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In-vitro comparison of TruNatomy and XP-endo Shaper on amount of dentin removal: A micro-computed tomography study

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ABSTRACT

Objective: To use micro-computed tomography to assess the effectiveness of the TruNatomy versus the XP-endo Shaper for removing dentin from single-rooted permanent teeth with straight root canals. *Materials and Methods:* Ninety-eight extracted human single-root teeth were collected and divided into two equal groups: TruNatomy and XP-endo Shaper (XPS). Root canal instrumentation was done for each system. Pre- and post-instrumentation images were scanned by using Skyscan 1172 micro-CT scanner at a resolution of 13.73 µm to measure dentin removal, differences in dentin thickness, and percent change in root canal volume. The data were analyzed using SPSS. *Results:* The TruNatomy group and XP-endo Shaper had no significant difference regarding the amount of removed dentin. *Conclusion:* There was no significant difference in post-instrumentation canal volume and dentine removal between TruNatomy and XP-endo Shaper. Thus, both file systems are equally recommended for clinical use as a practice of minimally invasive endodontics.

Keywords: Dentin removal, TruNatomy, XP-endo Shaper, Micro-computed tomography.

1. INTRODUCTION

Achieving successful endodontic therapy requires both mechanical and chemical root canal preparation. Various brands with many modifications of rotary endodontic nickel-titanium instruments have been introduced to overcome one or other shortcomings of the rotary system, with each claiming superiority in its mechanism of action (Thompson, 2000). When preparing a root canal, it is essential to avoid removing too much dentine since, without even coronal flaring, the total dentine removal from the overall root canal may change the anatomy of the root (Ruddle, 2002).

Radicular dentin removal, particularly in dangerous areas (developmental depression, concavities, and grooves), causes canal transportation, leading to

the creation of the ledge, strip perforation, and fracture (Elnaghy et al., 2020). Coronal and root fractures were the world's 3rd foremost reason for tooth loss, following only caries and periodontal disease. The dentinal wall thickness at the root circumference is crucial. The aptitude of the tooth to resist lateral stresses and avoid fracture is directly related to root thickness; therefore, the thinner the dentin, the more the tooth is prone to fracture. Over preparation of the coronal portion of the canal is one of the defects that may occur during root canal preparation, resulting in the weakening of the tooth (Talabani et al., 2014).

The strength of a tooth depends on the amount of dentine still present, so protecting what is there is crucial (Wu et al., 2004). Dentine thickness is critical around the base of the root. Therefore, one has to be cautious that dentinal cracks and fractures occurring during the root canal preparation can propagate into complete fractures due to continued pressure on the dentinal walls. It is a major drawback of having an endodontic procedure done (Topçuoğlu et al., 2014).

Rotary instruments help achieve the desired results of mechanical preparation. Therefore, it is necessary to protect the root canal and dentine's original shape while avoiding issues like the over-removal of dentine. Thus, many studies reported the amount of dentine removal as a part of studying the efficacy of the rotary instruments. One of the ways to prevent the excess removal of dentine is by using minimal invasive preparation (Plotino et al., 2020). Over the previous years, minimally invasive dentistry has become a standard clinical practice in endodontics, where tissue preservation is given prime importance and minimal damage to prevent or treat diseases (Ericson, 2004).

Due to its advantage, minimally invasive endodontics (MIE) has gained popularity (Clark and Khademi, 2010). Its main goal is to use such concepts to treat root canals while preserving as much tooth structure as feasible (Silva et al., 2021a). The use of instruments with varied geometric designs and metallurgical features, as well as lower tapers and tip diameters in minimally invasive dentistry, allow for better adaptation to the canal's shape during preparation (Pérez-Morales et al., 2021). As a result, using a small taper instrument during root canal procedures is stressed in minimally invasive dentistry to preserve dentin and reduce pressure, especially in the coronal third of teeth having root canal treatment (Pedullà et al., 2016).

