in the third cervical, the preparation was accomplished in the manual, as well as in the rotary group with rotary Pre-RaCe instruments 40.10 and 35.08 (FKG, Reads Chaux-de-Fonds, Switzerland). Following the crown down instrumentation philosophy, Flexo-File files 40.02, 35.02 and 30.02 were used for instrumentation in the manual group, and in the rotary, RaCe 25.06 and 25.04 instruments. The operator's purpose was to reach the working length with the 25.02 instruments. Once WL was reached, ten repetitions were accomplished with three seesaw movements each during the collection of muscular registrations that had a duration of 4 seconds each.

For the data collection, electrodes were attached to the operator's body, whose skin had already been depilated and cleaned with alchool to facilitate the adherence of the device and transport of EMG signals. Bipolar surface Electrodes (moeld 2.2L Inc., Boston, MA, USA) were attached to the Carpal Radial Flexor (RF), Carpal Radial Extensor (RE), Brachiradial (BR), Brachial Biceps (BBI), Brachial Triceps (TRI), Medium Deltoid (MD), and Upper Trapeze (UT) muscles. The electrodes were positioned in parallel with the muscular fibers, approximately at two centimeters from each muscle motor point, which was determined after an isometric contraction of each muscular group. The EMG signals were enlarged (x 2000) and recorded by a 200MHz oscilloscope (Gould Classic, Tau) (Fig. 1).

For the analysis of the movements, X, Y, and Z coordinates were recorded utilizing LED (Light Emission Diode) marks fastened to the skull-mandibular articulation, to the shoulder (acrome lateral portion), elbow (lateral epicondyle), fist (lister's turbercle), and hand (third metacarpian head). The emission of those marks infrared signals was captured at a frequency of 100 Hz, by a three-dimensional OPTOTRAK 3020 optical system (Digital Northern Inc., Waterloo, Ontario, CA).

Data processing

The resulting electromyographic signals (EMG) in MiliVolts (mV), and the X, Y, and Z records of those marks were synchronized by an ODAU II – *Optotrak Dates Acquisition Unit II*, and mathematically treated by a *MatLab Code(Math Works Inc.,* versão 6.0) thereafter.

In this code, the EMG signals were rectified, filtrated, and normalized by the maximum voluntary isometric contraction (MVIC) of each subject. The MVIC value was then calculated. The lineal displacement of the marks, the torque generated by the shoulder, elbow, and fist articulations, as well as deviations, angular speed, and acceleration were also calculated. The anthropometric data, center of mass, and moment of inertia were calculated based on the weight and sex of the subject, in accordance with Zatsiorsky's model, modified by De Leva (1996). Grounded on those data, the torque of the articulated shoulder, elbow, and fist were calculated through the inverse dynamics (Schneider et al. 1989) and later normalized to each subject's body weight.

The torque averages (Nm/Kg) for the shoulder, elbow, and fist, as well as the EMG signal percentile values were calculated at intervals of 100 ms each, starting from the beginning of the movement of the fist assessed by measuring the angular displacement.

Data Analysis

The Student's Test *t* for paired samples was applied in accordance with the research plan and type of variable, considering that this study involved a parametric variable and two experimental groups.

For the present analysis, the average of all subjects at each moment of the movement was calculated across intervals of 100 milliseconds (ms), and for each instrumentation method. After, the methods were compared through the paired test, because the same individuals accomplished the instrumentation with both methods. Then, a significance level of 5% was established.

Results

Kinematics (Angular displacement)

The results of the angular displacements are shown in Table 1. It is ascertained that there were differences between the results obtained with the use of Manual and Rotary techniques with regard to the variables of the minimum (Min.), maximum (Max.), and angular extension (AE) techniques for the shoulder, and low and maximum techniques for the fist.

Table 1 Distribution of the sample based on angular displacement between the articulations. Average values expressed in degrees and standard deviation.

Variable	Manual Method (n=8)	Rotary Method (n=8)	Difference Between Averages (SD)	p
Min_shoulder	33.06 (13.15)	38.268 (14.19)	5.209 (4.516)	0.01
Max_shoulder	33.55 (13.25)	38.49 (14.23)	4.944 (4.316)	0.01
AE_shoulder	0.49 (0.29)	0.23 (0.10)	0.264 (0.251)	0.02
Min_elbow	64.53 (9.78)	64.02 (11.24)	0.504 (9.610)	0.89
Max_elbow	65.49 (9.93)	64.57 (11.05)	0.920 (9.835)	0.80
AE_elbow	0.96 (0.65)	0.55 (0.33)	0.417 (0.563)	0.07
Min_fist	11.09 (5.94)	17.37 (10.21)	6.287 (6.134)	0.02

Max_fist	8.92 (4.73)	15.203 (11.02)	6.276 (6.938)	0.04
AE_fist	2.16 (1.78)	2.175 (1.76)	0.011 (2.981)	0.99

Min.: mínimum; Max.: maximum; AE: angular extension.

Kinetics (Muscular Torque)

The results regarding the average of the articulation torques for the shoulder, elbow, and fist (Nm/kg) are shown in Table 2. It can be observed that the instrumentation method did not influence any of the analyzed variables in a statistically significant way. In Figure 1, it is possible to verify that the use of the rotary technique presented a higher uniformity of the results values obtained regarding the torques during the intervals. The manual technique presented high oscillations during the analyzed intervals.

Table 2 Articular torque values for the shoulder, elbow, and fist (Nm/kg) during the movements for the preparation of simulated root canals with manual and rotary instruments. Average values expressed in Nm/kg and standard deviation.

Variable	Manual Method (n=8)	Rotary Method (n=8)	Difference between the averages (SD)	p
Shoulder	-0.0035 (0.1886)	-0.0067 (0.0579)	0.00317 (0.22037)	0.941
Elbow	0.0009 (0.1004)	-0.0026 (0.0361)	0.00348 (0.11869)	0.880
Fist	0.0029 (0.1016)	-0.0010 (0.0356)	0.00394 (0.10902)	0.853

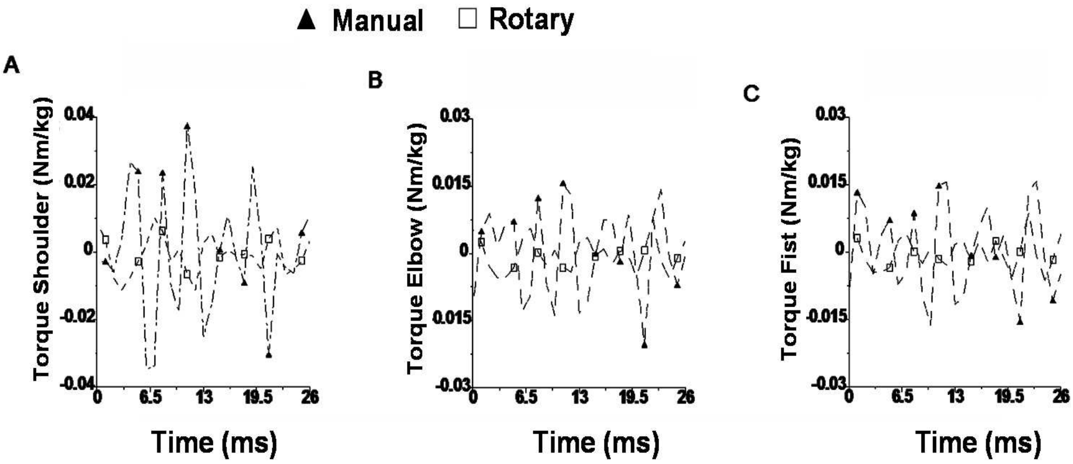

Figure 1 Comparison between the manual and rotary methods according to the muscular torque (Nm/kg) for the shoulder (A), for the elbow (B), and for the fist (C) during the movements for the preparation of simulated root canals with manual and rotary instruments.

Electromyography (% MVIC).

The results concerning the percentile values for the Maximum Voluntary Isometric Contraction (MVIC), in accordance with the electromyographic (EMG) signals (EMG) in milliVolts (mV) rectified, filtrated, and normalized to MVIC are shown in Table 3.

Table 3 Percent values with relation to MVIC of EMG signals during the movements for preparation of simulated root canals with manual and rotary instruments. Average values, (MVIC %) and standard deviation.

Variable	Manual Method (n=8)	Rotary Method (n=8)	Difference between averages (SD)	p

Extensor	31.152 (2.0801)	27.214 (2.8681)	3.938 (2.619)	<0.0001
Flexor	12.737 (0.9689)	8.544 (0.3549)	4.192 (0.916)	<0.0001
Brachioradial	16.385 (1.8337)	12.429 (0.5463)	3.956 (2.104)	<0.0001
Biceps	6.265 (0.3822)	6.546 (0.2874)	-0.281 (0.430)	0.002
Triceps	27.788 (1.4996)	26.966 (1.0224)	0.822 (1.748)	0.022
Deltoid	5.446 (0.1372)	6.146 (0.1586)	-0.700 (0.154)	<0.0001
Trapeze	17.793 (1.1981)	23.208 (0.8846)	-5.415 (1.380)	<0.0001

It could be observed that there was a higher MVIC of the extensor (Figure 2) and carpal radial flexor and brachioradial muscular groups, and lower MVIC of the medium deltoid and upper trapeze muscles when using the manual method. The biceps and brachial triceps muscular groups didn't show statistically significant differences related to the preparation methods.

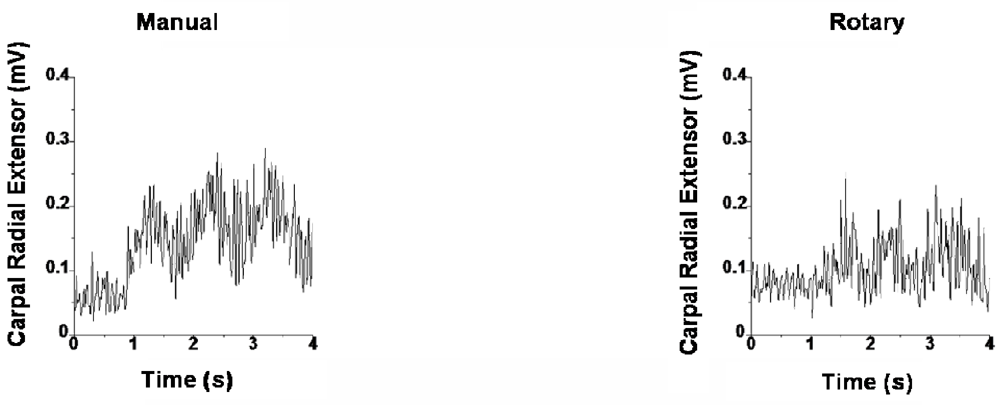

Figure 2 Representation of the electromyographic activity in milliVolts for the carpal radial extensor muscle during the preparation of simulated root canals with manual (MN) and rotary (RT) methods.

Discussion

With the advent of rotary instruments, doctors and endodontists accomplish faster treatments with better final quality of the preparations (Young et al. 2007). Rotary instruments, however, should provide for a smaller deal of physical effort and better life quality among professionals. However, no study has ever compared rotary and manual techniques with regard to the muscular biomechanical aspects.

Branson et al. (l998) corroborated that the angular repetitive movement of the articulation has a limit for the appearance of WMSD and that depending on how many grades such limit is exceeded the risks of WMSD are classified as low, medium, and high. Through the comparative kinematic analysis performed in this study, the resultant of angle displacements for the fist and elbow during the preparations using rotary, as ell as manual instruments was classified as low risk. As to the shoulder, such movements were classified as medium risk.

