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CENTERING AND SHAPING ABILITIES OF THREE DIFFERENT CROSS-SECTION ROTARY SYSTEMS IN CURVED CANALS USING CBCT

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ABSTRACT

The aim of the study was to examine the centering and shaping abilities of the E3 Azure, T Blue and XPRS rotary devices in severely curved root canals utilizing CBCT. 51 mesial roots were used in this study, then distributed into three groups of 17 mesial canals each according to the instrumentation technique: T-Blue, E3 Azure and XPS. The final apical size of instrumentation was 30/0.04 for all groups. At 2 mm, all pairwise comparisons were statistically significant, with Azure showing the highest transportation, followed by T-Blue, and XPS showing the least (p<0.001). At 4 mm and 6 mm, Azure and T-Blue showed significantly higher transportation than XPS (p<0.001). For XP-Shaper files, centering ratios followed a descending order from 6 mm to 4 mm and were lowest at 2 mm, with all pairwise comparisons being statistically significant (p<0.001). it was concluded that XPS show lesser transportation and better centering ability.

KEYWORDS: E3 Azure, XPS, T-Blue, curved canals, CBCT.

INTRODUCTION

For root canal preparation to be successful, the original canals and root structure must be preserved [(1)]. The furcal concavity of the mandibular first molar, especially in the coronal third area [(2)], sometimes referred to as the danger zone [(3)] is the reason of the mesial root's thin distal wall. Treatment failure may result from strip perforations brought on by over-instrumentation. Despite the lack of clarity about the ideal remaining dentin thickness [(4)] imply that > 0.30 mm of dentin is needed for lateral condensation to avoid perforation. If the dentin thickness is less than 0.50 mm, 3–4 mm below the furcation, the risk of perforation increases [(5)].

In root canals that are sharply and excessively curved, instrumentation becomes more difficult.

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Apical transportation and canal straightening may result from the instrument's restraining force [6].

The latest model, the XP-endo Rise Shaper (XPRS; FKG Dentaire, La Chaux-de-Fonds, Switzerland), boasts a triangular cross section and a distinctive 6-cutting-edge booster tip, setting it apart from the earlier XP-endo Shaper (XPS). Constructed from Max-Wire alloy, the XPS is known for its high resistance to cyclic fatigue and its ability to conform to the anatomy of root canals during the instrumentation process[7,8].

A new rotary system The T Blue rotary files features a rectangular cross-section which enhance canal contact, even stress distribution and Effective debris removal[9]. Made from black Ni-Ti alloy which is made with less carbon and oxygen impurities, blue heat treated for better adaptability and flexibility[11] .

The E3 Azure has a modified S-shape cross section (decreasing the core of the file so allowing for better debris removal and greater flexibility), a variable pitch and a safe cutting tip[12].

Cone beam computed tomography (CBCT) is useful for assessing root canal structure and dentin thickness[13]. It gives high-resolution three-dimensional (3D) information while causing no damage to the samples.

The hypothesis of this study is to see if the alloy has a positive effect on the shaping ability of the rotary files. The purpose of this study was to examine the centering and shaping abilities of the E3 Azure, T Blue and XPRS rotary devices in severely curved root canals utilizing CBCT.

Sample size calculation:

A power analysis was designed to have adequate power to apply a statistical test of the null hypothesis that there is no difference would be found between different tested groups regarding amount of dentine removal. By adopting an alpha (α) of (0.05) and a beta (β) level of (0.2) (i.e., power=80%) and an effect size (f) of (0.455) calculated based on the results of a previous study*; the **minimum total** required sample size (n) was found to be (51) samples (i.e., 17 samples per group). Sample size calculation was performed using R statistical analysis software version 4.3.2 for Windows**.

Sample selection

This study was approved by British university Research Ethics Committee (No.24-088). Fifty-one mesial root canals from extracted human mandibular molars. Buccolingual and mesiodistal periapical radiographs were obtained using a digital X-ray device (Myray; Cefla Dental Group, Imola, Italy; 65 kVp, 6 mA, 1 s exposure). The canal configurations and preliminary measurements of the angle (Schneider, 1971) and radius of the root canal curvature were evaluated. Inclusion criteria were complete root formation, type IV canal configuration (Vertucci, 1984), a 30°–54° curvature angle, and a radius > 4 mm and ≤ 8 mm. The exclusion criteria included dental anomalies, prior root canal treatments, restorations below the cemento-enamel junction, root caries, internal or external root resorption, or calcified canals that could not be negotiated with a #10 K-file (Dentsply Sirona).

