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Using Cone-Beam Computed Tomography to Evaluate Shaping, Transportation, and Dentin Thickness in Mandibular First Molars Prepared with Four Different NiTi Rotary Systems

Dr. Shubham Dalvi[1], Dr. Anil Dhingra[2], Dr. Sheetal Grover[3], Dr. Seema Dixit[4], Dr. Sahil Rohilla[5], Dr. Neetika Jain[6]

[1]Post Graduate Student, Department of Conservative Dentistry and Endodontics, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India (Corresponding Author)

[2]Professor and Head, Department of Conservative Dentistry and Endodontics, DJ College of Dental Sciences & Research, Modinagar, Ghaziabad, Uttar Pradesh, India

[3]Professor, Department of Conservative Dentistry and Endodontics, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

[4]Professor and Head, Department of Conservative Dentistry and Endodontics, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

[5]BDS, MDS (Endodontics)

[6]Senior Lecturer, Department of Conservative Dentistry and Endodontics, Kalka Dental College and Hospital, Meerut, Uttar Pradesh, India

Corresponding Author: Dr. Shubham Dalvi

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KEYWORDS

Endodontics, Nickel-Titanium, Cone-Beam Computed Tomography, Canal Transportation, Rotary Files, Root Canal

ABSTRACT:

Aim: The main aim of this ex vivo study was to evaluate the shaping characteristics and compare the transportation of the apical foramen along with the residual dentin thickness in the mesial curved canals of mandibular molars using Cone-Beam Computed Tomography (CBCT). The study evaluated four Nickel-Titanium (NiTi) instrumentation systems: Neoendo Flex Rotary File, Bondent UDG CC Platinum V.EU, Gen Endo ColteneWhaledentPvt. Ltd, and Mani Jizai.

Methods: An ex vivo study was conducted on freshly extracted human permanent mandibular first molars with mature apices. The root canals were prepared using a crown-down technique in mesial canals of mandibular first molars. After instrumentation, the canals were rinsed with a 17% EDTA solution and then with sterile saline. The transportation and residual dentin thickness were evaluated using CBCT before and after instrumentation. Statistical analysis was performed using SPSS version 23.0, and the results were analyzed with a p-value less than 0.05 being considered significant.

Results: The mean transportation was significantly less with the Gen Endo files, which showed a p-value of <0.001. The maximum mean transportation value was observed for Neo Endo files. The measured curvature angles showed greater variability with NeoEndo and Bondent, while GenEndo and Mani Jizai demonstrated more consistent shaping. GenEndo and Mani Jizai files resulted in a significantly higher average canal area after instrumentation, suggesting they made better contact with the canal walls and provided more effective cleaning and shaping.

Conclusion: The findings suggest that while all tested files are effective, Gen Endo files exhibited significantly less transportation. GenEndo and Mani Jizai files demonstrated more consistent shaping and greater effective cleaning of the canal walls.

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Introduction

The principal goal of root canal therapy is to achieve thorough cleaning and shaping of the root canal system while preserving the original anatomy of the root and the apical foramen[1]. Maintenance of the natural canal curvature and the creation of a continuous taper are considered essential for the penetration of irrigating solutions, effective removal of debris, and subsequent placement of obturating materials[2]. Excessive removal of dentin should be avoided in order to maintain structural integrity while ensuring an adequate taper[3]. The fundamental challenge for any instrumentation system lies in preparing the canal adequately without unnecessary dentin sacrifice[4]. This preparation includes both enlargement and shaping of the complex canal space along with its disinfection[5]. One of the critical mishaps during this process is canal transportation, in which the apical foramen deviates from its original position, potentially leading to zipping or perforation, thereby jeopardizing the long-term success of treatment[6]. The introduction of nickel-titanium (NiTi) alloy in the 1980s marked a major breakthrough in endodontics, as it resolved issues of instrument fracture commonly observed with stainless steel files in curved canals[7]. Compared with stainless steel, NiTi instruments exhibit superior flexibility, elasticity, and fracture resistance[8]. Their superelasticity permits the manufacture of rotary systems with multiple tapers, making root canal shaping more efficient and predictable[9]. Over time, several NiTi systems with distinct designs and metallurgical modifications have been introduced, and their shaping ability has been widely investigated using various imaging techniques[10]. Computed tomography (CT), micro-computed tomography (micro-CT), and more recently, cone-beam computed tomography (CBCT) have been employed to compare canals before and after instrumentation in a reproducible and non-invasive manner[11]. CBCT, which uses a cone-shaped X-ray beam to capture volumetric data in a single rotation, provides isotropic voxels, enabling precise dimensional measurements with lower radiation exposure, reduced scanning time, and lower costs compared with medical CT[12].