The muscular torque (Kinetics) represents the muscular action on the articulation added to the passive elements of which it is composed, such as ligaments, tendons, and articulation capsules (Schneider, 1989). Through the results obtained, we can observe that, despite the inexistence of a statistically significant difference between the root canal preparation techniques, the quality analysis of the behavior of torques for the shoulder, elbow, and fist revealed a greater uniformity of values during the intervals during the rotary instrumentation, allowing for a more homogeneous effort without high peaks. On the other hand, the analysis revealed many oscillations in torque behavior in the three articulations, thus suggesting the need for recruitment of a greater number of muscles to generate such torques and execute the task.

We can observe, through the electromyography results, that there has been a difference between the instrumentation techniques in the majority of the muscular groups under analysis. Except for the medium deltoid and trapeze, where the rotary instrumentation achieved a higher EMG level, the majority of the muscular groups showed less effort requirements when using this technique. The explanation for the occurrence of a higher electromyographic activity of some muscles during the manual instrumentation lies in the very fact that there is need for more instrument pickings to execute the task. The fist (radial flexor and extensor) and the elbow position (brachioradial) are fundamental for this execution. In the accomplishment of the procedure with rotary instruments there is a need to hold the equipment, but it is necessary to make less effort to penetrate and work in the interior of the root canals. In this case, the subjects utilized another motor strategy, using the muscles closer to the shoulder.

It is important to emphasize that the continuous activity of both the radial extensor and flexor observed in this study with the manual, as well as of the brachioradial, and of the upper trapeze, and medium deltoid, with the rotary instrumentation, characterize a static contraction. The tension generated by the static contraction may contribute to the alteration of microcirculation in the muscle (Larsson et al. 1999), thus determining the appearance of painful points called "trigger points", characteristic of myofascial pain (Wheeler et al. 2001, Treaster et al. 2006). Myofascial pain causes more muscular tension, giving continuity to bad blood circulation, which yields more pain, thence generating a vicious circle. Myofascial pain affects various regions of the body, however, one of the commonest points is the trapeze muscle region, important for the head posture positioning, as well as for the execution of the scapulae function.

The muscular recruitment for the realization of articular movements for the preparation of root canals with either the rotary or manual techniques are distinct. Nevertheless, the rotary instrument presented less difficulty in modulating the muscular torque in each articulation, thus, presenting a greater uniformity of movements. Concerning the ergonomic aspect, the idea of alternating rotary and manual instrumentation for root canal preparation might contribute to the decrease of WMSD casualties, however, studies in this direction must still be conducted.

Conclusions

Based on the results achieved with this experiment, it appears coherent to us to conclude that, through kinematic analysis, the resultant of the angular displacement for the fist and elbow during root canal preparations with the use of rotary and manual instruments was classified as low risk for the occurrence of WMSD casualties. As to the shoulder, the classification was medium risk. There were no statistically significant differences between the instrumentation techniques with regard to kinetic records, nonetheless, the rotary instrumentation showed more uniformity of movements, allowing for a more homogeneous effort. Concerning electromyography, a higher muscular recruitment was verified in the majority of the muscles assessed, although the motor strategy showed to be distinct for each of the two techniques.

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CAPÍTULO 3

Canal transportation and centring ability of RaCe rotary instruments

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Canal transportation and centring ability of RaCe rotary instruments

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Aim Evaluate, through computerized tomography, canal transportation and centring ability of RaCe rotary instruments after preparation of mesiobuccal root canals in maxillary molar teeth.

Methodology Twenty seven teeth were submitted to three Cone Beam tomographic analyses, one pre-operatively, and two after preparation with file size 35,.02 taper and size 50.,02 taper. Canal transportation and centring ability were measured with reference to the distance between the non-instrumented portion of the root canals and the mesial and distal periphery of the root, compared with images obtained after the preparation with size 35 and 50 instruments.

Results Canal transportation after preparation with the size 35 file was 0.030 ±0.253 mm and after the size 50 file was 0.057 ± 0.317 mm. The centring ratio values after preparation with the size 35 file was 0.42 ± 0.32 and after the size 50 file was 0.54 ± 0.29, with no significant statistical difference between the groups.

Conclusions RaCe instruments allowed the preparation of curved root canals with preparation diameters larger than those normally used with minimal canal transportation and adequate centring ability.

Canal transportation and centring ability of RaCe rotary instruments

Introduction

Root canal preparation with nickel-titanium (NiTi) instruments has been a resource available to dental professionals since Walia *et al*. (1988) demonstrated that these instruments are more flexible, possess shape memory, and are more resistant to torsion than those made of stainless steel. Several rotary systems have been introduced in recent years and research has demonstrated, through the analysis of various parameters, that their advantages over the manual method include a lower incidence of the formation of deviations, better canal shaping and reduced preparation time (Young *et al*. 2007).

However, considering curved root canals, and also, the use of stainless-steel instruments, the limit of flexibility must be respected to avoid deviations in their original direction. Several theories of root canal instrumentation techniques have established that the utilization of size 25 file in the apical region fulfills all prerequisites for root canal cleaning and shaping (Buchanan 2000, Pécora & Capelli 2006). Nevertheless, other studies have demonstrated that apical preparations with FlexoFile files with diameters larger than 30 significantly reduce the number of microorganisms and increase the antiseptic effects of irrigants (Shuping *et al.* 2000, Khademi *et al.* 2006).

Wu & Wesselink (1995) recommended the enlargement of root canals up to diameter size 40 to remove larger amounts of debris and promote a better cleaning of the apical third, through the removal of a larger portion of contaminated dentine. However, it can be observed that in these studies there was no concern regarding the determination of the anatomical diameter, a procedure that should be carried out after preflaring the cervical and middle thirds of the root canal (Wu *et al*. 2002, Vanni *et al*. 2005). The elimination of interferences in these regions allow a more accurate assessment of the real anatomical diameter of the apical constriction and more reliable determination of the preparation diameter, as well as, the appropriate cleaning of the root apical portion (Pécora & Capelli 2006, Siqueira-Júnior 2005).

Current literature supports that the biomechanical preparation of curved root canals should be carried out with large taper NiTi rotary instruments and minimum apical preparation diameter (ISO size 20, 25 or 30), allowing for the compaction of the filling material with a smaller chance of extrusion (Young *et al*. 2007). In spite of advantages in the filling phase, biologically the objectives may not be achieved, since the apical preparation of infected root canals is a critical point and should aim at maximum disinfection control, hence the existing literature also supports the philosophy of the preparation of larger apical size with moderate taper (Shuping *et al.* 2000, Falk & Sedgley 2005).

However, safety limits for NiTi rotary instruments due to possible morphological wearing of root canals have not yet been demonstrated. Apart from Card *et al*. (2002), who used Lightspeed instruments up to diameter 65 in mesial root canals of mandibular molars, reports on preparations of mesiobuccal root canals of maxillary molars with the use of current NiTi rotary systems have not yet appeared in the literature.

The most recent methodologies for deviation analyses are computerized tomography (CT) and computerized microtomography (μCT). Tomography has been widely used as a tool to evaluate the final shape of the root canal. It provides a threedimensional reproduction of the tooth dental, which results in better quality examinations in relation with other techniques. As CT and μCT are non-invasive techniques, they permit the visualization of root canals before, during, and after biomechanical preparation (Bergmans *et al.* 2001, Gluskin *et al.* 2001, Peters *et al.* 2001, Bergmans *et al.* 2003, Hübscher *et al.* 2003).

The objective of the present study was to evaluate, *ex vivo*, canal transportation and centring ability of mesiobuccal maxilary molar root canals after their biomechanical preparation with rotary instruments of different apical diameters (35 and 50), through Cone Beam computerized tomography.

Material and methods

Thirty extracted human maxillary first molars with complete root formation and apical foramina whereby it was possible to introduce a size 15 FlexoFile file (Dentsply-Maillefer, Ballaigues, Switzerland) were selected. The degree of curvature and radius were determined from periapical radiographs, according to Schneider (1971) and Pruett *et al*. (1997), respectively. All teeth were shortened to a length of 18 mm, and had curvatures between 32º and 49º and a radius between 5.5 and 9.9 mm.

For canal target, 3 mm of the palatal and distobuccal roots were separated using a bur and handpiece. The apices of the mesiobuccal roots were then inserted in a rectangular colourless paraffin base (100 X 80 X 3.5mm) mounted on a glass plate with the same dimensions, until all apices could be visualized into three arrays of ten teeth each.

Afterwards, the glass plate was wrapped with a stainless-steel band. Autopolymerized resin (Dencor, Classic Artigos Odontológicos, São Paulo, Brazil) was then poured to fill the whole space until covering the roots, except for the apical portion that was inserted in the paraffin base. After the polymerization, the paraffin and the glass plate were removed and kept in a closed container with 100% humidity (Versiani *et al.* 2008). Figure 1 shows a schematic drawing of the procedure described above.

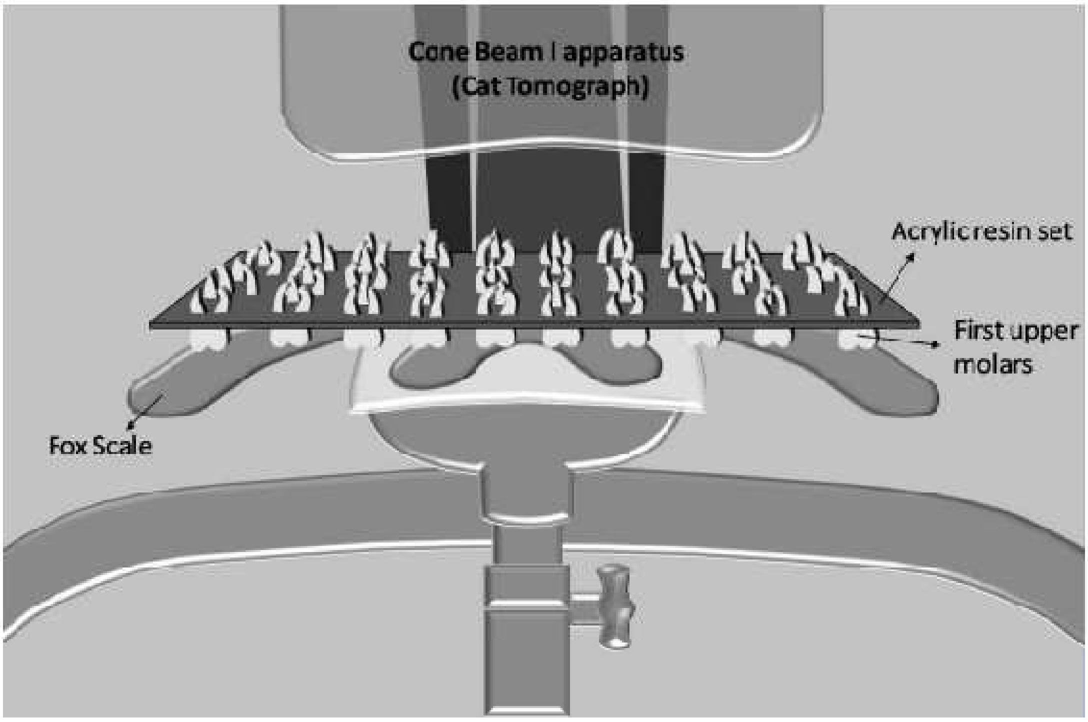

Figure 1. Test sample fitted into a Fox scale with two lateral fittings on each side for its correct positioning adapted to a Cone Beam I - Cat tomography (A and B).

