A CBCT EVALUATION OF THE SHAPING ABILITY OF TWO DIFFERENT ROTARY INSTRUMENTATION SYSTEMS IN OVAL-SHAPED ROOT CANALS: AN IN-VITRO STUDY

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Article History: Received: 12.12.2022 **Revised:** 29.01.2023 **Accepted:** 15.03.2023

Abstract

Introduction: The aim of the study was to evaluate and compare the shaping ability of Protaper Universal and XP-endo Shaper in oval-shaped canals of distal roots of mandibular molars using CBCT analysis.
Methods:A total of 30 mandibular molars with a single oval-shaped distal canal were selected and randomly divided into two experimental groups (n=15) according to the instrumentation technique:ProTaper Universal and XP-endo Shaper. Specimens from both the groups were scanned using CBCT before and after instrumentation to evaluate the canal preparation, number of prepared and unprepared surfaces at three thirds of the root canal and time taken for preparation with each instrument system. Data were statistically analyzed, and the significance level was set at $p<0.05$.
Results: Both groups caused significant preparation of all surfaces at all three thirds of the root canal. No statistical difference was observed in the mean difference of pre-instrumentation and post-instrumentation measurements for both the groups ($p>0.05$). However, XP-endo Shaper performed significantly better with lesser percentage of unprepared surfaces when compared to ProTaper Universal at the coronal, middle and apical thirds ($p<0.05$). Instrumentation with XP-endo Shaper was significantly faster than ProTaper Universal ($p<0.05$).
Conclusion:XP-endo Shaper and ProTaper Universal had similar shaping ability. However, XP-endo Shaper prepared the canals more effectively and efficiently with significantly lesser percentage of unprepared surfaces at all three thirds and a considerably shorter preparation time. Neither technique was capable of completely preparing the oval-shaped distal canals of mandibular molars.

Keywords: Cone-beam computed tomography, ProTaper Universal, Ni-Ti instruments, Root canal preparation, XP-endo Shaper.

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DOI: 10.31838/ecb/2023.12.s2.014

1. Introduction

Clinical endodontics comprises a variety of procedures, but they are all directed towards one specific aim which is to eliminate microbial contamination of pulp and root canal systems and prevent re-infection. The ultimate goal is for patients to preserve the natural dentition in both appearance and function.[1] The success of an endodontic treatment depends on several factors and adequate disinfection of the root canal space with proper mechanical instrumentation and irrigation is a crucial procedural step to eliminate pulpal and necrotic tissue, debris and microbes. [2]
An ideal objective of the mechanical instrumentation of the complex root canal system is a uniform preparation along the entire circumference of the canal while preserving the original root canal anatomy and elimination of inner layer of infected dentin. [3]The shaping of the canals significantly impacts the success of subsequent procedures by creating sufficient space for delivery of irrigants and medicaments as well as ideal canal configurations for effective three-dimensional obturation of the root canal system. [4]
The anatomyof the root canal system is very complex with various shapes, configurations and anastomoses which imposes physical limitations in the effective instrumentation and disinfection of these spaces. [5] Oneof the challenges is the cross-sectional root canal configuration which can be circular, oval, long oval, flattened, or irregular. Long oval canals have a maximum diameter of 2-4 times more than the minimum diameter, in contrast to oval canals, which have been described as having a maximum cross-sectional diameter of up to 2 times greater than the smallest diameter. [6] In such canals with variable anatomical features, fins or recesses have reportedly been left unaffected by hand and rotary instruments working in reaming action [7] thereby harbouring debris, pulpal tissue remnants and microbial biofilms which serves as a potential cause of persistent infection and significantly impacts the success of an endodontic treatment. [8,9]
Since the early 1990s, nickel–titanium (NiTi) rotary instruments have been developed which have shown to greatly enhance the quality of cleaning and shaping root canals. [10] ProTaper Universal (Dentsply/ Maillefer, Ballaigues, Switzerland) is one of the most commonly used conventional Ni-Ti rotary instruments which has patented, progressive taper and advanced flute design that significantly improves the flexibility and efficiency thereby accomplishing consistently successful cleaning and shaping results. [11] However, these files cut around a central axis, creating a round cross-sectional shape during rotary or reciprocating motion and can lead to deviations from the oval canal configuration. [6]
Recently, a series of modifications have been made in the geometry, surface and heat treatment of the conventional Ni-Ti instruments. [12] One such advancement is XP-endo Shaper (FKG Dentaire, La Chaux-de-Fonds, Switzerland). [13] It is a snake-shaped "One File Shaper" manufactured from a MaxWire alloy (Martensite-Austenite Electro-polishing-Flex, FKG) with an initial 0.01 taper across the length of the instrument. When introduced into the root canal, it expands from its original size to enlarge the canal to at least 0.04 taper while conforming to the root canal morphology. The Booster Tip (BT) with a unique geometry respects the trajectory of the canal and begins shaping at minimum ISO diameter 15 to achieve a final diameter of ISO 30 using only one instrument. Thus, XP-endoShaper adapts to the root canal anatomy, expanding or contracting as it progresses along the working length. [13]
Histologic sections, scanning electron microscopy, computed tomography (CT), cone-beam computed tomography (CBCT), and micro-computed tomography (micro-CT) [14] have all been used to evaluate the effectiveness of root canal instrumentation.With the help of CBCT, it is possible to assess the removed dentin's volume, surface area, taper, and cross-sectional shape without affecting the tooth's structure. [15] When compared to micro-CT, it offers lower radiation exposure, decreased cost and scanning time and also faster data acquisition. [16]
Therefore, the aim of the present study was to evaluate and compare the shaping ability of Protaper Universal and XP-endo Shaper in oval-shaped canals of distal roots of mandibular molars using CBCT analysis.

2. Materials and Methods

Teeth selection

The present study protocol was approved by the Institutional Ethics Committee and was carried out in the Department of Conservative Dentistry and Endodontics, Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital, Pune. A total of 58 human permanent mandibular molars extracted for compromised periodontal prognosis or non-restorable conditions were collected from the Department of Oral and Maxillofacial Surgery. Teeth with fully formed apices with straight and sound root structure, single oval distal canal with the buccolingual dimension of distal canal two or more times greater than that of the mesiodistal dimension were included in the study whereas those with apical curvature greater than 10°, two or more distal canals in distal root, previous root canal fillings, calcified canals, internal or external root resorption were excluded.

