ORIGINAL RESEARCH

Cone-beam Computed Tomographic Analysis of Apical Transportation and Centering Ratio of TruNatomy and V-taper 2H NiTi Rotary Systems in Curved Canals: An *In Vitro* Study

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Abstract

Aim: This study aimed to compare the canal transportation and centering ratio using cone-beam computed tomography (CBCT) in the preparation of curved root canals after instrumentation with TruNatomy (TN) and V-Taper 2H (VT) files.

Materials and methods: Twenty mandibular molar mesiobuccal canals with an angle of curvature ranging from 20 to 40° were split into two groups of 10 samples each based on the file system used to prepare the canals: TN (group I) and VT (group II). The teeth were instrumented according to the manufacturer's instructions up to 26 no. in TN and 25 no. in VT apical preparation. Before and after preparation, canals were examined using CBCT to assess the transportation and centering ratio at 3, 5, and 7 mm from the apex. The degree of transportation and the capacity for centering were evaluated. The two groups were statistically compared with the Mann–Whitney and Friedman's tests.

Results: Both instruments did not deviate from the original canal curvature having no significant difference in the apical transportation and remained centered in the canal.

Conclusion: TruNatomy and VT instruments produced less transportation and remained centered around the original canal to a great degree due to their cross-section, heat treatment, and reduced taper.

Keywords: Canal transportation, Centering ability, TruNatomy, V-Taper 2H.

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Introduction

A proper root canal treatment is dependent on a thorough cleaning and specific shaping of the root canals. Definite root canal shaping is the key to a good prognostic success factor. Ideally, the root canal preparation creates a continuous taper from the crown to the apex while maintaining the apical size as small as is practically attainable.[1] Regardless of how good the instrumentation is, iatrogenic errors such as zips, ledges, perforations, and root canal transportations can occur during the preparation of curved canals.[2] Root canal shaping causes removal of dentin and when excessive dentin is removed in a single wall rather than all the walls equidistantly from the main tooth axis it causes "canal transportation".[3] The centering ability of the instrument is necessary to keep the instrument centered in the canal for proper canal enlargement. In present times, various new NiTi rotary instruments with better flexibility, various cross-sections, heat treatments, and taper designs lead to a reduced incidence of iatrogenic errors even in severely curved canals.[4]

The TN (Dentsply Sirona, Switzerland) file system recently developed is manufactured using a special post-manufacturing thermal treatment. These have an off-centered parallelogram design with regressive taper, two cutting edges, and a slim 0.8 mm flute diameter. This unique design and heat treatment provides great flexibility and efficiency in cutting dentin only where clinically required.[5,6]

V-Taper 2H (SS White Dental, New Jersey, USA) has a controlled memory (CM) wire technology and creates a deep apical shape while conserving the coronal dentin. This is a one- or two-file system with the most affordable price per root canal procedure. It has a parabolic cross-section and a variable "V" taper from D0 to D12 with a maximum flute diameter of 0.7 to 0.8 mm that preserves the peri-cervical dentin at the same time allowing the irrigant to reach the apical third of the canal more effectively.[7]

There is currently no literature available that compares the canal transportation and centering ability of these two file systems. Cone-beam computed tomography is the most accepted approach due to its three-dimensional analysis of root canal anatomy. Since CBCT's correctness has been generally recognized, it has become the defacto method for evaluating various file systems for their ability to follow root canal anatomy.[8]

Hence, this study uses CBCT to assess and contrast the canal transportation and canal centering capabilities after instrumentation in curved root canals with TN and VT file systems.

