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Original Research Article

CBCT evaluation of the shaping characteristics of five different file systems in mesial canals of mandibular first molars – An ex vivo study

Anil Dhingra[1], **Sheetal Grover**[1], **Rohit Babu**[1]*, **Seema Dixit**[1], **Anshdeep Singh**[1], **Priya Pundir**[1]

[1] *Seema Dental College and Hospital, Rishikesh, Uttarakhand, India*

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CBCT - cone beam computed tomography
NiTi - Nickel Titanium
ANOVA- Analysis of variance
NaOCl- sodium hypochlorite

ABSTRACT

Background: Cone-Beam Computed Tomography (CBCT) has revolutionized endodontic research by providing detailed 3D imaging, crucial for assessing the shaping characteristics of endodontic file systems. In the challenging mesial canals of mandibular first molars, where complex anatomy often complicates treatment, CBCT offers precise evaluation of how different file systems shape these canals. This ex vivo study compares five distinct file systems, analysing their ability to maintain the original canal curvature and ensure effective cleaning. The study aims to identify the most effective file systems, potentially improving clinical outcomes in endodontic therapy.

Aim: This ex vivo study compared the shaping characterstics of five Ni-Ti rotary File Systems, File Univesal X7 Edge Endo, Bassilogic ProDesign Logic, Gen Endo Coltene Whaledent Pvt. Ltd., Endo Star E3 Azure Basic, Mani Jizai using Cone Beam Computed Tomography (CBCT).

Materials and Methods: One hundred extracted human permanent mandibular first molars with mesial root curvature angles ranging from 20-30 degrees were divided into five groups (n=20 each). The teeth were imaged using CBCT with CS9300 equipment, set at 84 kV, 5 mA, and a 10.8-second exposure, achieving a resolution of 90 microns and a slice thickness of 76 microns to obtain a pretreatment outline of the root canals. All scans were reoriented along the x, y, and z axes. Canal transportation and root canal volume were evaluated at 0.0, 1.0, 2.0, 3.0, 4.0, and 5.0 mm intervals. The mean differences in volume and area were analyzed using one-way ANOVA to determine the variance between the five different file groups.

Results: Gen Endo File System did the least modifications in the Canal Area and Volume.

Conclusion: Within the parameters of this study it was concluded that GEN ENDO Files did the least modifications in canal anatomy as compared to other groups.

1. Introduction

The primary goal of root canal treatment is to clean and shape the root canal system while preserving its original anatomy and curvature.[1] This requires maintaining a continuous taper to facilitate irrigation and proper obturation without excessive dentin removal. NiTi (nickel-titanium) alloy instruments have revolutionized root canal preparation due to their flexibility, elasticity, and fracture resistance, allowing for simpler and faster shaping compared to stainless steel files.[2] Rotary NiTi instruments, known for their super-elasticity and strength, can be manufactured with multiple taper options, ensuring consistent and predictable canal shaping with reduced risk of iatrogenic damage. This advancement overcomes the challenges associated with traditional stainless steel files, which often led to undesirable outcomes.[3,4]

* *Corresponding author.*
E-mail address: rohitbabu619@gmail.com (R. Babu).

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Various NiTi systems with different designs and tapers have been introduced, leading to numerous studies evaluating their efficacy using methods such as serial sectioning and computed tomography.[5] As NiTi systems continue to evolve, it is essential to conduct comprehensive investigations into their shaping effects to better understand their performance and design features.[6,7] This ongoing research is crucial for improving the efficacy and safety of root canal treatments, ensuring better patient outcomes and preserving tooth structure.[8]

2. Materials and Methods

The study aimed to evaluate the shaping characteristics of five Ni-Ti rotary file systems and compare the transportation and residual dentin thickness in the curved root canals of mandibular first molars using CBCT (Cone Beam Computed Tomography).

