



Multilevel Evaluation of Mesio Buccal Canals in Molars After Instrumentation with Rotary and Reciprocating File Systems: An *In Vitro* Study.

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KEYWORDS

Canal centering ability; canal transportation; Cone beam computed tomography; reciprocative files; rotary files.

ABSTRACT:

Introduction: Endodontic instrumentation aims to enlarge the root canal system for effective disinfection. With limited evidence available on shaping performance of the R-Motion (reciprocating) and Race Evo (rotary) systems, this study was undertaken.

Objectives: To evaluate and compare the canal transportation and centering ability of Race Evo and R-Motion file systems with NiTiflex hand K-files using cone-beam computed tomography (CBCT).

Methods: Forty-five extracted human molars were randomly assigned to three groups Race Evo, R-Motion and NiTiflex (control). The teeth were standardized to 19 mm in length, and the mesial canals of mandibular molars and mesio buccal canals of maxillary molars were selected. CBCT scans were performed before and after instrumentation. Canal transportation and centring ratio were evaluated at 3 mm, 5 mm, and 7 mm from the apex. Two-way ANOVA and Tukey's post hoc test were used for statistical analysis.

Results: R-Motion demonstrated significantly less canal transportation in the buccolingual plane while Race Evo showed lower transportation in the mesiodistal plane. NiTiflex files provided the best canal centering, followed by R-Motion and Race Evo.

Conclusions: R-Motion exhibited less transportation in buccolingual plane and Race Evo in mesiodistal plane. There was no significant difference in canal centring ability for R-Motion and Race Evo.

1. Introduction

Preparation of root canals is a crucial step of endodontic therapy since it affects the results of all ensuing procedures. Uniformly enlarging in all dimensions is essential for achieving ideal cleaning and shaping. This facilitates complete disinfection, while also preserving the original anatomy without causing iatrogenic errors.¹ Nevertheless, endodontic preparation of curved narrow canals has always presented difficulties due to the chance of deviation from their natural axes. Innovative techniques and approaches have been introduced with an intention to overcome the difficulties faced during endodontic therapy. NiTi-based devices and files are extensively utilized these days and can be categorized as rotary files and reciprocative files based on the type of motion. An ideal endodontic instrument should be

flexible enough and resistant to follow the canal curvature without getting fractured. Thus, the canal transportation risk and CCA were studied to describe the efficacy of a file system. The published literature has reported inconsistent evidence related to the preparation ability of reciprocative and continuous rotary file systems. Few studies reported minimal transportation and better centering ability by reciprocating system^{2,3,4,5,6} whereas few studies reported better performance by rotary system.^{7,8,9}

In other studies^{10,11,12,13} rotary and reciprocating files performed similarly with insignificant difference. Variable performances were reported regarding canal transportation and centering ability.^{14,15}



Only a couple of studies were reported till the date where the Race Evo rotary files were compared with R-Motion reciprocating files.

2. Objectives

The study's aim is to estimate and compare the CT risk and CCA of Race Evo and R-Motion in comparison with NiTiflex hand files using cone beam computed tomography in mesiobuccal canals of maxillary and mandibular molars. Null hypothesis tested was that there would be no difference in canal transportation and canal centering ability of Race Evo and R-Motion files.

3. Methods

The study's protocol was approved by ethics committee of the institution and University (IECG/21-22/04/22). Human extracted maxillary and mandibular first and second molars for this study. They were examined clinically and radiographically for intact mesial roots. Teeth were immersed in 5% NaOCl solution to remove the tissue tags. The hard deposits were removed from the specimens by using ultrasonic device. Later they were stored in 0.1 % thymol solution at 37°C till the test time frame. Intact human molars with minimum tooth length of 19mm and curvature angle ranging from 10° to 40° (Schneider's method) were included in the study. Preoperative radiographs were taken to detect the cracks, fracture lines, calcified canals and internal resorption. Teeth with these defects were excluded.

Considering the clinically acceptable type I error as 1% and 95% as power of the current study with 0.95 effect size, sample size was estimated using F test in G-power software version of 3.1. Thus, a net sample size of forty-five was required to identify compelling differences and fifteen samples per each group was finalized.