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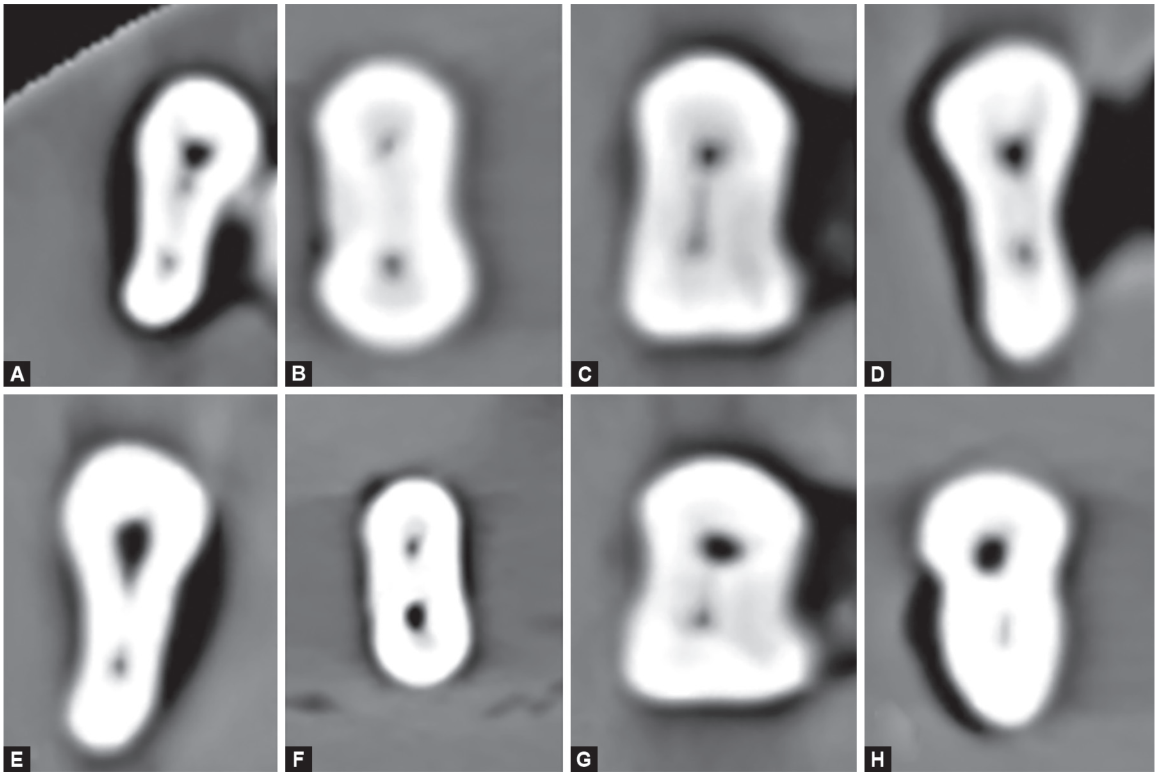

Figs 1A to H: Cone-beam computed tomography scan images before (A–B) and after instrumentation (E–F) with TN, (C and G) and (D and H) with VT, respectively

Materials and Methods

Sample Preparation

Twenty extracted first molars from human mandibles with curved roots, two distinct mesial canals, and apical foramina were chosen. Access was done using an Endo-Access bur (Dentsply, Maillefer), after which a 10 size K file (Dentsply, Maillefer) was used to find and investigate the mesiobuccal canals. Curvatures of the mesiobuccal canal were measured using the Schneider's technique.[9] This method uses two straight lines to get the angle. The first line runs parallel to the root canal's long axis, while the second crosses the apical foramen before meeting the first line where the curvature begins. Root canal curvature severity used to label the created angle (α) is as follows: straight: 5°, moderate: 10 to 20°, and severe: 25 to 70°. This study only included the canals with a 20 to 40° curvature. At the furcation level, distal roots with appropriate crown portion were sectioned and discarded. Using a surgical microscope at a magnification of ×8, the working length was determined by inserting a #10 K file till the apex of the tooth and taking out 1 mm from the measurement. Specimens were split into two equal groups ($n = 10$) based on the canal instrumentation file system. Roots were embedded into putty impression material (Zhermack Zeta Plus) in blocks of five samples each. Before instrumentation, CBCT was used to scan each tooth (Carestream 8100, Oral-D, India) to identify the anatomy of the root canals. Each tooth had three parts that were examined: at 3, 5, and 7 mm coronal to the root apex. A same operator instrumented the root canals with a uniform procedure using initial scans. A step back approach using sizes 10, 15, and 20 K files for all of the experimental teeth were prepared till the working length before rotary instrumentation.

Specimens in group I ($n = 10$) were prepared using TN files till 26 no. apical preparation and group II ($n = 10$) with VT files till 25 no. apical preparation abiding by the manufacturer's instructions, respectively.

In all the groups, canals irrigation was done with 3 mL of 3% NaOCl following the usage of every file. After the root canal preparation was finished, 1 mL of 17% ethylenediaminetetraacetic acid (NeoEDTA, Neoendo, India) was used for 1 min, and a final flush of 3 mL of NaOCl. Glyde was used as a lubricant during instrumentation (Dentsply Maillefer). Four canals were prepared before the files were disposed.

Image Analysis

The roots were placed in a putty impression block (Zhermack Zetaplus C Silicone Impression Material). Four blocks consisting of five roots each for ease of imaging were made which were further aligned at right angles to the beam and scanned pre- and post-preparation using a CBCT machine (Fig. 1). In order to ascertain the root canal preparation at 3, 5, and 7 mm from the apex, the teeth were scanned. The mesial and distal directions of the mesiobuccal root canal were calculated to determine the smallest interval from the canal wall to the external root surface. Pre- and post-preparation measurements were taken to ascertain the following: [1] the amount of canal transportation at each stage calculated using the formula: $(a1 - a2) - (b1 - b2)$ and [2] ratio of the canal centered at each stage as follows: $(a1 - a2)/(b1 - b2)$ or $(b1 - b2)/(a1 - a2)$, where a1 denotes the smallest distance between the mesial edge of the root and the unprepared canal's mesial edge, a2 denotes the smallest distance between the mesial edge of the root and the prepared canal's mesial edge, b1 denotes the smallest distance between the distal