A total of 100 recently extracted, intact, and caries-free human permanent mandibular first molars with mature apices were selected from the Department of Oral & Maxillofacial Surgery, Seema Dental College & Hospital. Extraneous soft tissue, superficial debris, and calculus were removed with an ultrasonic scaler, and the teeth were disinfected with 5.25% NaOCl (sodium hypochlorite) solution before being autoclaved at 137°C for 30 minutes. Inclusion criteria required that each tooth had a curved mesial root with two separate canals and apices, with curvature angles between 20-40° (Schneider 1971). Teeth were examined under an operating surgical microscope for microcracks, and only acceptable teeth were used. Selected teeth were stored in deionized water at 4°C until use.

Radiographs were taken in the buccolingual and mesiodistal dimensions before instrumentation. To standardize root canal length, teeth were decoronated at the cemento-enamel junction using a high-speed alloy grinder to obtain approximately 14 mm samples. K-File no.10 was inserted into the buccal and lingual canals to assess root canal curvature. Coronal access was achieved with a high-speed water-cooled airotor and Endo-Access Bur. Each tooth was sectioned at the furcation, and only the mesial portion was used.

Working length was established in 60 specimens by deducting 1 mm from the actual canal length, confirmed with radiographs. Biomechanical preparation was performed according to manufacturers' instructions for the file systems EdgeEndo, Bassi Logic, Gen Endo, E3 Azure, and Mani Jizai System (n=20 each).

Imaging was performed with CBCT using CS9300 equipment (Carestream Healthcare India) at 84kV, 5mA, and 10.8-second exposure, with a slice thickness of 76 μm, obtaining a pretreatment outline of the root canals. Images were three-dimensionally reconstructed into cross-sectional slices, and dentin thickness from the furcation to the apex was recorded. Teeth were marked for identification, mounted in acrylic blocks, and scanned with CBCT.

Comarision parameters were:

1. The mean difference of superimposition at 1,2,3,4,5 mm in Root Canal Area from Pre to Post Treatment (Figure 1 a,b, Figure 3).
2. The mean difference of superimposition in Mesio Buccal and Mesio Lingual Canal Volume from Pre to Post Treatment (Figures 4 and 5).
3. The mean difference of superimposition in Mesial and Distal Root Angulation from Pre to Post Treatment (Figure 2).

Comparisons parameters were calculated by subtracting values obtain for treated canals with those from untreated canals through CBCT.

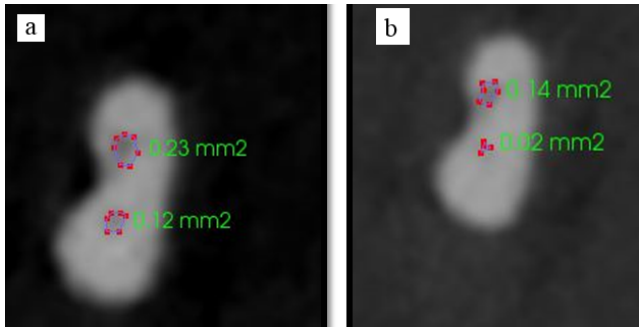

Figure 1: a: Pre-operative scan calculating area of the canal using CBCT; **b:** Post-operative scan calculating area of the canal using CBCT

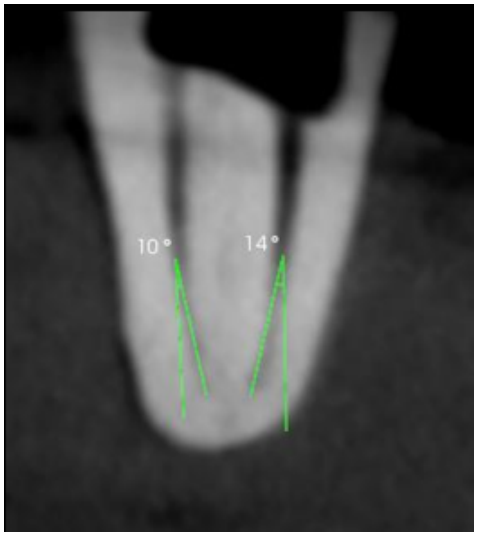

Figure 2: Calculating canal angulation ofmesiobuccal & mesiolingual canal using CBCT

