A comparative study of smear layer production following use of Mtwo and Race rotary instruments

Nona Khadivi Niajavan, Shahram Azimi, Kiamars Honardar, Noosha Khadivi Niajavan and **Sogol Seghatol Eslami** compare the cleaning efficacy of Race and Mtwo NiTi rotary systems in curved canals

CPD Aims and objectives

The clinical article aims to compare the formation of smear layer and residual debris amount following use of Mtwo and Race nickel titanium rotary instruments during the preparation of curved canals in extracted human teeth.

Expected outcomes

Correctly answering the questions on page XX, worth one hour of verifiable CPD, will demonstrate you understand that none of the canals were totally free of residual debris and smear layer. Although gaining similar scores for smear layer, Mtwo system appeared to be slightly more efficient in terms of debris removal, especially in coronal area, which could be attributed to the circumferential brushing motion of the rotary file advised by the manufacturer.

Successful root canal therapy (RCT) depends on thorough cleaning, shaping and three-dimensional obturation of the root canal system (Ahlquist et al, 2001; Ingle and Bakland, 2000; Mayer et al, 2002; Schäfer and Zapke, 2000). Debris and smear layer formation is seemingly inevitable through the instrumentation procedures (Bowmann and Baumgartner, 2000; Jeon et al, 2003). Debris is packed all over the root canal wall during filing and may consequently impair the proper adaptation of sealer and gutta percha. It may also serve as a micro-organism reservoir, which may increase the possibility of future infections (Bowmann and Baumgartner, 2000; Jeon et al, 2003). Smear layer may play a role in preventing antimicrobial agents to penetrate into the infected dentinal tubules (Kum et al, 2006). However, some studies suggest that the presence of smear layer may help protect the dentinal tubules from the penetration of bacteria or bacterial byproducts (Grandini et al, 2002; Pashley et al, 1981). Generally though, thorough removal of the smear layer has been associated with superior outcomes of RCTs (Torabinejad et al, 2002; Kum et al, 2006).

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NiTi instruments are now an important part of the endodontic armamentarium (Schäfer et al, 2006). Advanced instrument designs, such as non-cutting tips, radial lands, different cross-sections and varying tapers, have been associated with improved safety, decreased working time, and superior preparation flare (Paqué et al, 2005). These various characteristics have been shown to influence the cleaning efficiency of the instruments (Foschi et al, 2004).

NiTi instruments have shown to be more capable in preparation and cleaning the coronal and middle parts of the root canal when compared to apical parts (Schäfer and Vlassis, 2004; Schäfer et al, 2006). Irrigants can only irrigate 1mm further than the tip of the needle; thus regarding the dimensions of the dentin fragments (greater than 15-20µm) and the inability of irrigants to remove them it seems that irrigants may have only a partial role in cleaning the canal space (Foschi et al, 2004).

Foschi et al (2004) reported a superior cleaning efficiency for Mtwo compared to Protaper. Schäfer and Vlassis (2004) showed more satisfactory outcomes in terms of root canal cleaning with the application of Race compared to that of Protaper. On the other hand, to the best of our knowledge, no studies have concerned the comparison of Mtwo and Race at the time of the present study.

The purpose of this study was to compare in vitro the cleaning efficacy of Race and Mtwo NiTi rotary systems (removal of the debris and quality of smear layer) in curved canals.

Materials and methods

Freshly extracted maxillary first or second molars stored in saline or hypochlorite solution were used in this in vitro study. Teeth with root caries, open apices, cracks, internal or external resorption or calcification were excluded. Also, molars with a mesiobuccal (MB) root curvature of less than 25° or more than 35°, according to the Schneider technique (Pashley et al, 1981), were excluded. Forty-six molars were included in the study. Molars were selected so that 23 will have a root curvature of 25°-29° and the other 23 will have a root curvature of 30°-35°. This was to assure homogeneity of the specimens. Teeth were divided into two equal groups of 20 so that each group will equally contain both root curvatures. Six control teeth were randomly selected. MB canals were controlled for apical patency with #10 K-file (Dentsply-Maillefer, Ballaigues, Switzerland).

Working length (WL) was then measured radiographically by placing #15 K-file (Maillefer) into the mesiobuccal canals. The crowns were cut off to obtain a WL of 19mm, which was set as a standard for all the mesiobuccal canals.

Race instruments (FKG Dentaire, La Chaux-de-Fonds, and Switzerland) were used with a crown-down technique, according to the manufacturer's instructions using a gentle in-and-out motion. Instruments were changed when resistance was felt.