These factors were considered when different rotational instrument modifications were implemented in endodontic practice. There have been various innovations in rotary endodontic instruments used in endodontic treatment. Two innovative dental instruments are the TruNatomy and the XP-Endo Shaper. TruNatomy files showed promising dentin removal efficacy when used as a minimally invasive dentistry technique (Vyver et al., 2019). The XP endo shaper also showed positive results as a minimally invasive instrument (Velozo and Albuquerque, 2019). In this study, micro-computed tomography (micro-CT) was used to compare the results of dentine removal using either TruNatomy or XP-endo Shaper in teeth with single roots and single canals.

2. MATERIALS AND METHODS

This in-vitro study was conducted from October 2022 to January 2023. This experimental laboratory study was performed on freshly extracted human single-rooted teeth with a single canal advised for extraction owing to orthodontic or periodontal disorders. This research was reviewed and approved under reference 26-9-21 by the Institutional Review Board (IRB) of Cairo University before the commencement of the study. The sample size was calculated using the “PS software”. Thus, consideration of the total sample size for the study was 98 teeth. It was found that to get a reliable statistical difference, 49 teeth per group were appropriate.

Inclusion criteria were permanent single-rooted human teeth with a straight canal and teeth with complete root formation. Exclusion criteria were calcified root canal teeth, teeth with root caries, root irregularities, or other anomalies, internal or external root resorption in teeth, teeth that have previously had endodontic treatment, teeth with root curvature, and cracked teeth. The teeth' external root surfaces were cleaned with a curette to eliminate calculus and periodontal tissues. Then, soaked in 5.25% sodium hypochlorite (NaOCl) for 30 minutes to remove soft tissue debris.

Furthermore, sterile saline was used to store the teeth until use. All samples were examined under 10× magnifications to ensure the absence of caries, fractures, cracks, root deformities, or external resorption. To confirm the inclusion and exclusion criteria, pre-operative radiographs were taken from the buccolingual and mesiodistal aspects to assess the presence of a single patent canal and the absence of internal resorption. A diamond disc saw was used to decoronate the teeth under copious irrigation to obtain 16 mm uniform root lengths.

Micro-CT scanning was used to measure all specimens before and after root canal preparation (Figure 1B). Teeth were mounted on a custom-made resin holder “1 cm deep × 2 cm wide” and positioned in a metal cylinder with the access cavities facing down. Subsequently, each cylinder with the specimen was placed in a receptacle inside the scanner (Figure 1). After pre-operative micro-CT scanning, K-file size #10 was inserted in the canal to check patency. The working length was obtained and adjusted using K-file #15 until it showed from the apex and subtracted 1 mm; thus, a standardized WL of 15 mm was obtained. The specimens were

randomly distributed into two groups (n=49) based on the instrument used for mechanical preparation: TruNatomy and XP-endo Shaper.

Figure 1 (A) Mounted sample on a custom-made resin holder; (B) Skyscan 1172 Micro-CT machine

For TruNatomy, canal preparation started with TruNatomy orifice modifier 20/08 taper with 2 to 3 gentle, smooth apical movements' amplitudes of "2-5 mm" into the root canal using the X-SMART Endo Motor at a speed of 500 rpm with a torque value of 1.5 N.cm according to the manufacturer's instructions. Following this, TruNatomy Glider 17/02 taper was used with three easy amplitudes in a pass. Then, the TruNatomy Prime shaping file 26/04 taper was used with three easy amplitudes in a pass. For XP-endo Shaper, one file per specimen was used at a speed of 500 rpm with a torque value of 1.5 Ncm according to the manufacturer's instructions. Beginning with ISO #15, the working field was continuously extended until it reached ISO #30 for a canal preparation of 30/.04.

The canals in each group were irrigated with 3 ml of 3% NaOCl solution between each subsequent instrument using a 30-gauge max-i-Probe needle tip placed 1mm shorter from the working length in all specimens. Apical patency was retained using a #10 K file between each rotary file. To eliminate the smear layer, 3 ml of saline was used to irrigate the canal, followed by 3 mL of 17% EDTA. Finally, 3 ml of sterile saline was used as a final flush. Paper points were used to dry the canals. Under the same parameters as the pre-operative scanning, the specimen was repositioned in the receptacle for postoperative scanning.