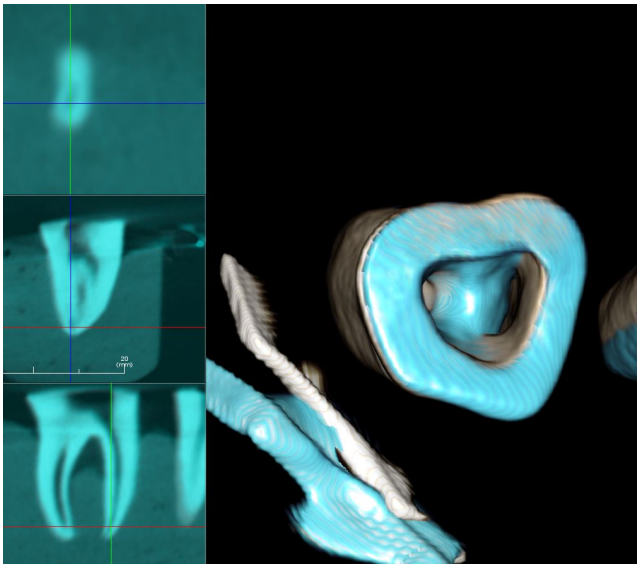

Figure 3: Superimposition Images using CBCT

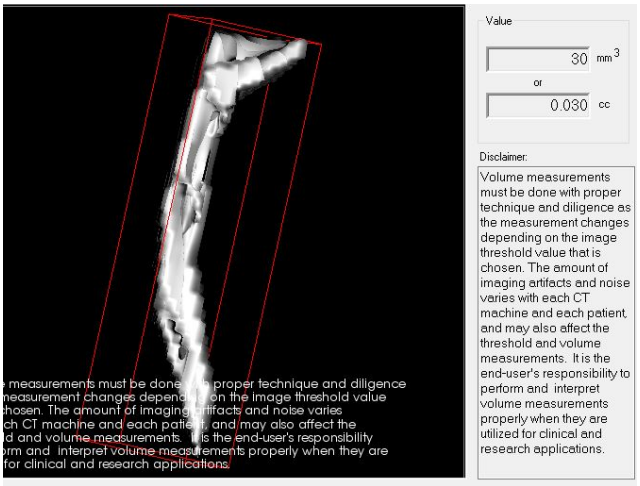

Figure 4: Pre-operative scan calculating volume of the canal using CBCT

2.1. Statistical analysis

The data was entered into spread sheets and analysed using Social Package for Statistical System- SPSS- 23.0 version (IBM; Chicago).

Parameters are expressed as mean and standard deviation. Oneway Analysis of variance (ANOVA) was used to determine the variance between the 5 different file groups.

The results were analysed with p value lesser than 0.05

Level of Significance (p-value)

The maximum probability of rejecting a correct null hypothesis. Statistical Analysis 95

In testing a given hypothesis, the maximum probability with which we would be willing to take risk is called Level of Significance of the Test.

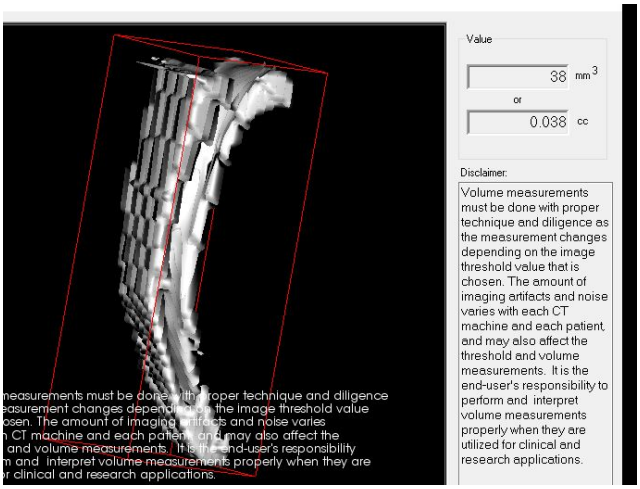

Figure 5: Post-operative scan calculating volume of the canal using CBCT

P- value≥0.05 – Non- Significant

P- value<0.05*- Siginificant

P-value<0.001**-HighlySignificant

3. Results

hows the mean transportation values of all file system at 2 mm.Oneway ANOVA showed a signiciant difference between the files with Bassilogic having the highest mean value (0.1740 + 0.0290) and GEN ENDO exhibiting lowest mean of 0.0920 + 0.0223 at p <0.001.