Specimen Preparation and Groups

All the collected teeth were scanned with CS 9600 CBCT Scanner (Carestream Dental India) at 80 kVp, 2 mA, a field of view of 8× 5 cm and 150 μm voxels.After assessing all the inclusion and exclusion criteria, 30 human permanent mandibular molars with oval-shaped distal canals determined at the transversal slice located 6mm from the apex were selected for this study. Tissue fragments and calculus were removed and the teeth were initially stored in 0.5% sodium hypochlorite for disinfection. Then it was transferred to physiological saline for storage until further use.After confirming a single oval-shaped distal canal, the teeth were decoronated at the level of the cementoenamel junction (CEJ), mesial roots of all teeth were separated at furcation using a diamond disc and distal roots with a standardised length of 14mm were obtained.For all the specimens, access to the distal canal was achieved using small sized round bur and apical patency was determined by inserting a size 10 K-file into the root canal until its tip was visible at the apical foramen. Working length was set 0.5mm short of this measurement and a glide path to a size #15 K-file was established. 30 specimens were then randomly divided into two experimental groups according to the instrumentation technique. Specimens in Group A (n=15) were instrumented with ProTaper Universal whereas those in Group B (n=15) were instrumented with XP-endo Shaper.

Fabrication of Template

In order to standardise the position of the specimens for the pre-instrumentation and post-instrumentation CBCT scans, a template was fabricated using putty base elastomeric impression material. (Fig-1)

Fig-1: Template with specimens mounted on CBCT for scanning

Pre-instrumentation CBCT Scanning

Specimens from both the groups were subjected to cone beam computed tomography scanning using 3D digital model scan for impressions (8×5 cm field of view, 80 kVp, 2.0 mA, and 20 seconds exposure time with 150 μm voxel size). Linear measurements (mm) were made from the canal wall to the external surface of the root in buccal, lingual, mesial and distal directions at three levels: apical, middle and coronal third of the root using CS Imaging software.For each specimen, three tomograms were chosen according to the distance from the root apex, as follows: 4 mm from the root apex (represented the apical third), 8 mm from the root apex (represented the middle third) and 12 mm from the root apex (represented the coronal third).

Root Canal Preparation

The instrumentation of all specimens was performed with CanalPro CL2 Led Endomotor

(Coltene) by a single operator who was blinded to both the experimental groups. In order to mimic clinical conditions the specimens were placed in an incubator at 37° throughout the study. The preparation sequences were as follows:

1. **ProTaper Universal (Group A):** According to the manufacturer's instructions, ProTaper Universal instruments were used in continuous clockwise rotation using a gentle in-and-out motion in a modified crown-down manner. SX was used at two thirds of the WL, S1 and S2 at WL-1 mm; and then F1, F2, F3at the WL.The instruments were used at 250 rpm with a torque of 3 Ncm for SX and S1, 1.5 Ncm for S2 and F1, and 2 Ncm for F2 and F3. After each instrumentation step, the files were cleaned with gauze impregnated with 70% isopropyl alcohol, and the canals were irrigated with 5 mL 2.5% sodium hypochlorite in disposable syringes with Lifelong Matrix 24-G needles placed 2 mm short of the WL. (Fig-2)

2.

3. XP-endo Shaper (Group B): The XP-endo Shaper file was operated at 900 rpm and 1 Ncm torque. The file was inserted in the canal and 5 strokes of gentle up-and-down motion were applied until the WL was reached. In cases where the file failed to reach the WL after the first 5 strokes, the canals were rinsed with 2 mL of 2.5% NaOCl, recapitulated with #15K-file and the procedure was repeated. Once the instrument reached the WL, additional 5 up-and-down movements over the entire length of the canal was performed. (Fig-2)

After complete instrumentation, a final rinse with 5 mL 17% EDTA followed by 5ml distilled water was done for specimens in both the groups. The preparation time for each canal was recorded in minutes using a stopwatch. The preparation time was calculated from the time the first rotary file was inserted in the canal till the time when the preparation was completed. Each XP-endo Shaper and ProTaper Universal instrument was used on a single tooth and then discarded.

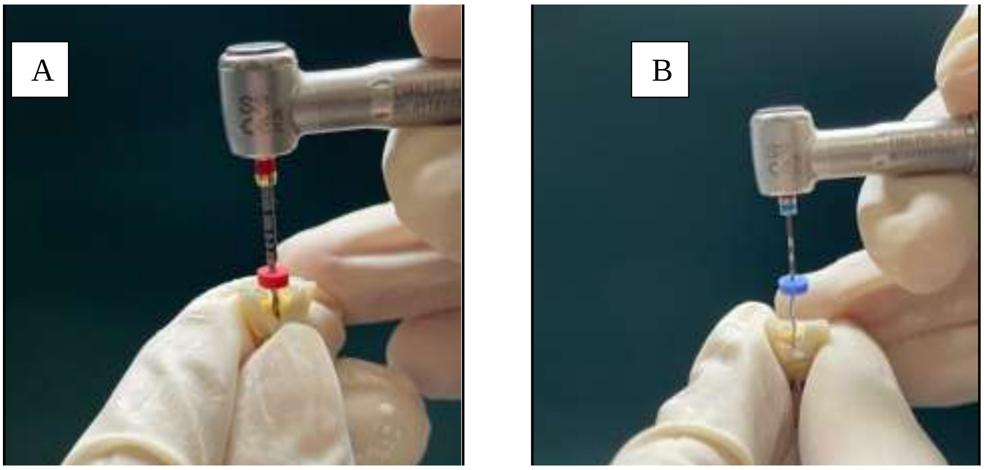


Fig-2: Canal preparation with A) ProTaper Universal and B) XP-endo Shaper

Post-instrumentation CBCT Scanning

After complete instrumentation, the root canals were dried with absorbent paper points (Dentsply Maillefer) and the specimens were repositioned in the fabricated template for post-instrumentation scanning following the same parameters as the pre-instrumentation scanning.

