# XP Shaper, A Novel Adaptive Core Rotary Instrument: Micro–computed Tomographic Analysis of Its Shaping Abilities

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## Abstract

**Introduction:** The aim of this study was to investigate the shaping abilities of the XP Shaper (FKG, La Chaux-de-Fonds, Switzerland) and compare the findings with Vortex Blue (Dentsply Tulsa Dental Specialties, Tulsa, OK) using micro–computed tomographic imaging. **Methods:** Twenty matched, extracted, mandibular, central incisors with a single, oval canal were scanned preoperatively at 25-$\mu$m resolution and postoperatively after instrumentation with either Vortex Blue in a crown-down manner up to size 30.04 or XP Shaper. The percent of untouched walls, changes in canal volume and surface area, the amount of dentin removed, debris remaining in the canal, and the preparation taper were determined. The total time required for instrumentation using each technique was calculated in seconds. Statistical analysis was used to compare between both groups using repeated measures multivariate analysis of variance with Bonferroni correction for post hoc comparison and independent sample $t$ tests. **Results:** The XP Shaper significantly increased the canal volume ($F$ = 77.948, $P$ < .001), surface area ($F$ = 5.543, $P$ = .030), and amount of dentin removed ($F$ = 10.044, $P$ = .001) and had significantly less untouched walls (38.6% $\pm$ 8.1%) compared with VB (58.8% $\pm$ 8.5%). There was less debris at all levels of the canal in the XP Shaper group. Results were almost significant ($P$ = .059). The XP Shaper was also significantly faster in completing the mechanical preparation of the root canal space by almost 1 minute ($t$ = 6.216, $P$ < .001). **Conclusions:** The XP Shaper can expand beyond its core size to adapt to the anatomy of the root canal space. The XP Shaper can prepare and touch more canal walls in oval-shaped canals compared with Vortex Blue. However, the final preparation taper will vary according to the anatomy of the treated tooth. *(J Endod 2017;■:1–7)*

## Key Words

Canal taper, micro–computed tomography, untouched walls, Vortex Blue, XP Shaper

**Significance**

Using the XP Shaper, RCT can be completed predictably after enlarging the canal to size #15. The XP addresses more canal walls in oval-shaped canals compared with VB. The final preparation taper will vary depending on the root canal anatomy.

Disinfection of the root canal space using instrumentation and irrigation is a major procedural step to remove pulp tissue, debris, and bacteria (1). The primary goal of mechanical instrumentation is to remove the inner layer of dentin and facilitate mechanical disruption of bacterial biofilms while maintaining the original shape of the canal (2). However, the root canal space is not rounded but rather an irregular oval shape, particularly toward the cervical region (3–5). Most rotary instruments can instrument those oval canals without major procedural errors. However, up to 80% of the canal walls may remain untouched (6, 7). There have been major improvements in the treatment of nickel-titanium (NiTi) instruments, such as electropolishing, electrodischarge machining, and thermal treatment protocols that provide rotary instruments with more flexibility (8). However, completely addressing the 3-dimensional structure is still a major limitation with the current rotary files used today. Failure to adequately clean the root canal space may result in treatment failure or delayed healing (9).

The XP Shaper (FKG, La Chaux-de-Fonds, Switzerland) is a recently introduced endodontic rotary instrument. It is manufactured from a MaxWire alloy and has a tip size of ISO #27 with a 0.01 taper across the length of the instrument. The manufacturer claims that the instrument can expand from its original size to enlarge the canal to at least 30/04 while addressing the 3-dimensional structure of the root canal space. They also claim that the booster tip of the instrument enables the file to enlarge the canal from an apical size of #15 to #30 in a single step without the need of the traditional incremental increase in apical size. To our knowledge, there are no published data on the canal preparation quality of the XP Shaper or its ability to expand beyond its core size. Therefore, the aim of this study was to investigate the shaping ability, canal taper, and operation time of the XP Shaper in oval-shaped mandibular central incisors using micro–computed tomographic (micro-CT) imaging and compare the findings with a

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group of matched teeth instrumented using a standard rotary file system (Vortex Blue; Dentsply Tulsa Dental Specialties, Tulsa, OK).