The mean mesiobuccal volume was highest for GEN ENDO with a mean of 16.5770 + 2.5554, followed by E3 AZURE with a mean of 13.6945 + 2.0097, Mani JIZAI system with a mean of 13.6145 + 2.0077, BASSILOGIC system with a mean of 9.3233 + 1.1366 and Edge Endo having a mean of 8.3007 + 1.3461. This finding was significant at p=0.002 when tested with oneway ANOVA (Table 2)

The mean mesiolingual volume was highest for GEN ENDO with a mean of 13.1400 + 1.2657, followed by E3 AZURE with a mean of 12.2464 + 0.7901, MANI JIZAI with a mean of 12.2064 + 0.7601, Bassilogic with a mean of 9.2904 + 0.8414 and Edge Endo having a mean of 7.4570 + 0.6966. This finding was significant at p=0.012 when tested with oneway ANOVA (Table 3) and (Table 4) shows the mean difference of canal angulation in superimposition of mesial and distal root angulation.

resents the area parameter of all files.E3 AZURE had the highest area of 0.754, while EDGE ENDO had the lowest with a mean of 0.156.

resents the volume parameter of all files.GEN ENDO had the highest area of 8.468, while Edge Endo had the lowest with a mean of 3.257.

Table 1: The mean difference of superimpositon at 1, 2, 3, 4, 5 mm in root canal area from pre to post treatment

Groups	Mean + S.D	Std. Error	Anova (F) statistic	P value
Edge Endo	0.1630 + 0.4105	0.00918		
Bassilogic ProDesign Logic	0.1740 + 0.0290	0.0065	28.153	<0.001**
Gen Endo Coltene	0.0920 + 0.0223	0.0050		
Endo Star E3 Azure	0.1280 + 0.0296	0.0066		
Mani Jizai	0.1272 + 0.0316	0.0065		

Table 2: Difference in mesio-buccal volume from pre to post treatment

Groups	Mean + S.D	Std. Error	Anova (F) statistic	P value
Edge Endo	8.3007 + 1.3461	0.3010		
Bassilogic ProDesign Logic	9.3233 + 1.1366	0.2541	87.111	0.002*
Gen Endo Coltene	16.5770 + 2.5554	0.5714		
Endo Star E3 Azure	13.6945 + 2.0097	0.4494		
Mani Jizai	13.6145 + 2.0077	0.4483		

Table 3: Comparison ofmesiolingual volume at pretreatment and post treatment periods

Groups	Mean + S.D	Std. Error	Anova (F) statistic	P value
Edge Endo	7.4570 + 0.6966	0.1557		
Bassilogic ProDesign Logic	9.2904 + 0.8414	0.1881		
Gen Endo Coltene	13.1400 + 1.2657	0.2830	160.842	0.012*
Endo Star E3 Azure	12.2464 + 0.7901	0.1766		
Mani Jizai	12.2064 + 0.7601	0.1616		

Table 4: The mean difference of canal angulation in superimposition of mesial and distal root angulation

Groups	Mean + S.D	Std. Error	Anova (F) statistic	P value
Edge Endo	7.9606 + 0.8364	0.1870		
Bassilogic ProDesign Logic	11.4079 + 1.0189	0.2278	44.4330	<0.0372*
Gen Endo Coltene	11.6750 + 0.7730	0.1728		
Endo Star E3 Azure	10.6518 + 1.6940	0.3788		
Mani Jizai	10.5038 + 0.640312	0.2931		

Table 5: Area parametersof files

Area	Mean	S.D
Edge Endo	0.156	0.016
Bassilogic ProDesign Logic	0.292	0.025
Gen Endo Coltene	0.754	0.320
Endo Star E3 Azure	0.618	0.019
Mani Jizai	0.516	0.026