Aim

This study aims to investigate the shaping characteristics of four commercially available NiTi file systems: Neoendo Flex Rotary File, Bondent UDG CC Platinum V.EU, Gen Endo Coltene Whaledent Pvt. Ltd, and Mani Jizai.

Materials and Methods

This *ex vivo* study was conducted on freshly extracted, intact, and caries-free human permanent mandibular first molars with mature apices.

Materials

- Freshly extracted human permanent mandibular first molars
- 5% sodium hypochlorite and Deionized Distilled Water
- Measuring Scale
- Endodontic Block
- Stainless Steel K-files (#10, #15, #20)
- Endo Access Bur
- 0.9% w/v Normal saline
- Ethylene Diamine Tetra Acetic Acid (EDTA)
- Disposable Syringe 5 ml with 30-gauge side vent opening needles
- Cavit
- Endodontic Rotary Files · Neo Endo Flex Rotary File ·Bondent UDG CC Platinum V.EU· Gen Endo ColteneWhaledentPvt. Ltd. · Mani Jizai

Study Groups

80 teeth were prepared and then randomly divided into four groups based on the rotary file system used.

- **Group 1: Neo Endo Flex Rotary File:**
- **Group 2: Bondent UDG CC Platinum V.EU:**
- **Group 3: GenENDO:**
- **Group 4: Mani Jizai:**

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Figure 1

Methodology

Eighty recently extracted intact and caries free Human permanent mandibular first molars with mature apices were selected for the evaluation in modifications in canal anatomy. The CDC Guidelines for infection control in dental health-care setting 2003 were followed for the preparation of samples. Teeth were scrubbed with detergent using ultrasonic cleaner to clean off visible blood and gross debris. Disinfected by first immersion in 10 % Formalin for 7 days followed by autoclaving at 121 ºC, 15 psi for 15 minutes. The specimens were placed in a radiographic mount. The radiographs in the buccal-lingual and mesio-distal dimension were taken to confirm the presence of two distinct and separate root canals. Teeth were imaged (90 micron resolution) with CBCT imaging software set at 84Kv, 5mA, 10.8 second exposure and a slice thickness of 76 um to obtain a pretreatment outline of the root canals. Each tooth was sectioned through furcation and mesial portion of the root.Working length was established with 15 K-File. Biomechanical preparation was done with the file systems used in the study and irrigation was done using sodium hypochlorite. Post operative scanning was done under CBCT at distances 0, 1, 2, 3, 5 mm from the apical point of each specimen and comparative parameters were calculated by subtracting values obtain for treated canals with those from untreated canals through CBCT. The mean difference in Area, and Angulation, Volume from pre to post treatment was done. After completion of the study, all the data was collected and subjected to Statistical Evaluation.