## Materials and Methods

### Teeth Selection

The study was approved by the institutional review board of University at Buffalo, Buffalo, NY (no. 00000240). A total of 58 extracted human mandibular incisors were collected for this study. Teeth with cracks, immature apices, resorptive defects, caries, or root fillings as well as teeth presenting with an initial apical diameter greater than a size #25 K-file or an apical curvature greater than 10° were excluded from this study. All teeth were examined using periapical radiographs followed by cone-beam computed tomographic imaging using Veraviewepocs 3De (J Morita Mfg Corp, Kyoto, Japan) at 80 kVp, 10 mA, a field of view of 4 × 4 cm, and 0.125-mm voxels. The Digital Imaging and Communication in Medicine files were evaluated with AMIRA software (5.4.0; Visage Imaging GmbH, Berlin, Germany) to obtain a preliminary anatomic evaluation before micro-CT scanning. Twenty teeth with type I oval canals with a similar length and apical diameter were selected for this study. The oval anatomy was defined by a ratio greater than 2 (of the maximum to the minimum canal diameter) obtained at the transversal slice located 6 mm from the apex as defined by Paqué and Peters (10). Teeth were then randomly assigned to 1 of the instrumentation groups, Vortex Blue or XP Shaper. Micro-CT evaluation confirmed a normal distribution of samples between groups regarding apical diameter, length, volume, and surface of the root canal space.

### Root Canal Preparation

All teeth were accessed through the crown using a high-speed diamond bur, and patency was achieved using K-file size #10. The working length (WL) was set 0.5 mm short of the apical foramen. A glide path was established with a #15 K-file to the WL. All teeth were then scanned using micro-CT imaging. Before root canal preparation, each tooth was immersed up to the cementoenamel junction in a warm water bath (37°C) to mimic clinical conditions. Another warm water bath was used to keep the irrigant solution and the files at 37°C throughout the experiment. All instrumentation was performed by a single endodontist who was blinded to the 3-dimensional virtual models of the teeth.

### Vortex Blue Group

All instruments were operated using an electric motor set at 500 rpm and 1.3 Ncm. Each canal was instrumented in a crown-down manner starting with 30/04 followed by 25/04 and 20/04, if needed, until the file reached the WL. After that, the canal was enlarged in an ascending order to size 30/04; 2 mL 5% sodium hypochlorite (NaOCl) was used between each instrument over 30 seconds. To confirm complete instrumentation, a gutta-percha cone size 30/04 was placed to the WL.

### XP Shaper Group

The XP Shaper file was operated at 900 rpm and 1 Ncm torque. The file was inserted in the canal, and 5 strokes were applied (in-and-out