The scanned pre-and post-instrumentation raw images were processed with NRecon Version 1.6.4.8 for the cross-section images (bitmap format). The volume of interest for each specimen, extending from the cervical region to the apex, was set by integrating the regions of interest in all cross-sections. Then, the cross-section images were processed through Skyscan CT Analyser Version 1.11.10.0+ software for 3D analysis measurement of the canal volume (Figure 2).

For the 3D analysis measurement, the 1st scanned images and the 2nd scanned images (cross-section images) with the region of interest were processed through the software. The custom processing was run in both 1st and 2nd scanned images, and the result was the canal volume. The volume of dentin removal was calculated by subtracting the values for the post-instrumented canals from those recorded for the pre-instrumented counterparts.

Data were tested for normality using the Shapiro-Wilk test. Data were presented as mean, standard deviation (SD), median, range, and 95% confidence interval. Mann-Whitney U test was used for between-group comparisons. The level of significance was set at $p < 0.05$. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS), version 25, SPSS Inc. Chicago, IL, USA.

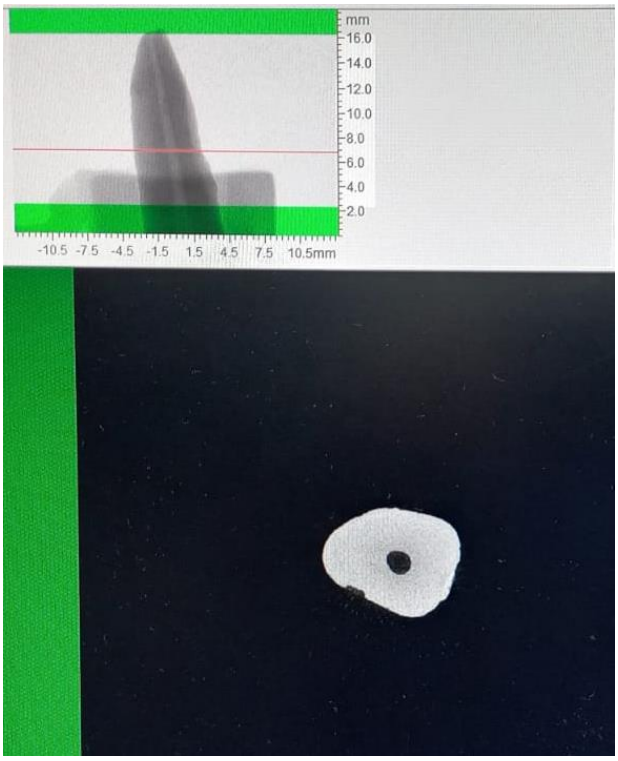


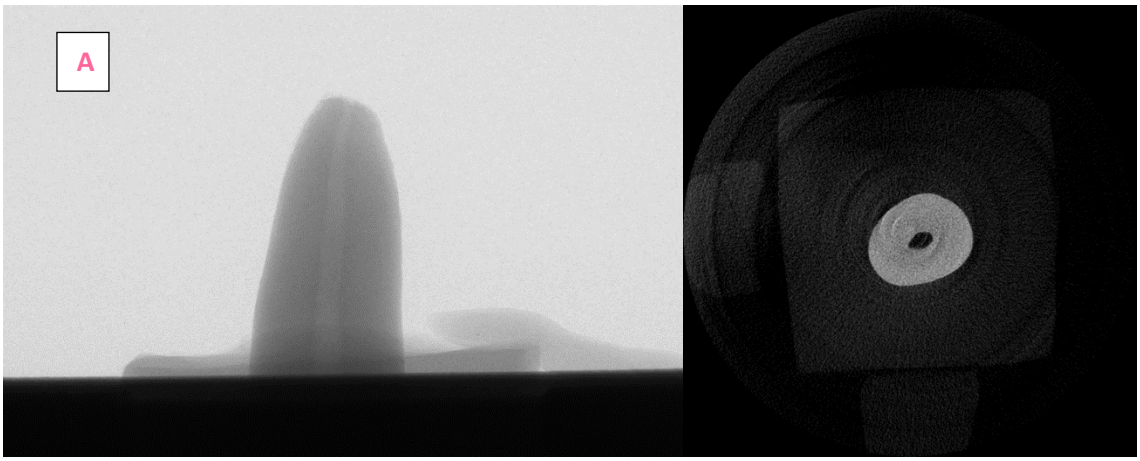
Figure 2 Skyscan CT Analyzer software used for measurement of the canal volume