The specimens were fitted into a Fox scale (Bio Art Equipamentos Odontológicos, São Carlos, Brazil) and were adapted to a Cone Beam I - Cat tomograph (Imaging Sciences International, Hatfield, PA, USA). The images were captured in a small-field of view (6 cm) with 40 seconds of exposure time and resolution of 0.2 voxels (maximum resolution), and pixel size of 0.20 mm, totalizing 599 cuts in the axial and frontal directions. Xoran-Cat software was used (Imaging Sciences International, Hatfield, PA, USA) for image reconstruction.

Twenty-seven out of the thirty specimens were selected to comply with the tomography performance field. Three topograms were selected for each assessed specimen. The first corresponded to the area located 3 mm (apical third), the second 6 mm (middle third), and the third 9 mm (cervical third) from the root apex. The control group comprised tomographic images of the mesiobuccal roots, which were measured mesiodistally, from the most mesial to the most distal zone, on the topogram surfaces before root canal instrumentation and after preparation with instruments 35 and 50.

Biomechanical preparation of the root canals was carried out by an experienced operator with NiTi RaCe rotary instruments (FKG, Le Chaux-of-Fonds, Switzerland) placed in a contra-angle handpiece, driven by an Endo-Mate TC electric motor (NSK, Japan). Firstly, the working length (WL) was reached with a size 15 file (Dentsply Maillefer, Ballaigues, Switzerland). The sequence of RaCe instruments used in the present study are shown in Table 1. The instruments were replaced by new ones after every 8 canals. The irrigating solution used was 1% sodium hypochlorite (Dermus Manipulação, Florianópolis, Brazil); 2ml of which were deposited with syringe and NaviTips (Ultradent Products, Inc., South Jordan, UT, USA) in the interval between each instrument used.

Table 1 Sequence of instruments as used in this study with rpm, Torque and penetration depth for each instrument used in this study.

Instruments	rpm	Torque (N.cm)	Penetration depth (mm)
Pre-RaCe 40.10	500	1.5	10
Pre-RaCe 35.08	500	1.5	12
RaCe 30.06	350	1	14

RaCe 25.04	350	0.5	16
RaCe 25.02	350	0.5	17
RaCe 30.02	350	0.5	17
RaCe 35.02	350	0.5	17
RaCe 40.02	350	1	17
RaCe 45.02	350	1	17
RaCe 50.02	350	1	17

The first preparation stage of the root canals was achieved with size 35,.02 taper instruments at WL. The test samples were then submitted to tomography examination following the same protocol described above. After this procedure, the root canals were prepared up to a Race 50.02 instrument, when another tomography examination was carried out.

After capturing the Cone Beam tomograph in pdf format with Adobe Acrobat 7.0 software (Adobe Systems Incorporated, San José, CA, USA), the images were edited with CS3 Photoshop software (Adobe Systems Inc., USA) and recorded in JPEG format.

Evaluation of canal transportation

To compare the degree of canal transportation, a technique developed by Gambill *et al.* (1996) was used. The canal transportation corresponds to the deviation of the axis (in millimeters) after the instrumentation, compared with the control group. The values were obtained from the measurement of the shortest distance of the non-instrumented portion of the root canal and the mesial and distal aspects of the root, compared to the same measurements obtained from the root canal images after preparation with instruments 35 and 50. The measurement of the real distance of the points of interest for obtainment of canal transportation was carried out with the tool called ‘Distance’ of UTHSCSA Image

Tool 3.0 software for Windows (University of Texas Science Center, San Antonio, TX, USA). The following formula was used for the calculation of transportation:

$$(M1 - M2) - (D1 - D2)$$

The following formula was then used for the preparation with instrument 50.

$$(M1 - M3) - (D1 - D3)$$

The symbols correspond to the shortest distance between the root mesial aspect and the mesial portion of the non-instrumented canal (M1), the root mesial aspect and the mesial portion of the instrumented canal after preparation with file size 35 (M2) and after file size 50 (M3), as well as to the root distal aspect and the distal portion of the non-instrumented root canal (D1), the root distal aspect and the distal portion of the canal instrumented after file sizes 35 (D2) and 50 (D3) (Fig. 2). The transportation direction was assessed from the results obtained for the canal transportation of each specimen. A negative result indicated transportation toward the distal portion, a positive result toward the mesial portion, and null, the absence of transportation.

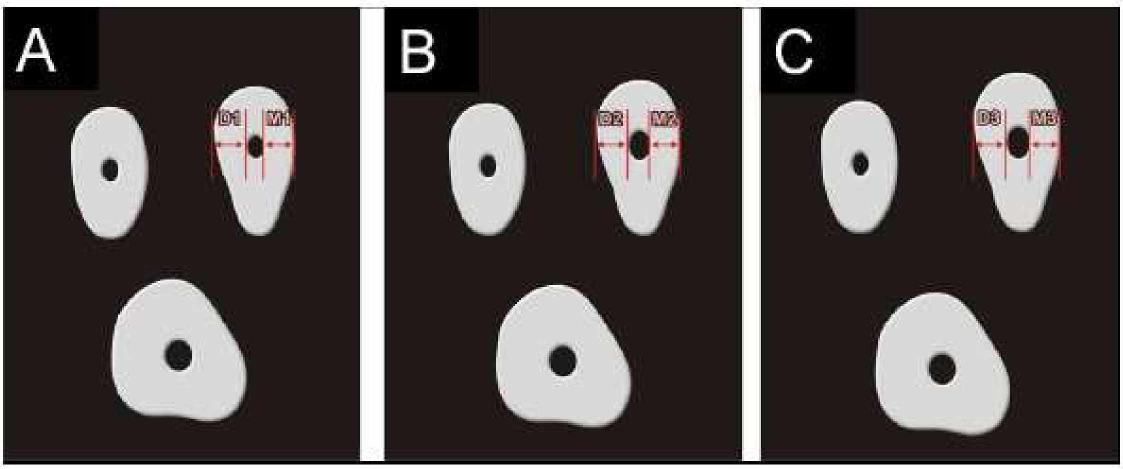

Figure 2. Topograms of the middle third, where D and M correspond to the shortest distance between the root mesial and distal aspect, respectively, in relation to the non-instrumented root canal (A), after instrument 35 (B), and after instrument 50 (C).

Evaluation of centring ability

According to Gambill *et al.* (1996) the mean centring ratio indicates the ability of the instrument to stay centred in the canal. This ratio was calculated for each section using the following ratio:

M1 – M2 / D1 – D2 or D1 – D2 / M1 – M2

The example described above establishes centring ratio between the initial tomography cut and after the use of instrument 35. The centring ratio after the use of instrument 50 was performed according to the following formula:

M1 – M3 / D1 – D3 or D1 – D3 / M1 – M3

The formula was chosen according to the numbered value that should always be the lowest of the results obtained through the difference. A result of 1 (one) indicated perfect centralization capacity and the closer the result to zero the worse the ability of the instrument to keep itself in the canal central axis. The results were submitted to statistical analysis.

The data were submitted to preliminary tests with the purpose of verifying the normality of the sampling distribution. As the tested sample presented normal distribution, parametric statistical tests were applied, with the aid of the GraphPad InStat *software* (GraphPad Software Inc, San Diego, CA, USA), together with the Variance Analysis to verify the existence of statistically significant differences between the averages, and with the complementary Tukey test to verify the difference among the groups, with a significance level of 5%.

Results

The average curvature angle of the specimens varied between 38.7 º ±5.5 º, while the variation of the average curvature radius was 8.08 ±1.3mm. The sample was considered homogeneous according to the one sample *t* test ($p > 0.0001$).

The values for the average canal transportation after the use of file 35 in the apical, middle and cervical thirds were - 0.038 ± 0.215, 0.057 ± 0.243 and 0.072 ± 0.301 mm, respectively. After the use of instrument 50, the index was 0.021 ± 0.303 in the third apical, 0.065 ± 0.320 in the middle third, and 0.085 ± 0.328 in the cervical third, with no statistically significant difference between the groups (p> 0.05). The total canal transportation after the use of instrument 35 was 0.030 ±0.253 and after the use of instrument 50 was 0.057 ±0.317mm, with no statistical difference between the groups (p> 0,05). The results are shown in Figure 3.

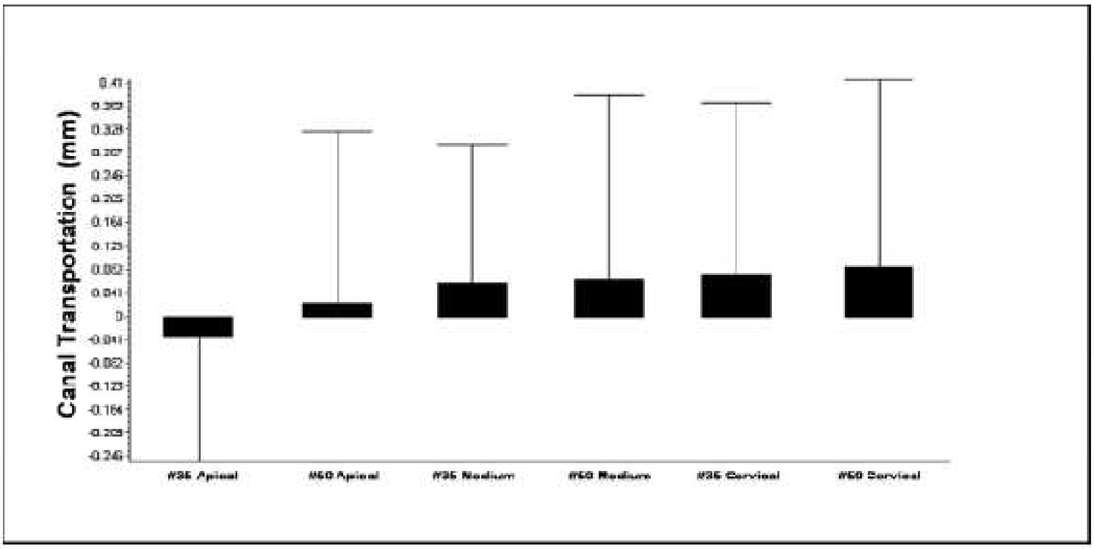

Figure 3. . Average of canal transportation (in millimeters) after the use of instruments 35 and 50 in the apical, middle, and cervical thirds of the root canals.

It was observed that after the use of instrument 35 the average centring ratio values were 0.45 ± 0.32, 0.43 ± 0.39 and 0.39 ± 0.25 for the apical, middle, and cervical thirds, respectively. After the use of instrument 50, the values were 0.64 ± 0.24 in the apical third, 0.45 ± 0.35 in the middle third, and 0.54 ± 0.28 in the cervical third, with no statistically significant difference between the thirds (p> 0.05). The total mean centring ratio after the use of instrument 35 was 0.42 ±0.32, and after instrument 50 was 0.54 ±0.29, with no statistical difference between the groups (p> 0.05). The results of the centring ratio average are shown in Figure 4.

