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In Vitro Comparative Study of Manual and Mechanical Rotary Instrumentation of Root Canals Using Computed Tomography

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This *in vitro* study compared, using computed tomography (CT), the amount of dentin removed from root canal walls by manual and mechanical rotary instrumentation techniques. Forty mandibular incisors with dental crown and a single canal were selected. The teeth were randomly assigned to two groups, according to the technique used for root canal preparation: Group I - manual instrumentation with stainless steel files; Group II - mechanical instrumentation with RaCe rotary nickel-titanium instruments. In each tooth, root dentin thickness of the buccal, lingual, mesial and distal surfaces in the apical, middle and cervical thirds of the canal was measured (in mm) using a multislice CT scanner (Siemens Emotion, Duo). Data were stored in the SPSS v. 11.5 and SigmaPlot 2001 v. 7.101 softwares. After crown opening, working length was determined, root canals were instrumented and new CT scans were taken for assessment of root dentin thickness. Pre- and post-instrumentation data were compared and analyzed statistically by ANOVA and Tukey's *post-hoc* test for significant differences (p=0.05). Based on the findings of this study, it may be concluded that regarding dentin removal from root canal walls during instrumentation, neither of the techniques can be considered more effective than the other.

Key Words: manual root canal instrumentation, mechanical root canal instrumentation, mechanical rotary system, computed tomography.

INTRODUCTION

With the advent of nickel-titanium (NiTi) instruments (1), mechanical instrumentation was re-introduced to practice, mostly represented by the rotary systems.

The findings of a scanning electron microscopic study (2) have shown that manual instrumentation of root canals with stainless steel files produced less amount of debris than ProFile Ni-Ti rotary instruments. Comparison of apical preparation with manual and rotary instrumentation showed similar apical transportation for both techniques (3).

Rödig et al. (4) evaluated the instrumentation of distal canals of mandibular molars using ProFile 0.04, Quantec SC and Lightspeed rotary systems and found that all systems yielded a circular preparation of root canals. They also observed that, because of their oval shape, buccal and lingual surfaces were not adequately instrumented. A previous study (5) examined root dentin thickness after instrumentation of the mesial roots of mandibular molars with ProFile and Hero 642 rotary systems and reported that both systems promoted only a slight reduction of the thickness of the root

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canal walls. Hülsmann et al. (6) compared different parameters of root canal preparation using Quantec SC and Lightspeed nickel-titanium rotary instruments and concluded that, although both systems respected the original root-canal curvature well, their cleaning ability was not satisfactory.

The findings of a previous study (7) confirmed that in oval-shaped canals some dentin walls may remain intact, i.e., uninstrumented, during root canal preparation. Accordingly, Albrecht et al (8) evaluated removal of apical debris using various sizes and tapers of ProFile GT files. Root canals were instrumented with .04-, .06-, .08-, and .10-tapered size 20 and size 40 files. The size 40 preparations had significantly lesser percentage of remaining debris at 1- mm level for all tapers, except for the .10 taper group, in which there was no statistically significant difference. There were no significant differences between the groups at 3 mm.

Schäffer and Vlassis (9) compared the shaping ability of ProTaper and RaCe systems using rotary nickel-titanium instruments in simulated curved canals. The authors reported that both systems were safe for root canal preparation, but RaCe respected better the original root canal curvature and promoted lesser transportation. Another study (10) compared root canals instrumented with the Great Taper (GT) manual system using nickel-titanium and stainless steel files and observed lesser transportation and dentin removal when nickel-titanium instruments were used.

Based on the findings in the literature, the purpose of this *in vitro* study was to compare, using computed tomography (CT), the amount of dentin removed from root canal walls by manual and mechanical Ni-Ti rotary instrumentation techniques.

MATERIAL AND METHODS

Forty extracted human mandibular incisors with dental crown and a single canal were selected from the tooth bank of the School of Dentistry of Ribeirão Preto, University of São Paulo, Ribeirão Preto, SP, Brazil of Dentistry of the Lutheran University of Brazil and used for this experiment. In each tooth, root dentin thickness of the buccal, lingual, mesial and distal surfaces in the apical, middle and cervical thirds of the canal was measured (in mm) using a multislice CT scanner (Siemens SOMATOM Emotion Duo™; Siemens Medical Solutions USA, Inc., Malvern, PA, USA). The measurements on each surface were obtained based on the distance, in straight line, perpendicular to the external root surface and the limit of the root canal. The collected data were stored using the SPSS software for Windows, version 11.5 (SPSS Inc., Chicago, IL, USA) and SigmaPlot 2001 software for Windows, version 7.101 (SPSS Inc.).