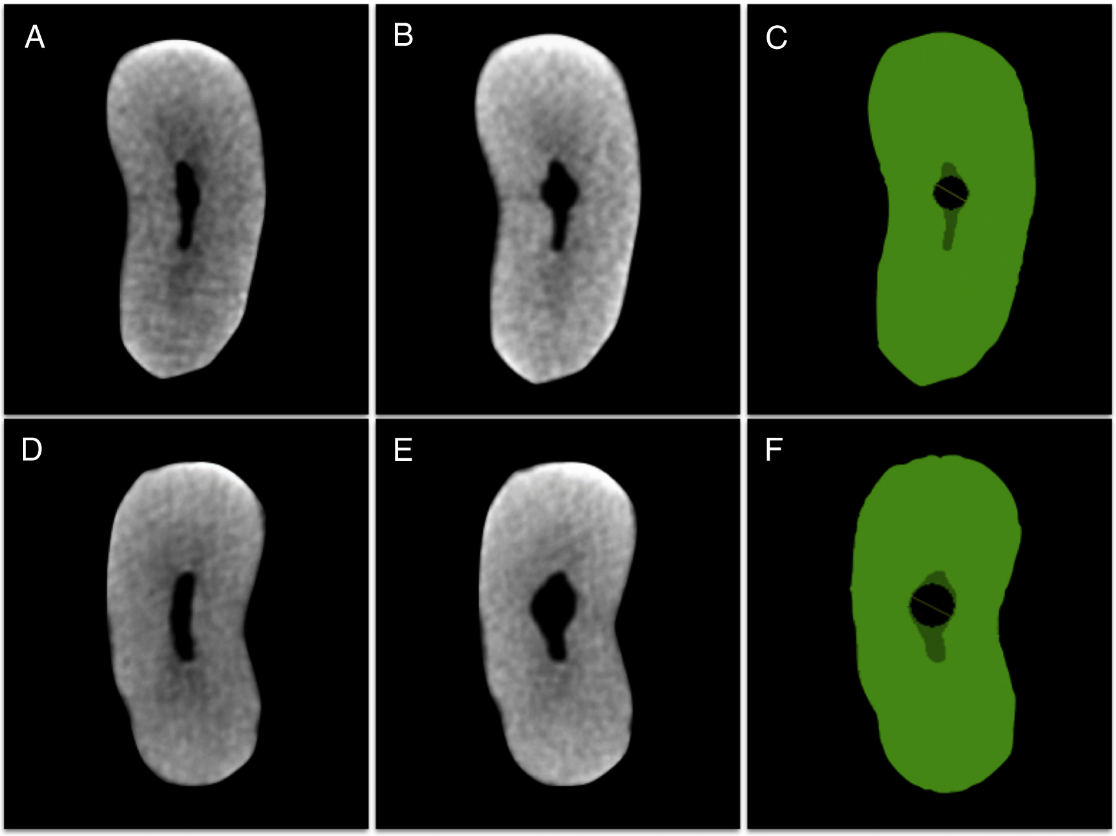


**Figure 1.** An image showing the transversal cross sections of the middle third of incisors. The preparation taper was calculated to determine the appropriate gutta-percha cone size to be used at the middle third of the canal. (*A–C*) Instrumentation with Vortex Blue. (*D–F*) Instrumentation with the XP Shaper. (*A* and *D*) Preinstrumentation micro-CT images. (*B* and *E*) Postinstrumentation micro-CT images. (*C* and *F*) Superimposition of a rounded figure resembling gutta-percha in the most rounded portion of the canal.

motion) until the file reached 0.5 mm shorter of the WL (adjusted WL) as recommended by the manufacturer. In case the file failed to reach the adjusted WL from the first 5 strokes, the canals were irrigated with 2 mL NaOCl over 30 seconds, and the procedure was repeated. Once the file reached the adjusted WL, 5 up-and-down movements were made with the file. Similar to Vortex Blue, the preparation was checked with a 30/04 gutta-percha cone.

In both groups, after complete instrumentation, each canal was rinsed with 1 mL 5% NaOCl followed by 1 mL 17% EDTA. The preparation and irrigation time for each canal were recorded in seconds using a digital chronometer. The preparation time was calculated only when the file was rotating inside the canal.

## Micro-CT Evaluation

Individual custom jigs were used to ensure the reproducible position of the teeth for the pre- and postinstrumentation micro-CT scans. The SkyScan 1172 micro-CT scanner (Bruker micro-CT, Aartselaar, Belgium) was used to scan all teeth at a resolution of 25 $\mu$m. The scanning and reconstruction parameters were kept constant for the pre- and postinstrumentation scans. The pre- and poststack of images were geometrically aligned using 3-dimensional registration software (Data Viewer 1.5.2.4, Bruker micro-CT) with a shift step of 0.5 pixels and a rotation of 0.1°. The volume of interest was established from the cementoenamel junction up to 0.5 mm short of the most coronal slice showing the apical foramen (11). The transversal slices were then divided into apical, middle, and cervical thirds. A task list was created to obtain the volume, surface area, and structure model index. The pre- and postbinarized canals were superimposed to calculate the untouched surfaces, the volume of debris, and the amount of dentin removed. The percentage of the canal walls that were not enlarged at least by 0.025 mm were considered as untouched surfaces. Materials with a density similar to that of dentin in regions previously occupied by air in the preoperative canal space were identified as debris (12). To determine the final size of the preparation (diameters and taper), an innovative method was used to virtually determine the appropriate gutta-percha cone that clinicians could use for obturation (Fig. 1). All scans were visualized and analyzed by a single, calibrated, blinded operator.

