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Abstract

Introduction: The aim of this study was to compare the effectiveness of TRUShape (TS) instruments with ProFile Vortex Blue (VB) instruments for the removal of obturation materials during retreatment of single-canal mandibular premolars performed through 2 access outlines. Methods: Initial root canal treatment was completed through a contracted endodontic cavity (CEC) design. Canals were instrumented to an F2 ProTaper instrument, obturated with warm lateral condensation of gutta-percha with AH Plus sealer, and allowed to set for 30 days at 37°C and 100% humidity. For retreatment, specimens were divided into 2 groups (n = 24) on the basis of access outline, CEC or traditional endodontic cavity (TEC). Retreatment was initiated by using ProTaper Retreatment instruments (D1–D3). Specimens were then stratified, further divided (n = 12), and reinstrumented up to TS 40 .06v or 40 .06 VB. Irrigation was performed by using 8.25% NaOCl and QMix 2in1. Retreatment time was recorded. Teeth were sectioned and photographed, and the percentage of remaining obturation materials was measured. Data were analyzed with Kruskal-Wallis analysis of variance for two-factor tests (α < 0.05). Results: The interaction between access design and instrument type showed that the combination of CEC-VB presented significantly higher amounts of remaining obturation materials on the canal surface when compared with TEC-VB, CEC-TS, and TEC-TS (P ≤ 0.05). None of these other combinations were different from each other (P > .05). Significantly more time was required for retreatment with CEC-TS (27.68 ± 1.4 minutes) than the other groups (P < .05). Conclusions: Neither retreatment protocol was able to completely eliminate all obturation materials from the root canal surface of mandibular premolars. However, in the presence of a CEC access design, using TS instruments removed more obturating material in single-rooted, oval-shaped canals. (J Endod 2016;42:1550–1554)

Key Words

Endodontic cavity, instrumentation efficacy, nickel-titanium instrument, ProFile Vortex Blue, retreatment, TRUShape

The goal of retreatment of endodontically treated teeth is to eradicate persistent or emerged apical periodontitis and provide a favorable environment for healing (1, 2). Retreatment aims to remove all filling materials from the canal system, followed by chemomechanical disinfection and obturation (3). The most common obturation material is gutta-percha in combination with a sealer or cement as a luting agent (4). Mechanical removal of gutta-percha is routinely performed by using hand files, rotary instruments, ultrasonic tips, or heating devices (5–8). The presence of residual obturation materials on root canal walls can prevent irrigating solutions and intracanal medicaments from contacting the surface of the underlying dentin, hindering disinfection (2).

A major complicating factor in the elimination of materials from root canal systems is the cross-sectional anatomy. Rotary instrumentation with nickel-titanium (NiTi) instruments often machines a round area with limitations in treatment of oval-shaped canals because instrumentation is directed largely by the shape-memory of the alloy and the canal curvature (9–11). Although brushing or circumferential filing movements are often used to overcome this challenge, a high percentage of walls still remain untouched (11). Although the overall design of NiTi engine-driven instruments is suitable for removing root-filling debris coronally, to date, no studies have shown complete removal of the obturation materials during the retreatment of root canals regardless of the technique or instruments used (4, 7, 8, 12).

Instrument designs have been progressively altered to increase their cutting efficiency and resistance to fatigue. Newer instruments have focused on alterations to the taper, cross-sectional shape, variable pitch, and helical angles (13–15). Advances have also been made in the metallurgy, optimizing the nanocrystalline structure (16, 17) and with post-grinding heat treatment (15, 16). Despite changes in metallurgy and design,
the long axis of endodontic instruments has remained linear to a large extent. TRUShape (TS) instruments (Dentsply Tulsa Dental Specialties, Tulsa, OK) have a multi-planar S-shaped curve from the tip of the instrument to the beginning of the shank, thereby creating an envelope of motion with the aim of increasing the percentage of walls touched during instrumentation of irregular cross sections. The ability of TS instruments to compress into smaller canal spaces and return to their original shape as the canal widens could enable their use through a contracted endodontic cavity (CEC) design minimizing tooth structure removal. Few studies have examined instrumentation through CEC (18, 19), and no studies have investigated the impact such an access design would have on retreatment effectiveness.

Therefore, the aim of the present study was to compare the effectiveness of the TS and ProFile Vortex Blue (VB) rotary instruments on the removal of obturation materials from single-rooted, oval-shaped mandibular premolars through CEC or traditional endodontic cavity (TEC) access designs.