Evaluation of Root Canal Preparation

The pre-instrumentation and post-instrumentation linear measurements were obtained for the specimens in each group for the four co-ordinates (buccal, lingual, mesial and distal) at coronal, middle and apical third of the canal. (Figs-3,4) The following parameters were assessed:

1. **The canal preparation with both the instrument systems for 4 co-ordinates (buccal, lingual, mesial and distal) at coronal, middle and apical third** by determining the mean difference of pre-instrumentation and post-instrumentation measurements.
2. **The efficacy of the instrument systems** by determining the number of prepared and unprepared surfaces at all three levels.Surfaces showing no difference in the pre- instrumentation and post-instrumentation measurements(pre-instrumentation- post-instrumentation = 0) were considered as unprepared.
3. **Time taken for root canal preparation with each instrument system.**

CBCT images for Group A: ProTaper Universal

Pre-instrumentation **Post-instrumentation**

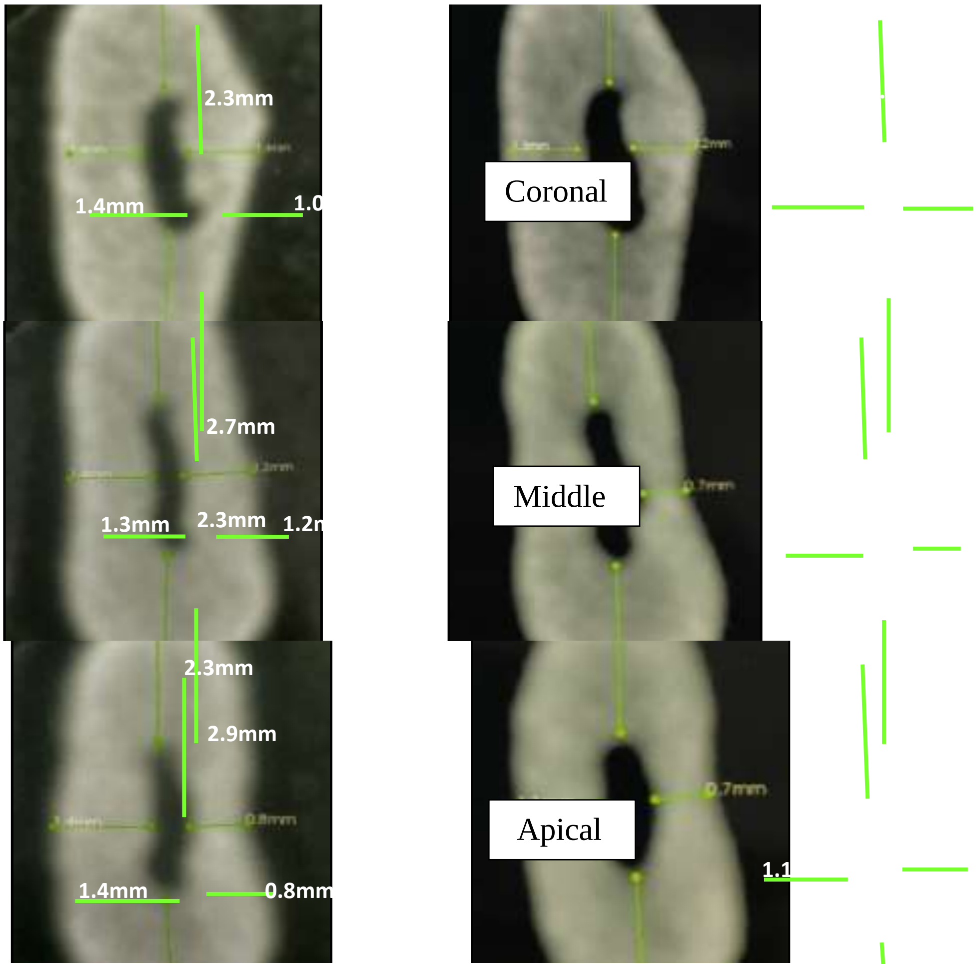
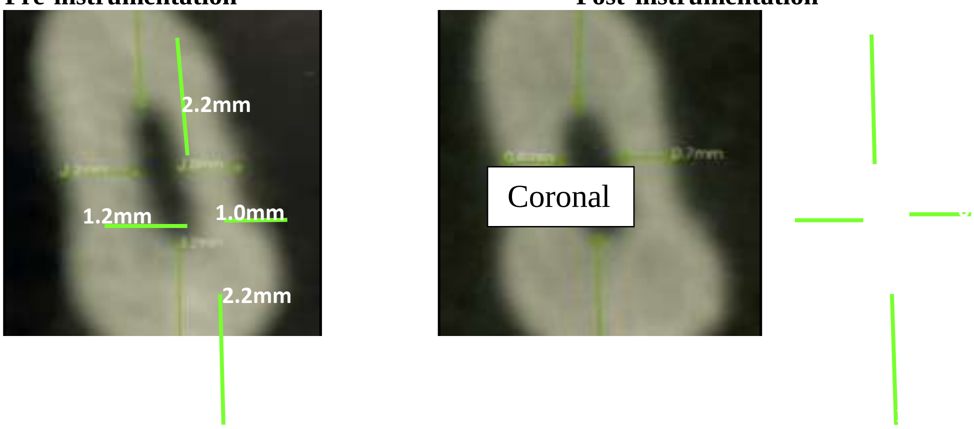


Fig-3: Pre-instrumentation and post-instrumentation CBCT images showing linear measurements for four coordinates at all three thirds