## Statistical Analysis

Assumptions of normality were met across the initial data set for the apical diameter, root length, canal volume, and total surface area. The amount of untouched surface; increase in canal volume and surface area; debris; and dentin removal in the apical, middle, and coronal areas in both groups as well as the time required to complete instrumentation were compared using repeated measures multivariate analysis of variance with Bonferroni correction for post hoc comparison and independent sample $t$ tests. The level of statistical significance was set at $\alpha$ = .05.

# Results

The Levene test yielded no statistical significance for all variables, indicating that assumptions of homogeneity in the data set were met. The $t$ test showed a statistically significant difference in the percentage of untouched surfaces between both groups overall ($t$ = 5.395, $P$ < .001), and particularly at the middle third. The XP Shaper performed considerably better at all 3 locations (apical, middle, and coronal) with uniformly less untouched surfaces ($F$ = 25.81, $P$ < .001). There was also a statistically significant difference between both groups in the total canal volume ($F$ = 77.948, $P$ < .001) and an increase in the canal surface area ($F$ = 5.543, $P$ = .030). The XP Shaper removed more dentin than Vortex Blue ($F$ = 10.044, $P$ = .001). This difference was present in the middle

**TABLE 1.** The Mean ± Standard Deviation of the % Increase in Volume, % Increase in Surface Area, % of Untouched Surfaces, Debris, and Dentin Removed after Preparation with XP Shaper or Vortex Blue

| | Apical third | | Middle third | | Coronal third | | Total | |
|---|---|---|---|---|---|---|---|---|
| | XP | VB | XP | VB | XP | VB | XP | VB |
| % volume increase (mm$^3$) | 62.4 ± 25.6 | 43.5 ± 29.2 | 57.7 ± 19.2$^a$ | 29.1 ± 19.1$^b$ | 31.9 ± 30$^c$ | 11.2 ± 10.6$^d$ | 41.3 ± 24.6* | 19.6 ± 14.4 |
| % surface increase (mm$^2$) | 20.4 ± 10.5 | 15.6 ± 11 | 10.1 ± 3.4$^a$ | 6 ± 4.9$^b$ | 7.6 ± 5.2$^c$ | 2.7 ± 4.5$^d$ | 12.7 ± 9.2* | 8.3 ± 9.2 |
| % untouched surface | 30.7 ± 11.6 | 47.4 ± 10.3 | 39.6 ± 8.3$^a$ | 56.2 ± 5.5$^b$ | 40.8 ± 8.5 | 64.3 ± 13.3 | 38.6 ± 8.1* | 58.8 ± 8.5 |
| Debris (mm$^3$) | 0.01 ± 25.6 | 0.05 ± 0.06 | 0.03 ± 0.02 | 0.05 ± 0.03 | 0.06 ± 0.04 | 0.07 ± 0.03 | 0.10 ± 0.05 | 0.16 ± 0.07 |
| Dentin removed (mm$^2$) | 0.26 ± 0.09 | 0.32 ± 0.27 | 0.70 ± 0.15$^a$ | 0.36 ± 0.14$^b$ | 0.77 ± 0.29$^c$ | 0.30 ± 0.19$^d$ | 1.73 ± 9.2* | 0.98 ± 0.49 |

VB, Vortex Blue; XP, XP Shaper.

Data are presented as total as well as at the coronal, middle, and apical third of the canal. Different superscript letters in each row indicate statistical significance.

*Indicates statistical significance in the total.