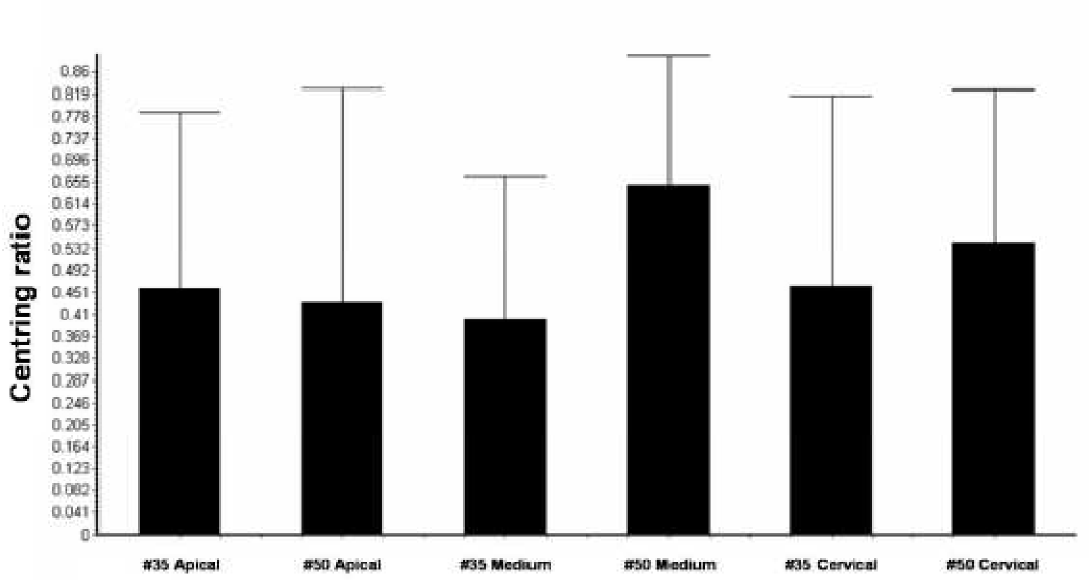

Figure 4. Centring ratio after the use of instruments 35 and 50 in the apical, middle, and cervical thirds of the root canals.

The results demonstrate that the increase in the file diameter did not influence the capacity of the instrument to remain centralized inside the root canals.

Discussion

The introduction of NiTi alloy allowed the manufacture of instruments that were capable of preparing curved root canals with safety, less deviations, and in less working time, in comparison with instruments made of stainless-steel (Young *et al.* 2007).

Several methodologies have been used in order to evaluate the final shape of root canal preparations such as the Serial Sectioning Technique (Bramante *et al.* 1987) and optical microscopy (Jung *et al.* 2005). However, when using these methods, part of the specimen structure is lost, since there is a need to cut the tooth before the postoperative evaluation. The use of simulated root canals in resin blocks (Thompson *et al.* 1997), in spite of allowing for a high degree of reproducibility and standardization, does not reflect the clinical behaviour of the instruments, due to the difference in hardness between the resin and dentine. Radiographic evaluation (Sydney *et al*. 1991), however, is not destructive, but only allows for two-dimensional evaluation of the root canal.

Recently, Cone Beam volumetric tomography has been adapted for dentistry and compared to medical tomography it leads to increased precision and resolution, as well as reducing the image acquisition time and, as a consequence, the time of exposure to radiation. Another advantage of this method is that there is no destruction of the sample (Arnheiter *et al*. 2006).

The selection of teeth with a similar root canal angle and radius of curvature was important and were found to be statistically homogeneous. The angles and radius selected were considered severe, as more deviations occur in teeth with these characteristics (Schneider 1971, Lopes *et al.* 1998).

Preparations to the WL were carried out with the instrument with a size 35 instrument, and then sequentially up to a size 50 instrument. The results demonstrated there was no statistically significant difference between the thirds of the canals analyzed with regard to the average of canal transportation, which indicates safety in the preparation of root canals with rotary instruments with diameters larger than those normally used. However, more specifically in the apical third, the taper of these instruments was .02, i.e. the NiTi instrument flexibility was maintained, a fact that would probably not occur if the taper were larger in the apical portion. Another factor that could contribute to the preparations remaining centralized and maintaining the original direction of the root canals could lie in the design of the active part of the RaCe instruments, with alternating cutting edges and are claimed to prevent the instrument from screwing into the root canal thus reducing intraoperative torque values (Paqué *et al.* 2005, Schäfer & Vlassis 2004).

The direction of transportation in the apical area is mainly related to the external curvature (Tasdemir *et al.* 2005, Merrett *et al.* 2006), although some studies have demonstrated that it can occur in several directions. This indicates that the occurrence of deviations can depend on factors other than the curvature, such as the instrument design, the physical properties of the alloy, and the technical instrumentation (Kosa *et al.* 1999, Peters *et al.* 2001). Bergmans *et al*. (2001) reported that at one millimeter from the root apex the direction of transportation was toward the distal portion in maxillary molar mesiovestibular canals, on the internal side of the curvature. In this study, except for the extended apical third with the use of instrument 35 (- 0.038 ± 0.215), there was a greater tendency of average transportation to the mesial direction (external side of the curvature) in the other thirds, an occurrence that was also detected in the apical third extended up to instrument 50. The probable reason for the transportation to the inner side of the curvature with the use of size 35 instrument lies in the hypothesis that superelastic instruments follow the canal curvature (Garip & Günday 2001) and depend on factors such as the instrument design, the physical properties of the alloy, and the technical instrumentation (Kosa *et al.* 1999, Peters *et al.* 2001).

A limited canal transportation may be related to the good centralization capacity of the instruments in the root canal, mainly in the apical third, which had a better centring ratio compared to the middle and cervical thirds which were influenced by the instruments with a larger taper (.10, .08 and .06). Therefore, besides the previous cervical enlargement and the metallic alloy used, the factors which allowed RaCe instruments to maintain the original direction of curved root canals and remain centralized in their interior were the design and the smallest taper of the instruments used in the apical third (Paqué *et al.* 2005).

In cases where 35 to 40% of the walls of maxillary molar buccal root canals remain untouched when enlarged up to instrument 40 along the WL (Peters *et al.* 2001), it is may be advisable to enlarge the root canals up to the preparation diameters frequently utilized, with advantages such as the better cleaning of oval canals or the use in canals where the shape does not allow for the action of the instrument on all walls (Rödig *et al*. 2002, Albrecht *et al.* 2004). It is possible that when the root canals were enlarged up to file size 35 some parts of the walls were not touched. However, when the size 50 instrument was used, more canal walls were prepared, which contributed to better centring. Such enlargement also favours the removal of a larger amount of pulpal remains, dentine and microorganisms, due to the larger volume of irrigating solution that can act in this area (Khademi *et al.* 2006, Peters & Barbakow 2000), thus contributing to a better disinfection of the root canals (Siqueira-Júnior 2005, Falk & Sedgley 2005).

Conclusions

Size 35,.02 taper and 50,.02 taper RaCe instruments allowed the preparation of curved root canals with preparation diameters larger than those normally used and did not influence in canal transportation and the ability of the instrument to remain centralized inside the root canals.

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Figure Legends

Figure 1. Test sample fitted into a Fox scale with two lateral fittings on each side for its correct positioning adapted to a Cone Beam I - Cat tomography (A and B).

Figure 2. Topograms of the middle third, where D and M correspond to the shortest distance between the root mesial and distal aspect, respectively, in relation to the non-instrumented root canal (A), after instrument 35 (B), and after instrument 50 (C).

Figure 3. . Average of canal transportation (in millimeters) after the use of instruments 35 and 50 in the apical, middle, and cervical thirds of the root canals.

Figure 4. Centring ratio after the use of instruments 35 and 50 in the apical, middle, and cervical thirds of the root canals.

O emprego de dispositivos mecanizados por alunos de graduação durante o preparo dos canais radiculares ainda é limitado, conforme constatado por meio de questionário enviado para os professores responsáveis pelas disciplinas de endodontia das IES do país, que 84,61% delas não utilizam instrumentos rotatórios na graduação e 15,38%, responderam que utilizam (LIMONGE et al., 2006).

Entretanto, vários autores de diferentes países, relataram a experiência positiva da introdução dos instrumentos rotatórios no ensino da endodontia na graduação, com índices de sucesso no tratamento dos canais radiculares superiores à instrumentação manual em aço-inoxidável, principalmente quanto à forma final dos canais e o tempo de trabalho (QUALTROUGH; PIDDOCK, 1999; GLUSKIN et al., 2001; HÄNNI et al., 2003; SONNTAG et al., 2003; ARBAB-CHIRANI; VULCAIN, 2004; PERU et al., 2006), o que nos leva a refletir como esta tecnologia pode ser incluída no ensino da graduação, por meio de ações no projeto pedagógico.

Um aspecto que deve ser levado em consideração é se o aluno de graduação, que não apresenta a habilidade psicomotora desenvolvida, consegue realizar o preparo biomecânico com qualidade. Além disso, a adoção de novos parâmetros no ensino de graduação demanda debates, discussões e reflexões relacionadas aos fatores facilitadores e que eventualmente possam ser motivo de dificuldade para que os discentes absorvam essa realidade que lhes é proposta, tais como a possibilidade de que eles tenham mais opções terapêuticas diante dos casos concretos, infra-estrutura disponível para o ensino, as questões financeiras e o conhecimento e uso da técnica rotatória por parte dos professores que executam tratamentos endodônticos, de modo a assegurar a eficiência do processo de ensino/aprendizado (HÄNNY et al., 2003).

Porém, deve-se refletir que, conforme afirmado por KFIR et al. (2003), a adoção da técnica e de instrumentos rotatórios em cursos de graduação de Odontologia requer tempo e experiência, e as escolas deveriam aceitar os desafios de oferecer aos estudantes de graduação a possibilidade de realizarem preparos dos canais radiculares com maior eficiência e segurança.

Desse modo, o estudo da eficiência do preparo do canal radicular realizado com as técnicas rotatória e manual em canais curvos de molares inferiores, analisando eventuais desvios de instrumentação, perda do comprimento de trabalho e o tempo do preparo, é plenamente justificável, uma vez que permite aferir o resultado do tratamento endodôntico realizado pelo corpo discente em relação aos parâmetros apontados, que servem como indicadores indiretos da qualidade de apreensão do conhecimento da técnica.

Os resultados do presente estudo encorajam a adoção do ensino da técnica rotatória nos cursos de graduação, já que nenhum desvio foi encontrado nos canais quando se usou a técnica rotatória, entretanto, esse acidente foi evidenciado em 78% dos canais preparados pelo método manual. Esses achados foram semelhantes aos de VELTRI et al. (2005) e aos de IQBAL et al. (2003), que encontraram desvios considerados irrelevantes com instrumentos rotatórios de NiTi. Entretanto, PARASHOS; MESSER (2006) ressaltam que é importante que os educadores tenham experiência e domínio da técnica, para que sejam bons exemplos, e também tenham familiaridade com as técnicas de instrumentação para melhor eficácia do ensino.

Ainda mais, em associação à segurança do ensino da técnica em questão, está o fato de o uso dos instrumentos rotatórios permitir a redução do tempo de preparo dos canais radiculares, o que, por hipótese, reduz a fadiga do operador e traz conforto ao paciente, que suporta sessões de tratamento mais curtas. Tais hipóteses sugerem maior conforto e bem-estar para os profissionais (SHORT et al., 1997;

GLUSKIN et al., 2001; TASDEMIR et al., 2005), e teriam repercussão sobre a biomecânica muscular, que seria afetada pela redução do esforço físico despendido durante a terapia endodôntica. Tendo em vista a lacuna desse conhecimento na literatura, justificada está a segunda pesquisa realizada.

Porém, a expectativa de que a instrumentação rotatória trouxesse ganhos no que se relaciona ao padrão muscular dos operadores não se confirmou tendo em vista o fato de a análise da cinemática muscular, a resultante dos ângulos de deslocamento para o punho e o cotovelo durante os preparos com o uso dos instrumentos rotatórios terem determinado a classificação das manobras operatórias como sendo de baixo risco para o aparecimento dos DORT, da mesma forma como ocorreu com a técnica manual. Em relação ao ombro, os riscos foram classificados como médio para ambas as técnicas.