CBCT images for Group B: XP-endo shaper

Pre-instrumentation **Post-instrumentation**



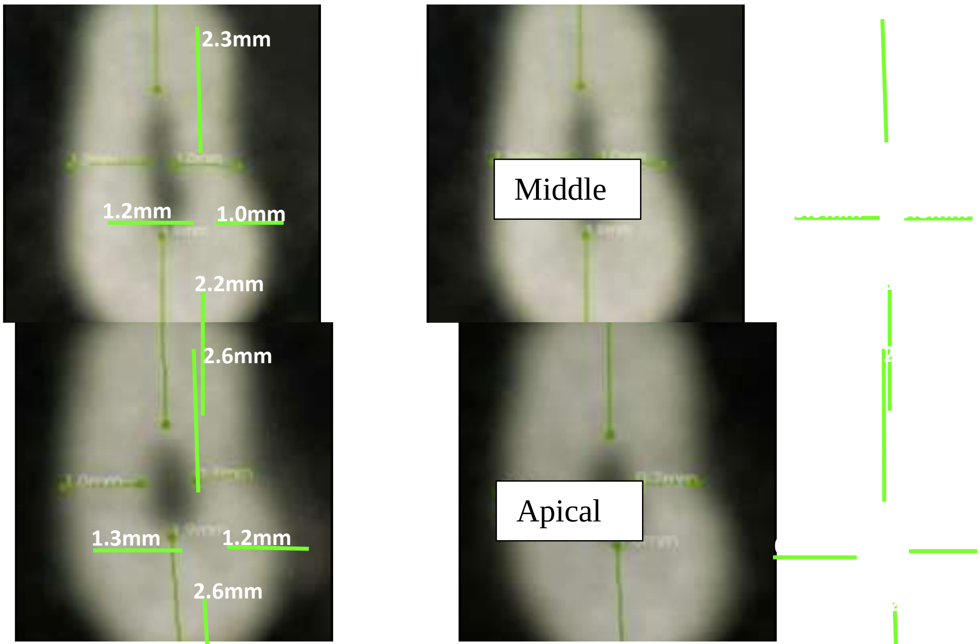


Fig-4: Pre-instrumentation and post-instrumentation CBCT images showing linear measurements for four coordinates at all three third

Statistical Analysis

The instrumentation values so obtained were then subjected to statistical analysis.The Statistical software IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) was used for the analyses of the data. Level of significance was fixed at p=0.05 and p<0.05 was considered to be statistically significant while p<0.001 was statistically highly significant.

- Mann Whitney U test was used to find the significance of study parameters on continuous scale between two groups.
- Chi square analysis was used to find the significance of study parameters on categorical scale.
- Student t test (two tailed, unpaired) were used to find the significance of study parameters on continuous scale between two groups (intergroup analysis).

Results

The mean difference of pre-instrumentation and post-instrumentation measurements of both the instrument systems for 4 co-ordinates at coronal, middle and apical third is depicted in Tables-1,2,3 respectively. XP-endo Shaper prepared more surfaces in the buccal, lingual, mesial and distal coordinates at the coronal, middle andapical third when compared to ProTaper Universal. This difference, however, was not statistically significant.

The Chi-Square test(Table-4) showed a statistically significant differencein the percentage of unprepared surfaces between both the groups at all the three thirds of the root canal. XP-endo Shaper performed significantly better (5%, 3.3%, 6.7% unprepared surfaces) when compared toProTaper Universal (16.7%, 21.7%, 20% unprepared surfaces) at the coronal, middle and apical thirds (p value:0.040, p value:0.002, p value:0.032)respectively (Fig-5,6,7).

Regarding the time taken for instrumentation, unpaired t-test (Table-5)revealed a statistically highly significant difference between both the groups. (p<0.001) XP-endo Shaper took lesser time (mean value - 1.3700 minutes) for the mechanical preparation of the canal when compared to ProTaper Universal (mean value - 4.1507 minutes).

Coronal Third	Group	n	Mean	Std. Deviation	Z value	p value
Buccal	Group A	15	0.3867	0.26957	0.418	0.676
	Group B	15	0.4533	0.27482		
Lingual	Group A	15	0.3800	0.25411	0.125	0.900
	Group B	15	0.3867	0.23563		
Mesial	Group A	15	0.2733	0.27637	0.859	0.390
	Group B	15	0.3667	0.30158		
Distal	Group A	15	0.3667	0.22887	0.189	0.850
	Group B	15	0.4600	0.48226		

Table 1: Intergroup comparison of the mean difference of instrumentation measurements (Pre-instrumentation - Post-instrumentation) in terms of {Mean (SD)} for all the four coordinates at coronal third using Mann Whitney U Test

Middle Third	Group	n	Mean	Std. Deviation	Z value	p value
Buccal	Group A	15	0.1667	0.11751	0.906	0.365
	Group B	15	0.2467	0.22318		
Lingual	Group A	15	0.2333	0.23503	0.933	0.351
	Group B	15	0.3400	0.31351		

Mesial	Group A	15	0.2800	0.29081	0.985	0.325
	Group B	15	0.3467	0.24162		
Distal	Group A	15	0.2200	0.18593	2.298	0.322
	Group B	15	0.4667	0.39219		

Table 2: Intergroup comparison of the mean difference of instrumentation measurements (Pre-instrumentation - Post-instrumentation) in terms of {Mean (SD)} for all the four coordinates at middle third using Mann Whitney U Test

Apical Third	Group	n	Mean	Std. Deviation	Z value	p value
Buccal	Group A	15	0.2267	0.23442	1.439	0.150
	Group B	15	0.2867	0.14573		
Lingual	Group A	15	0.1400	0.16818	1.686	0.092
	Group B	15	0.2467	0.16847		
Mesial	Group A	15	0.3333	0.19518	1.028	0.304
	Group B	15	0.4133	0.20999		
Distal	Group A	15	0.3333	0.22573	1.535	0.125
	Group B	15	0.4800	0.27308		

Table 3: Intergroup comparison of the mean difference of instrumentation measurements(Pre-instrumentation - Post-instrumentation) in terms of {Mean (SD)} for all the four coordinates at apical third using Mann Whitney U Test

Level	Groups	Prepared surface count / % within group	Unprepared surface count / % within group	Total	Chi square value	p value
Coronal	Group A	50(83.3%)	10 (16.7%)	60 (100.0%)	4.227	0.040*
	Group B	57(95.0%)	3 (5.0%)	60 (100.0%)		
Middle	Group A	47(78.3%)	13 (21.7%)	60 (100.0%)	9.219	0.002*
	Group B	58(96.7%)	2 (3.30%)	60 (100.0%)		
Apical	Group A	48 (80.0%)	12 (20.0%)	60 (100.0%)	4.615	0.032*
	Group B	56 (93.3%)	4 (6.7%)	60 (100.0%)		

Table 4: Intergroup comparison of the prepared and unprepared surfacesusing Chi square test