Sample preparation and CBCT imaging

The canals in each tooth were made with a high-speed diamond bur (#2; Jota AG, Rüthi, Switzerland). Later, each tooth was split and also mesial roots were set up in a clear acrylic material (Acro-Stone; Egypt) block and put in a acrylic mold on the chin rest of the CBCT scanner for consistent positioning.

* Damkoengsunthon, Chanapa, et al. "Evaluation of the shaping ability of different rotary file systems in severely and abruptly curved root canals using cone beam computed tomography." The Saudi Dental Journal 36.10 (2024): 1333-1338.

** R Core Team (2023). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Using a CBCT (3D Accutomo XYZ Slice View Tomograph, Kyoto, Japan; 90 kVp, 5 mA, 0.08 mm voxel size, and 40 × 40 mm field of view). The exact angle and radius of the root canal curvature of the mesiobuccal (MB) and mesiolingual (ML) canals were remeasured using CBCT images and ImageJ software (version 1.54 h). The mesial roots were evenly divided into three rotary groups: 17 mesial roots for the T-Blue group, 17 for the XPRS group, and 17 for the Azure E3 group.

Root length was measured (mean 10.0 ± 2.0 mm) and working length was determined by subtracting 1 mm. A glide path was made with a #10-15 K-files with MD-ChelCream (EDTA, META BIOMED, Korea) as a lubricant. Five percent NaOCl (10 ml total) was used to irrigate the root canals in room temperature using a 27-gauge needle delivering 2 ml of an irrigant with every 2–3 mm of penetration of the file. Prior to the last rinse, the root canals were recapitulated using a #15 K-file.

All rotary systems were used with X-smart Plus endodontic motors (Dentsply Sirona) at the recommended speed and torque settings.

In the T-Blue group, the root canals were instrumented using an orifice opener, path files, File No. 1(04/20) was used followed by. File No. 2&3(04/25, 04/30).

In the Endostar E3 Azure group. Small File No. 1 (06/20) orifice was used, file No. 2 (06/25) was then used to shape the canal up to two-thirds of its working length. Using an apex locator and a size 15 hand file, the working length was examined. Then, file number two was presented in its entirety. Using file No. 3 (04/30).

In the XPRS group, samples were immersed in a 40 °C water bath during instrumentation to maintain a temperature ≥ 35 °C inside the root canals. Canals were instrumented using the XPRS (30/0.01) with in-and-out motion and gentle 2–3 mm strokes until the working length was achieved.

Image analysis

Dentin removal, RDT, canal transportation, and the centering ratio were quantified from the analyzed CBCT scans using AImageJ. For evaluation of transportation, each sample's final and initial images were overlapped using Adobe Photoshop (10 Adobe Systems, San Jose, CA, USA), followed by a comparison with ImageJ analysis software.

The area between the furcation and the root apex of the mesial roots was divided into three equidistant levels: coronal, middle, and apical. Apical pieces were sliced transversally every 0.08 mm, perpendicularly to the longitudinal axis of the root.

The minimum dentin thickness (MDT) of the mesial root canals was assessed using ImageJ. Pre- and post-instrumentation images were created and combined using different color channels to achieve precise superimposition through aligned RGB planes[14]. MDTs were identified in the aligned post-instrumentation images by locating canal centroids with the Find Maxima command. Concentric circles were drawn around each root canal centroid, and a reference line was established from the centroid to where the innermost concentric circle intersects the external root surface, allowing for the measurement of MDTs, designated as M1, D1, M2, and D2.

Dentin removal was calculated for the mesial (M1 – M2) and distal (D1 – D2) sides. The minimum thickness after instrumentation was recorded as remaining dentin thickness (RDT), represented by M2 and D2, with an RDT of less than 0.5 mm at each level noted. Canal transportation was quantified using the equation (M1 – M2) – (D1 – D2), where a value of 0 indicates no transportation, while negative and positive values indicate shifts toward the distal and mesial sides, respectively. The centering ratio was determined using either (M1 – M2)/(D1 – D2) or (D1 – D2)/(M1 – M2). A result of 1 signifies that the file remained centered in the root canal, whereas a value approaching 0 suggests a reduced ability to keep the file in the center [15].

