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Original Article

The minimum residual root thickness after using ProTaper, RaCe and Gates-Glidden drills: A cone beam computerized tomography study

Nahid Mohammadzadeh Akhlaghi[1], Laleh Mohammadian Bajgiran[2], Amirali Naghdi[2], Elaheh Behrooz[2], Zohreh Khalilak[1]

Correspondence: Dr. Zohreh Khalilak
Email: dr.z.khalilak@gmail.com

[1]Department of Endodontics, Dental Branch, Islamic Azad University, Tehran, Iran,
[2]Private Practice, Tehran, Iran

ABSTRACT

Objective: The aim of this study was to evaluate the minimum residual root thickness (MRRT) of the danger zone after preflaring of the mesio-buccal (MB) canal of mandibular first molars using ProTaper, RaCe and Gates-Glidden (GG) drills as coronal shapers by cone beam computerized tomography (CBCT). **Materials and Methods:** In this experimental study, the initial CBCT scans of 75 MB canals of mandibular first molars were provided within 1, 2, 3 and 4 mm of the furcation level. The samples were divided into three groups. The samples of ProTaper and RaCe groups were prepared up to F2 and #25.04 as the master apical file (MAF), respectively. The coronal preparation of the samples in the GG group was done using GG drills #2, #3 and #4 and canals were prepared till MAF # 25. After obtaining the postinstrumentation images, the MRRT and the amount of removed dentin were analyzed by *t*-test and ANOVA statistical analyses. **Results:** The GG drills removed significantly more dentin than RaCe at all the sections ($P < 0.05$) and more than ProTaper at 3 mm from the furcation. Statistically there was no significant difference between ProTaper and RaCe groups ($P > 0.05$). There was no significant difference in MRRT between the groups ($P > 0.05$). The mean MRRT was not < 0.75 mm at all sections. **Conclusion:** Based on the results of this study, when an appropriate root thickness is initially present, all of the instruments that were investigated may safely be used as coronal shapers in MB canals of mandibular first molars.

Key words: Dental instruments, dentin, instrumentation, root canal preparation

INTRODUCTION

Coronal flaring is recommended for eliminating middle and coronal third interferences in root canals. It results in better control of files during apical preparation[1,2] and also facilitates the working length (WL) determination and apical enlargement.[3-7] Preflaring allows a deeper penetration of irrigation needles and thereby permits more effective debridement.[8] On the other hand, over-preparing the coronal third of the root canal can increase the risk of perforation especially in the furcation area.[9] Furthermore, preflaring results in thinning of the canal walls and increase the risk of tooth fracture.[1]

Gates-Glidden (GG) drills are the most common instruments used in coronal flaring. The low cost, high cutting potential, and easy use of GG drills, have made them widely-used instruments for coronal preparation of root canals.[10] GG drills #1 and #2 used in the coronal third of mesio-buccal (MB) canals of mandibular molars do not significantly decrease the residual dentin thickness.[11,12] On the other hand, it was reported that regardless of the size of the GG drill and the depth of penetration, it weakens the furcation area of mandibular molars.[13]

Nickel-titanium (Ni-Ti) instruments effectively improve the funnel shape of canals and have the least

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risk of root canal transportation.[14,15] Rotary files not only make facilitate and hasten preparations, but also produce a predictable and reproducible root canal shape with less iatrogenic damage.[16,17] Different Ni-Ti file systems with specific coronal shapers have been introduced to the market.[18]

The ProTaper rotary file system has three coronal shapers (S1, S2 and SX), and the RaCe rotary system has two coronal shapers (#35.08 and #40.10).

Numerous studies have compared the Ni-Ti files,[17,19] but few have evaluated coronal enlargers.[20-22] The aim of this study was to evaluate the minimum residual root thickness (MRRT) of danger zone after canal preparation using GG drills, ProTaper and RaCe rotary files in MB canals of mandibular first molars by cone beam computerized tomography (CBCT).

MATERIALS AND METHODS

A total of 135 mandibular first molars, extracted from the patients aged 35 to 55 years due to periodontal disease, were collected and disinfected by immersion in a 5.25% NaOCl solution for 1 h, then stored in saline until further use. All teeth with external or internal root resorption, open apices, visible cracks, fractures, caries, and previous root canal treatment were excluded. The root canals with lengths of 9–12 mm (from furcation level to the apex) were used in this study. Access cavities were prepared and distal roots were cut from 1 mm below the furcation level using diamond discs. The presence of two separate mesial canals was confirmed by simultaneous placement of two K-files #10 (Maillefer, Ballaigus, Switzerland) in the canals. Canal patency was checked by visualizing the tip of the K-files #10 from the apical foramen of the MB canal. Root canals with apical stops up to file #15 were included, and those beyond #15 were excluded. To determine the canal curvature, a K-file #10 was placed in the MB canal and parallel radiographs were provided in bucco-lingual and mesio-distal directions. Using Schneider's technique,[23] canal curvature was determined. Only teeth with a curvature ranged 20°–35° were included. Eventually, 75 mandibular first molars were coded for further assessment.