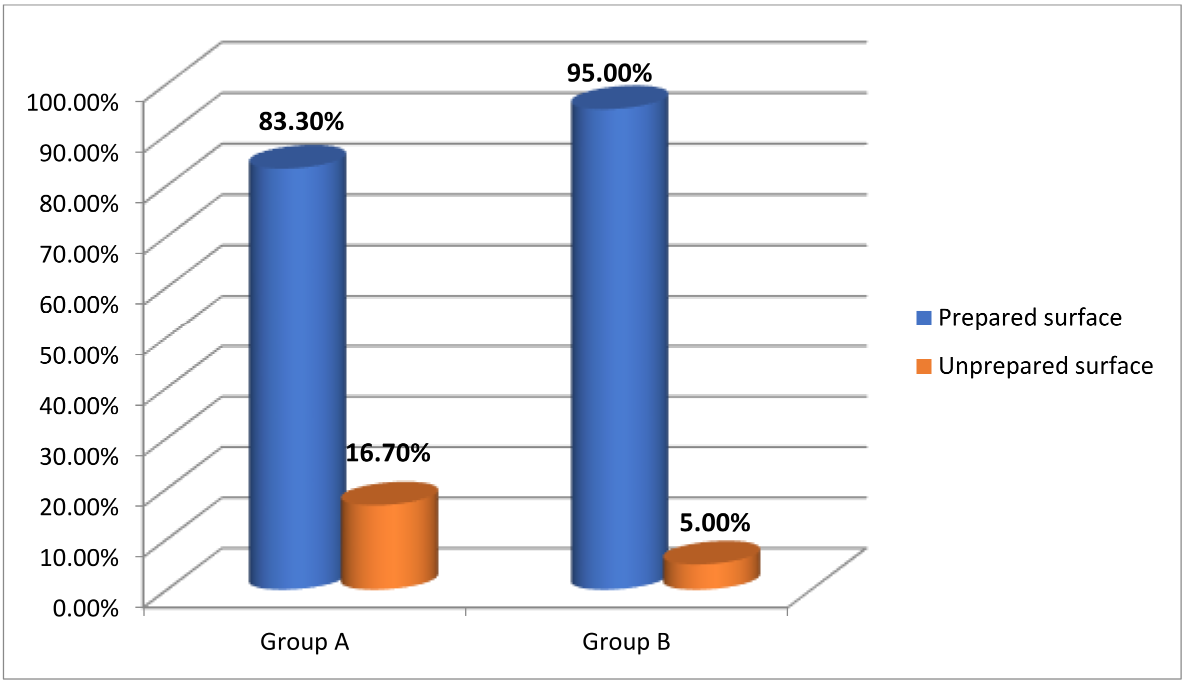


Fig-5: Intergroup comparison of the prepared and unprepared surfaces atcoronal third

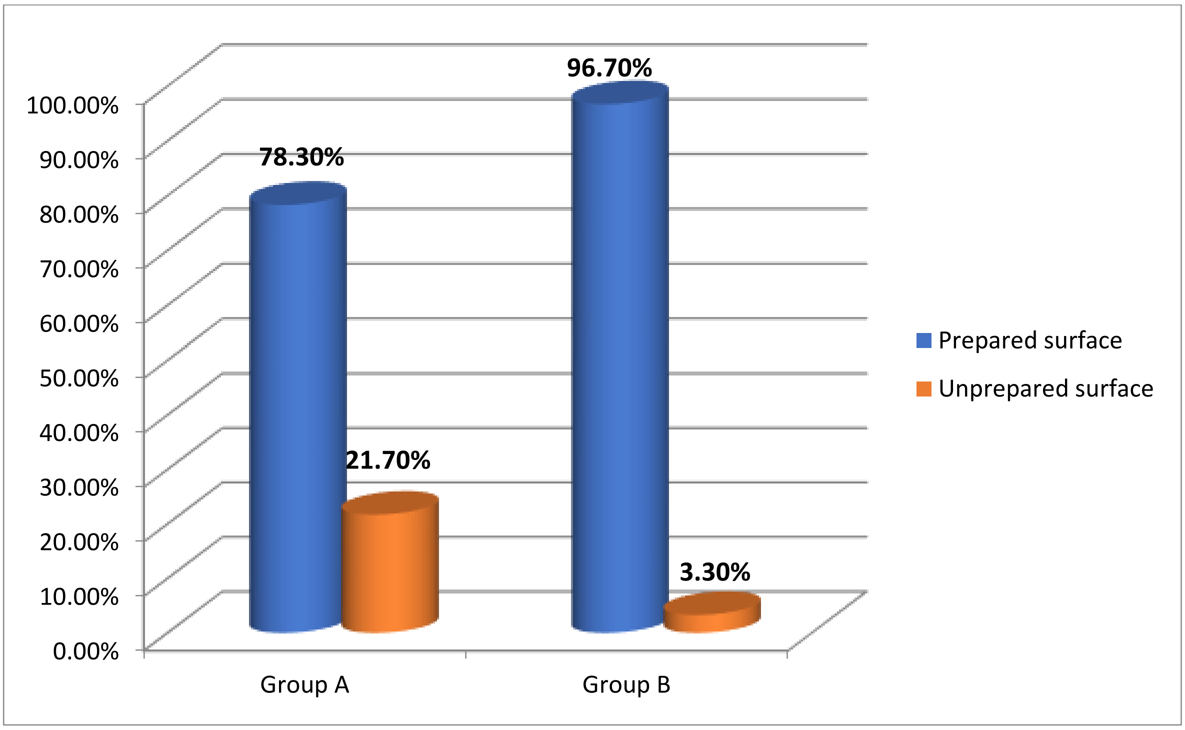


Fig-6: Intergroup comparison of the prepared and unprepared surfaces at middle third