The instrumentation sequence was:
• A .10 taper size 40 instrument was used at one third to half of the WL
• A .08 taper size 35 instrument was used at half of the WL
• A .06 taper size 25 instrument was used at half to two third of the WL
• A .04 taper size 25 instrument was used at the WL.

Once negotiated to the end of the canal and rotating freely, the instrument was removed.

Mtwo system (VDW, Munich, Germany) was introduced directly to the WL according to the manufacture's instruction, maintaining a permanent rotation (300rpm), with slight in-and-out motion pattern:
• A .04 taper size 10 instrument was used at the WL
• A .05 taper size 15 instrument was used at the WL
• A .06 taper size 20 instrument was used at the WL
• A .06 taper size 25 instrument was used at the WL
• A .05 taper size 30 instrument was used at the WL
• A .04 taper size 35 instrument was used at the WL.

A #15 K-file (FKG) was used for the initial assessment of the canal space and also in a watch-winding motion to assure the presence of a gliding path for each next Mtwo instrument (Schäfer et al, 2006). To prevent excess smear layer and debris formation, each rotary instrument was used only four times. The root canals were irrigated with 5ml of 2.5% NaOCl after each instrument and with 5ml of normal saline at the end of the instrumentation.

Both types of instruments were set into permanent rotation with a 20:1 reduction contra-angle (W&H, Austria) powered by a torque-limited electric motor (Endomate DT, NSK, Nakanishi, Japan).

Three MB canals were cleaned and shaped with hand instruments to serve as a positive control (C+) for the smear layer formation. Three other MB canals were only irrigated with 2.5% NaOCl to serve as a negative control (C-) (to show that smear layer will not form in the absence of instrumentation).

The specimens were then stored in 100% relative humidity at 37°C. A diamond bur (Dentsply, York, PA, USA) was then used to cut off the crowns and other roots of all the study molars. A coronal-apical groove was prepared on the buccal and lingual surfaces of all MB canals. Specimens with the evidence of the penetration of the groove into the root canal lumen or with irregular groove were replaced with new prepared specimens. Roots were split longitudinally into two halves using a mallet and a chisel on the grooves. All halves were coded and mounted on an aluminum stab by a silver point coated with a 550A° thick layer of gold-palladium using a sputter coater (SCDoos, BAL-TEC, Liechtenstein, Switzerland) and examined under a scanning electron microscope (SEM) (Philips XL30, Eindhoven, Netherlands) at x1000 magnification. Serial photomicrographs (PMGs) were taken at coronal (2mm below CEJ), middle (at the exact middle of the canal) and apical (1mm above the apex) levels.

Dentin chips, pulp remnants, large particles and aggregates appearing on the MB root canal walls were considered debris. Smear layer was defined as a surface film including dentin and pulp tissue remnants. The PMGs were coded randomly from one to 138 and were separately assessed to determine the amount of debris and smear layer based on a numerical evaluation scale by three trained blind endodontists. Since

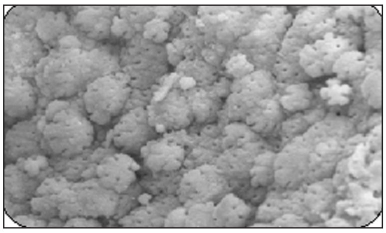

Figure 1: Uninstrumented canal irrigated with sodium hypochlorite 2.5%

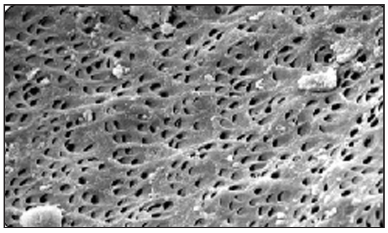

Figure 2: Debris score 1; smear layer score 1 (x1000)

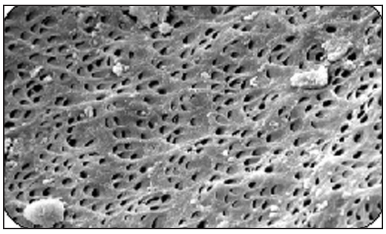

Figure 3: Debris score 2; smear layer score 2 (x1000)

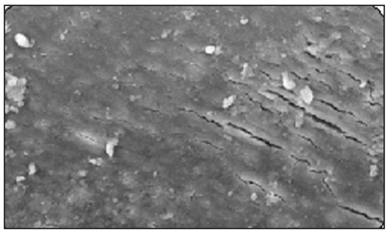

Figure 4: Debris score 1; smear layer score 5 (x1000)

different parts of each single PMG showed different scores, each PMG was divided into four parts and the top right one fourth was included in the scoring.