Statistical analysis:

Numerical data was represented as mean and standard deviation (SD) values. They were explored for normality by viewing the distribution and using Shapiro-Wilk's test. Data were non-parametric and were analyzed using a two-way mixed model Aligned Rank Transform (ART) analysis. The comparisons of simple main effects were made utilizing the error term of the model with p-value adjustment using the False Discovery Rate (FDR) method. The significance level was set at p<0.05 within all tests. Statistical analysis was performed with R statistical analysis software version 4.4.2 for Windows.

RESULTS

The test for normality (Shapiro-Wilk's test) revealed that the data were non parametric or not normally dis-tributed.

Results in table (1) & figure (1) revealed that the transportation differences between file types at various levels were significant (p<0.001). At 2 mm, all pairwise comparisons were statistically significant, with Azure showing the highest transportation, followed by T-Blue, and XPS showing the least (p<0.001). At 4 mm and 6 mm, Azure and T-Blue showed significantly higher transportation than XPS (p<0.001). Within each file type, transportation varied significantly between levels (p<0.001). For Azure and T-Blue files, transportation was highest at 4 mm, followed by 2 mm, and lowest at 6 mm (p<0.001). For XPS, transportation at 2 mm and 4 mm was significantly higher than at 6 mm (p<0.001).

Results in table (1) & figure (2) revealed that the centering ratio comparisons revealed significant differences between file types at 4 mm and 6 mm (p<0.001), but no significant differences were found at 2 mm (p=0.161). At 4 mm, T-Blue files had significantly higher centering ratios than the other files (p<0.001). At 6 mm, Azure and XP-Shaper files had significantly higher ratios than T-Blue (p<0.001). Centering ratios varied significantly between levels (p<0.001) within each file type. For Azure and T-Blue files, ratios were highest at 6 mm (p<0.001). For XP-Shaper files, centering ratios followed a descending order from 6 mm to 4 mm and were lowest at 2 mm, with all pairwise comparisons being statistically significant (p<0.001).

TABLE (1) Comparisons of simple main effects.

	Level	Mean±SD			p-value
		Azure	**XP-Shaper**	**T-Blue**	
Transportation	**2 mm**	0.44 ± 0.05^{Ab}	0.22 ± 0.01^{Ca}	0.36 ± 0.03^{Bb}	**<0.001***
	4 mm	0.57 ± 0.08^{Aa}	0.28 ± 0.12^{Ba}	0.50 ± 0.04^{Aa}	**<0.001***
	6 mm	-0.04 ± 0.06^{Ac}	-0.22 ± 0.10^{Bb}	-0.01 ± 0.05^{Ac}	**<0.001***
	p-value	**<0.001***	**<0.001***	**<0.001***	
Centering ratio	**2 mm**	0.31 ± 0.04^{Ab}	0.38 ± 0.04^{Ac}	0.36 ± 0.04^{Ab}	**0.161**
	4 mm	0.38 ± 0.05^{Bb}	0.61 ± 0.16^{Ab}	0.41 ± 0.03^{Bb}	**<0.001***
	6 mm	0.93 ± 0.04^{Aa}	0.73 ± 0.11^{Ba}	0.95 ± 0.04^{Aa}	**<0.001***
	p-value	**<0.001***	**<0.001***	**<0.001***	

Values with different upper and lowercase superscripts within the same horizontal row and vertical column, respectively, are significantly different, * significant (p<0.05).

* R Core Team (2024). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

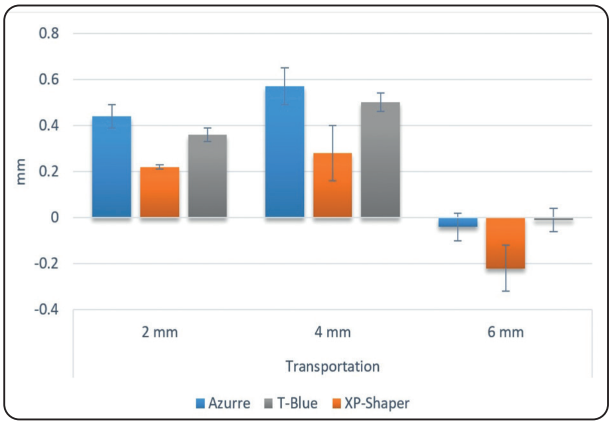

Fig. (1) Bar chart showing transportation's mean and standard deviation values.