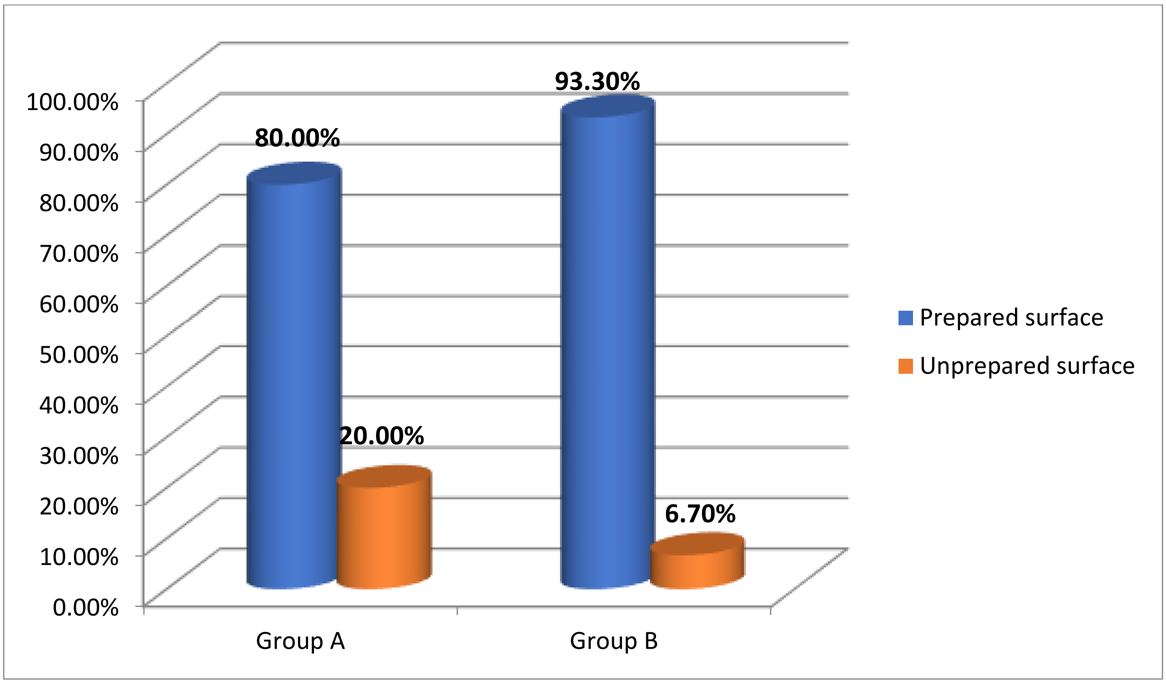


Fig-7: Intergroup comparison of the prepared and unprepared surfaces at apical third

Group	n	Mean	Std. Deviation	t value	p value
Group A	15	4.1507	.94479	10.549	<0.001**
Group B	15	1.3700	.38687		

Table-5: Intergroup comparison of time taken (minutes) for instrumentation in terms of {Mean (SD)} using Unpaired T-Test

4. Discussion

The present in-vitro study compared the shaping ability of ProTaper Universal and XP-endo Shaper in oval-shaped root canals using CBCT analysis. Human permanent mandibular molars were selected for this study as oval-shaped canals are common in the distal roots of mandibular molars [17] and presents mechanical challenges to adequate instrumentation and disinfection. [7,18] The Ni-Ti MaxWire technology enables XP-endo Shaper to expand on coming in contact with the body temperature inside the root canal system. [13] Therefore, in order to mimic the in-vivo clinical situation, specimens were placed in an incubator at 37°C [19] to allow the transition of XP-endo Shaper from the martensite to the austenite phase during shaping procedure inside the root canal system.

In order to evaluate the canal preparation, specimens from both the groups were scanned before (pre-instrumentation) and after instrumentation (post-instrumentation) using Cone Beam Computed Tomography (CBCT). It is a non-invasive method for evaluation of root canal preparation without loss of specimen.[20] CBCT allows detailed three-dimensional (3D) observation of the root canal anatomy with high resolution images, faster acquisition and reconstruction scheme [21] When compared to micro-CT, CBCT has lower effective radiation dose, decreased cost and comparatively shorter scanning time. [22] It also serves as an effective tool for measuring dentin thickness and assessing the cross-sectional geometry of the canal. [20,21] and hence it was used in this study to evaluate the root canal preparation by the twoinstrumentation systems.

The intergroup comparison of the mean difference (Pre-instrumentation – Post-instrumentation) values at coronal, middle and apical third (Table/fig-5,6,7) revealed that XP-endo Shaper performed better in all three thirds with increased preparation of the surfaces when compared to ProTaper Universal (mean difference of XP-endo

Shaper > mean difference of ProTaper Universal), however this difference was not statistically significant and did not appear to influence the system's ability to prepare oval shaped canals. This could be because of the similar dimension of the final instrument used in the ProTaper Universal group where all the specimens were prepared till F3 (tip diameter- 0.3mm).XP-endo Shaper, a "one-file shaper"begins shaping at minimum ISO diameter 15 and also achieves a final diameter of ISO 30 (tip diameter- 0.3mm) by virtue of the Booster Tip which has six cutting edges at the tip for optimal guidance. [13] This result is in accordance with the study conducted by Versiani MA et al. [23] where the ProTaper Universal system had shown similar performance when compared to SAF, another example of expanding NiTi instrument in oval-shaped canals of mandibular canines. Versiani et al. evaluated [24] the shaping ability of the XP-endoShaper, iRaCe and EdgeFile systems in thirty long oval-shaped canals of mandibular incisors using micro-CT and observed that XP-endo Shaper significantly altered the overall geometry of the root canal to a more conical shape when compared with the other groups. However, all the three file systems, XP-endo Shaper, iRaCe, and EdgeFile systems showed a similar shaping ability.

The results of the Chi-square tests (Table/fig-8,9,10,11) revealed that specimens from both the groups showed unpreparedsurfaces of the root canal wall, indicating that neither of the instruments were able to completely prepare the walls. This result is in agreement with the study conducted by Versiani et al [23] where the shaping ability of various single file systems was compared with ProTaper Universal in oval-shaped mandibular canines and it was observed that neither technique was capable of completely preparing the oval-shaped root canals. Velozo et al. [12] observed that neither XP-endo Shaper nor ProTaper Nextwas able to fully prepare the long oval-shaped canals of mandibular incisors.No study has so far demonstrated instruments that were able to fully prepare all root canal walls (Belladonna et al. 2018 [25], Gavini et al. 2018 [26], Zhao et al. 2019 [27]).