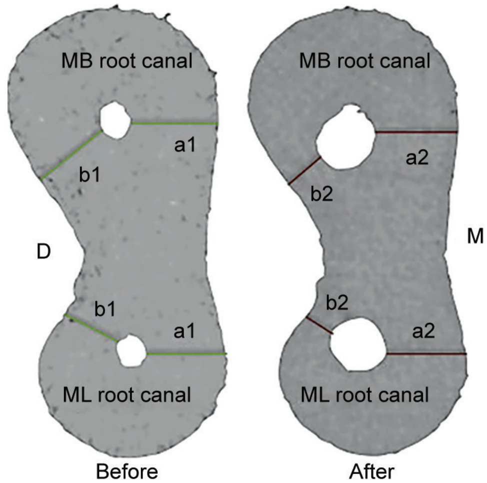

Fig. 2: Schematic representation of measurement for shaping ability

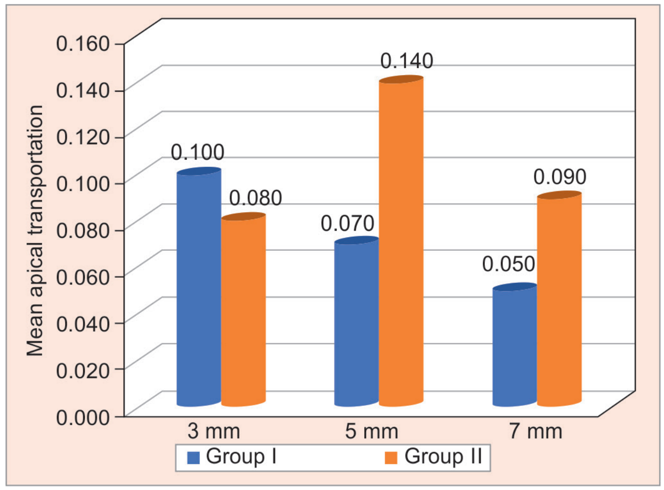

Fig. 3: Mean apical transportation between two groups at different distances, group I – TN and group II – VT

Table 1: Comparison of mean apical transportation between two groups at various distances

Distance	*Groups*	*N*	*Mean*	*SD*	*Mean diff*	*p-value*
3 mm	Group I	10	0.100	0.163	0.020	0.80
	Group II	10	0.080	0.079		
5 mm	Group I	10	0.070	0.095	−0.070	0.13
	Group II	10	0.140	0.127		
7 mm	Group I	10	0.050	0.097	−0.040	0.13
	Group II	10	0.090	0.074		

edge of the root and the unprepared canal's distal edge, and b2 denotes the smallest distance between distal edge of the root and the prepared canal's distal edge (Fig. 2).[10]

Statistical Analysis

Regarding canal transportation and centering abilities, the means, standard deviations, lowest, and highest values were computed for each group. To compare average apical transportation and canal centering between two groups at various distances, the Mann–Whitney test was used. Using SPSS version 22.0 (IBM Algorithmics, Armonk, NY, USA) the mean apical transportation and canal centering between various distances in each group were compared using Friedman's test. The cutoff for statistical significance was set at $p = 0.05$.

Results

Table 1 illustrates the two groups' canal transportation means, variances, and medians at three distinct distances from the root apex.

- It demonstrates that there are no appreciable differences in the mean transportation at a distance of 3 mm from the apex between TN and VT with $p = 0.80$.
- The mean transportation at 5 mm distance from the root apex has no significant difference between TN and VT with $p = 0.13$.
- The mean transportation at 7 mm distance from the root apex has no significant difference between TN and VT with $p = 0.13$.
- The test results showed that the mean apical transportation in the TN group at 3, 5, and 7 mm showed a decreasing trend.

Table 2: Comparison of mean canal centering between two groups at various distances

Distance	*Groups*	*N*	*Mean*	*SD*	*Mean diff*	*p-value*
3 mm	Group I	10	0.740	0.412	0.032	0.52
	Group II	10	0.708	0.322		
5 mm	Group I	10	0.550	0.497	−0.417	0.31
	Group II	10	0.967	0.811		
7 mm	Group I	10	1.100	1.101	0.317	0.38
	Group II	10	0.783	0.729		

The mean apical transportation in the VT group at 5 mm marginally increased from 3 mm and further decreased at 7 mm. However, there was no significant difference observed in the mean apical transportation between the TN group with $p = 0.78$ and the VT group with $p = 0.60$ (Fig. 3).