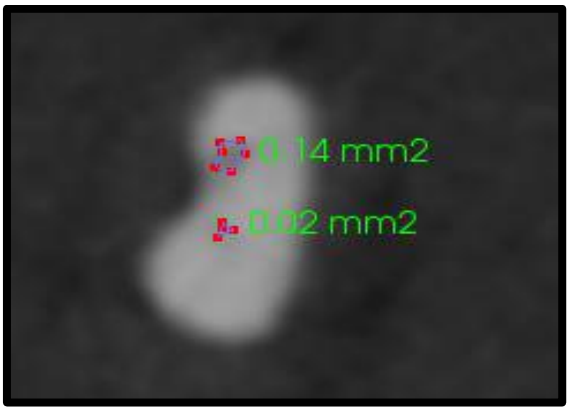

Figure 2

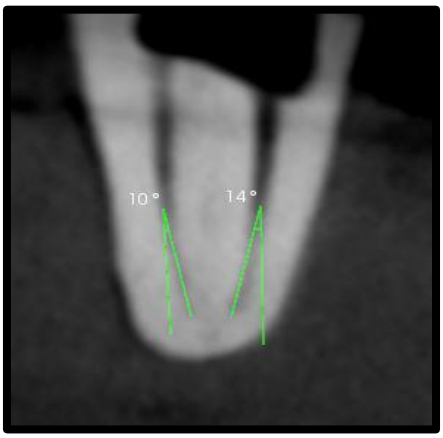

Figure 3

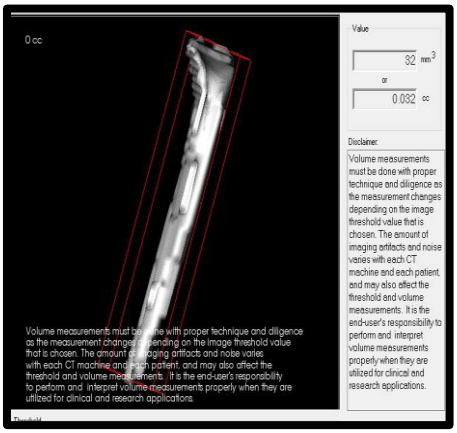

Figure 4

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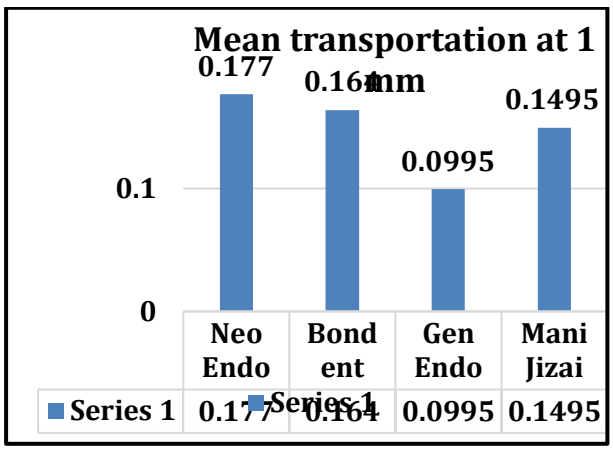
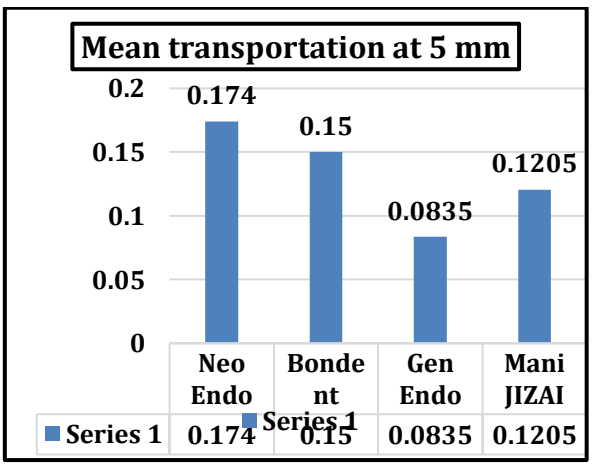
Statistical Analysis

The data was analyzed using the Social Package for Statistical System (SPSS) version 23.0. One-way Analysis of Variance (ANOVA) was used to determine the variance between the file groups.

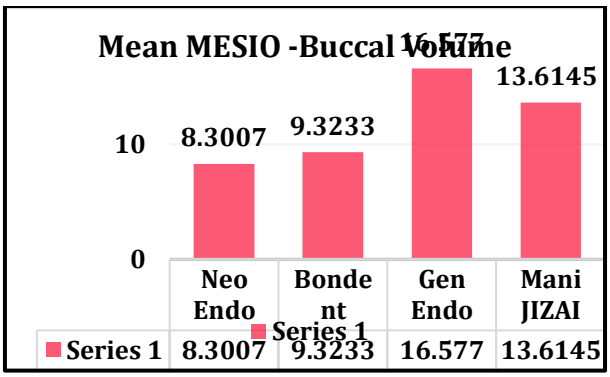
Results



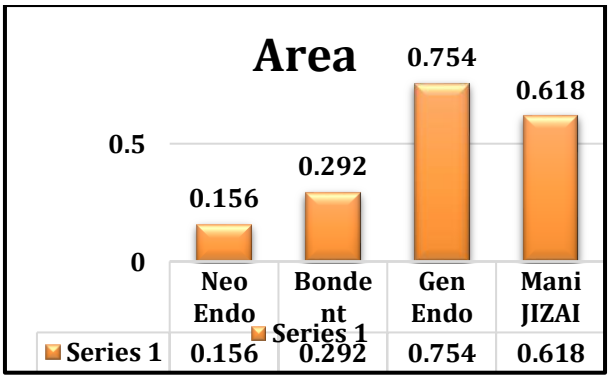
Graph 1: Mean transportation at 1 mm in five file system is shown in Graph 1. Maximum mean value was achieved for Neo Endo with a mean of 0.1770 + 0.0335, followed by 0.0995 + 0.0305. Transportation was significantly lesser with GEN ENDO at p<0.001