Os resultados acima indicados devem ser confrontados com os de REGIS-FILHO (1997), que avaliou somente a instrumentação manual e encontrou resultados altos para o aparecimento dos DORT no punho e ombro. Deve ser feita a ressalva de que o pesquisador, na sua análise, abrangeu todas as manobras relacionadas à técnica endodôntica, e não apenas às manobras relacionadas à técnica de instrumentação.

Embora a realização da técnica mecanizada pelos endodontistas não lhes tenha trazido ganhos relacionados à cinemática e cinética muscular, uma vez que foram semelhantes àquelas verificadas com a instrumentação manual, as estratégias motoras para as diferentes técnicas de instrumentação demonstraram padrões desiguais, com melhor uniformidade dos movimentos e esforço mais homogêneo, sem grandes picos, para a rotatória, e maior oscilação no comportamento dos torques nas três articulações na manual, acompanhada de maior atividade eletromiográfica em alguns grupos musculares.

Em síntese, os resultados encontrados quando se utilizou a técnica rotatória, embora não possam ser definitivamente caracterizados como melhoria de padrão ergonômico, não afetam negativamente os operadores de modo a desencorajar a prática avaliada. Sem repercussões musculares importantes, a adoção da técnica rotatória deve ser embasada levando-se em consideração outros fatores, além das repercussões musculares que ela ocasiona.

Outro aspecto do presente estudo refere-se aos debates existentes na literatura relacionados ao diâmetro cirúrgico em canais curvos, no nível do batente apical, correlacionando-o à limpeza e à segurança da manobra, vinculada à flexibilidade dos instrumentos utilizados para tal finalidade. Canais mais alargados possuem menos microorganismos (CARD et al., 2002; ROLLISON et al., 2002; FALK; SEDGLEY, 2004) e são mais fáceis de serem obturados (SPÅNGBERG, 2001), mas estão sujeitos à ocorrência de desvios do seu leito anatômico.

Os instrumentos rotatórios de NiTi do sistema Race, usados nesta pesquisa, permitiram o preparo dos canais mésio-vestibulares curvos de molares superiores com rapidez e pouco desvio, tanto com diâmetros cirúrgicos equivalentes ao instrumento 35 .02 como também ao 50 .02., o que indica segurança no preparo de canais radiculares com instrumentos rotatórios de diâmetros maiores que os normalmente utilizados, entretanto, mais especificamente no terço apical, o *taper* desses instrumentos foi .02, ou seja, mantiveram a flexibilidade dos instrumentos de NiTi, fato que provavelmente não ocorreria se o *taper* fosse maior na porção apical. Outro fator que pode contribuir para que os preparos ficassem centralizados e com manutenção da direção original dos canais poderia recair sobre o desenho da parte ativa dos instrumentos Race, com desenho anti-rosqueamento devido à variação dos ângulos helicoidais e com vantagem de operar em um torque extremamente baixo (SCHÄFER; VLASSIS, 2004; PAQUÉ et al., 2005).

O sentido do transporte na região apical é relacionado principalmente em direção à parte externa da curvatura (TASDEMIR et al., 2005), embora alguns trabalhos tenham demonstrado que pode acontecer em variadas direções. Isso indica que a ocorrência de desvios pode ser dependente de outros fatores além da curvatura, como o *design* do instrumento, as propriedades físicas da liga e a técnica de instrumentação (KOSA et al., 1999; PETERS et al., 2001). BERGMANS et al. (2001) reportaram que, a um milímetro aquém do vértice radicular, o sentido do transporte foi direcionado para distal em canais mésio-vestibulares de molares superiores, no lado interno da curvatura. Neste trabalho, com exceção do terço apical dilatado com o uso do instrumento 35 (- 0,038 ± 0,215), nos demais terços houve maior tendência de transporte médio para o sentido mesial (lado externo da curvatura), ocorrência detectada também no terço apical dilatado até o instrumento 50.

Os resultados do baixo índice de transporte podem estar relacionados à boa capacidade de centralização dos instrumentos no canal radicular, principalmente no terço apical, que apresentou melhor índice de centralização, comparado aos terços médio e cervical que, sofreram maiores influências dos instrumentos de maior *taper* (.10, .08 e .06). Portanto, os fatores relacionados para que os instrumentos Race mantivessem a direção original de canais radiculares curvos e ficassem centralizados no seu interior foram, além do alargamento cervical prévio e a liga metálica usada, o *design* e o menor *taper* dos instrumentos que atuaram no terço apical (PAQUÉ et al., 2005).

Se 35 a 40% das paredes de canais vestibulares de molares superiores permanecem intocadas quando se amplia até o instrumento 40 no CT (PETERS et al., 2001), seria conveniente então, ampliar os canais radiculares até diâmetros cirúrgicos maiores que os freqüentemente utilizados, com vantagens que podem ser atribuídas a melhor limpeza de canais achatados ou naqueles em que a forma não permite a ação do instrumento em todas as suas paredes (RÖDIG et al., 2002; ALBRECHT et al., 2004) ainda, favorece a remoção de maior quantidade de remanescentes pulpares, dentina e microrganismos, pois maior volume de solução irrigante pode atuar nesta região (PETERS; BARBAKOW, 2000; KHADEMI et al., 2006) contribuindo para melhor desinfecção dos canais (FALK; SEDGLEY et al., 2005; SIQUEIRA-JÚNIOR, 2005).

Outra vantagem de se alargar canais curvos até o diâmetro 50 no CT pode estar relacionada à maior facilidade de obturação, independentemente da técnica escolhida para tal finalidade (SPÅNGBERG, 2001). A literatura demonstra que o maior alargamento apical contribui para melhor limpeza e desinfecção dos canais radiculares, que, somados aos resultados do presente estudo, onde foi possível preparar canais curvos com diâmetros cirúrgicos maiores que os usuais, se revela conduta segura e possível para ser aplicada em protocolos clínicos. Entretanto, estudos epidemiológicos são necessários para estabelecer a relação definitiva entre o maior alargamento e sucesso clínico.

Em última análise, o ensino da técnica de instrumentação rotatória para os alunos de graduação em Odontologia é uma realidade possível que, embora não tenha repercussões musculares vantajosas em relação à técnica manual, constitui-se em procedimento seguro, rápido e eficiente, o que encoraja a sua adoção pelas IES.

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DETALHAMENTO DA METODOLOGIA

CAPÍTULO 1

Ensino da técnica de instrumentação rotatória para alunos de graduação com diferentes experiências na aprendizagem da endodontia

Este estudo utilizou 80 molares inferiores humanos extraídos, pertencentes ao banco de dentes de quatro Instituições de Ensino Superior (IES) do Brasil que estavam armazenados em solução de timol 0,1% até o momento do uso. Após a lavagem em água corrente por 24 horas a fim de se remover qualquer traço da solução, os dentes foram radiografados para verificar o grau e o raio de curvatura de acordo com SCHNEIDER (1971) e PRUETT et al. (1997), respectivamente (Figura 1.1). Foram selecionadas raízes mesiais com curvaturas entre 20 e 49 ^{o} e raios entre 4 e 10 mm e que tivessem dois canais mesiais que terminassem em forames distintos. O comprimento de trabalho (CT) foi determinado a 1 mm aquém do real do dente. Após o acesso, as raízes foram incluídas em silicona de condensação (Zetaplus, Zhermack, Alemanha), e montados em uma plataforma radiográfica o que permitiu a múltipla exposição radiográfica das amostras (Figura 1.2).

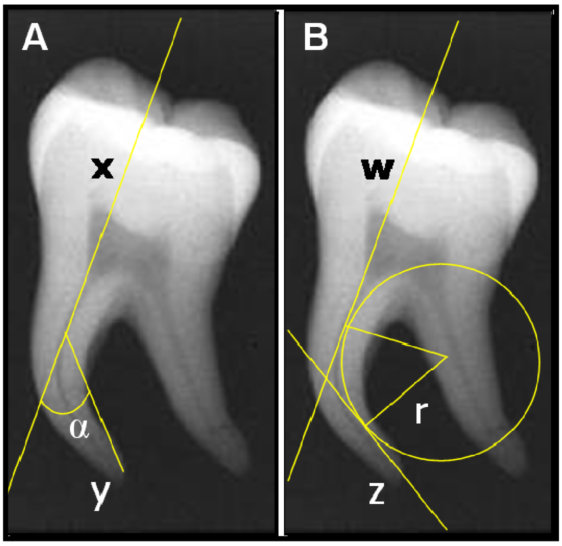

Figura 1.1. Esquema utilizando radiografia da raiz mesial do molar inferior onde foram traçados: **A)** o ângulo de curvatura (α) e **B)** o raio de curvatura (r).

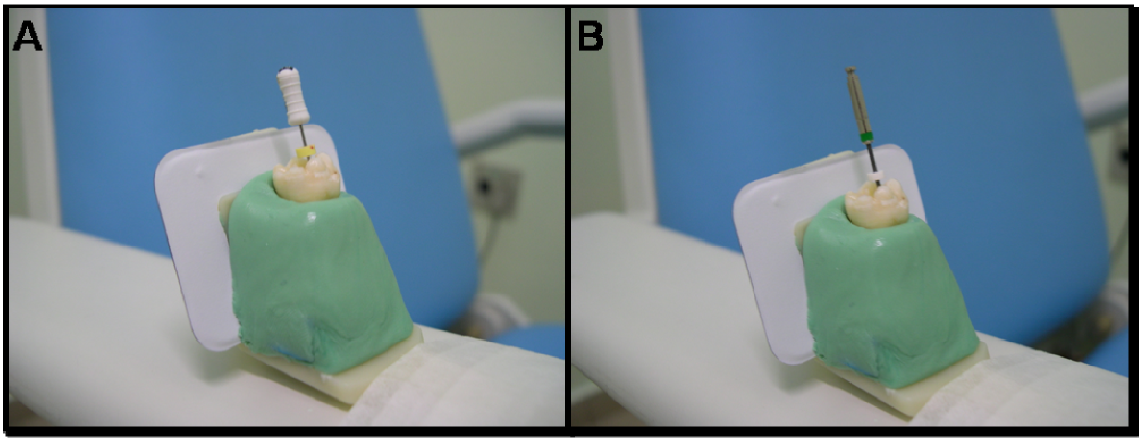

Figura 1.2. Espécime incluído em silicona de condensação e montado na plataforma radiográfica com instrumento inicial **(A)** e final **(B).**

Foram selecionados, aleatoriamente, dez alunos de graduação de odontologia, que cursavam a disciplina clínica de endodontia, de quatro IES com as seguintes características: na IES A, os acadêmicos selecionados tinham experiência somente com a técnica manual no tratamento em molares; na IES B, os alunos não realizavam endodontia em molares; na IES C, os acadêmicos somente realizavam a técnica rotatória e na D, os alunos tinham experiência com as duas técnicas. Os quarenta alunos receberam treinamento teórico prévio sobre as técnicas empregadas e, após, cada um instrumentou dois canais, sendo um pela manual em que o preparo coroa-ápice foi realizado utilizando as brocas de Gates - Glidden no terço cervical, utilizando a nº 1 até o início da curvatura e a nº 2 a 2 mm aquém deste nível. Após este procedimento, utilizou-se uma lima Flexo-file 40 (Dentsply-Maillefer, Ballaigues, Suíça) justaposta à entrada do canal para iniciar o preparo manual com movimentos oscilatórios e, em seqüência, até a primeira lima que alcançasse o comprimento de trabalho de acordo com a técnica descrita por Sydney (2002). Então, a partir da primeira lima que tivesse alcançado o comprimento de trabalho e agora com movimentos de limagem o batente apical foi ampliado sequencialmente até o instrumento de diâmetro 35.