The Chi-square analysis revealed that XP-endo Shaper system resulted in 5%, 3.3%, 6.7% of unprepared surfaces when compared to 16.7%, 21.7%, 20% unprepared surfaces by ProTaper Universal at coronal, middle and apical levels respectively suggesting that XP-endo Shaper performed significantly better than ProTaper Universal in all the three thirds with lesser percentage of unprepared surfaces. This is attributed to the fact that conventional Ni-Ti files, like ProTaper Universal, despite their flexibility or surface treatment, can be all classified as "nonadaptive core" instruments which prepares the canal to a rounded uniform shape without adaptation to the individual variations of each canal. [28] On the other hand, the XP-endo Shaper expands beyond its core size and address more canal walls due to the superior mechanical properties offered by the MaxWire technology which enables the phase transition of these instruments from M-phase (Martensitic phase) to A-phase (Austenitic phase) when introduced into the root canals at body temperature. The Booster tip respects the trajectory of the canal, whilst removing more material with each pass. The MaxWire and Booster Tip (BT) technologies combine to make the XP-endo Shaper a "One File Shaper" which expands and conforms to the root canal anatomy as it progresses along the working length. [13,19]

Lacerda et al. [29] reported17.31%of untouched walls in the distal roots of mandibular molarsprepared with XP-endo Shaper, whilst Webber et al.[30] obtained 29.98%, 23.13% and 31.57% of untouched walls in the coronal, middle and apical third, respectively in the mesial roots of mandibular molars.

In the present study, XP-endo Shaper prepared the oval-shaped canal in significantly lesser time (mean -1.37 minutes) than ProTaper Universal (mean- 4.15 minutes) (Table/fig-12). Preparation time is dependent on the technique, the numbers of instruments used, and the operator experience. [31] ProTaper Universal, being a multiple file system required more frequent irrigation between files to remove debris and facilitate the insertion of the subsequent file. [23] This was not necessary for the single file system, the XP-endo Shaper group. Additionally, because of its smaller core and turbulence generated by continuous rotation at high speed, it keeps debris in the solution, vortexing it up coronallyduring instrumentation thereby preventing it from being compacted into canal irregularities and consequently aids in faster instrumentation and disinfection. [13]

The concept of using a single NiTi instrument to prepare the entire root canal was proposed a few years ago. [32] This is a compelling idea that may be cost-effective, time-saving, and may lower the learning curve for practitioners to embrace the new technique in a variety of clinical settings.Moreover, using a single file system used to prepare the root canal may reduce the potential of dentinal microcracks formation which are typically observed when multiple file systems are used. [33]However, it is crucial to remember that the short instrumentation time may not allow adequate contact time for the irrigants to debride the canal irregularities untouched by the file and kill microbes. Necrotic tissue, debris and biofilms must be cleaned and removed from unprepared areas by chemical methods, and using sodium hypochlorite to its maximum potential is essential for getting the best outcomes in these areas. [34] This highlights the significance of effective root canal irrigation when using the single-file approach, and therefore to maximise preparation and accomplish proper disinfection increased volumes of the irrigant or use of continuous irrigation devices such as hollow vibrating instrument delivering continuous irrigation in Self-adjusting File (SAF) should be encouraged. [5]

5. Conclusion

Although there was no statistically significant difference in the shaping ability of XP-endo Shaper and ProTaper Universal in the preparation of oval shaped distal canals of mandibular molars, XP-endo Shaper prepared the canals more effectively and efficiently with significantlylesser percentage of unprepared surfaces at all three thirds and a considerably shorter preparation time. The biologic aims of endodontics, driven by new technology, are now more achievable because of substantial advancements in Ni-Ti instruments andthe XP-endo Shaper is a truly unique broad spectrum "One-File Shaper" which may be utilised to considerably simplify endodontic sequences.

Limitations

The present study is an in-vitro study. The XP-endo shaper is a one-file shaper which at the body temperature within canals, is claimed to expand and contract to adapt itself to the canal morphology. Thus, more in-vivo studies are required for affirmation of the findings associated with this mechanical behaviour of XP-endo Shaper.

Acknowledgement

The author wishes to express her gratitude to the colleagues and faculty of The Department of Conservative Dentistry and Endodontics, BVDU Dental College and Hospital, Pune for the constant help, support and valuable suggestions provided in making this manuscript.

Conflict of Interest

The authors report no conflict of interest.

6. References

Hargreaves KM, Berman LH, Cohen’s pathways of the pulp, 11th edition, St. Louis, Missouri, Elsevier, 2016

Azim AA, Aksel H, Zhuang T, Mashtare T, Babu JP, Huang GT. Efficacy of 4 Irrigation Protocols in Killing Bacteria Colonized in Dentinal Tubules Examined by a Novel Confocal Laser Scanning Microscope Analysis. J Endod. 2016 Jun;42(6):928-34

Velozo C, Albuquerque D. Microcomputed Tomography Studies of the Effectiveness of XP-endo Shaper in Root Canal Preparation: A Review of the Literature. ScientificWorldJournal. 2019 Aug 19;2019:3570870.

H. Schilder, “Cleaning and shaping the root canal,” Dental Clinics of North America, vol. 18, pp. 269–296, 2004.

Siqueira JF Jr, Alves FR, Almeida BM, de Oliveira JC, Rôças IN. Ability of chemomechanical preparation with either rotary instruments or self-adjusting file to disinfect oval-shaped root canals. J Endod. 2010 Nov;36(11):1860-5.

Jou YT, Karabucak B, Levin J, Liu D. Endodontic working width: current concepts and techniques. Dent Clin North Am. 2004 Jan;48(1):323-35.

Weiger R, Elayouti A, Löst C. Efficiency of hand and rotary instruments in shaping oval root canals. J Endod. 2002 Aug;28(8):580-3.

De-Deus G, Reis C, Beznos D, de Abranches AM, Coutinho-Filho T, Paciornik S. Limited ability of three commonly used thermoplasticized gutta-percha techniques in filling oval-shaped canals. J Endod. 2008 Nov;34(11):1401-1405.

Ricucci D, Siqueira JF Jr, Bate AL, Pitt Ford TR. Histologic investigation of root canal-treated teeth with apical periodontitis: a retrospective study from twenty-four patients. J Endod. 2009 Apr;35(4):493-502.

