



# Canal Transportation and Centering Ability of Root Canals Prepared Using a New Rotary Nickel-Titanium File System: An in Vitro Study

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## KEYWORDS

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## ABSTRACT:

**Introduction:** This study aimed to compare and evaluate the canal-centering ability, and apical transportation of three different NiTi rotary instruments: HyFlex EDM, JIZAI, and WaveOne Gold using cone-beam computed tomography (CBCT).

**Objectives:** It is crucial to correlate instrument properties with root canal anatomical features, and evaluating canal centering ability and apical transportation will help with the increased chances of success of endodontic treatment.

**Methods:** Seventy-two extracted human single-rooted mandibular teeth were used in the present study. Pre-instrumentation scans of all teeth were taken, and the samples were randomly divided into three groups with twenty-four samples in each group: Group I – HyFlex EDM, Group II – JIZAI, and Group III – Wave One GOLD. Post-instrumentation scans were performed and the two scans were compared to determine the canal-centering ability, and canal transportation at 1, 3, and 5 mm from the root apex.

**Results:** Using ANOVA and Tukey's post hoc analysis, results were as follows: for canal-centering ability, at all levels. JIZAI had the highest canal-centering ability, followed by WaveOne Gold and HyFlex EDM ( $p < 0.05$ ). For canal transportation, JIZAI caused the least transportation at all levels ( $p < 0.05$ ).

**Conclusions:** Within the constraints of the current study, it was discovered that the JIZAI file produced significantly less transportation, stayed centered, and respected the original canal anatomy better than Wave One GOLD and HyFlex EDM. More research is needed to extrapolate these findings to clinical conditions.

## 1. Introduction

Effective debridement of the root canal, which entails removing debris and microorganisms, is necessary for

successful root canal therapy. The instruments used to prepare a root canal should always adhere to and preserve the canal's original shape. While maintaining the canal's



original outline form, a perfectly finished canal must have a continually tapered funnel shape.<sup>1</sup> Curvatures make the preparation more challenging, and the preparation methods tend to deflect the prepared canal off its original axis.<sup>2</sup> Cleaning the entire root canal system is still difficult, despite the use of sophisticated instrumentation technologies.<sup>[3]</sup> Procedure errors, which include ledges, zips, perforations, and apical transportation in the preparation of curved canals, can result in treatment failure.<sup>4,5</sup>

The capability of the instrument to stay centered within the canal is known as canal centering. This shows the removal of dentin evenly over the entire area by the instrument.<sup>4</sup> The removal of canal wall dentin on the outer curve in the apical part of the canal is called canal transportation. During biomechanical reparation, ledge formation and probable perforation can occur as the files tend to return to their former shape.<sup>6</sup>

Back-filtered projection is used in CBCT to create 3D images of an object. CBCT gives useful information on root canal morphology despite having less spatial resolution than micro-computed tomography. Root canal transportation and centering ability can be measured at various levels of the root canal by taking measurements with the help of CBCT.<sup>7,8</sup>

HyFlex EDM (Coltene), a fifth-generation NiTi rotary system, is created by controlled memory treatment and an EDM process resulting in increased fracture resistance, enhanced flexibility, and cutting efficiency.<sup>9,10</sup>

WaveOne GOLD (Dentsply Maillefer) is made using the GOLD treatment technique which involves heating, followed by slow cooling of the file. According to the manufacturer, the flexibility of the files is improved by this heat treatment.<sup>11,12</sup>

A recently created NiTi rotary system called JIZAI (MANI) is composed of a proprietary heat-treated NiTi alloy that displays bending deformation similar to Hyflex EDM. Jizai is not entirely austenitic at the body or room temperature but also has an R-phase and/or martensite. According to the manufacturer, the off-center quasi-rectangular cross-sectional shape delivers minimal screw-in stresses because of the radial land and offers space for debris clearance.<sup>13</sup>

To ensure the success of endodontic treatment, it is crucial to correlate instrument properties with root canal anatomical features. Hence, the present study compared, using CBCT, transportation, and canal centering within the root canal of WaveOne Gold, HyFlex EDM, and JIZAI.

## 2. Objectives

It is crucial to correlate instrument properties with root canal anatomical features, and evaluating canal centering ability and apical transportation will help with the increased chances of success of endodontic treatment.

## 3. Methods

This article was approved by the Institutional Ethics Committee, Kalinga Institute of Medical Sciences, KIIT Deemed to be University, Bhubaneswar, Odisha under the ethical code of KIIT/KIMS/IEC/874/2022

Seventy-two extracted human permanent mandibular single-rooted teeth with completely developed apices were included in this study. Radiographic examination revealed that each sample had one canal and apical foramen, no sign of endodontic treatment, root resorption, or root canal calcification. Single-rooted teeth with fully developed apices and curvature angles ranging from 0° to 10° were chosen using Schneider's method. The crowns were decorated, and the canal length was standardized to 16mm and stored in normal saline.<sup>14,15</sup> The access cavity was prepared and a 10 K-file (Mani, Japan) was used to determine the patency of the canal to full length, with the Working length (WL) set 0.5 mm short of this length.<sup>16</sup>

The prepared samples were embedded in modeling wax and then divided into 3 groups (n=24).