The samples were allocated into three categories based on Schneider's angles 10°-20°, 20°-30° and 30°-40°. The teeth lengths were standardized to 19mm by resecting the coronal portions. A diamond disk was utilized to isolate the mesial/mesiobuccal segments of the teeth. The resected mesial/mesiobuccal sections were studied radiographically to verify the presence of two distinct canals.

The specimens were allocated into three groups in such a way that each group consists of roots of three categories of curvatures (10°-20°, 20°-30°, 30°-40°) in equal

number. They were allocated into group A – Race Evo (rotary), group B – R-Motion (reciprocating) and group C – NiTiflex hand K-files (control). Later, specimens were embedded in wax blocks for better radiographic outcome. A total of nine wax blocks of dimensions 4cm x 2cm were prepared and five samples were embedded in each wax block. Access cavity preparations were done with Endoaccess bur, mesiobuccal root canal orifices were explored with DG-16 explorer and patency was established with #10K files. 3% NaOCl solution was utilized for irrigation and preoperative CBCT scans were taken before starting cleaning and shaping.

Gates Glidden drills were used to enlarge the mesiobuccal canal orifices (#1, #2) for NiTiflex (manual instrumentation) group. In Race Evo and R-Motion groups, orifices were enlarged with Race Evo orifice opener. Instrumentation for NiTiflex group was done up to #35.02 NiTiflex file. For the group A, canals were prepared as per manufacturer's recommendations using Race Evo rotary files. For the group B, canals were prepared as per manufacturer's recommendations by using R-Motion reciprocating files.

Post-instrumentation, all specimens scanning was done utilizing CBCT equipment utilizing the identical exposure parameters. The CT and CCA were determined at different levels for each specimen. They were measured at 3 mm, 5 mm, and 7 mm from the tip of the root apex. **Figure 2** The formula given by **Gambill et al**¹⁶ was used to calculate the CT and CCA.

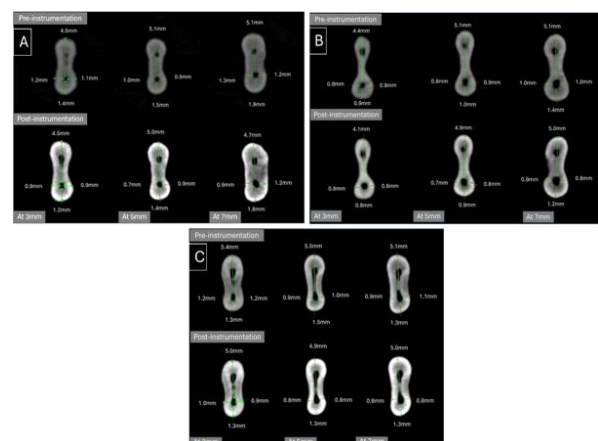


Figure 2: Pre and post instrumentation CBCT images A: Race Evo; B: R-Motion and C; NiTiflex group sample.



The formula for canal transportation was $(M1 - M2) - (D1 - D2)$, mesiodistally and $(B1 - B2) - (L1 - L2)$, buccolingually where M1, D1, B1, L1 are dentin thicknesses before preparation and M2, D2, B2, L2 are dentin thicknesses after preparation on four sides i.e., mesial, distal, buccal and lingual aspects respectively (figure:1).

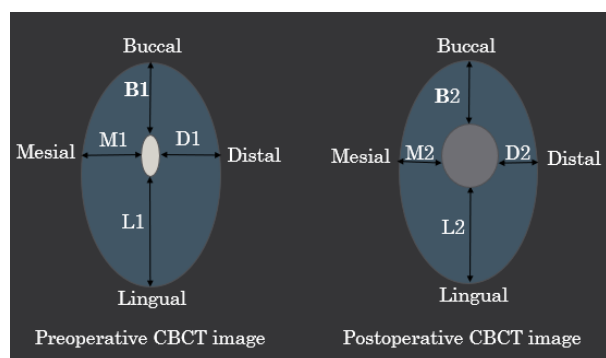


Figure 1: Diagrammatic representation of canal cross-section for evaluation.