**TABLE 2.** The Time Required (in Seconds) to Completely Prepare the Root Canal Space with and without Irrigation

| Instrument | Time of instrument rotating inside the canal | Total preparation time (Shaping + irrigation) |
|---|---|---|
| XP Shaper | 20 ±6[a] | 95 (1 minute 34 seconds) ± 26[a] |
| Vortex Blue | 26 ±4[b] | 161 (2 minutes 31 seconds) ± 19[b] |

Different superscript letters indicate statistical significance within each column.

and coronal areas ($F$ = 14.442, $P$ = .001) but not in the apical area ($P$ > .05). There was a tendency toward less debris accumulation in the XP Shaper group. Results were almost significant ($P$ = .059). The XP Shaper was significantly faster than Vortex Blue in instrumenting the root canal space ($t$ = 2.394, $P$ = .028) and even more so for the total instrumentation time ($t$ = 6.216, $P$ < .001) with an almost 1-minute difference between the 2 groups. The apical preparation at the WL was ISO size #30 (±1) for the VB group with a consistent taper of 4% and minimal variation at each level. For the XP Shaper group, the apical size at the WL was ISO #31 (±2) with an inconsistent taper along the canal length and a higher degree of variation. Data sets are displayed in Tables 1–3, respectively.

## Discussion

This study highlights the efficiency, shaping abilities, and expansion properties of a newly designed instrument, the XP Shaper. It is clear that this file represents a new generation of rotary files that can expand beyond its nominal size. Standard rotary files, despite their flexibility or surface treatment, can be all classified as "nonadaptive core" instruments. They instrument the canals to a rounded uniform shape without adaption to the individual variations of each canal. As a result, rotary instruments often leave behind untouched walls (6, 13) and more debris packed toward the canal walls and isthmi (14, 15). To overcome this issue, recently introduced files, such as TruShape (Dentsply Tulsa Dental Specialties), have been designs with an off-centered motion to address more untouched surfaces. However, results have shown no superiority over "nonadaptive" rotary files in preparing more canal walls (16). The Self-Adjusting File (ReDent NOVA, Ra'anana, Israel) is another engine-driven endodontic instrument that showed a great potential in addressing the 3-dimensional structure of the root canal space (17). Its "hollow core" enables the instrument to compress and expand, allowing it to touch more canal walls (18). However, it requires preflaring and a long operating time to address most of the root canal surfaces (17, 19). On the other hand, the XP Shaper can be classified as an "adaptive core" instrument. Its small mass and expanding properties appear to better address the 3-dimensional structure of the canal while allowing enough spaces for debris to escape. This was evident by the significant increase in canal volume, surface area, percentage of untouched walls, and the amount of dentin removed while having less debris accumulation at the different levels of the canal. The XP Shaper may not be the first file system designed to address the canal in a 3-dimensional manner. However, its innovative design and concept represent a new philosophy for instrumentation.

**TABLE 3.** The Mean ± Standard Deviation of the Apical Size at the Working Length (ISO) and the % Increase in Preparation Size (Canal Taper) in the Apical, Middle, and Coronal Thirds

| | Vortex Blue | XP Shaper |
|---|---|---|
| Apical size at WL (ISO) | 30 ± 1 | 31 ± 2 |
| Preparation taper | | |
| Apical third | 4% ± 1.1% | 6% ± 2.4% |
| Middle third | 4% ± 0.9% | 6% ± 2.3% |
| Coronal third | 4% ± 1.5% | 5% ± 2.5% |

WL, working length.