Group I – HyFlex EDM

Group II – JIZAI

Group III – WaveOne GOLD

Distances of 1mm, 3mm, and 5mm from the root apex were taken into account preoperatively and postoperatively in the CBCT scans to measure transportation and centering ability. In all groups, the biomechanical root canal preparation was handled by a single operator. Group I was prepared using a Hyflex EDM file having a 0.25mm tip size with variable taper. Group II was prepared using a Jizai file with a 6% taper and 0.25mm tip size, and Group III was prepared using Wave One gold with a 6% taper and 0.25mm tip size. The files were slowly pecked into the canal until they reached the working length. All of the teeth underwent CBCT imaging again following root canal preparation. In the diagnostic and postoperative CBCT scans, mesiodistal and buccolingual diameters were measured at 1 mm, 3 mm, and 5 mm from the apex.<sup>2</sup>

Canal transportation was measured by using the following formula<sup>17</sup>



[M1-M2]-[N1-N2]

where M1 and M2 are the shortest distances from the root's mesial edge to the mesial edge of the uninstrumented and instrumented canals, respectively; and N1 and N2 are the distances from the root's distal edge to the distal edge of the uninstrumented and instrumented canals, respectively. Any result apart from "0" indicates that transportation has taken place, while a result of "0" implies that there has been no canal transportation.

Canal centering ability was measured by the following formula:

$[M1-M2]/[N1-N2]$  or  $[N1-N2]/[M1-M2]$

According to these calculations, a value of 1 denotes total centering whereas values other than 1 account for alterations in the canal pathway.

All the data were analyzed by using IBM SPSS version 25. Inter-group comparison of canal centering ratio and apical transportation at 1mm, 3 mm, and 5 mm was done using ANOVA and Tukey's post-hoc analysis. For all analyses, a p-value of <.05 was regarded as significant.

#### 4. Results

[Table 1, Graph 1] shows the mean and standard deviation of ANOVA test results for the variable of canal centering at 1, 3, and 5mm in different groups. At all levels, Jizai (Group II) showed the highest canal-centering ability, followed by Wave One GOLD (Group III) and Hyflex EDM (Group I). Between each group, there was a significant difference ( $P < 0.05$ ).

[Table 2, Graph 2] shows the mean and standard deviation of ANOVA test results for the variable of apical transportation at 1, 3, and 5mm in different groups. Jizai (Group II) showed the least transportation at all levels, whereas Hyflex EDM (Group I) showed the highest transportation at all the levels (1,3, and 5 mm). There was a significant difference between all groups ( $P < 0.05$ ).

#### 5. Discussion

Preserving the tooth's natural or original canal shape is the goal of root canal mechanical preparation to facilitate proper irrigation, intracanal medication placement, and obturation. Canal deviations or curvatures make endodontic planning more difficult, particularly in the apical third. Adequate canal cleaning is only achievable when the canal is properly shaped to allow the irrigant to reach the apical area.<sup>[15,18]</sup> NiTi instruments were developed to address the drawback of stainless steel files, particularly when canals are curved. Files made of

nickel-titanium reduce working time and procedural errors.

In our study, CBCT was employed as a non-invasive imaging modality that permitted reliable 3-dimensional assessment of the root canal system without inflicting damage to the specimens. The 3D geometric values are authentic when compared to traditional radiographic tools. CBCT produces images in which superimpositions are avoided, resulting in good image quality. CBCT scans provide two methods for measuring canal transportation. Previous studies superimposed pre- and postoperative images. Others measured the distance between the external root surface and the internal canal wall at three different levels on pre- and postoperative cross-sectional images. Changes in the canal path were calculated using relevant formulas. To determine changes at various levels of the root canal, the distance between the external root surface and the internal root canal wall was determined at 1, 3, and 5 mm from the apex in this study.<sup>19,20</sup>

The type of alloy used in the manufacturing process of a file, as well as the design of the file, which includes the cross-section, tip, and taper, influence the canal centering ability of the file.<sup>[4,21]</sup> The lower the value of the centering ratio analysis, indicates more centered the preparation within the canal.<sup>16</sup> It has been proven that flexible instruments are less likely to cause deviated canal preparations.<sup>22</sup> In our study, at all measuring points, JIZAI demonstrated superior centering performance compared to WAVE ONE and HYFLEX EDM. This is accordant with the findings by Nakatsukasa et, al.<sup>[13]</sup> in which JIZAI was compared to protaper Next and Hyflex EDM. The larger taper of Hyflex EDM could explain the lower centering ability that produced more degrees of transportation.<sup>23,24</sup> Jizai has a smooth design that provides optimal cutting of the root canal. Radial lands help avert over-instrumentation and exorbitant engagement on the root canal walls. These bearing surfaces contribute to the file's excellent centering ability in the root canal and reduce the screwing-in effect. Sharp cutting edges with varying