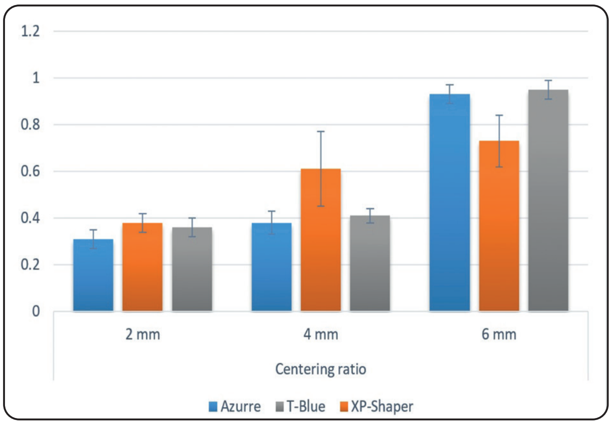

Fig. (2): Bar chart showing the centering ratio's mean and standard deviation values.

DISCUSSION

Cleaning the canal walls while maintaining the natural anatomy is the aim of mechanical instrumentation for root canals. Better root canal preparation minimizes unnecessary dentin removal and makes it possible for 3-dimensional obturation, irrigation, and intracanal medicament (16). However, all preparation methods have been demonstrated to alter the root canal pathway due to the fact that canals are bent primarily in the apical third, curved canals provide a problem in endodotic preparation (17). Additionally, various degrees of canal transportation emerge from the uneven dentin removal caused by canal curvature during shaping. This is more significant in molar teeth that possess complex root canal anatomy (18,19) hence the choice of the samples for this study. Because endodontic files are composed of a straight metal alloy, the tool has a propensity to change itself inside the curved canal in a straight line and the force distribution is uneven in certain contact areas (20) . Many factors affect the behavior of the endodontic file within the root canal including the root canal curvature (18,19) the access cavity design that may allow curved trajectories only (21) the employed motion and its parameters and more importantly the alloy used in any heat treatment it may have received. Iatrogenic mistakes that happen during root canal preparation are known as endodontic mishaps. Zip-and elbow production shares a common characteristic with other preparation effects, such as ledges, strip perforations, or significant weakening of root canal walls: they are all most likely the result of canal transit (17). Although the latter word can be more broadly defined as any undesired variation from the regular canal pathway, it has been characterized and approximated in several ways (19,20) .

Because mesibuccal canals of human extracted permanent lower mandibular teeth are typically short and curved in two planes, which increases the level of instrumentation challenges and the incidence of canal transportation, they were chosen for this study. The distal concave region of the mesial root was identified as the risk zone by Razcha et al. (21) . In addition to being especially vulnerable to extreme fragility and iatrogenic damage like strip perforation and canal transportation, it tends to drastically diminish during canal preparation. Lower molar mesiobuccal root canals are the preferred tooth for this investigation in order to evaluate the shaping capability of these rotary file systems because of all these features (22,23,24) .

While the most accessible method to assess transportation and centering ability is micro CT imaging, CBCT remains the best easily-accessible one, and its accuracy has been repeatedly demonstrated in endodontic applications, CBCT scanning was chosen for the current study to evaluate canal transportation and centering ability. This method provides more accurate results when evaluating root canal transportation for clinical applications. Images produced by a CBCT imaging system are distortion free and geometrically accurate in all plane measurements.Kumar et al. (25) and Kiran et al. (26) among others have employed CBCT imaging as a measuring tool to assess the efficacy of different root canal preparation and instrumentation approaches.CBCT imaging is the most reliable method for accurately examining root canal anatomy in three dimensions.

XP demonstrated the least transportation and the highest centering ability. This agrees with previous studies (27) while disagrees with others (28,29). This contrast can be easily attributed to the differences in the parameters and alloys of the employed files in these studies. The smaller core size of the file and its unique metallurgical features provide it with a more free oscillatory motion within the root canal. The XP design took into account the body temperature while determining its finishing temperature thus phase transformations are significant and enhance its performance. Also its reduced number of contact points reduce the probability of transportations and respect the root canal uniqueness (30) . This feature probably provides another advantage by reducing the probability of binding and torsional failures that complicate treatment plans; a separated file in the apical one third of a mandibular second molar for example represents a challenging dilemma where the decision to attempt retrieval or going for endodontic surgeries are both undesirable scenarios due to the proximity of vital structures (31,32) .

CONCLUSION

Within the limitations of this study, the XP shaper shown better performance in comparison to the other rotary systems.

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