3. RESULTS

The mean (SD) pre-operative canal volume was 5.31 (2.56) mm^3 in TruNatomy and 4.65 (2.25) mm^3 in XP-endo Shaper. However, the mean difference was statistically not significant ($p > 0.05$) (Table 1) (Figure 3). Similarly, the mean (SD) post-instrumentation canal volume was 6.08 (2.34) mm^3 in TruNatomy and 5.7 (2.18) mm^3 in XP-endo Shaper. However, the mean difference was statistically not significant ($p > 0.05$) (Table 2) (Figure 4).

Table 1 Comparison of pre-operative canal volume between the groups

	TruNatomy	XP-endo Shaper	*p-value*
Mean (SD)	5.31 (2.56)	4.65 (2.25)	0.245
95% CI	4.52 - 6.1	3.96 - 5.34	



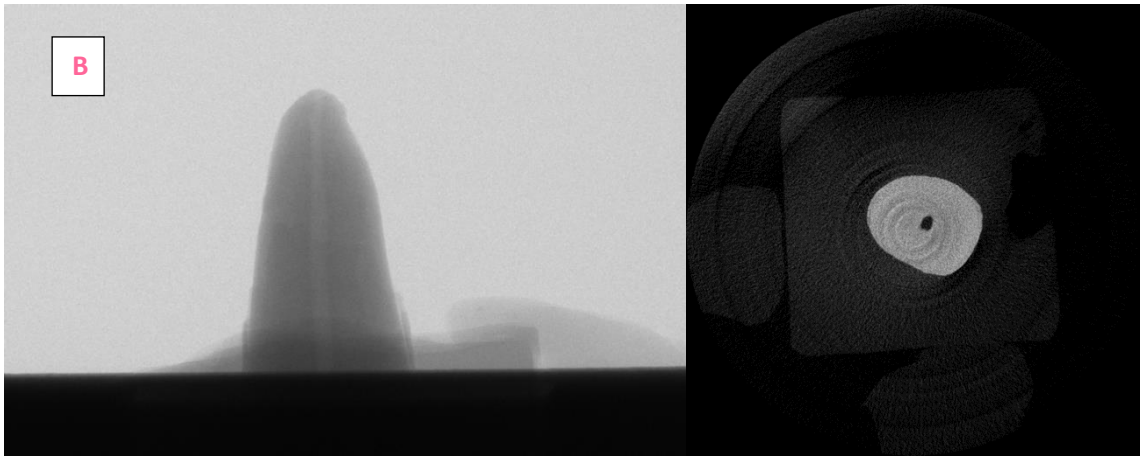
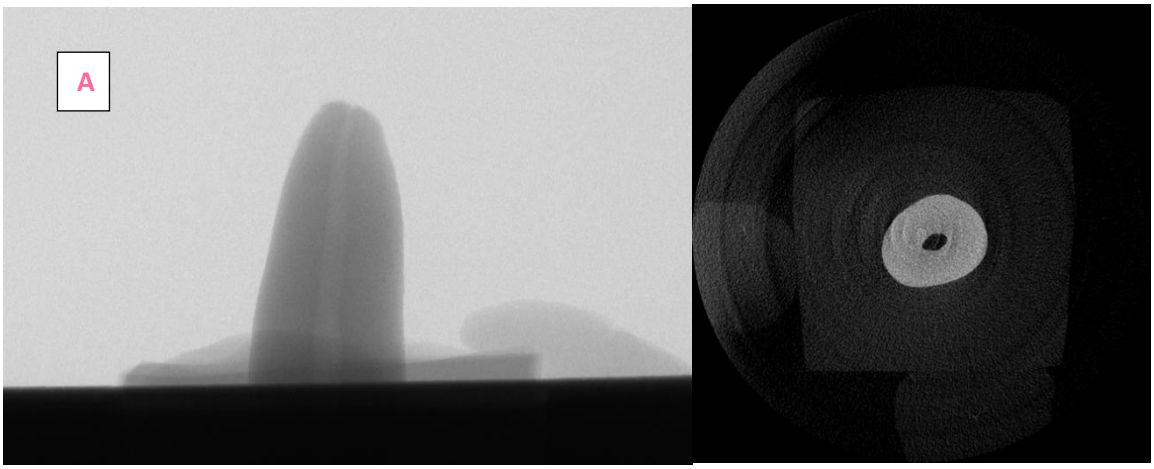