Table 6: Volumeparameters of all files

Volume	Mean	S.D
Edge Endo	3.257	0.298
Bassilogic ProDesign Logic	4.013	0.574
Gen Endo Coltene	8.468	1.013
Endo Star E3 Azure	4.960	1.964
Mani Jizai	4.640	1.298

4. Discussion

To investigate the efficacy of instruments and techniques for root canal preparation, various methods have been employed to evaluate canal shape before and after instrumentation.[9] Cone-beam computed tomography (CBCT) is a non-invasive technique ideal for analyzing canal geometry and the efficiency of shaping techniques. CBCT allows comparison of the root canal's anatomic structure before and after preparation without cutting into the tooth. Additionally, the superior quality of the 3-dimensional images acquired by CBCT enhances geometric analysis of the root canal area.[10] A significant advantage of CBCT is its 3-dimensional geometric accuracy compared to conventional radiographs, as well as the elimination of structural superimpositions.[11]

This study evaluated the canal shaping characteristics of the EdgeEndo, Bassi Logic, Gen Endo, E3 Azure and Mani Jizai Files using CBCT imaging, a non-destructive, reproducible, and well-established method for the 3D assessment of the root canal preparation. All instruments showed untouched areas of the root canal wall, indicating that none were able to completely clean the dentin walls, which is in agreement with previous studies on NiTi rotary systems.[12]

It has been shown that variations in canal geometry before instrumentation may have a greater effect on observed changes than the instrumentation techniques themselves. In this way, a less complex preoperative configuration of the root canals selected in this study may explain the results. Overall, the GEN ENDO (Group 3) and E3 AZURE(Group 4) systems resulted in significantly less untouched canal walls and a higher increase in the surface area, perimeter, and minor diameter of the canals than the Edge Endo and Bassi Logic filesystem. These results might be explained by differences in the design of the instruments.

The mean pre-instrumentation canal volumes were comparable, indicating similar root canal sizes. The mesio-buccal and mesio-lingual canals were used given that these canals are prone to iatrogenic errors because they are often narrow and have accentuated curves that increase the level of instrumentation difficulty.[13] Canal volume is a variable used to analyse the effects of canal instrumentation on dentine removal.[14] Over-instrumentation of the root canal could result in excessive thinning of the root.[15,16]

The mean curvature angle, area and volume recorded for Group 1(Edge Endo Files),Group 2(Bassilogic), Group 3(Gen Endo),Group 4 (E3 Azure),Group 5 (Mani Jizai) showed that group 1(Edge Endo) and ,Group 2(Bassilogic), were not sufficient to properly clean and shape the root canal system.

The mean curvature angle recorded pre and post for Mesio Buccal and Mesio Lingual canals for Group 1 (Edge Endo), Group 2(Bassilogic),Group 3 (Gen Endo), Group 4 (E3 Azure) and Group 5 (Mani Jizai) were MB-(13.75±6.40) and ML(10.75±5.01), MB-(10.25±6.70) and ML- (14±3.91), MB-(11.25±2.50) and ML-(12±5.71) , MB(16±6.05) and ML-(15.75±2.25), MB-(13.61 + 2.01) and ML-(12.21 + 0.76)respectively showed that Edge Endo Files (Group 1) , Bassi Logic (Group 2) were not sufficient to maintain a specific canal shape during cleaning and shaping Better results in Group3 (Gen Endo), Group 4 (E3 Azure).

If canal preparation in the apical third of the root is not centered, it can cause blockages, perforations, and ledges. This may result in inadequately cleaned canals, increasing the risk of persistent apical periodontitis.[17]

The mean area recorded pre and post for Group 1 (Edge Endo), Group 2(Bassi Logic), Group 3(Gen Endo), Group 4 (E3 Azure) and Group 5(Mani Jizai) 0.156, 0.292, 0.754 , 0.618 and 0.516 respectively showed that Group 1 (Edge Endo) and Group 2 (Bassilogic) were not able to touch the walls of the canal while shaping. Better results were observed in Group 3 (Gen Endo) and Group 4 (E3 Azure) as the files touched the walls of the canals leading to proper cleaning and shaping of the canal.