Kuzekanani M. Nickel-Titanium Rotary Instruments: Development of the Single-File Systems. J Int Soc Prev Community Dent. 2018 Sep-Oct;8(5):386-390.

Ruddle CJ. The ProTaper endodontic system: geometries, features, and guidelines for use. Dent Today 2001;20:60–7.

Velozo C, Silva S, Almeida A, Romeiro K, Vieira B, Dantas H, Sousa F, De Albuquerque DS. Shaping ability of XP-endo Shaper and ProTaper Next in long oval-shaped canals: a micro-computed tomography study. Int Endod J. 2020 Jul;53(7):998-1006.

FKG Dentaire SA. XP-Endo shaper: the one to shape your success. Available at: http:// www.fkg.ch/sites/default/files/201704_fkg_xp_endo_shaper_brochure_v4_en_web.pdf. Accessed July 7, 2017.

Liu J, Luo J, Dou L, Yang D. CBCT study of root and canal morphology of permanent mandibular incisors in a Chinese population. Acta Odontol Scand. 2014 Jan;72(1):26-30.

Dhingra A, Ruhal N, Miglani A. Evaluation of Single File Systems Reciproc, Oneshape, and WaveOne using Cone Beam Computed Tomography -An In Vitro Study. J Clin Diagn Res. 2015 Apr;9(4):ZC30-4.

Domark JD, Hatton JF, Benison RP, Hildebolt CF. An ex vivo comparison of digital radiography and cone-beam and micro computed tomography in the detection of the number of canals in the mesiobuccal roots of maxillary molars. J Endod. 2013 Jul;39(7):901-5.

Wu MK, R'oris A, Barkis D, Wesselink PR. Prevalence and extent of long oval canals in the apical third. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2000 Jun;89(6):739-43.

Elayouti A, Chu AL, Kimionis I, Klein C, Weiger R, Löst C. Efficacy of rotary instruments with greater taper in preparing oval root canals. Int Endod J. 2008 Dec;41(12):1088-92.

ArıcanÖztürk B, AtavAteş A, Fişekçioğlu E. Cone-Beam Computed Tomographic Analysis of Shaping Ability of XP-endo Shaper and ProTaper Next in Large Root Canals. J Endod. 2020 Mar;46(3):437-443.

Reham H, Roshdy N, Issa N. Comparison of canal transportation and centering ability of XP Shaper, WaveOne and One Shape: a cone beam computed tomography study of curved root canals. Acta OdontolLatinoam2018;31:67–74.

Cotton TP, Geisler TM, Holden DT, Schwartz SA, Schindler WG. Endodontic applications of conebeam volumetric tomography. J Endod 2007; 33:11211132.

Kamburoğlu K. Use of dentomaxillofacial cone beam computed tomography in dentistry. World J Radiol 2015 June 28; 7(6): 128-130

Versiani MA, Leoni GB, Steier L, De-Deus G, Tassani S, Pécora JD, de Sousa-Neto MD. Micro-computed tomography study of oval-shaped canals prepared with the self-adjusting file, Reciproc, WaveOne, and ProTaper universal systems. J Endod. 2013 Aug;39(8):1060-6.

Versiani MA, Carvalho KKT, Mazzi-Chaves JF, Sousa-Neto MD. Micro-computed Tomographic Evaluation of the Shaping Ability of XP-endo Shaper, iRaCe, and EdgeFile Systems in Long Oval-shaped Canals. J Endod. 2018 Mar;44(3):489-495.

Zuolo ML, Zaia AA, Belladonna FG, Silva EJNL, Souza EM, Versiani MA, Lopes RT, De-Deus G. Micro-CT assessment of the shaping ability of four root canal instrumentation systems in oval-shaped canals. Int Endod J. 2018 May;51(5):564-571. doi: 10.1111/iej.12810. Epub 2017 Jul 31. PMID: 28667674.

Gavini G, Santos MD, Caldeira CL, Machado MEL, Freire LG, Iglecias EF, Peters OA, Candeiro GTM. Nickel-titanium instruments in endodontics: a concise review of the state of the art. Braz Oral Res. 2018 Oct 18;32(suppl 1):e67. doi: 10.1590/1807-3107bor-2018.vol32.0067. PMID: 30365608.

Zhao Y, Fan W, Xu T, Tay FR, Gutmann JL, Fan B. Evaluation of several instrumentation techniques and irrigation methods on the percentage of untouched canal wall and accumulated dentine debris in C-shaped canals. Int Endod J. 2019 Sep;52(9):1354-1365.

Paque F, Balmer M, Attin T, et al. Preparation of oval-shaped root canals in mandibular molars using nickel-titanium rotary instruments: A micro-computed tomography study. J Endod 2010;36:703–7.

Lacerda MFLS, Marceliano-Alves MF, Pérez AR, Provenzano JC, Neves MAS, Pires FR, Gonçalves LS, Rôças IN, Siqueira JF Jr. Cleaning and Shaping Oval Canals with 3 Instrumentation Systems: A Correlative Micro-computed Tomographic and Histologic Study. J Endod. 2017 Nov;43(11):1878-1884.

Webber M, Piasecki L, Jussiani EI et al. (2020) Higher speed and no glide path: a new protocol to increase the efficiency of XP shaper in curved canals – an in vitro study. Journal of Endodontics 46, 103–9.

Hülsman M, Peters OA, Dummer PMH. Mechanical preparation of root canals: shaping goals, techniques and means. Endod Topics 2005;10:30–76.

Yared G. Canal preparation using only one Ni-Ti rotary instrument: preliminary ob- servations. Int Endod J 2008;41:339–44.

Liu R, Hou BX, Wesselink PR, Wu MK, Shemesh H. The incidence of root microcracks caused by 3 different single-file systems versus the ProTaper system. J Endod. 2013 Aug;39(8):1054-6.

Dey, N., Kamatchi, C., Vickram, A. S., Anbarasu, K., Thanigaivel, S., Palanivelu, J., ... & Ponnusamy, V. K. (2022). Role of nanomaterials in deactivating multiple drug resistance efflux pumps–A review. Environmental Research, 204, 111968.

Haapasalo M, Shen Y, Qian W, Gao Y. Irrigation in endodontics. Dent Clin North Am 2010;54:291–312.