Prepreparation images

The teeth were placed halfway into acrylic resin molds with their buccal surface facing upwards. To facilitate the orientation of canal in the CBCT sections (Somatom Sensation 16 computerized tomography [CT] Scanner, Siemens, Berlin, Germany), a copper filament was inserted into the resin, parallel to the long axis of the tooth, near the mesio-lingual line angle. The samples were then randomly stabilized on a fiber board, on which all furcations were aligned and tooth codes were recorded. Due to the slice thickness of the CBCT scan (0.8 mm) and the slice distance of 0.2 mm, sections were obtained of 1, 2, 3 and 4 mm from the furcation level. Teeth were then fixed and placed in the CBCT scanner and the initial images were provided. The minimum initial root thickness (MIRT) of the furcation area in the MB canal was evaluated in the mentioned sections by Syngo CBCT software VB20 (Siemens AG, Erlangen, Germany); Siemens program [Figure 1]. Then the samples were randomly divided into three groups by the table of random numbers (Group G, Group R and Group PT). The average MIRT was assessed in the three groups and hence that no significant difference would be present.

Canal preparation procedures

In Group G, based on the passive step-back technique,[24] the coronal shaping was done using GG drills #2, 3 and 4 (Dentsply, Maillefer, Switzerland) respectively by a conventional motor at low speed of 2500 rpm. The penetration depth of GG drills was as follow: #2 maximum to the coronal half of the canal, #3 to the coronal third, and #4 to the canal orifice. Canal preparation of the middle and apical thirds was done using k-Flexofiles #15–25 (Maillefer, Ballaigus, Switzerland). File #25 was considered as master apical file (MAF).

In Group R, the canals were prepared with RaCe rotary files (FKG-Dentaire) as follows: File #40.10, #35.08, #25.06 for the coronal two-thirds and #25.04 to the WL as MAF.

Figure 1: The cone beam computerized tomography scans of the pre and postpreparation images of the mesio-buccal canals of mandibular first molars

In Group PT, canal preparation was done by ProTaper (Dentsply, Maillefer, Switzerland) files SX, S1, S2, F1, and F2 respectively as instructed by the manufacturer and F2 was selected as MAF.

A motor controller (X-smart, Maillefer/Dentsply, Ballaigus, Switzerland) with the recommended torque and speed was used for each rotary file. In order to avoid perforations, the anti-curvature method was used.

After using each file, the canals were irrigated with 2 mL of regular saline and 1 mL of 2.5% NaOCl, while file #10 was used to ensure patency. An endodontist (NMA) prepared all the canals and each instrument was used for the preparation of 5 canals. The number of strokes for each of the instruments was five.

Postpreparation images

After canal preparation, the samples were placed again in the initial molds and CBCT scans were obtained in a similar fashion to the initial imaging. Subsequently, the MRRT was assessed [Figure 1]. The amount of the dentin removal (DR) was calculated by subtracting the amount of the residual root thickness (RRT) from the initial root thickness (IRT). In this study, the relative percentage of DR was calculated by dividing the amount of DR to IRT (DR/IRT) ×100.[25]

Statistical tests

To compare the thicknesses of pre and postpreparation in each group and in each section, the paired *t*-test was used. For comparison of the MIRT, MRRT, and the amount of DR in each group, the repeated measure ANOVA was used. Furthermore, to compare the mentioned values among the groups, the ANOVA test was applied. The significance level was set at 5%.

RESULTS

Evaluation of the minimum initial root thickness

The MIRT in the furcation area of the MB canals in all the groups and for all the sections was determined [Figure 2 and Table 1].

In intra-group comparison, there was a statistically significant difference among the sections in each group ($P < 0.001$). In inter-group comparison of each section, no significant difference could be detected ($P > 0.05$).