In this study, we attempted to provide some preliminary findings on the XP Shaper instrument. To better understand its properties and behavior inside the root canal space, we compared its shaping abilities with a uniform taper rotary instrument, Vortex Blue. Human mandibular incisors were deemed to be a suitable model for comparison because their oval-shaped anatomy often presents mechanical challenges during instrumentation to address all canal walls (6, 17). In this study, we scanned all teeth initially using a cone-beam computed tomographic scan. This allowed better selection of appropriate teeth for micro-CT analysis in a time and cost-effective manner. Instrumentation of all the teeth was performed in a water bath at 37°C. Previous studies showed that heat-treated instruments, such as those used in this study, can change from the martensite to the austenite phase when used clinically (20). Although these changes may primarily affect the flexibility and cyclic fatigue resistance of rotary files for an instrument like XP Shaper, we anticipated that changes in temperature may also affect its expansion properties. Previous studies often used Gates Glidden burs to enlarge the coronal portion of the canal before instrumentation (17, 19). This procedure may impact the data by enabling the instruments to better adapt to the canal walls and may positively affect the volume enlarged and the percentage of prepared surfaces. To properly compare between the 2 file systems, no attempts were made to use any rotary instruments to enlarge the coronal third of the canal. A limitation of this study may be the small sample size. However, care was taken to perform the anatomic matching of groups, and also statistical analysis revealed that the sample size was adequate for a meaningful comparison.

In this study, there were significantly more walls untouched in the Vortex Blue group (58.8%) compared with the XP Shaper group (38.6%) ($P$ < .01). This was noticed at all canal levels (apical, middle, and coronal) (Fig. 2). The percentage of prepared walls in the Vortex Blue group seems to be consistent with previous reports on "nonadaptive" rotary files (6, 7, 13). On the other hand, the XP Shaper was clearly able to expand beyond its core size and address more canal walls. According to the manufacturer's recommendation, the XP Shaper was operated by instrumenting 1 mm short of the apical foramen (ie, 0.5 mm short of the WL). We initially assumed that the recommendation is based on the fact that the file can expand in the apical direction. However, this was not apparent from our micro-CT analysis. At 0.5 mm from the apical foramen, 40% of the instrumented samples in the XP Shaper group showed areas of packed debris or no changes in canal volume, indicating that the file did not reach the 0.5-mm level. This was not observed in any of the samples of the Vortex Blue. These results suggest that the XP Shaper may only expand in the mesiodistal and buccolingual direction but not in the coronoapical direction. Further studies are needed to confirm these results. In this study, the XP Shaper was significantly faster than Vortex Blue to completely shape the canal by almost 1 minute. Although the actual instrumentation time in both groups was close, more time was required to completely shape the canals in the Vortex Blue group because of the need to irrigate more frequently between files to remove debris and facilitate the insertion of the subsequent file. This was not necessary