O outro canal foi instrumentado iniciando com o instrumento Endoflare (Micro-Mega, Besancon, França) montado em motor elétrico (Driller ENDO PLUS, São Paulo, Brasil) e contra-ângulo Dabi Atlante (Dabi Atlante, Ribeirão Preto, Brasil) para o preparo cervical. Então o instrumento Hero 642 30 .06 (Micro-Mega, Besancon, França) foi utilizado nos 2/3 do comprimento total ou até o início da curvatura, seguido pelo 25.02 até o comprimento de trabalho. O instrumento 25.04 foi usado também no CT ou até dois milímetros aquém. O preparo foi finalizado com os instrumentos 30.02 e 35.02 (Figura 1.3). O torque selecionado foi de 5N e a velocidade de 250 RPM.

Figura 1.3. Intrumento EndoFlare (primeiro da esquerda para direita) e seqüência de instrumentos Hero 642, usados para o preparo dos canais pela técnica rotatória.

Cada espécime foi previamente radiografado na plataforma posicionadora, com uma lima 15 (Dentsply-Maillefer, Ballaigues, Suíça) estabilizada no CT. O tempo de trabalho foi monitorado com o auxílio de um cronômetro digital (NexxTech, Orbyx Eletronics, CA, EUA) desde o uso da primeiro instrumento que iniciou o preparo até o seu término, que foi finalizado com um instrumento 35 e então, uma segunda exposição radiográfica foi efetuada na mesma película radiográfica, agora com o último instrumento utilizado no CT. A solução irrigadora utilizada foi o hipoclorito de sódio a 1% (Dermus Manipulação, Florianópolis, Brasil) e foram depositados 2 ml da solução entre cada instrumento utilizado.

A plataforma, que permitiu dupla exposição radiográfica das amostras estudadas, foi utilizada para avaliar a manutenção da direção original do canal e a perda do comprimento de trabalho. Depois do processamento, as radiografias foram analisadas com auxílio do programa Image Tool version 3.00 (Heath Science Center Texas University, San Antonio, TX), para verificar a presença ou não de desvios na forma original dos canais e a perda do comprimento de trabalho. Por meio da ferramenta *Angle,* foi verificado o ângulo, quando havia, entre o instrumento 15 e o

35, decorrente do desvio apical. Já para a perda do comprimento de trabalho, a ferramenta *Distance* foi usada para medir a distância (mm), quando havia, entre a ponta do instrumento 15 e a do 35 (Figura 1.4).

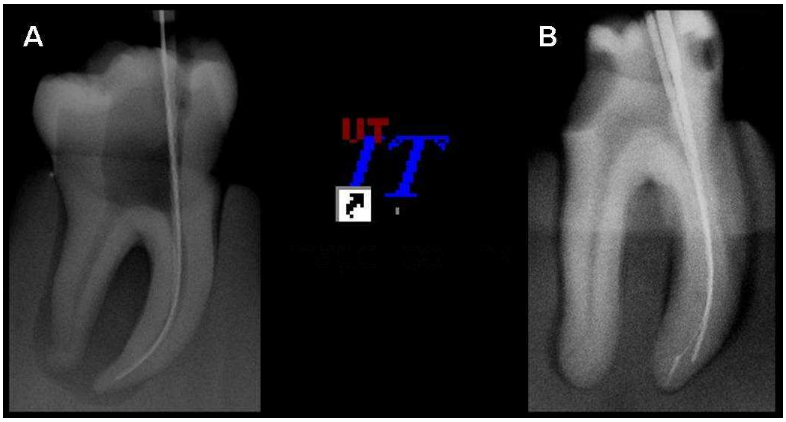

Figura 1.4. Radiografia obtida de espécime, por meio do método da plataforma radiográfica, em que não foi encontrado desvio e perda do CT **(A)** e em **B**, desvio, perda do CT fratura de instrumento.

A ocorrência de fraturas e deformações foi registrada. Os instrumentos com quaisquer alterações morfológicas foram prontamente substituídos.

De acordo com o delineamento da pesquisa e o tipo de variável, foi realizada a Análise de Variância para experimentos inteiramente casualizados com arranjo fatorial dos níveis dos fatores IES e Método. O nível de significância estabelecido foi de 5%.

CAPÍTULO 2

Análise dos padrões cinemático, cinético e eletromiográfico durante o preparo do canal radicular com instrumentos rotatórios e manuais

Oito sujeitos saudáveis, quatro do sexo feminino e quatro do masculino, destros e com idade entre 23 e 39 anos participaram deste estudo. Todos eram endodontistas, com experiência clínica de pelo menos dois anos.

Para a participação no experimento, antes da coleta de dados, todos leram e assinaram termo de consentimento aprovado pelo Comitê de Ética em Pesquisa da Universidade de Ribeirão Preto – UNAERP.

Cada um dos endodontistas, sentados em mocho e em posição 12 horas, preparou dois canais simulados em blocos de resina com diâmetro correspondente a um instrumento 20 e curvaturas de 40^{o} (Crinodonto Produtos Odontológicos, Curitiba, Brasil) (Figura 2.1). Num deles, usaram-se instrumentos rotatórios de Ni-Ti Race 25 (FKG, La Chaux-de-Fonds , Swiss), noutro, limas manuais FlexoFile 25 (Dentsply-Maillefer, Ballaigues, Swiss). No momento do uso dos instrumentos descritos acima, os blocos de resina foram presos a uma morsa e já estavam preparados, sendo que, no terço cervical, o preparo foi realizado tanto no grupo manual como no rotatório com instrumentos Pré-Race 40.10 e 35.08 (FKG, Le Chaux-de-Fonds , Swiss). Seguindo-se a filosofia da técnica coroa-ápice, no grupo manual foram usadas limas Flexo-file 40.02, 35.02 e 30.02 e no rotatório, instrumentos Race 25.06 e 25.04. O objetivo do operador foi alcançar o comprimento de trabalho com os instrumentos 25.02. Uma vez alcançado, foram realizadas dez repetições, com três movimentos de vai-e-vém cada durante tempo de coleta dos registros musculares de 4 segundos cada.

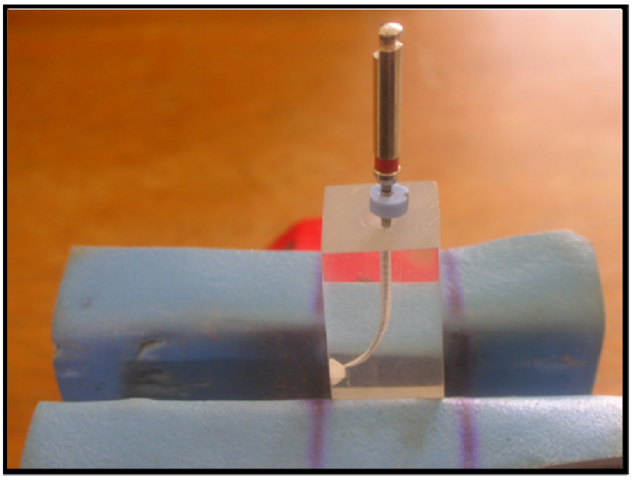

Figura 2.1. Canal simulado em bloco de resina preso a uma morsa.

Para a coleta dos dados, foram colocados eletrodos no corpo do operador, sendo que, o local foi depilado e limpo com álcool, para facilitar a aderência do dispositivo e a condução de sinais de EMG. Eletrodos de superfície bipolar Del SYS (modelo DE 2.2L Inc., Boston, MA, USA) foram colocados no músculo Flexor Radial do Carpo (FR), Extensor Radial do Carpo (ER), Braquiorradial (BR), Bíceps Braquial (BIC), Tríceps Braquial (TRI), Deltóide Médio (DM) e Trapézio Superior (TS). Os eletrodos foram posicionados em paralelo com as fibras musculares, aproximadamente dois centímetros de distância do ponto motor de cada músculo, determinado após uma contração isométrica de cada grupo muscular. Os sinais EMG foram ampliados (x 2000) e registrados em um osciloscópio de 200 MHz (Gould Classic, Tau) (Figura 2.2).

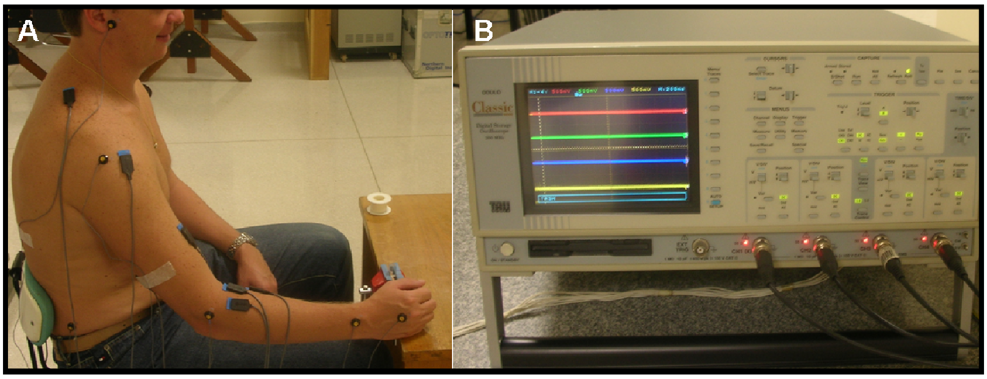

Figura 2.2. A) Eletrodos de superfície bipolar Del SYS e marcas com LEDs. **B)** Osciloscópio 200 MHz para registro da EMG.

Para análise dos movimentos, foram registradas as coordenadas X, Y e Z, utilizando-se marcas com LEDs (Light Emission Diodo) que foram fixadas na articulação crânio mandibular no ombro (porção lateral do acrômio), cotovelo (epicôndilo lateral), punho (turbérculo de lister) e mão (cabeça do terceiro metacarpiano). A emissão do sinal infravermelho dessas marcas foi capturada à freqüência de 100 Hz, por um sistema óptico tridimensional OPTOTRAK 3020 (Northern Digital Inc., Waterloo, Ontário, CA) (Figura 2.3).

Figura 2.3. Sistema óptico tridimensional OPTOTRAK 3020, usado para captura do sinal infravermelho das marcas do ombro, cotovelo, punho e mão.

Processamento dos dados

Os sinais eletromiográficos (EMG) resultantes, em miliVolts (mV), os registros das marcas X, Y e Z foram sincronizados por um sincronizador ODAU II – *Optotrak Dates Acquisition Unit II*, e depois tratados matematicamente por um código em *MatLab* (*Math Works Inc.*, versão 6.0). Neste código, os sinais de EMG foram retificados, filtrados, normalizados pela contração isométrica voluntária máxima (CIVM) de cada sujeito e, posteriormente, o valor percentual referente à CIVM foi calculado. Também foi calculado o deslocamento linear das marcas, o torque gerado na articulação do ombro, cotovelo e punho, deslocamento, velocidade e aceleração angulares. Os dados antropométricos, centro de massa e momento de inércia foram calculados com base no peso e sexo do sujeito, de acordo com o modelo de *Zatsiorsky*, modificado por DE LEVA (1996). A partir desses dados, foram calculados os torques articulares no ombro, cotovelo e punho, por meio da dinâmica inversa (Schneider et al., 1989) e, posteriormente, esses torques foram normalizados pelo peso de cada sujeito.