Table 2 gives the mean, SD, and median values for the ability of the canal to center itself for two groups at three distinct distances from the root apex.

- It shows that centering ability at 3 mm distance from root apex shows no significant difference between TN and VT with $p = 0.52$.
- The mean centering ability at 5 mm distance from the root apex has no significant difference between TN and VT with $p = 0.31$.
- The mean centering ability at 7 mm distance from the root apex has no significant difference between TN and VT with $p = 0.38$.
- The test results showed that the mean centering ability in the TN group at 3 mm marginally decreased at 5 mm and has a steep increase at 7 mm. However, there is no significant difference observed in the mean canal centering ability between different distances in TN group with $p = 0.22$ and in VT group with $p = 0.97$ (Fig. 4).

Discussion

This study tends to assess the canal transportation and centering ability of files in acutely curved root canals. Preserving natural anatomy of root canals is very important and extensively researched.[11] Ledging, zipping, or perforations may result from failing to respect the anatomy of the canal.

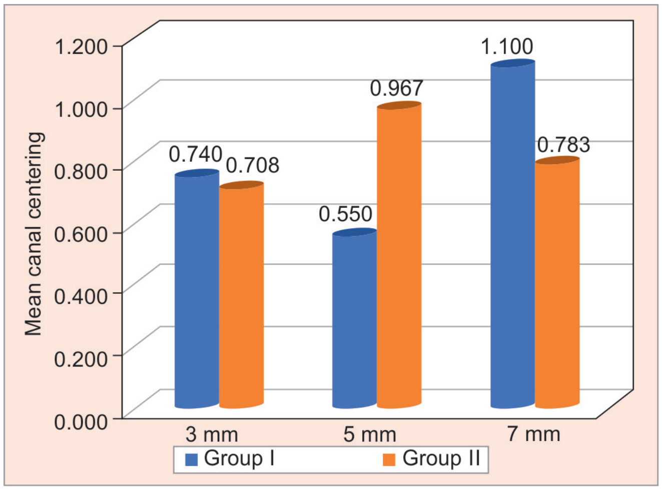

Fig. 4: Mean canal centering between two groups at different distances, group I – TN and group II – VT

To avoid such errors, operators should engage in controlled instrumentation and remove all contaminated dentin. The mesial roots of mandibular molars were used in this study because their canals typically curve in two planes.[12]

Cone-beam computed tomography is noninvasive and offers repeatable, three-dimensional, and accurate images of changes seen in both root canal volume and relative dentin thickness before and after preparation without destroying the specimens.[13,14] Spiral CT and micro-CT can be used to assess the same *in vitro*.[15] Due to ease of accessibility and cost-effectiveness CBCT was used. The apical and middle thirds of the root canals were represented by three levels, which are 3, 5, and 7 mm from the root apex, where iatrogenic mishaps are most commonly seen. V-Taper 2H files are variable-taper NiTi rotary files permitting extensive apical preparations with not many instruments. These tend to preserve the pericervical area also known as the heart of the tooth by creating a conservative preparation. V-Taper 2H files have a parabolic cross-section design with high flexibility and high efficiency which give them the ability to resist fracture. The VT files show similar canal centering ability and canal transportation as TN files. This can be attributed to the smaller cross-section and reduced shaft diameter of the VT files. Highlights from various literatures show that NiTi files with non-cutting tips and a smaller cross-section have better canal centering ability.[16,17] According to this study, VT files showed some deviation at the 5 mm mark in all three sections, although not significant.

While most other variable taper files are off-centered and have a maximum flute diameter of 1.2 mm, TN files have a slim shape, a maximum flute diameter of 0.8 mm, and respect the true anatomy of the canals by removing dentin only where necessary and preserving structural dentin. They also operate at a higher speed with less torque. These TN files are offered in three sizes, small-size file system 20/0.04, prime-size file system 26/0.04, and medium-size file system 36/0.04, with additional large file sizes are available if needed. In the current study, TN files showed consistent centering ability and less transportation throughout.

Apical preparation sizes of 25 and 26, respectively, were chosen for the VT and TN system, respectively. The more thorough the apical instrumentation, the more effectively it removes debris and disinfects the root canal. A study by Akhlaghi et al. found that the ability of the 25 apical sizes eradicating microbes was not significantly different from that of other canals with bigger apical diameters. Additionally, as the apical size increases, flexibility decreases, making canal transportation more likely. In all three sections, both TN and VT, file systems showed similar results and had no statistically significant differences for canal centering ability and apical canal transportation.

Conclusion

It is possible to draw the conclusion that both instruments exhibit some level of apical canal transportation within the confines of this investigation. This level is well within the permissible range. Additionally, because to their cross-section, heat treatment, and reduced taper, the TN and VT instruments produced the least transportation and were largely centered around the original canal.

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