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Shaping Ability of Different Rotary and Reciprocating File Systems in Stimulated S- Shaped Root Canals

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KEYWORDS

Shaping Ability, Canal Transportation, S Shaped Canal

ABSTRACT:

Objective: In order to recreate S-shaped root canals, this study looked at the shaping capabilities of six rotary and reciprocating file systems as well as hybrid techniques.

Methodology: 20 S-shaped blocks of thermosetting epoxy resin that are radiopaque were grouped based on the biomechanical preparation technique. Using TruNatomy, Procodile, VDW Rotate, Hyflex CM, OneCurve, and WaveOne Gold, six groups of fifteen canals each were created. Following an assessment of the performance of the separate systems, two further hybrid groups (n=15 each) were added: Procodile/Hyflex CM and Procodile/TruNatomy. All groups were statistically compared with analysis of variance and Tukey honest significant difference test ($p<0.05$).

Results: The greatest and most cautious diameter increase was produced by Hyflex CM in all three thirds (coronal, middle, and apical; $p<0.001$). In the coronal and middle thirds, Procodile had the best centering ability (p0.001), whereas TruNatomy produced the least amount of canal transportation and the greatest amount of centering preparation in the apical third (p0.001). In the middle third, hybridization of Procodile and Hyflex CM resulted in a small amount of canal transit and the best centering ability (p0.001). Throughout canal preparation, no ledge, elbow, or apical zip formation was seen, and no tool failure happened.

Conclusion- The middle section of the canal exhibited the least amount of canal transportation and the best centering capability.

Introduction

S-shaped root canals have a distinct morphology that can make endodontic care extremely difficult. The most frequent reasons for these kinds of failures are procedural ones, like ledges, broken tools, obstructions in the canal, and fabrication of elbows and zips. The effectiveness of endodontic treatment depends on the patient's understanding of dental anatomy and its variations. Before starting therapy, a practitioner must have a thorough understanding of the shape, form, and structure of the tooth. The assessment of these structural differences in the root canal system is facilitated by routine periapical radiography.

The creation of an exact diagnosis and a thorough treatment plan are prerequisites to effective root canal therapy. To undertake necessary and proper biomechanical preparation, one must possess a thorough understanding of the anatomy and physiology of root canals. The goal of biomechanical preparation is to remove debris and microorganisms from the root canal system while preserving the original morphology and geometry of the canal.[1] The ideal way to accomplish this goal is to prevent the root canal from becoming overly

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instrumented, transportation, zip, ledge, elbow and flattening of the canal.[2]

S-shaped or double curve canals, also known as bayonet-shaped root canals[3], are found in 30–40% of clinical cases and are commonly present in the mesial root of mandibular molars and in the distobuccal canals of maxillary molars.[4] Owing to their complexity and vast morphological variability, S-shaped canals are very difficult to appropriately shape without the iatrogenic production of previously mentioned aberrations.[5]

Unlike stainless steel instruments, canal preparation using rotary nickel-titanium (NiTi) instruments leads to faster and more predictable preparation. NiTi instruments can preserve the original shape of the canal and minimize procedural errors such as ledges, zip, or perforations, especially in complex canal morphologies. Despite these advantages, unexpected fractures of NiTi instruments are possible, especially in narrow or highly curved canals.[6]

The distinctive features of the newly created NiTi files can be recognised by their taper, cross-section, and flute number and angle. These tools are thought to decrease the amount of steps required in the procedure as well as the likelihood of fracture and canal abnormalities.[7,8] There isn't just "one ideal" rotary NiTi system for the whole root canal therapy because there are so many different instances, anatomies, and characteristics of canals. Furthermore, NiTi devices have a variety of qualities that make them suitable for application in "hybrid" concepts.[9]

The hybrid technique's basic idea is to merge separate files from several systems to produce the fewest aberrations possible while yet achieving the best biomechanical cleaning and shaping outcome. The greatest features of several file systems are combined using hybrid technology to produce effective and reliable outcomes. The crown-down approach, that entails creating a glide path, shaping the canal's body up to the first curvature's centre, and then preparing the root canal in the apical third, ought to be used for biomechanical pretreatment when assessing utilising a combination of techniques.[9]

In order to create and design a hybridised system, this investigation set out to: (a) assess the optimal shaping protocol of various NiTi rotary and reciprocating systems in recreated S-shaped canals; (b) evaluate and contrast a number of parameters and iatrogenic aberrations, such as diameter increase, canal transportation, and centric ability; and (c) analyse the outcomes of individual file systems.

Methodology

One hundred twenty replicated S-shaped resin blocks with an apical diameter of 0.15 mm, 2% taper, and a working length of 16 mm were utilised. The simulated canal has an apical curvature angle of 20 degrees and a coronal curvature angle of 30 degrees with a radius of 5 mm.