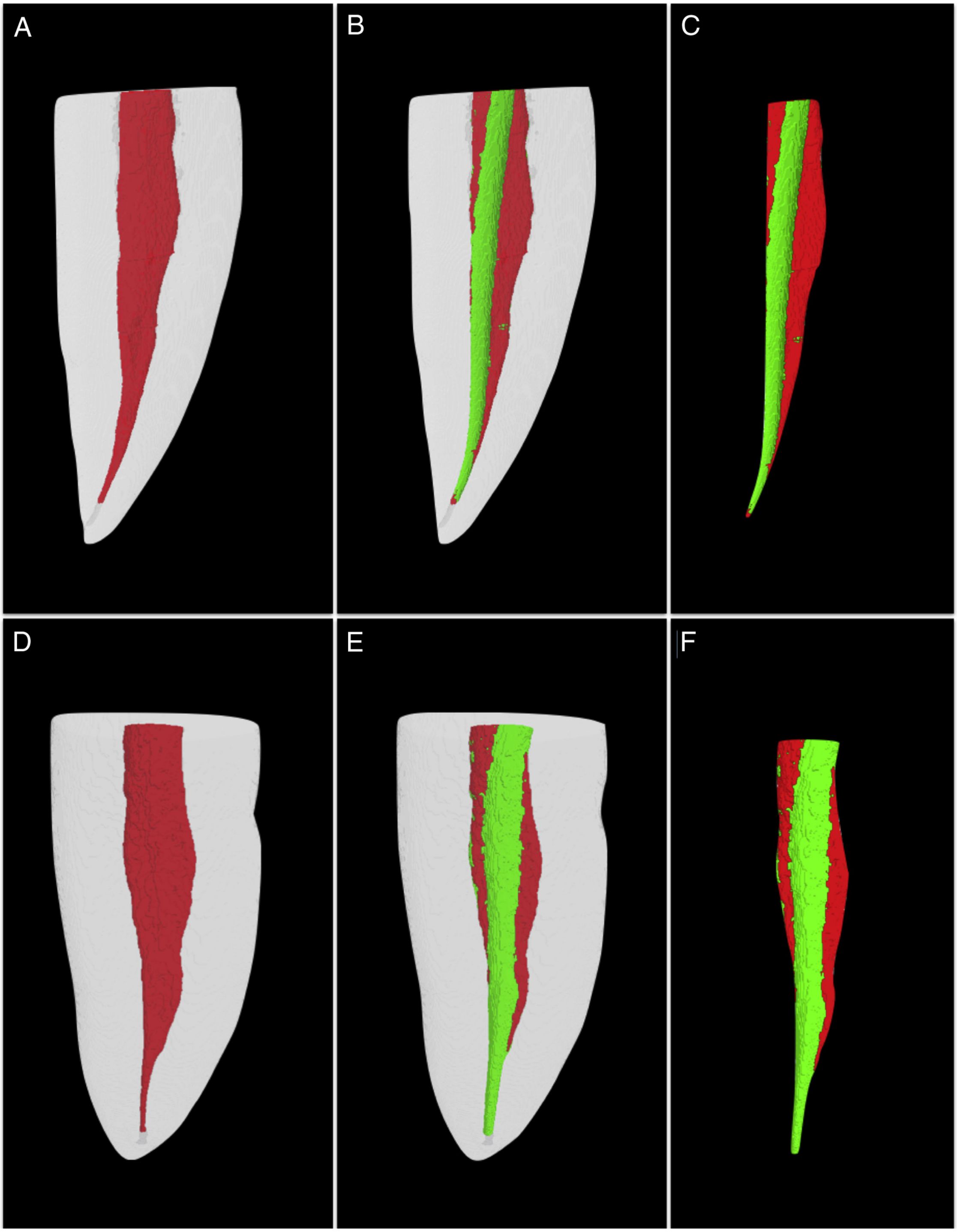


**Figure 2.** Three-dimensionally reconstructed micro-CT images show the root canal space (*A* and *D*) before and (*B* and *E*) after instrumentation using (*A–C*) Vortex Blue and (*D–F*) XP Shaper. The *red color* indicates the canal before instrumentation. The *green color* indicates the canal after instrumentation.

for the XP Shaper group possibly because of its smaller mass and its irregular movement, which allows debris to escape during instrumentation, as explained previously and shown in Table 1. It should be noted that larger volumes of irrigants may still be required to achieve adequate disinfection. However, a large volume of irrigants was not needed to facilitate mechanical instrumentation in the XP Shaper group. In this study, we did not attempt to use the XP Shaper inside the canal for longer periods than recommended because information on its shaping ability and mechanical properties were not available. It is plausible that operating the XP Shaper for a longer time or in a brushing motion may result in addressing more canal walls. Further studies are needed to test this hypothesis.

Given that the XP Shaper expands to reach a larger size than its core size (27/01), it was deemed necessary to calculate the final preparation taper of the instrumented canal space. The preparation taper for the Vortex Blue group was consistent with the size of the instrument