Three areas were demarcated for assessment of dentin thickness relative to root surface. The apical limit was established at 3 mm from the apical vertex and the upper limit was established at 2 mm from the root canal entrance. The remaining 2/3 of the root surface were divided into 2 equal parts considered as cervical and middle limits.

Thereafter, crown opening was performed by removal of dentinal projections of the lingual wall using a #2 Largo bur (Maillefer Instruments, Ballaigues, Switzerland), which penetrated 2 mm at most into the canal. The working length (WL) was established at 1 mm from root canal foramen.

The teeth were distributed in pairs according to their length and randomly assigned to two groups (n=20). In Group I, root canal instrumentation was performed manually with flexible stainless steel K-files (FKG Dentaire, La Chaux-de-Fonds, Switzerland), according to the crown-down technique. After fixation of the tooth in a clamping device, instrumentation started with a size 40 K-file, which was passively introduced. Using pendulous and traction movements, files of decreasing size were successively introduced into the canal until the WL was reached. Apical instrumentation started with forward-to-backward movements of the file until preparation was completed with a size 40 K-file. The same kinematics was employed for step-back preparation with programmed progressive recoil with size 45, 50 and 55 K-files.

In group II, the root canals were mechanically instrumented with RaCe rotary nickel-titanium instruments (FKG Dentaire) driven by an electric engine (TC 3000; Nouvag AG, Goldach, Switzerland) at 250 rpm. Root canal instrumentation was initiated at the cervical third with 40/10 file followed by 35/.08, 25/.06 and 25/.04 files. The apical third was prepared with 25/.02, 30/.02 and 40/.02 files. All rotary nickel-titanium instruments were used with 'brushing' movements. Apical instrumentation was completed with step-back preparation with programmed progressive recoil using 25/.04, 25/.06, 30/.08 and 40/.10 files with forward-to-

backward movements, which consistedo of tractioning the instrument against the dentinal walls while it was removed from the canal ('brushing' action from inside to outside the root canal).

In both groups, the canals were alternately irrigated with 1% sodium hypochlorite and 17% trisodium EDTA at each change of instrument. Each file was discarded after preparation of 3 specimens.

After instrumentation, all specimens were submitted to new CT scans to assess root dentin thickness. The areas where no reduction in thickness was observed were considered as uninstrumented, i.e., it was assumed that the files did not act in these regions. The canals were instrumented by the same operator and the CT scans were evaluated by CT specialist.

Dentin thickness before and after root canal instrumentation was compared and the results were analyzed statistically by ANOVA and *post- hoc* Tukey at 5% significance level.

RESULTS

Comparison of dentin removal on buccal and lingual surfaces in the three thirds and preestablished zones revealed that, in the apical third, there was greater dentin removal on the buccal surface, with statistically significant difference for manual technique ($p<0.05$). The mechanical technique yielded greater dentin removal on the lingual surface, although this difference was not significant statistically ($p>0.05$).

Comparison of instrumentation on the proximal surfaces revealed that greater dentin removal occurred on the mesial surface, with significant difference for the manual technique ($p<0.05$) and borderline significance with the mechanical technique.

The middle third exhibited slightly greater dentin removal on the lingual surface in comparison to the buccal surface, but no significant difference was observed ($p>0.05$). Regarding dentin removal on the proximal surfaces, the techniques used for root canal preparation did not differ statistically ($p>0.05$).

In the cervical third, the lingual surface had greater dentin removal than the buccal surface. The manual technique had better performance than the mechanical technique with borderline statistical significance ($p=0.05$). Comparing the proximal surfaces, the mesial surface exhibited greater removal of dentin than the distal surface.

DISCUSSION

Mandibular incisors were selected for this study because they present an accentuated mesiodistal flattening which renders difficult the instrumentation of all root canal surfaces (7). It should be pointed out that in infected canals microorganisms are lodged mainly in the polar zones, which compromises disinfection.

An important variable in this study was the presence of the coronal portion. The crown of mandibular incisors has a strong inclination to lingual, which might decisively interfere with the action of the instruments. The maintenance of tooth crown basically tried to reproduce a routine situation in endodontic clinical practice.

Computed tomography, as a method of assessment of root canal instrumentation, has been investigated with respect to its use in Dentistry, particularly in Endodontics (11). Because of its non-invasive nature, this technique allows evaluating not only the action of the instruments inside the root canals, but also the root canal system internal anatomy and apical lesions (12).