Schäfer-Schlingmann (Schäfer and Schlingemann, 2003) scoring system was used to score the observed debris and smear layer, as follows:

Debris

Score 1: Clean canal walls with only very few debris particles (Figures 2 and 4).
Score 2: Few small conglomerations (Figure 3).
Score 3: Many conglomerations; less than 50% of the canal wall covered.
Score 4: More than 50% of the canal wall covered.
Score 5: Complete or nearly complete covering of the canal wall by debris.

Smear layer

Score 1: No smear layer (Figure 2).
Score 2: Small amount of smear layer, some open dentinal tubules (Figure 3).
Score 3: Homogenous smear layer along almost the entire canal wall, only very few open dentinal tubules.
Score 4: The entire root canal wall covered with a homogenous smear layer, no open dentinal tubules.
Score 5: A thick, homogenous smear layer covering the entire root canal wall (Figure 4).

Three endodontists were trained using the Schäfer-Schlingmann scoring system and calibrated. The inter-examiner reliability tests showed a high consistency between the three of them. Consequently, all scans of the PMGs were assessed and scored by one examiner. The data were analyzed statistically using Wilcoxen W and Mann-Whitney U tests.

Results

Varying amounts of debris and smear layer remnants were detected on the instrumented canal walls of the study groups.

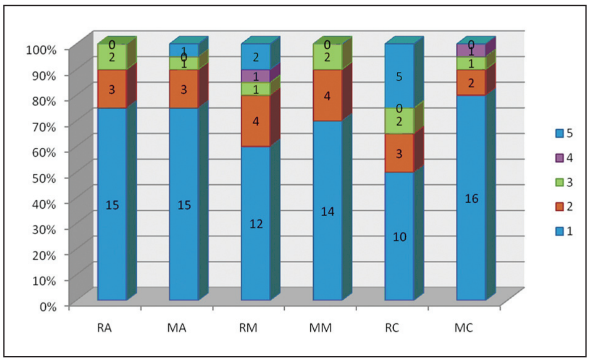

Figure 5: Comparative illustration of debris scores for the study groups. Different colors represent different scores as presented in the legends.
RA: Race-Apical, MA: Mtwo-Apical, Race: Middle, Mtwo-Middle, Race-Coronal, Mtwo-Coronal

Globular appearance of the uninstrumented dentin, pulp remnants and debris were found in all C- specimens. Smear layer was formed on the entire root canal surface in all C+ specimens.

The mean scores of debris and smear recorded at three coronal, mid and apical levels of the study groups are shown in Tables 1 and 2, and Figure 5. Mtwo and Race rotary systems did not show a statistically significant difference in terms of residual debris and smear layer on the canal walls of the study specimens ($p > 0.05$). The mean debris scores for Mtwo and Race systems were respectively 1.4 and 1.58. The sum of debris scores 1 and 2 for all studied surfaces were 90% for Mtwo and 78% for Race. The mean smear layer scores for Mtwo and Race systems were respectively 4.3 and 4.2. The sum of smear layer scores 1 and 2 was 6.6% for Mtwo and 10% for Race.

About 90% of the apical debris scores of both systems were within the satisfactory range (1 or 2) ($p = 0.989$). The sum of coronal debris scores 1 and 2 was 90% for Mtwo and 65% for Race ($p = 0.134$). The mean debris scores for the coronal area of Mtwo and Race systems were respectively 1.35 and 2.35, which showed a slightly higher yet not statistically significant efficiency for the Mtwo system.

No statistically significant differences were detectable in smear layer scores of apical, middle and coronal areas of both rotary systems.

Discussion

Forty-six MB root canals of extracted maxillary molars were included in this experimental study to comparatively assess the cleaning (removal of debris and smear layer) of two NiTi rotary systems, Mtwo and Race, in curvatures of 25° to 35°. WL and canal curvatures were standardized to further avoid bias.

SEM analysis is seemingly adequate for the studies on the cleaning efficacy of different instruments and substances. There are, however, some minor differences such as magnification, area selection, transparent grid assessment and scoring systems that exist in the application of this technique (Kum et al, 2006).

Different magnifications ranging from x45 to x2500 have been used through the endodontic literature (Schäfer and Zapke, 2000; Ahlquist et al, 2001; Mayer et al, 2002) Low magnifications allow the examiner to easily detect large debris, while details of smear layer or the identification of dentinal tubules need a closer look. Higher magnification, however, may result in misinterpretation. The magnification in the present study was x1000.

Two separate, five-step numerical evaluation scales have been recommended by Hülsmann et al (Blum et al, 2003) and Haikel and Allemann (Hülsmann et al, 1997) for debris and smear layer scoring. Others have used three- or four-step scoring systems. In our study, three endodontists were first familiarized with Schäfer and Schlingmann's (2003) five-step scoring system and photomicrographs were used for evaluation.