Canal transportation was interpreted as follows; CT equal to 0 (zero) denoted lack of transportation, a positive value denoted transportation towards the mesial/buccal direction, and a negative value denoted transportation towards the distal/lingual direction. The formula for canal centering ability was $(M1 - M2) / (D1 - D2)$ or $(D1 - D2) / (M1 - M2)$ mesiodistally and $(B1 - B2) / (L1 - L2)$ or $(L1 - L2) / (B1 - B2)$ buccolingually. The formula was employed such that the lower number was placed in the numerator position. A result of 1.0 indicated excellent centering ability. A value near to zero or above 1 indicated poor CCA.^{9,16}

4. Statistical analysis

Documentation of data was done in Excel sheet and SPSS Statistics Windows 22.0 software Version (IBM, Armonk, NY) was employed for the statistical analysis. The CT and CCA analysis were done by using two-way ANOVA and pair-wise analysis was performed by Tukey's post hoc analysis (Figure:2).

5. Results

In the mesiodistal plane, the mean canal transportation (CT) values ranked in ascending order as follows: Race Evo < NiTiflex < R-Motion, indicating that Race Evo exhibited the least transportation in this direction. In the

buccolingual plane, the mean CT values followed the order: R-Motion < NiTiflex < Race Evo, with R-Motion demonstrating the lowest transportation.

With respect to canal centering ability, NiTiflex showed the highest mean centering ratio in both planes. In the mesiodistal plane, the centering ability ranked: NiTiflex > R-Motion > Race Evo. A similar trend was observed in the buccolingual plane, where the order was: NiTiflex > R-Motion > Race Evo.

Although variations in canal transportation and centering ratios were observed among the three systems, the differences in centering ability were not statistically significant. All file systems exhibited comparable shaping performance across the evaluated levels.

File System	Parameter	Plane	7 mm	5 mm	3 mm
Race Evo	Canal Transportation	Mesiodistal	-0.0467	0.0000	0.0400
		Buccolingual	-0.1067	-0.1200	-0.1733
	Centering Ratio	Mesiodistal	0.6200	0.8378	1.0444
		Buccolingual	0.6735	0.6333	0.4711
R-Motion	Canal Transportation	Mesiodistal	0.0933	0.0733	0.1067
		Buccolingual	-0.0533	0.0533	0.0000
	Centering Ratio	Mesiodistal	1.6500	0.2756	0.6078
		Buccolingual	0.5833	1.1587	0.7352
NiTiflex	Canal Transportation	Mesiodistal	-0.0067	0.0000	-0.0200
		Buccolingual	-0.0333	-0.0800	0.0667
	Centering Ratio	Mesiodistal	1.0667	0.7267	0.9333
		Buccolingual	1.0222	0.7489	1.2500

Table1: Mean canal transportation and canal centering ability values in mesiodistal and buccolingual planes.

6. Discussion

The primary purpose of canal preparation is to disinfect the canal without causing any deviation of the canal path. The main advantage of resin blocks is standardized canal curvature in all the specimens, but it cannot simulate the natural dentin of the tooth. The primary justification for selecting real teeth in this study over plastic blocks is their increased clinical relevance as the preparation of natural tissue, such as dentin, differs greatly from that of acrylic especially when the rotary files are being used.¹⁷



* Indicates statistically significant differences ($p < 0.05$).

S.No	Comparison	Transportation (MD plane)	Transportation (BL plane)	Centering Ratio (MD plane)	Centering Ratio (BL plane)
1	Race Evo vs R-Motion (RE vs RM)	0.0500*	0.0120*	0.9988	0.3900
2	Race Evo vs NiTiflex (RE vs NF)	0.9853	0.0314*	0.9373	0.0500*
3	R-Motion vs NiTiflex (RM vs NF)	0.0367*	0.9407	0.9531	0.5653

Table 2: Intergroup comparison of the three file systems (Race Evo, R-Motion and NiTiflex)

The mesiobuccal roots of maxillary and mandibular first molars were utilized as these canals possess with remarkable curvatures.^{18,19}

The curvatures ranging from 10° to 40° (according to Schneider's technique) have been used as they cover wide range of situations, with moderate to severe curvatures, according to the criteria given by American association of endodontists.²⁰

Though microCT technique results in high resolution images it cannot be used in clinical situations, thus cbct has been used as it offers an accurate, repeatable, clinical relevance and three-dimensional study of any modifications that might be seen in dentin, like dentin thickness, it has been utilized to estimate the ability of the three file systems to shape the canal.