In spite of its high cost and difficult sensitivity, computed tomography is well indicated as a methodological resource in this research line (13).

The results of this study showed that CT scanning is an accurate and efficient method for assessment of root canal instrumentation techniques. Good results have been reported *in vitro* (14) and *in vivo* with C-shaped canals (15).

There was greater dentin removal on the buccal surface in the apical third compared to lingual surfaces, practically reproducing what happens during instrumentation of curved canals. In these cases, there is greater action of the file on the convex wall of the middle root canal third, while in the apical third there is a projection on the concave wall caused by the instrument pressure, due to the canal curvature. The presence of the crown with its inclination to lingual could result in a pseudo-curvature.

In this region, in spite of using instruments of same size and taper and regardless of the type of file (NiTi files for the RaCe system and stainless steel files for hand instrumentation), the techniques acted differently from each other. Canal transportation was observed to a greater or lesser extent. However, rotary instrumentation produced more centered canal preparations, which is consistent with previous findings (16,17).

In the cervical third, the greater removal of dentin on the lingual surface compared to the buccal surface may be attributed to tooth crown, which is usually lingually tipped and could interfere with instrumentation by displacing the file from the buccal surface.

In the cervical third, it was observed that the rotary NiTi instrumentation produced more centered and conservative canal preparations, despite the taper of the RaCe files used in this region (40/.10 and 35/.08). With these tapers and the sequence of forward-to backward movements in the step-back preparation with programmed progressive recoil, it may be assumed that the greatest cutting action in rotary technique occurs during the introduction of the file into the canal, whereas in the conventional manual technique there is also an important cutting action during file removal. The lesser cutting ability of NiTi files should be considered as well.

The fact that engine-driven NiTi instruments produce more conservative and centralized root canal preparations have already been demonstrated (14,15).

Comparing both instrumentation techniques, the manual technique did not show an overall difference in dentin removal between buccal and lingual surfaces in the canal thirds. Mechanical rotary instrumentation of the cervical third yielded greater dentin removal from the lingual surfaces, while no significant differences were observed between buccal and lingual surfaces during preparation of the other canal thirds.

The findings of this investigation highlight the fact that in addition to choose the best root canal preparation technique for each case, the endodontist should be careful to make a decision on the type and concentration of irrigating solutions and use an effective intracanal medication. For vital and non-vital teeth alike, there will always be areas that the instruments cannot reach and hence disinfection will strongly rely on irrigants and intracanal dressings, which are especially important in infected canals.

According to the proposed methodology and the results of this study, it may be concluded that regarding dentin removal from root canal walls during instrumentation, neither of the techniques can be considered more effective than the other because they behaved differently in each canal third and surface.

RESUMO

Este estudo *in vitro* avaliou comparativamente, por meio de tomografia computadorizada (TC), a quantidade de dentina removida das paredes do canal radicular utilizando-se as técnicas de preparo manual e automatizada de instrumentação rotatória. Foram selecionados 40 incisivos inferiores com coroa dental e um único canal. Os dentes foram divididos aleatoriamente em 2 grupos, de acordo com a técnica empregada para o preparo dos canais radiculares: Grupo I - técnica manual com limas manuais de aço inoxidável e Grupo II - técnica automatizada de movimentos rotatórios RaCe com limas de níquel-titânio. Em cada dente, procedeu-se à mensuração (em mm) da espessura da dentina radicular nas faces vestibular, lingual, mesial e distal dos terços apical, médio e cervical por meio de tomografia computadorizada multislice (Siemens Emotion, Duo). Os dados coletados foram armazenados utilizando-se os softwares SPSS versão 11.5 e SigmaPlot 2001 v. 7.101 (SPSS Inc.). Após a abertura coronária, o comprimento de trabalho foi estabelecido, os canais radiculares foram instrumentados e novas tomadas de tomografia computadorizada foram realizadas para mensuração da espessura das paredes dentinárias radiculares. Os dados obtidos antes e após o preparo biomecânico dos canais foram comparados. Os resultados foram estatisticamente por meio de análise de variância (ANOVA) com localização de diferenças *post hoc* de Tukey (p=0,05). Com base nos achados desse estudo, pode-se concluir que: com relação à remoção de dentina das paredes dos canais radiculares durante a instrumentação nenhuma das técnicas avaliadas pode ser apontada como mais efetiva que a outra.

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