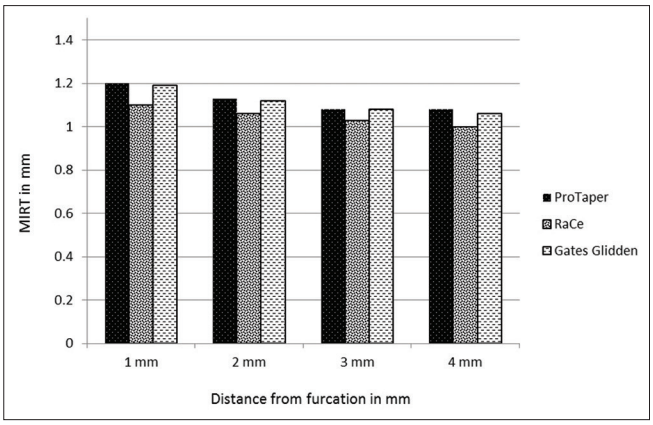

Figure 2: The minimum initial root thickness of the furcation area in different sections of the mesio-buccal canals of mandibular first molars in millimeter

Table 1: The mean±SD of the MIRT at different sections of the MB canals of mandibular first molars in the three groups (in mm)

Sections	Groups			*P*
	PT	RaCe	GG	
1 mm	1.20±0.19	1.10±0.18	1.19±0.19	0.09
2 mm	1.13±0.16	1.06±0.16	1.12±0.19	0.31
3 mm	1.08±0.14	1.03±0.14	1.08±0.18	0.32
4 mm	1.08±0.15	1.00±0.15	1.06±0.18	0.21
P	0.000	0.000	0.000	

SD: Standard deviation, MIRT : Minimum initial root thickness, MB: Mesio-buccal, PT: ProTaper, GG: Gates-Glidden

Evaluation of the minimum residual root thickness

In intra-group comparison of the root thickness of pre and postcanal preparation there was a significant difference in each of the groups ($P < 0.05$) [Figure 3 and Table 2].

In inter-group comparisons, there was no significant difference between the groups ($P > 0.05$).

The amount of dentin removal

In intra-group assessments, no significant difference was detected in any of the groups ($P > 0.05$). In inter-group comparisons, there was a significant difference ($P < 0.05$).

The amount of DR by GG drills was significantly greater in all the sections than the R group, whereas compared with PT group; it was only greater in sections that were 3 mm from the furcation. Groups R and PT had no significant difference for the amount of DR in any of the sections [Table 3].

The lowest relative percentages (LRP) of DR/IRT and the greatest relative percentages (GRP) of DR/IRT in the three groups were as follows:

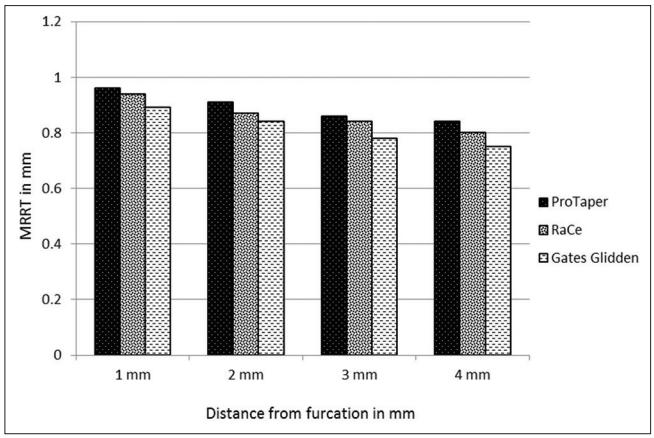

Figure 3: The minimum residual root thickness of the furcation area in different sections of the mesio-buccal canals of mandibular first molars (in mm)

Table 2: The mean±SD of the MRRT at different sections of the MB canals of mandibular first molars in the three groups (in mm)

Sections	Groups			*P*
	PT	RaCe	GG	
1 mm	0.96±0.20	0.94±0.18	0.89±0.21	0.46
2 mm	0.91±0.18	0.87±0.16	0.84±0.21	0.35
3 mm	0.86±0.19	0.84±0.17	0.78±0.20	0.25
4 mm	0.84±0.19	0.80±0.20	0.75±0.21	0.25
P	0.000	0.000	0.000	

SD: Standard deviation, MB: Mesio-buccal, PT: ProTaper, GG: Gates-Glidden, MRRT: Minimum residual root thickness

Table 3: The mean±SD of the DR at different sections of the MB canals of mandibular first molars in the three groups (in mm)

Sections	Groups			*P*
	PT	RaCe	GG	
1 mm	0.25±0.15	0.16±0.14	0.30±0.11	0.002
2 mm	0.22±0.14	0.19±0.11	0.29±0.08	0.012
3 mm	0.22±0.14	0.18±0.10	0.31±0.07	0.000
4 mm	0.25±0.13	0.20±0.13	0.30±0.01	0.021
P	0.946	0.287	0.792	

SD: Standard deviation, MB: Mesio-buccal, PT: ProTaper, GG: Gates-Glidden, DR: Dentin removal

Group PT

- The LRP of DR/IRT was 19% at the section 2 and the GRP of DR/IRT was 23% at the section 4 mm from the furcation.

Group R

- The LRP of DR/IRT was 14% at the section 1 and the GRP of DR/IRT was 20% at the section 4 mm from the furcation.

Group G

- The LRP of DR/IRT was 25% at the section 1 and the GRP of DR was 29% at the section 3 mm from the furcation.