**Materials and Methods**

After Institutional Review Board approval (14-03594-XM), human first and second mandibular premolars were obtained from a bank of teeth and screened in clinical and proximal radiographic views. Forty-eight teeth were selected with the following inclusion criteria: intact crowns, fully formed apices, single roots and canals, 21–24 mm length, and canals wide in the buccolingual direction. All endodontic procedures were performed by a single operator under the clinical microscope at ×10.9 magnification (OPMI Pico; Carl Zeiss Meditec Inc, Jena, Germany).

**Initial Root Canal Treatment**

Teeth were accessed with a high-speed mosquito 392 bur (Spring Health Diamonds, St Louis Park, MN) under water spray. The CEC access approach was used in all teeth (18). Briefly, premolars were accessed 1 mm buccal to the central fossa, and cavities were extended apically, maintaining part of the chamber roof and lingual shelf. A new bur was used for each specimen.

For instrumentation and reinstrumentation procedures, canals were approached by changing the entry angle of the instruments as if the teeth presented as 2 separate systems in a buccolingual direction because of the oval shape configuration. Working length was established by visualizing the tip of ISO #10 K-file at the canal foramen and subtracting 0.5 mm. A confirmatory radiograph was exposed to ensure accurate working length, and values were recorded for all specimens. Instrumentation was performed up to F2 ProTaper instrument (Dentsply Tulsa Dental Specialties). Canals were irrigated with 2 mL 8.25% NaOCl (Clorox Professional Products Company, Oakland, CA) between instruments, followed by irrigation with 5 mL 17% EDTA (Roth International Ltd, Chicago, IL) for 3 minutes and finally by 5 mL 8.25% NaOCl. Canals were dried with paper points. AH Plus root canal sealer (Dentsply De Trey GmbH, Konstanz, Germany) was applied to the canal walls by using a 30/04 gutta-percha master cone (Brasseler USA, Savannah, GA) and obturated with modified lateral compaction of warm gutta-percha. A proximal radiograph showing dense obturation material from orifice to apex with no voids was considered adequate. If voids were observed in the obturation mass, the specimen was replaced. Access cavities were sealed with Cavit G (3M ESPE, Neuss, Germany), and the teeth were stored in 100% humidity at 37°C for 30 days to allow full setting of the sealer.

**Retreatment Technique**

Teeth were divided into 2 groups by using a random number generator according to the access design used for retreatment, CEC or TEC. The CEC group was composed of 24 specimens from which only the temporary restorations were removed. The remaining 24 specimens were further enlarged to a TEC with an LA Axcess high-speed diamond (SybronEndo, Glendora, CA) under water spray to allow straight-line access to the obturation material and pulp chamber and eliminate remaining pulp horns. Final access outlines are demonstrated in Figure 1A and C. In all specimens, the bulk of the obturation material was removed with ProTaper Universal Retreatment instruments (Dentsply Tulsa Dental) at pre-set lengths: D1 (30/09, 16 mm, coronal one third), D2 (25/08, 18 mm, middle one third), and D3 (20/07, 21 mm, apical one third) at 600 rpm. The stratified specimens were further divided into 2 subgroups, TS and VB.

Reinstrumentation with TS was carried out as follows: 20/08v TS orifice modifier followed by 20/06v, 25/06v, 30/06v, and 40/06v. The instruments were used passively at 300 rpm in the presence of 8.25% sodium hypochlorite, with gentle 2–5 mm pecking motions up to the mid-root and 2–3 mm pecking motions toward working length. The remaining 24 teeth were instrumented with 16 mm 20/08 ProFile Vortex Orifice Opener (Dentsply Tulsa Dental) and VB 20.06, 25.06, 30.06, and 40.06 at 500 rpm. Retreatment was considered complete when

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**Figure 1.** Photographs of occlusal surface of mandibular premolars showing (A) CEC before instrumentation, (B) CEC after instrumentation, and (C) TEC design.
instruments were removed with no obturation materials visible on their surface. A new set of instruments was used for each specimen.

All specimens were irrigated with 8.25% NaOCl between instruments. Final irrigation was done for all specimens with 5 mL QMix 2in1 (Dentsply Tulsa Dental Specialties), followed by 5 mL 8.25% NaOCl. Total time (minutes) for retreatment was recorded.