Figure 3 Pre-operative canal volume (A) TruNatomy file (B) XP-endo Shaper file

Table 2 Comparison of post-instrumentation canal volume between the groups

	TruNatomy	XP-endo Shaper	*p-value*
Mean (SD)	6.08 (2.34)	5.7 (2.18)	0.395
95% CI	5.36 - 6.8	5.03 - 6.37	



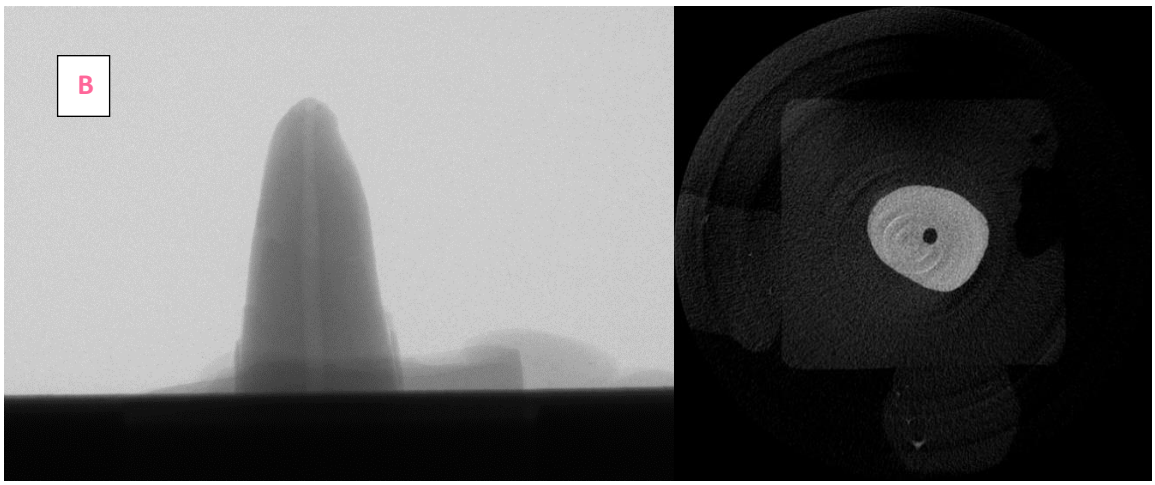


Figure 4 Post-instrumentation canal volume (A) TruNatomy file (B) XP-endo Shaper file

The mean (SD) volume of removed dentin was 0.77 (0.55) mm^3 in TruNatomy and 1.05 (0.76) mm^3 in XP-endo Shaper. However, the mean difference was statistically not significant ($p > 0.05$) (Table 3).

Table 3 Comparison of the volume of removed dentin between groups

	TruNatomy	XP-endo Shaper	*p*-value
Mean (SD)	0.77 (0.55)	1.05 (0.76)	0.077
95% CI	0.6 - 0.94	0.81 - 1.28	

4. DISCUSSION

As per the literature review, this is the first study to use micro-CT to for analyzing dentine removed and canal volume in the single-rooted canal using the two endo-rotary systems, TruNatomy and XP-endo Shaper, as a minimally invasive procedure. In endodontic clinical practice, the minimally invasive technique has gained popularity. Using instruments with smaller tapers and tip diameters or instruments with different geometry designs and metallurgical properties enables better adaptation to the canal's morphology during the root canal preparation. The minimally invasive dental procedure makes it possible to achieve better results (Pérez-Morales et al., 2021), where tissue preservation is given prime importance with minimal damage to prevent or treat diseases (Ericson, 2004).