High risk of endodontic mishaps during cleaning and shaping happen usually at three levels: apical, middle and coronal third. The average length of mesiobuccal/mesial roots of maxillary/mandibular first molars range from 7.9mm to 10 mm, thus 3mm, 5mm and 7mm⁹ have been selected to study the effects of rotary files.

The Race Evo and R-Motion file systems' guidelines were followed for canal preparation in the two test groups.⁵ The apical preparation for all the specimens was standardized to ISO #30 file tip in the current study as

larger files can remove excessive dentin. Though larger files can improve cleaning efficiency, they also increase the risk of iatrogenic perforations in curved canals. Thus, size #30 file could represent a balance between effective cleaning of the canal and thereby reducing the possibility of preparation difficulties.²¹

Race Evo showed highest transportation at 3mm and 7mm and no transportation at 5mm in M-D plane whereas an equal amount of transportation was observed at all 3mm, 5mm and 7mm levels in B-L plane. This variation could be because of excessive curvature of mesiobuccal canal in mesiodistal plane than distobuccal plane. The root canal curvatures in first and second molars were observed to be greater than 20° in mesiobuccal plane, whereas $5-20^\circ$ in buccolingual plane.¹⁹

When compared to R- Motion, more number of files were used in the Race Evo system. Thus, greater transportation resulted with Race Evo system. NiTiflex files exhibited no transportation at 5mm level but negligible distal transportation at 3mm and 7mm level in mesiodistal plane. These files exhibited lingual transportation at 5mm and 7mm levels and buccal transportation at 3mm level in buccolingual plane. The low rigidity of these files may be a reason for these inconsistent results. These observations are similar to the studies reported by earlier researchers^{2,3,4,5,6} where reciprocating files performed better than rotary files in CT and CCA. In other studies^{10,11,12,13} rotary and reciprocating files performed similarly with insignificant difference. **Table 1 and 2**

Contrary findings were reported by a few earlier researchers.^{7,8,9} The difference in results reported by **Mittal A et al**⁷ could be attributed to differences in metallurgy and design of the Reciproc instrument. **Hasheminia et al**⁸ compared EdgeFile rotary files with Reciproc and WaveOne reciprocative files whereas in current study Race Evo and R-Motion files were compared. **Hassan et al**⁹ compared WaveOne, OneShape and XP shaper files and reported low transportation with XP shaper. The difference in the results can be attributed to metallurgical variations.

Mixed/variable results were reported regarding canal transportation and centering ability by **Prabhakar et al**¹⁴, **Singh S et al**¹⁵ where canal transportation was lower



for rotary files whereas centering ability was higher for reciprocating files. The difference in transportation and centering ability among various studies are due to the type of file system (rotary motion/ reciprocating) used, taper and metallurgy of files.

Single-file reciprocation is beneficial as it results in disengagement and better dentin removal which allows, good apical progression and improved efficiency.²² Additionally, they preserve the root canal's original curvature due to better CA. Glidepath creation can result in minimal transportation and better centering ability with any kind of file system.²³ Selection of a suitable file system for the individual case would enable an efficient preparation of the canal system.²⁴

Though the use of natural teeth samples is more clinically relevant than resin blocks, there exists a constraint of obtaining a homogenous sample in terms of canal curvature. Practically it is unfeasible to obtain samples that are replicas of one another in terms of curvature ratios, canal widths and the level of curvature. Major clinical challenge is lack of limited information in buccolingual plane with routine intraoral periapical radiographs. More *in vivo* research is needed to know the performance of these files systems in various clinical situations.

7. Conclusion

It can be concluded that in the buccolingual plane, R-Motion rotary file system resulted in lower canal transportation than Race Evo, whereas in the mesiodistal plane, Race Evo demonstrated lower canal transportation than R-Motion which was significant. NiTiflex had superior canal centering ability in both the buccolingual and mesiodistal planes, trailed by R-Motion and Race Evo. However, there was no significant difference in centering ability. All file systems performed similarly at all the levels in terms of canal transportation and canal centering ability.

8. Clinical significance

This study provides key insights for dentists by comparing the effectiveness of rotary and reciprocating file systems in preparing complex mesiobuccal canals. It helps clinicians choose optimal instrumentation techniques to minimize errors and improve root canal treatment outcomes.

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