Graph 2: It shows the mean transportation values of all file system at 5 mm. Oneway ANOVA showed a significant difference between the files with Neo Endo Results having the highest mean value (0.1740 + 0.0225) and GEN ENDO exhibiting lowest mean of 0.0835 + 0.2007 at p <0.001



Graph 3: The mean mesiobuccal volume was highest for GEN ENDO with a mean of 16.5770 + 2.5554, followed by Mani JIZAI system with a mean of 13.6145 + 2.0077, BONDENT system with a mean of 9.3233 + 1.1366 and Neo Endo having a mean of 8.3007 + 1.3461. This finding was significant at p=0.002 when tested with oneway ANOVA



Graph 4: It presents the area parameter of all files. Gen Endo had the highest area of 0.754, while Neo Endo had the lowest with a mean of 0.156

Discussion

The central aim of contemporary endodontic treatment is to obtain a three-dimensional seal by meticulous cleaning and shaping of the root canal system while conserving its natural anatomy[13]. This allows not only deeper penetration of irrigants and intracanal medicaments but also promotes an optimal seal during obturation[14]. In this context, the present investigation contributes to the growing body of evidence by evaluating the shaping outcomes of four modern NiTi rotary file systems in curved canals. NiTi instruments have transformed root canal preparation by improving efficiency, safety, and predictability compared to stainless steel files[15]. Their unique properties—

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particularly superelasticity and a lower elastic modulus—allow them to negotiate severe curvatures with reduced risk of mishaps such as ledging, zipping, or transportation[16]. However, a persistent drawback is the risk of instrument separation, primarily due to cyclic fatigue, especially in the apical third of curved canals[17]. To counter this, thermomechanical treatments such as the development of M-Wire have been introduced, offering improved flexibility and enhanced fatigue resistance[18].

In the present study, CBCT was utilized for morphological evaluation, as this technology provides high-resolution, three-dimensional imaging without anatomical overlap, offering distinct advantages over conventional two-dimensional radiographs[19]. The technique is particularly useful in quantifying canal transportation, an undesirable deviation from the canal's original path that may compromise long-term treatment success[20]. Our findings confirmed earlier reports that all tested NiTi systems, despite their improved designs, left portions of the canal walls untouched, underlining a persistent limitation of current instrumentation methods[21]. Nevertheless, a comparative analysis revealed differences among the systems. GenEndo and Mani Jizai demonstrated superior shaping, with more uniform preparation and greater increases in cross-sectional area and canal volume than NeoEndo and Bondent. This suggests that the design features of these systems promote better wall contact and potentially enhance irrigation and obturation efficacy[22]. Interestingly, some inconsistencies were observed in the data. While GenEndo initially appeared superior in terms of canal enlargement, subsequent findings suggested that NeoEndo and Bondent also performed well by leaving less unprepared dentin. This highlights the complexity of shaping evaluation and suggests the need for further research to reconcile these conflicting outcomes[23]. Nonetheless, the overall results consistently supported the superior shaping consistency of GenEndo and Mani Jizai. Maintaining dentin thickness is a critical consideration in root canal preparation, as excessive removal increases the risk of structural weakness and fracture[24]. In our analysis, Mani Jizai and GenEndo preserved dentin more effectively by maintaining a centralized canal path, further supporting their clinical reliability[25]. Collectively, these outcomes emphasize that while NiTi technology has revolutionized canal preparation, the choice of file system plays a decisive role in long-term treatment prognosis. Within the parameters of this study, GenEndo and Mani Jizai showed the best balance between canal shaping efficiency, dentin preservation, and maintenance of original canal anatomy, thereby supporting their potential clinical advantage[26].

Conclusion

Within the limitations of the our study, GEN ENDO files demonstrated superior performance with minimal canal modification compared to the other file systems evaluated. Nevertheless, further ex vivo and clinical studies with larger sample sizes are necessary to substantiate these findings and to establish their clinical relevance.

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