A média dos torques (Nm/Kg) no ombro, cotovelo e punho, e os valores percentuais dos sinais EMG foram calculados em intervalos de 100 ms cada, a partir no início do movimento do punho, avaliado pelo deslocamento angular.

Análise dos dados

De acordo com o delineamento da pesquisa e o tipo de variável, foi realizado o Teste t de Student pareado, por se tratar de variável paramétrica e dois grupos experimentais.

Para a análise, foi calculada a média de todos os indivíduos em cada momento do movimento, em intervalos de 100 milissegundos (ms), e em cada método de instrumentação. A seguir, os métodos foram comparados por meio do teste pareado porque os mesmos indivíduos realizaram a instrumentação com os dois métodos. O nível de significância estabelecido foi de 5%.

CAPÍTULO 3

Transporte dos canais e capacidade de centralização com instrumentos rotatórios RaCe

Após aprovação do projeto desta pesquisa pelo Comitê de Ética da Universidade de Ribeirão Preto, foram selecionados 30 primeiros molares superiores humanos extraídos, armazenados em solução de timol 0,1% até o momento do uso, quando então foram lavados em água corrente por 24 horas a fim de se remover qualquer traço da solução.

Os dentes apresentavam rizogênese completa e forames apicais onde era possível ultrapassar a lima Flexofile 15 (Dentsply-Maillefer, Ballaigues, Suíça). O grau e o raio de curvatura foram determinados a partir de radiografias periapicais, de acordo com Schneider (1971) e Pruett et al. (1997), respectivamente. Foram selecionados dentes com raízes mésio-vestibulares com comprimento ≥ 10 mm, portadoras de curvaturas em torno de 32,21 a 49,18 ^{o} e raios entre 5,52 e 9,92 mm. As coroas de todos os espécimes foram desgastadas para que estes ficassem com 18 mm de comprimento.

Previamente ao procedimento experimental, foram obtidos resultados preliminares no sentido de se verificar a homogeneidade da amostra, quanto ao ângulo e raio das curvaturas dos canais.

Preparo do corpo-de-prova

Para o preparo do corpo-de-prova inicialmente, seccionaram-se 3 mm da porção apical da raiz palatina e da disto-vestibular de cada espécime com auxílio de uma broca tronco-cônica em alta rotação, sob refrigeração, de forma que, posteriormente, fosse possível manter todos os ápices das raízes mésio-vestibulares em um mesmo nível e, assim, garantir o preciso reposicionamento dos espécimes durante os exames tomográficos.

Os ápices das raízes mésio-vestibulares dos dentes selecionados foram, então, inseridos em uma base de parafina incolor retangular (100 X 80 X 3,5 mm), montada sobre uma placa de vidro, com as mesmas dimensões, até que pudessem ser visualizados todos os ápices de forma que os dentes ficassem organizados em três fileiras de dez dentes cada. Tomou-se a precaução de se dispor os eixos vestíbulo-linguais e mésio-distais de todos os dentes em um mesmo sentido.

A seguir, o conjunto dentes/parafina/placa de vidro foi envolto por uma matriz de aço inox (6mm) e as bordas da base de parafina foram aquecidas de forma a promover o vedamento de toda a porção periférica do conjunto. Foi então vertida, de forma progressiva, quantidade suficiente de resina termopolimerizável manipulada (Dencor, Clássico Artigos Odontológicos, São Paulo, Brasil) até que ocupasse todo o espaço presente entre os dentes e cobrisse todas as raízes, exceto a porção apical, previamente inserida na base de parafina. Após a polimerização, a parafina e a placa de vidro foram removidos e os conjuntos dentes/resina foi denominado corpo-de-prova, sendo mantido em recipiente fechado com 100% de umidade, durante todo o experimento.

Exame Tomográfico Inicial

O corpo-de-prova foi adaptado a uma régua de Fox (Bio Art Equipamentos Odontológicos, São Carlos, Brasil) (Figura 3.1), com dois encaixes laterais de cada lado para o correto posicionamento e este conjunto adaptado a um tomógrafo Cone Beam I – Cat (Imaging Sciences International, Hatfield, PA – USA) (Figura 3.2). As imagens foram capturadas em campo pequeno (6 cm), com tempo de aquisição de 40 segundos e resolução de 0,2 voxel (resolução máxima), *pixel size* de 0,20mm, totalizando 599 cortes, que geraram arquivos com 350 MB, nos sentidos axial e frontal. Para a reconstrução da imagem, foi utilizado o software Xoran-Cat (Imaging Sciences International, Hatfield, PA – USA), que gerou arquivo com tamanho de 7,57 MB.

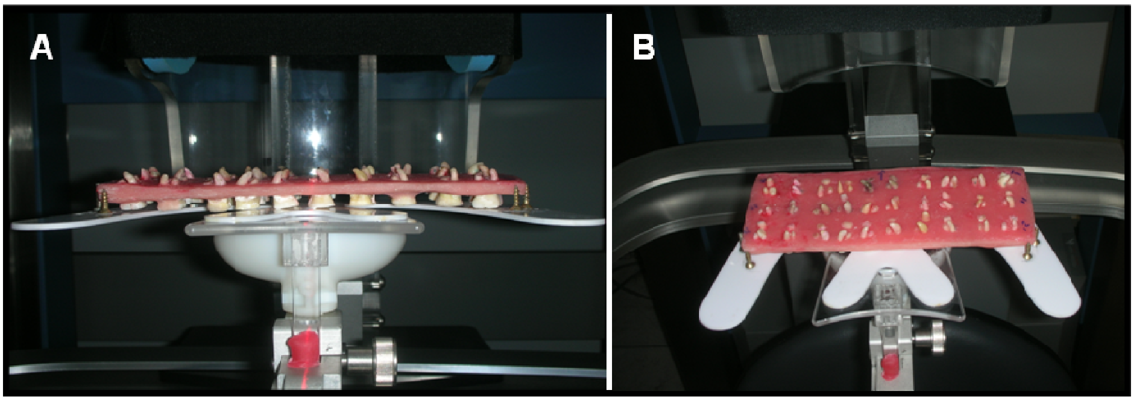

Figura 3.1: A) e **B)** Conjunto dentes / resina (corpo-de-prova), adaptados à régua de Fox acoplada ao tomógrafo Cone Beam I – Cat.

Figura 3.2: Tomógrafo Cone Beam I – Cat.

Dos 30 espécimes presentes no corpo-de-prova, 27 foram selecionados devido ao campo de atuação do tomógrafo (Figura 3.3). Foram selecionados três topogramas para cada espécime avaliado. O primeiro correspondeu à região localizada a três milímetros do vértice radicular (terço apical), o segundo a seis milímetros (terço médio), e o terceiro a 9 mm (terço cervical) (Figura 3.4).

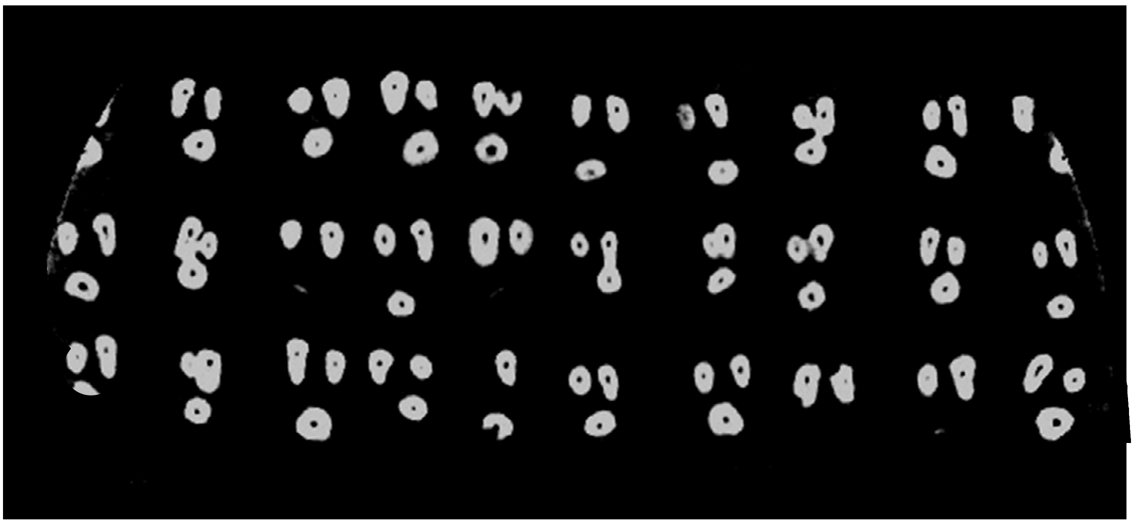

Figura 3.3: Imagem transversal inicial dos espécimes em formato JPEG (6 milímetros do vértice, terço médio).

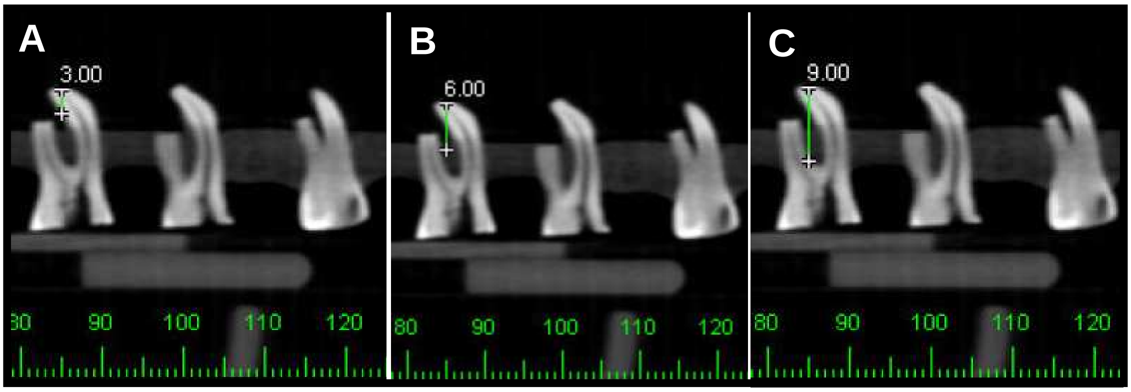

Figura 3.4: Topograma frontal dos espécimes em formato pdf. **A)** 3 milímetros do vértice, terço apical. **B)** 6 milímetros do vértice, terço médio. **C)** 9 milímetros do vértice, terço cervical.

Preparo Biomecânico

O preparo biomecânico dos canais radiculares foi realizado por um único operador, especialista em endodontia, com instrumentos rotatórios de NiTi Race (FKG, Lê Chaux-de-Fonds, Suíça) acoplados ao contra-ângulo NML-F16R, acionado pelo motor Endo-Mate TC (NSK, Japan).

A seqüência dos preparos respeitou a ordem descrita a seguir, sendo que, após o esvaziamento dos canais com lima manual Flexofile 15 (Dentsply-Maillefer, Ballaigues, Suíça), no comprimento de trabalho (CT) estabelecido igualmente para todos os espécimes, ou seja, de 17 mm, utilizou-se o instrumento Pré-Race 40 .10 e 35 .08 para o preparo cervical dos canais. Após este procedimento foi verificado em todos os canais que o diâmetro anatômico foi equivalente ao 25 .02. Então foi usado o instrumento Race 30 .06 ainda na parte reta ou até o início da curvatura, avançando com o Race 25 .04 próximo ao CT, então o instrumento Race 25. 02 no

CT seguido do 30 .02, 35 .02, 40 .02, 45 .02 e 50 .02, todos também no CT. Os instrumentos foram renovados a cada 8 canais preparados.