**Table 1: Inter group comparison of canal centering ratio at 1mm, 3mm, and 5 mm using ANOVA.**

Group	1mm		3mm		5 mm	
	Mean	SD	Mean	SD	Mean	SD
Hyflex EDM	.66	.01	.51	.04	.66	.005
Jizai	.95	.08	.82	.04	.89	.053
Wave one	.72	.04	.67	.04	.67	.045



<b>F statistic (p value)</b>	187.24 (<.001)	296.517 (<.001)	248.624 (<.001)
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SD: Standard Deviation

**Table 2: Inter group comparison of apical transportation at 1mm, 3mm and 5 mm using ANOVA.**

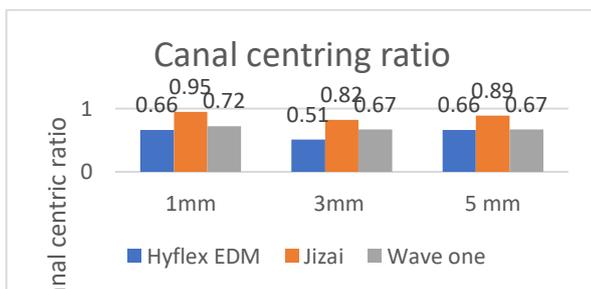
Group	1mm		3mm		5 mm	
	Mean	SD	Mean	SD	Mean	SD
Hyflex EDM	.10	.00	.20	.00	.20	.00
Jizai	.04	.07	.01	.04	.10	.00
Wave one	.04	.05	.10	.00	.10	.00
<b>F statistic (p value)</b>	11.514 (<.001)		438.661 (<.001)		176 (<.001)	

SD: Standard Deviation

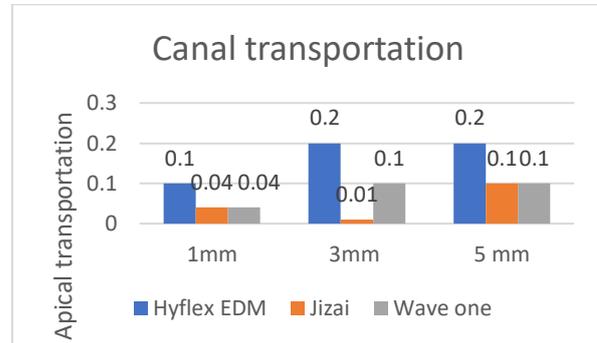
angles and a non-cutting tip are designed for efficient cutting without being aggressive.

Owing to the file's rigidity during canal preparation, the canal is transported. This causes a non-uniform distribution of stress, causing the file to straighten at the canal curvature.<sup>18</sup> In the current study, the Jizai (Group II) system showed the least transportation at all levels followed by WaveOne Gold and Hyflex EDM. Inferring that some variance exists but not to the point where it could endanger the tooth, the differences in canal transportation among the three groups were statistically significant. Jizai is made from an optimized R-Phase/Austenitic NiTi alloy which allows the file to have superior cutting ability despite the finer tip size. The unique heat treatment delivers unmatched flexibility. The heat treatment that each JIZAI file receives significantly reduces the risk of ledge, transportation, and perforation.

**Graph 1: Inter group comparison of canal centering ratio.**



**Graph 2: Inter group comparison of canal transportation.**



The findings of our study are also consistent with a prior study by Elashiry et. al,<sup>25</sup> who found that WaveOne Gold provided a more centralized canal preparation with less transportation at the apical level than Hyflex EDM. Wave Advanced metallurgy and a unique thermal process are used to create WaveOne Gold files from gold wire.<sup>26</sup> The file's special heat treatment and these distinguishing design features improved its performance inside the root canal.<sup>27</sup> Özyürek T et, al. found no difference between HyFlex EDM files and WaveOneGold files<sup>28</sup>; these differences could be associated with the methodology, which used resin canals, not natural canals used in our study.

The findings of the present study must be evaluated for clinical relevance with other studies. Wu et al.<sup>29</sup> stated that root canal transportation apically of less than 0.3 mm has little effect on prognosis. As a result, even though there was a significant difference in transportation between the groups at 1 mm, 3 mm, and 5 mm within the middle thirds of the root canals, it can be concluded that this difference would not be clinically significant. Although technological advancement has contributed to the improvement of technical procedures, there is still a thin line between published research findings and their clinical significance. More research in severely curved canals with a larger sample size is needed.

**6. CONCLUSION**

Within the constraints of the current study, it was discovered that the JIZAI file produced significantly less transportation, stayed centered, and respected the original canal anatomy better than WAVE ONE and HYFLEX EDM. More research is needed to extrapolate these findings to clinical conditions.

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