The pulp chambers were temporarily sealed (Blu-Tack, Bostik, Victoria, Australia) during post-processing to prevent debris from entering the canal system. A 30-mm diameter × 0.030-mm width double-sided diamond disk (AXIS; SybronEndo) was used at low speed to create a longitudinal groove along the buccal and lingual surfaces of the root at ×10.9 magnification, using care not to reach the root canal. Teeth were fractured longitudinally with a bi-tapered chisel and a surgical hammer and photographed at 1:1 ratio (EOS Rebel T5i; Canon, Melville, NY). The photographs were evaluated by 2 independent observers who were calibrated and standardized before examining the specimens. The evaluators were blinded as to which retreatment method was used. Adobe Photoshop CC 2014 (Adobe Systems Inc, San Jose, CA) was used to measure the total area of the root canal space and the areas of remaining obturation material in millimeters squared for separate root canal thirds (apical, middle, and coronal). The measurements were repeated to ensure reproducibility. Mean percentage values were determined and compared. The intraclass and interclass correlation coefficients were calculated by using a 95% confidence interval.

Data Analysis

The Shapiro-Wilk test was used to assess normality of the data. Data that followed a non-normal distribution were expressed as median and interquartile range. The interaction between the access design and type of instrumentation technique was analyzed with the Kruskal-Wallis analysis of variance (ANOVA) for 2-factor tests (access × instrument) and Mann-Whitney rank sum for 1-factor test (access or instrument). The location (coronal, middle, and apical) of the remaining obturation materials was analyzed with the Friedman repeated-measures ANOVA, followed by the Tukey honestly significant difference pairwise testing. Time required for retreatment procedures was analyzed with one-way ANOVA and Tukey honestly significant difference tests. The level of significance was set at α < 0.05 (SigmaPlot 13.0; Systat, San Jose, CA).

Results

Data obtained for the percentage of remaining obturation materials on the root canal surface and total retreatment time are shown in Table 1. Significantly more time was required for retreatment with the CEC-TS (27.68 ± 1.43 minutes) when compared with other groups (P < .05).

There was a highly significant difference between the instruments overall (P < .001), with VB showing more remaining obturation materials on the root canal surface. There was also a highly significant difference between CEC and TEC access designs overall (P = .001), with CEC resulting in more obturation materials remaining on the root canal surface.

The interaction between access design and instrument type showed that the combination of CEC-VB presented significantly higher amounts of remaining obturation materials on the canal surface when compared with TEC-VB, CEC-TS, and TEC-TS (P ≤ .05). None of these other combinations were different from each other (P > .05; Fig. 2).

When evaluating the canal thirds, the CEC-VB group showed higher amounts of obturation materials remaining in the coronal and middle thirds when compared with the apical third (P ≤ .05). All other access design–instrument combinations showed no differences in the location of remaining obturation materials (P > .05).

The intraobserver and interobserver agreements were 1.000 (ranging from 0.999 to 1.000) and 0.990 (ranging from 0.985 to 0.994), respectively, which suggest an excellent level of agreement.

Discussion

For CEC designs to be adopted, they must not be less effective than their traditional counterparts, regardless of trends toward maintenance of pericervical dentin. To our knowledge, there have been no previous reports in the literature that assessed the efficacy of different access cavity designs on the ability of NiTi rotary instruments to remove obturation materials.

The initial CEC access outline followed the design proposed by Krishan et al (18) and resulted in a tapered preparation in an occlusal-apical direction because of the inherent shape of the bur. Initial root canal instrumentation with F2 ProTaper instrument unintentionally enlarged the cavity because of the cutting blades of the rotary instrument. Similarly, after the retreatment phase, the CEC access underwent gradual expansion (Fig. 1B). The volume of remaining pericervical dentin was not evaluated in this study because of limitations in the methodology used. However, the clinician should take this into consideration when determining how small the access can be to eliminate unnecessary stress on the rotary instruments and avoid unnecessary increased treatment time for the patient. In our study, significantly more time was required for retreatment with the CEC-TS combination when compared with other groups.