A solução irrigadora utilizada foi o hipoclorito de sódio a 1% (Dermus Manipulação, Florianópolis, Brasil) e foram depositados 2 ml da solução no intervalo entre cada instrumento utilizado.

Exames Tomográficos Após Instrumentos

A primeira etapa do preparo dos canais radiculares teve por objetivo alcançar o instrumento Race 35.02 no CT. Então, os corpos de prova foram submetidos a um novo exame tomográfico seguindo o mesmo protocolo descrito na secção Exame Tomográfico Inicial. Após este procedimento, os canais foram preparados até o instrumento Race 50.02, e novamente realizado o exame tomográfico.

Foram selecionados três topogramas para cada espécime avaliado. O primeiro correspondeu à região localizada a três milímetros do vértice radicular (terço apical), o segundo a seis milímetros (terço médio) e o terceiro a 9 mm (terço cervical).

Preparo das imagens

Após a captação das imagens do tomógrafo Cone Beam em formato *pdf* pelo *software* Adobe Acrobat 7.0 (Adobe Systems Incorporated, San Jose, CA, USA), elas foram editadas pelo *software* Photoshop CS3 (Adobe Systems Inc., EUA) e gravadas em formato JPEG .

Índice de transporte

O índice de transporte corresponde à variação, em milímetros, do desvio do eixo central do canal radicular após a instrumentação. Foi obtido, a partir da mensuração da menor distância entre a porção não instrumentada do canal e os aspectos mesial e distal da raiz, comparadas com as mesmas medidas obtidas a partir das imagens dos canais após o preparo com o instrumento 35 e 50. A mensuração da distância real entre os pontos de interesse para obtenção do índice de transporte foi executada com a ferramenta *Distance* do *software* UTHSCSA Image Tool 3.0 for Windows (University of Texas Science Center, San Antonio, TX, EUA).

O cálculo do índice de transporte (IT) foi realizado utilizando-se a seguinte fórmula em cada um dos três terços da raiz, primeiramente para o preparo após 35.

$$\mathbf{IT = (M1 - M2) - (D1 - D2)}$$

Então, foi utilizada a fórmula a seguir para o preparo após 50.

$$\mathbf{IT = (M1 - M3) - (D1 - D3)}$$

Os símbolos correspondem à menor distância entre o aspecto mesial da raiz e a porção mesial do canal não instrumentado (M1), o aspecto mesial da raiz e a porção mesial do canal instrumentado após 35 (M2) e após 50 (M3), assim como o aspecto distal da raiz e a porção distal do canal não instrumentado (D1), o aspecto distal da raiz e a porção distal do canal instrumentado após 35 (D2) e após 50 (D3) (Figura 3.5).

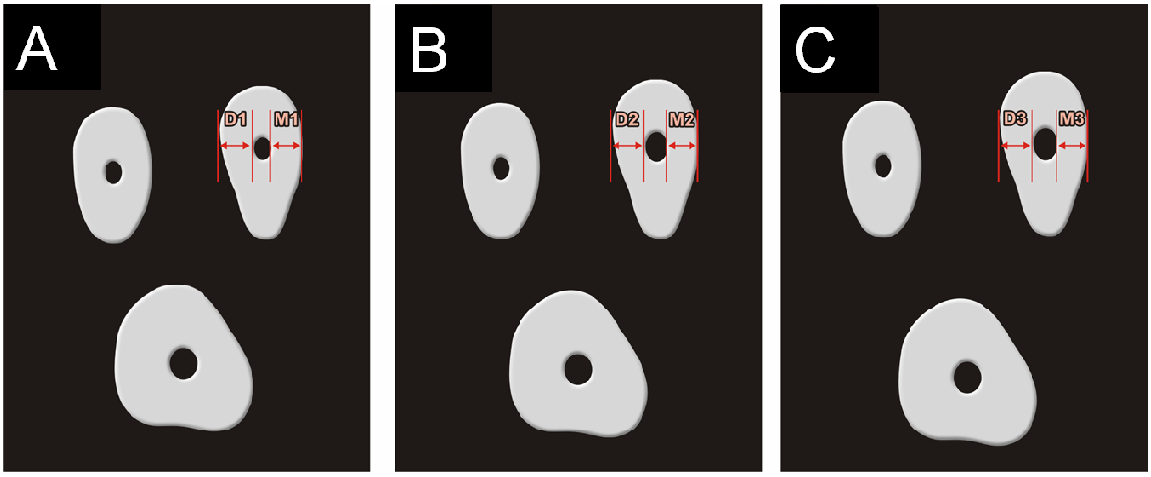

Figura 3.5: Topogramas do terço médio, onde D e M corresponde a menor distância no aspecto distal e mesial da raiz, respectivamente, em relação ao canal não instrumentado **(A)**, após instrumento 35 **(B)** e após instrumento 50 **(C)**.

Sentido do transporte

O sentido do transporte foi avaliado a partir dos resultados obtidos no Índice de transporte de cada espécime. Assim, o resultado negativo indicava transporte para distal, o positivo, para mesial e o nulo, ausência de transporte.

Índice de Centralização

Corresponde ao grau de manutenção do instrumento no eixo central do canal radicular. Este índice foi calculado em cada secção usando os valores obtidos durante a mensuração do índice de transporte, a partir da seguinte fórmula:

M1 – M2 / D1 – D2 ou D1 – D2 / M1 – M2

O exemplo descrito acima estabelece o índice de centralização entre o corte tomográfico inicial e após o uso do instrumento 35. O índice de centralização estabelecido após o uso do instrumento 50 foi realizado com a seguinte fórmula:

M1 – M3 / D1 – D3 ou D1 – D3 / M1 – M3

Os símbolos correspondem à menor distância entre o aspecto mesial da raiz e a porção mesial do canal não instrumentado (M1), o aspecto mesial da raiz e a porção mesial do canal instrumentado após 35 (M2) e após 50 (M3), assim como o aspecto distal da raiz e a porção distal do canal não instrumentado (D1), o aspecto distal da raiz e a porção distal do canal instrumentado após 35 (D2) e após 50 (D3). A fórmula era escolhida de acordo com o valor numerador, devendo este ser sempre o menor dos resultados obtidos pelas diferenças. Um resultado igual a 1 (um) indicava perfeita capacidade de centralização. Quanto mais próximo de zero pior a habilidade do instrumento em manter-se no eixo central do canal. Os resultados foram submetidos à análise estatística.

Os dados foram submetidos a testes preliminares com o objetivo de verificar a normalidade da distribuição amostral. Como a amostra testada apresentou distribuição normal, foram aplicados testes estatísticos paramétricos, com o auxilio do software GraphPad InStat (GraphPad Software Inc, San Diego, EUA), de Análise de Variância para verificar a existência de diferença estatística significante entre as médias e o teste complementar de Tukey para verificar a diferença entre os grupos, com nível de significância de 5%.

UNAERP
Ribeirão Preto
Guarujá

Comitê de Ética
em Pesquisa da Unaerp

Memorando ComÉt/ N.º 015/08

Para: **Ricardo Gariba Silva**

De: **Luciana Rezende Alves de Oliveira**
Coordenadora do Comitê de Ética em Pesquisa em Seres Humanos

Data: *11/4/2008*

REF.: Projeto de pesquisa n. **015/08**

Prezado (a) Senhor (a),

Vimos por meio desta informar que Comitê de Ética em Pesquisa em Seres Humanos da Universidade de Ribeirão Preto CEP/UNAERP analisou e aprovou sem restrições, o Projeto intitulado "Sistemas Rotatórios na graduação: mito ou realidade" tendo como pesquisador(a) Ricardo Gariba Silva, bem como o respectivo Termo de Consentimento Livre e Esclarecido, em reunião ocorrida na data de 25/03/08, registrado sobre o ComÉt: 015/08

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Solicitamos que sejam encaminhados os relatórios parciais e finais, bem como envie-nos possíveis emendas e novos termos de consentimento livre e esclarecido, notifique qualquer evento adverso sério ocorrido no centro e novas informações sobre a segurança do estudo para que possamos fazer o devido acompanhamento.

Sem mais para a oportunidade,

Atenciosamente,

Profª. Drª. Luciana Rezende Alves de Oliveira
Coordenadora do Comitê de Ética em Pesquisa em Seres Humanos
Universidade de Ribeirão Preto

Av. Costabile Romano, 2201 – Bairro Ribeirânia – Ribeirão Preto-SP - CEP. 14096-380 - Fone: (xx16) 3603-6915 - e-mail cetica@unaerp.br

UNAERP Ribeirão Preto Guarujá

Comitê de Ética em Pesquisa da Unaerp

Memorando ComÉt/ N.º 014/08

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De: **Luciana Rezende Alves de Oliveira**
Coordenadora do Comitê de Ética em Pesquisa em Seres Humanos

Data: *11/4/2008*

REF.: Projeto de pesquisa n. **014/08**

Prezado (a) Senhor (a),

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Sem mais para a oportunidade,

Atenciosamente

Profª. Drª. Luciana Rezende Alves de Oliveira
Coordenadora do Comitê de Ética em Pesquisa em Seres Humanos
Universidade de Ribeirão Preto

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cetica@unaerp.br

UNAERP Ribeirão Preto Guarujá

Comitê de Ética em Pesquisa da Unaerp

Ribeirão Preto, 31 de outubro de 2006.

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Solicitamos que o senhor encaminhe os relatórios parciais e finais, bem como envie-nos possíveis emendas e novos termos de consentimento livre e esclarecido, notifique qualquer evento adverso sério ocorrido no centro e novas informações sobre a segurança do estudo para que possamos fazer o devido acompanhamento.

Atenciosamente,

Profª Drª Luciana Rezende Alves Oliveira
Coordenadora do Comitê de Ética em Pesquisa da UNAERP
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Artigo 1: "Rotary instrumentation teaching techniques to graduate students with different learning experiences in endodontics".

07-May-2008

Dear Prof. Sousa Neto:

Your manuscript entitled "Rotary instrumentation teaching techniques to graduate students with different learning experiences in endodontics" has been successfully submitted online and is presently being given full consideration for publication in the European Journal of Dental Education.

Your manuscript ID is EJE-08-0181.

Please mention the above manuscript ID in all future correspondence or when calling the office for questions. If there are any changes in your street address or e-mail address, please log in to Manuscript Central at http://mc.manuscriptcentral.com/eje and edit your user information as appropriate.

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Thank you for submitting your manuscript to the European Journal of Dental Education.

Sincerely,
European Journal of Dental Education Editorial Office

Artigo 2: "Analysis of kinematics, kinetic and electromyographic patterns during the preparation of the root canal with rotary and manual instruments".

06-May-2008

Dear Prof. Sousa-Neto

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Thank you for submitting your manuscript to the International Endodontic Journal.

Kind regards

Paul Dummer
Editor, International Endodontic Journal
iejeditor@cardiff.ac.uk

Artigo 3: "Canal transportation and centring ability of RaCe rotary instruments".

04-Nov-2008

Dear Prof. Sousa-Neto

Manuscript ID: IEJ-08-00225.R3

Manuscript Title: Canal transportation and centring ability of RaCe rotary instruments

I am delighted to inform you that your manuscript is ready for publication in the International Endodontic Journal.

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