Mishaps

There were no deformities, broken instruments, or perforations during root canal preparation.

DISCUSSION

This study compared the MRRT of the furcation area of MB canals of mandibular first molars using RaCe, ProTaper and GG drills by CBCT method. When measuring the amount of DR, there was no significant difference in intra-group comparisons. This suggests that the DR was uniform in all the groups.

In this study, in inter-group comparisons, RaCe and ProTaper systems removed similar amounts of dentin with no significant difference, whereas GG drills significantly removed more when compared with RaCe system.

In comparing different techniques and instruments or anatomical evaluations, among the different techniques, the CBCT method has the capability of three-dimensional description of the root canal.[26,27] This was especially evident in the coronal and middle thirds, which are the major areas altered by enlarging endodontic instruments.[28,29] In this study, a CBCT method with slice thickness of 0.8 and slice distance of 0.2 was used.

The samples used in this study had 20°–35° root canal curvature in bucco-lingual or mesio-distal radiographs. Such a limited range for curvature cannot be seen in many studies.[20,21]

Considering that age is an influential factor in the IRT, for better comparison, teeth from the patients aged 35–55 years were selected.

Some previous researchers have[8,30,31] mentioned that the area within 3–4 mm below the root canal orifice is the most sensitive area during rotary preparation of mesial canals of molar teeth. Therefore, similarly to previous studies,[9,19,20] this evaluation was conducted regarding the danger zones of furcation area.

In the present study, MIRT of MB canal of mandibular first molars in the danger zones was more than 1 mm in all the sections except in the 4 mm from the furcation. In all groups, the amount of MIRT gradually decreased from 1 mm to 4 mm from the furcation.

Berutti and Fedon[32] reported that the root thickness of the mesial canal of mandibular first molars was smallest (1.2–1.3 mm) within 1.5 mm of the furcation.

Mahran and AboEl-Fotouh[20] evaluated the effect of HeroShaper, ProTaper system, and GG drills in the coronal portion (within 3 mm from the furcation) of MB canals of the mandibular first molars and similar to the present study, reported that the mean IRT was more than 1 mm.

In a study conducted by Coutinho-Filho *et al*.,[10] the average IRT at a 3 mm distance from the furcation area in the mesial canal of mandibular first molars was 0.8 mm ± 0.17 mm. Akhlaghi *et al*.[25] stated that, at the coronal level (1–2 mm from the furcation), the mean of IRT of distal and distolingual walls of MB canal in mandibular first molars were <1 mm (0.94 and 0.78 mm respectively). Garala *et al*.[33] reported the IRT is the most important factor in determining the RRT after the root canal preparation.

In a study by Uyanik *et al*.,[17] the amount of DR in the coronal third was not significantly different between RaCe and ProTaper systems, as seen in the present study. Mahran and AboEl-Fotouh[20] showed that ProTaper files removed less dentin compared to GG drills in the furcation area of the MB canal of mandibular first molars.

Considering that the mean MRRT in all the groups of this study had no significant difference and were >0.75 mm, each of these instruments may be used as safe coronal enlargers.

The results of the current study showed that, if rotary instruments are used in brushing movements and in an anti-curvature style, a proper and safe root thickness would be maintained. Lim and Stock[34] showed that the MRRT after preparation should be no <0.3 mm to resist against the forces during root canal obturation. According to their results, MB canals of mandibular first molars after rotary instrumentation have sufficient resistance to root canal obturation.

Unlike this study, Wu *et al*.[13] reported that using GG drills in mandibular molars weakens the furcation area, regardless of the size of the instrument or the penetration depth. They mentioned that using the anti-curvature method does not lower the risk of strip perforation.

Zuckerman *et al*.[11] evaluated the RRT of mesial canals of mandibular molars with curvatures <30° using the light speed system and GG drills and similar to this study, reported no significant difference between the IRT and RRT.

In the present study, the average of the MRRT in all sections and groups was < 1 mm. Raiden *et al*.[35] have shown that at least 1 mm of root thickness must be maintained around the post, to resist against vertical fracture. Akhlaghi *et al*.[25] indicated that the RRT of the MB canal of mandibular first molars in the distal and disto-lingual walls of the furcation area after canal preparation was <1 mm (0.72 and 0.53 mm respectively). Therefore, it seems that the mesial canals of mandibular first molars are not sufficiently resistant to vertical fractures when posts are inserted in them.

CONCLUSIONS

Based on the results of this study, GG drills removed significantly more dentin than RaCe rotary files in furcation area. However, the MRRT was not significantly different among the groups. Considering the limitations, when optimum IRT are present, GG drills, RaCe and ProTaper systems may safely be used for preflaring the MB canals of mandibular first molars without weakening the furcation area.

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