The constricted nature of the CEC access design for the single-rooted teeth used in this study did not permit continuous wave obturation because of the dimensions of the reduced access. Insufficient space prevented retrieval of gutta-percha with System B heat source because it remained in the pulp horns on withdrawing the carrier. Moreover, matched F2 gutta-percha was too large to be accommodated through the constricted access; hence there was the need to use .04 tapered gutta-percha cones. Therefore, a modified warm lateral compaction technique was used. A CEC access design in multitoothed teeth has

### Table 1. Percentage of Remaining Obturation Materials in Each Canal Third (Median and Interquartile Range) and Time Required (minutes) for Retreatment (mean ± standard deviation)

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Access</th>
<th>Coronal</th>
<th>Middle</th>
<th>Apical</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS</td>
<td>CEC</td>
<td>0.02*</td>
<td>0.11*</td>
<td>0.34*</td>
<td>27.7 ± 1.4*</td>
</tr>
<tr>
<td></td>
<td>TEC</td>
<td>0.46*</td>
<td>0.07*</td>
<td>0.00*</td>
<td>23.9 ± 5.1*</td>
</tr>
<tr>
<td>VB</td>
<td>CEC*</td>
<td>11.85*</td>
<td>13.94*</td>
<td>2.27*</td>
<td>20.1 ± 3.3*</td>
</tr>
<tr>
<td></td>
<td>TEC</td>
<td>0.96*</td>
<td>0.06*</td>
<td>1.35*</td>
<td>22.6 ± 1.7*</td>
</tr>
</tbody>
</table>

CEC, contracted endodontic cavity; TEC, traditional endodontic cavity; TS, TRUShape; VB, Profile Vortex Blue.

Pairwise comparison tests showed that the combination of CEC-VB resulted in significantly more debris than all other combinations (P ≤ .05). Different letters indicate statistically significant differences within each row. Different symbols indicate statistically significant differences between treatments (P < .05).
greater potential for sufficient space, allowing easier retrieval of gutta-percha because the access would be larger.

Several methods have been used to determine the amount of residual obturation materials on the canal surface after retreatment (4, 7, 8, 12, 20). Similar to previous studies that used single-rooted teeth, our specimens were split longitudinally for evaluation (7, 8). More accurate measurements can be obtained with longitudinal sectioning when compared with conventional radiographic techniques because the latter may be subject to magnification or distortion (20). In our study, high-resolution images were traced by using Adobe Photoshop to quantitatively assess the presence of obturation material remnants and were reported in relation to the total canal surface area. No attempt was made to distinguish between residual sealer or gutta-percha.

Neither evaluated NiTi instrumentation systems completely removed all obturation materials from the root canals of mandibular premolars. These findings are in agreement with several studies that evaluated different instruments and systems for this purpose (4, 7, 8, 12). In our study, mandibular premolars with similar length and internal and external anatomy were used to allow standardization of the sample. Canals were initially prepared to a 25/08 instrument and further enlarged apically in the retreatment phase to minimize the presence of residual filling materials (12, 21). No solvents were used to allow for sole evaluation of the effect of instrumentation. Each tooth was re-treated with new instruments to decrease fatigue and avoid instrument separation. The active cutting tip of the D1 ProTaper retreatment instrument easily created a pilot space in the gutta-percha/sealer mass (22). Retreatment was initiated with the entire ProTaper retreatment series in all groups and was followed with either TS or VB instruments. Patency was reestablished during retreatment in all specimens independently of access design or instrument used.
Our results demonstrated that the use of VB instruments through a CEC access design showed higher amounts of obturation materials on the root canal walls, particularly in the cervical and middle thirds. A possible reason for this is that the constricted access and the linear design of the VB instruments prevented the file from engaging the gutta-percha, despite best efforts to introduce the instruments into the canal in a buccolingual direction as if the teeth presented as 2 separate systems because of the oval canal shape. The material remnants were burntished against the canal walls.

A recent study on the removal of obturation materials from root canals when using TS instruments showed no advantage of the latter when compared with Reciproc files (23). Our results showed that the use of TS instruments through a CEC access design provided the greatest amount of obturation material removal from the root canal surface, similar to the use of VB and TS instruments in a TEC design. If a contracted design is desired by the clinician during access, then TS instruments can be used with no deleterious effect on the overall amount of obturation material removal. Per this study, this is specific to root canals of single-rooted, oval-shaped mandibular premolars. However, regardless of the retreatment protocol or access design used, residual obturation materials were evident on the root canal surface.

**Conclusions**

Within the limitations of this ex vivo study, neither retreatment protocol was able to render root canals free of obturation materials. However, in the presence of a CEC access design, TS instruments removed more obturation material in single-rooted, oval-shaped canals.

**Acknowledgments**

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**References**