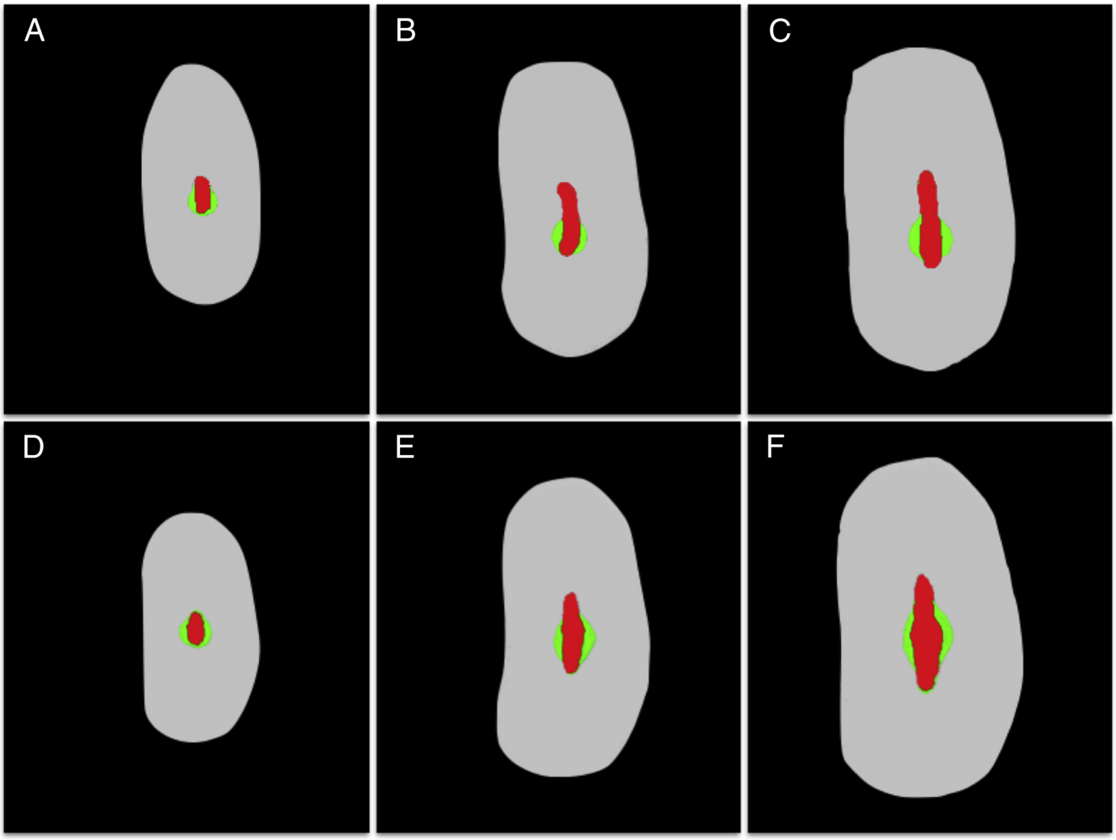


**Figure 3.** A representative example of micro-CT data of a flat, oval-shaped root canal of the mandibular incisor prepared with (*A–C*) Vortex Blue and (*D–F*) XP Shaper rotary systems in the (*A* and *D*) apical, (*B* and *E*) middle, and (*C* and *F*) coronal thirds of the canal. (The *red* and *green areas* are preoperative and postoperative superimposed cross sections, respectively.) Note that Vortex Blue increased the diameter of the canal in a round cross section compared with a more oval-shaped canal in the XP group.

(4%) with minimal standard deviation (Table 3). This variation can be attributed to the presence of debris in the root canal space that hinders proper calculation of the prepared portion (if the % increase is less than 4%) or possible deviation of the files from the center of the canal during instrumentation while attempting to reach the working length (if the % increase is more than 4%). In the XP Shaper group, the variation was quite larger. The XP Shaper appears to create a nonuniform preparation to enable adapting to the nonuniform structure of the root canal anatomy (Fig. 3). Such results suggest that it may not be possible to predict the final preparation taper achieved by the XP Shaper. Within the limitations of this study, it can be concluded that the XP Shaper appears to be superior to Vortex Blue in addressing the 3-dimensional structure of the root canal space of oval-shaped canals by preparing more canal walls. The file does not provide a predetermined round shape preparation but rather an inconsistent tapered preparation that complies with the 3-dimensional structure of the canal.

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*The authors deny any conflicts of interest related to this study.*

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