The mean area recorded before and after treatment for Groups 1 through 5 showed that Groups 1 and 2 failed to effectively touch the canal walls during shaping. Group 3 showed better results, with files adequately touching the canal walls, leading to proper cleaning and shaping. Overall, Groups 1 and 2 resulted in significantly less unprepared root dentin canal walls and a higher increase in surface area, perimeter, and minor diameter of the canals compared to Groups 3 and 4. These differences may be attributed to the design and geometry of the instruments.

The rationale for measuring changes in the cross-sectional area was to enable comparisons at standardized cut planes. This makes comparisons with previous studies, which measured changes in the total area of the root canal system, challenging. Our results show that regardless of the reciprocating system used, the cross-sectional area increased at all levels. However, no significant differences were observed between the reciprocating systems at any cut plane.

Evaluating dentin thickness is crucial as excessive removal of dentin can predispose teeth to root fractures.[18] When an instrument remains centered in the canal, it is expected to preserve more dentin, which may explain the greater percentage of remaining dentin thickness observed with Endostar and Gen Endo files. Both Endostar and Gen Endo systems also showed similar increases in volume and surface area in the coronal and middle thirds of the root canal, despite their different dimensions.

The mean Volume recorded pre and post for Group 1(EdgeEndo File), Group 2(Bassilogic), Group 3(Gen Endo),Group 4 (E3 Azure),Group 5(Mani Jizai) were 3.257, 4.013, 8.468, 4.960, 4.640 respectively showed that EdgeEndo(for Group 1) and Bassilogic (Group 2) were

not able to touch the walls of the canal while shaping. Better results were observed for Gen Endo(Group 3) , E3 Azure(Group 4) and Mani Jizai(Group 5)as the files cleaned and shaped the root canal approaching the maximum walls of the canal.

In this study, root canal instrumentation resulted in an increase in canal volume, which improves access of irrigants to the apical-third of the canal, but is also an indication that mechanical debridement might not be as effective apically as it is coronally.

The mean difference in superimposition at 1mm, 2mm, 3mm, 4mm and 5mm in distal aspect from pre to post treatment was done between using the One- ANOVA test with post-hoc bonferroni test for inter-group comparisons. The mean difference in distal aspect from pre to post treatment was significantly more among Gen Endo Files and E3 Azure Files in comparison to Edge endo Files and Bassilogic Files.

The rationale for measuring changes in the cross-sectional area was to facilitate comparisons at standardized cut planes.[19,20] Consequently, comparing our results with previous studies that measured changes in the total area of the root canal system is challenging. Our findings indicate that, regardless of the rotary system used, the cross-sectional area increased at all levels. However, no significant differences were observed between the rotary systems at any cut plane.

The mean difference in mesial aspect from pre to post treatment was done between 1(EdgeEndo File), Group 2(Bassilogic File), Group 3(Gen Endo),Group 4 (E3 Azure), Group 5(Mani Jizai) using the One-ANOVA test with post-hoc bonferroni test for inter-group comparisons. The mean difference in mesial from pre to post treatment was significantly more among Gen Endo, Mani Jizai and E3 Azure Files in comparison to Edge Endo Files and Bassilogic Files.

Within the limitations of this study long term use of this method should be followed up in clinical studies. However more Ex Vivo studies need to be conducted to correlate the result of this study.

5. Conclusion

Within the parameters of this study it was concluded that GEN ENDO Files did the least modifications in canal anatomy as compared to other groups.

Within the limitations of this study long term use of this method should be followed up in clinical studies. However more EX Vivo studies need to be conducted to correlate the result of this study.

6. Conflict of Interest

None.

7. Source of Funding

None.

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Author's biography

Anil Dhingra, HOD https://orcid.org/0000-0002-4045-5945

Sheetal Grover, Professor https://orcid.org/0000-0002-7256-2382

Rohit Babu, 3rd Year Post Graduate https://orcid.org/0009-0004-8714-9074

Seema Dixit, Professor https://orcid.org/0000-0002-7504-488X

Anshdeep Singh, Professor

Priya Pundir, Reader

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