This study used micro-CT to evaluate the canal volume and the amount of dentine removed. Using micro-CT to examine a specimen before and after root canal preparation is a more precise and "non-invasive" technology than its predecessor, cone beam computed tomography. It is advisable to do this to monitor changes in the dentin without causing any harm to the tooth. Because of its high level of precision, this imaging technique is utilized relatively frequently. Its applications include analyzing un instrumented areas, the shaping potential of file systems, and untouched contaminated areas. This method has been applied in many endodontic research (Faisal et al., 2021; Htun et al., 2020; Silva et al., 2021b; Yılmaz et al., 2020; Zhang et al., 2021). Thus, considering micro-CT utilization in our study is justifiable.

In this particular investigation, we used two distinct endo rotary systems: XP-endo Shaper and TruNatomy. As per our knowledge, this is the first study to compare XP-endo Shaper and TruNatomy using the least invasive method. No significant difference in the canal volume and dentine removal between the TruNatomy and XP-endo Shaper was found in the present study. Both the endo system found to be equally effective resulted in required dentine removal and also maintained the canal volume with no significant difference between both. These study results are similar to Perez-Morales et al., (2020) who compared the TruShape with the XP-endo Shaper and showed no significant difference.

Lacerda et al., (2017) reported no substantial differences in the number of unprepared surfaces using XP-endo Shaper and TruShape in a study comparing the two systems using micro-computed tomography. Furthermore, Velozo et al., (2020) observed no significant difference between XP-endo Shaper and ProTaper regarding the percentage increase in volume. Lima et al., (2020) compared the percentage of dentine removed using the XP-endo Shaper and the Bassi Logic™.03 taper and found no significant differences between the two systems.

It was indirectly demonstrated by Aksoy et al., (2019) that XP-endo Shaper did not stimulate the creation of new dentinal microcracks on the mesial roots of mandibular molars, which was correlated with decreased dentine removal and overall canal volume maintenance. Silva et al., (2022) concluded that endodontic practitioners would benefit more from TruNatomy than ProTaper Gold because the former requires less dentine to be removed from mandibular molars. Pit et al., (2020) reported that TruNatomy and VDW systems provided more conservative preparations by removing less tooth substance and preserving the canal's original shape during the endodontic treatment's preparation step.

However, this difference was not seen in the outcome of the present study, where the two groups did not differ significantly from one another in dentine removal. When comparing with other rotary systems, Azim et al., (2017) reported that XP-endo Shaper was better than Vortex Blue in the root can preparation of the single oval canals. Versiani et al., (2018) also reported that the XP-endo Shaper had better results than the iRaCe and EdgeFile in terms of attaining the final conical shape. Zhao et al., (2019) found that compared to the Reciproc Blue system, the XP-endo Shaper system generated less hard-tissue debris during the instrumentation process.

Overall, the present study results were comparable to those available in the literature, with both instruments considered efficient in maintaining the canal volume and dentine removal. However, there are certain limitations. The current study focused on

single-rooted teeth that only had one canal in each tooth. The result of the study need not apply to curved or any other morphologically altered root canals and multi-rooted teeth. Furthermore, this is an in-vitro study. Whatever the condition simulated to compare it with the in-vivo, it may still lack specific other considerations in the patient's mouth.

5. CONCLUSION

There is no significant change in post-instrumentation canal volume and dentine removal between TruNatomy and XP-endo Shaper. Both instruments are equally effective in both canal volume and dentine removal; thus, both file systems can be equally recommended for clinical use as a practice of MIE.

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Author contribution(s)

All authors contributed equally to the manuscript.

Ethical approval

This research was reviewed and approved under reference 26-9-21 by the Institutional Review Board (IRB) of Cairo University before the commencement of the study.

Informed consent

Not applicable.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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