An important goal of endodontic treatment is the elimination of necrotic and vital pulp tissue from root canal system. Evaluation of debris and smear layer is a method for assessing the efficiency of canal instrumentation (Ahlquist et al, 2001; Ingle and Bakland, 2000; Mayer et al, 2002; Schäfer and Zapke, 2000). The present study took advantage of these two criteria to compare the cleaning efficacy of Mtwo and Race instruments. Debris was defined as dentin chips and residual vital or necrotic pulp tissue attached to the root canal walls, which is mostly considered as a source of infection (Bowmann and Baumgartner, 2000; Jeon et al, 2003). The smear layer, which is a mainly inorganic surface film approximately 1-2µm in thickness, is the result of instrumentation (Pashley et al, 1981; Grandini et al, 2002; Kum et al, 2006). As in C-, no smear layer was seen in PMGs. Heavy debris glomerules were detected in C+.

Although it is generally suggested to remove the smear layer using a combination of sodium hypochlorite and EDTA, mere sodium hypochlorite irrigation was used.

Uninstrumented surfaces were detected with both systems. Regardless of the instrument used, these surfaces were mostly seen in coronal or middle thirds of the canal wall rather than the apical areas. It is reported that approximately 35% of the canal wall remains uninstrumented with the use of different NiTi systems (Pashley et al, 1981).

In the study of Schäfer and Vlassis (2004), using Race instruments resulted in less debris formation compared to Protaper. Sixty per cent of the specimens prepared with Race showed debris scores 1 or 2. This efficacy is consistent to the findings of the present study (75%). However, Schäfer and Vlassis reported no significant difference between Race and Protaper rotary systems in smear layer formation. The sum of smear layer scores in their study was 23%, which is not in accordance to the findings of the present study (10%). The difference may be attributed to the fact that they had used heavier irrigation and used every instrument only two times. In the study of Schäfer et al (2006) much less residual debris was associated with Mtwo compared to those of K3 and Race. Again, no significant difference was found in smear layer formation. Based on their report, 86% of the specimens prepared with Mtwo showed debris scores 1 or 2. Consistently, Mtwo showed better results in terms of debris removal especially in coronal and middle areas in the present study. However, the difference was not significant. Similar to the findings of Schäfer et al (86%), 95% of the Mtwo preparations in the present study scored 1 or 2. Proper apical preparation was achieved using both.

On the other hand, Paque et al (2005) did not report satisfactory results in terms of cleaning, with the application of both systems. In the present study, comparing Mtwo and Race instruments, Mtwo was more efficient in debris removal especially in middle and coronal areas. This superiority is thought to be attributed to the cross-section and flute design of Mtwo instrument. Some studies have noticed that different

Area	Apical					Middle					Coronal				
score	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Mtwo	15 (75%)	3 (15%)	1 (5%)	0	1 (5%)	14 (70%)	4 (20%)	2 (10%)	0	0	16 (80%)	2 (10%)	1 (5%)	1 (5%)	0
Race	15 (75%)	3 (15%)	2 (10%)	0	0	12 (60%)	4 (20%)	1 (5%)	1 (5%)	2 (10)	10 (50%)	3 (15%)	2 (10%)	0	5 (25%)
p value	0.989					0.478					0.134				

Table 1: Summary of scores of debris in three regions of the prepared canals

Area	Apical					Middle					Coronal				
score	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Mtwo	1 (5%)	0	3 (15%)	3 (15%)	13 (65%)	2 (10%)	0	3 (15%)	2 (10%)	13 (65%)	0	1 (5%)	5 (25%)	2 (10%)	12 (60%)
Race	1 (5%)	1 (5%)	3 (15%)	3 (15%)	12 (60%)	0	2 (10%)	5 (25%)	3 (15%)	10 (50%)	0	2 (10%)	4 (20%)	0	14 (70%)
p value	0.738					0.495					0.779				

Table 2: Summary of scores of smear layer in three regions of the prepared canals

rotary nickel titanium instruments differ in their debris removal efficiency possibly because of the difference in cross-section and flute design (Foschi et al, 2004). The design of Mtwo instruments with two blades and a large groove between them, seems to reduce the core diameter and increase the flexibility; thus it is anticipated that, due to the active sharp angle of the blade, the resistance of the instrument could not be affected. The blade angle is almost vertical and the helical pitches increases from tip to handle. These characteristics are claimed to reduce debris accumulation and to gain a more effective cutting ability (Veltri et al, 2005).

Conclusion

Both Mtwo and Race were effective in debris removal, although it seemed that Mtwo instruments have more superiority especially in coronal areas.

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