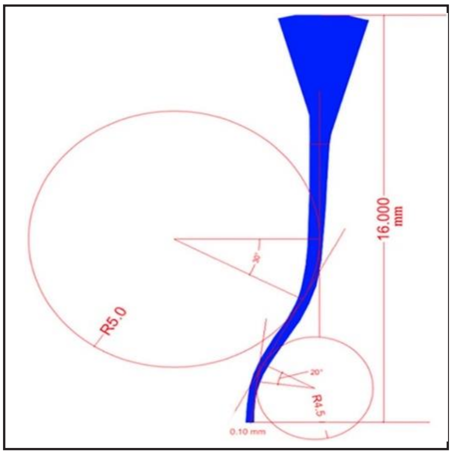
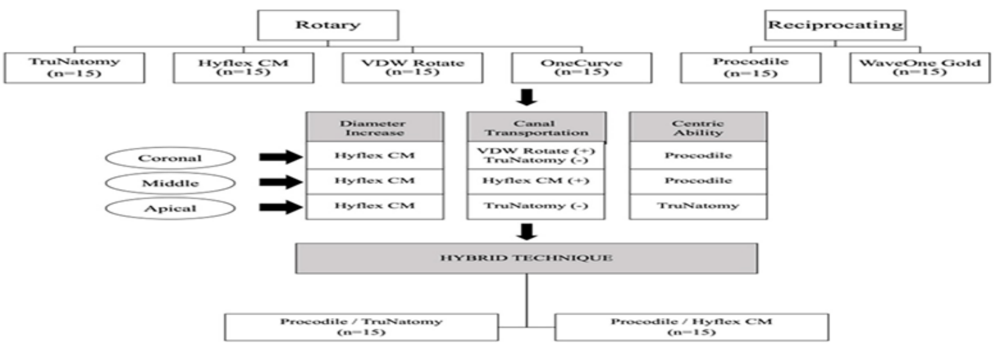


Figure 1. Dimensions of a simulated S-shaped canal



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All resin blocks were secured in place using a resin block holder in order to minimise procedures and operational errors and maximise standardisation. The entire experiment was carried out at a 10X magnification using a microscope. A patent canal was ensured and irrigation to the apical region was facilitated by using a stainless steel K-file size 10 in a pecking action twice or three times. During instrumentation, a 17% ethylenediaminetetraacetic acid (EDTA) lubricant was utilised. Using a side-vented irrigation needle, copious irrigation was performed at 37°C using standard saline (10 mL) after each file. One opera- tor handled all preparation, and for every three resin blocks, one rotary file was used. Every group's file was utilised in accordance with the the manufacturer's instructions using X-smart Plus Motor.

The list below describes the steps undertaken for instrumentation in each group.

Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Group 6**	**Group 7**	**Group 8**
Continuous Action	Manual Glide-Path	Rotate glide path file (15/04)	Hyflex CM wasused in two gentle in-and-out pecks with a rotational speed of 500 RPM	Glide Path With The One G (14/03) File	20/06 Procodile file	glide path using K-file size 15	A manual glide path
Torque Of 1.5 Ncm,	Torque Of 1.3 Ncm	torque of 1.3 Ncm	torque was 2.5Ncm	Torque Was 2.5 Ncm		25/06 Procodile file, for up to 12 mm	Torque Was 2.5 Ncm
Speed Of 500 Rpm Amplitudes.- 2-3 Mm	Two-Thirds of The Canal In Gentle Amplitudes.	Two-Thirds of The Canal in Gentle Amplitudes.	Two-Thirds of The Canal In Gentle Amplitudes	300 Rpm	programmed reciprocating motion.	Programmed Reciprocating Motion.	Rotational Speed Of 500 Rpm

Image Analysis and Assessment of Canal Preparation

The pre-operative pictures of each canal was created by filling it with blue ink, and then photographing it with a 10X magnification microscope at a fixed reproducible position with constant settings. The canals were subsequently washed with saline before and after instrumentation, and subsequently coated with red ink and captured again under identical circumstances. The pre and post-instrumentation images were superimposed employing AutoCAD (Autodesk, 2018). The measurement points were arranged in 1-mm increments, and the locations of the measurements were used to determine the amount of eliminated residual after instrumentation at 11 points, each representing an apical curve, the middle curve, and the coronal part of the canal. A blinded examiner to all experimental groupsassessed the diameter increase, canal transportation and cen- tric ratio before and after instrumentation.

The parameters at 11 levels from the apex at 1-mm intervals were calculated using the following formulas:

Diameter increase = (X2–X1) + (Y2–Y1) Canal transportation = (X2–X1) – (Y2–Y1)Centring ratio = (X2–X1) / (Y2–Y1)

if (Y2–Y1) > (X2–X1)

or Centring ratio = (Y2–Y1) / (X2–X1)

if (X2–X1) > (Y2–Y1)

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A positive number indicated movement towards the inner wall of the canal's curvature, and a negative number indicated movement towards the outer wall.

The instrument's ability to stay centred improved with the centring ratio getting closer to 1. If any other iatrogenic mistakes were noticed, they were scored according to conventional guidelines. These errors included canal straightening, instrument breakage, and ledge, apical zip, or elbow creation.

Using the Statistical Package for the Social Sciences Statistics Desktop version 23.0, the raw data extracted from AutoCAD was input and examined. The gathered information was arranged and summarised as descriptive findings, containing the average (mm) and standard deviations for every file as well as the total values for every parameter (diameter increase, canal transportation, and centric ability) in each of the three groups' upper thirds. Afterwards, the Shapiro-Wilk test was used, with a p-value of less than 0.05, to verify the assumption of normality and assess the validity of the parametric test. Moreover, post-hoc statistical tests (LSD) were utilised to ascertain the significant difference of the various rotating file systems between every two groups, whereas one-way ANOVA was employed to ascertain the degree of difference between each group with the dependent variables. A 95% confidence level for statistical significance was selected at 0.05 ($p=0.05$).

Results

The findings revealed that there was no elbow, ledge, or apical zip formation, nor was there any instrument breakage. As a result, all cases (100%) received an average score of zero for these mistakes. When the Hyflex CM file system was employed, the findings in the coronal (7–11), middle (3–7), and apical (0–3) thirds showed the least amount of diameter growth. In all thirds, there was a significant difference in the growth in diameter between the groups ($p<0.001$).

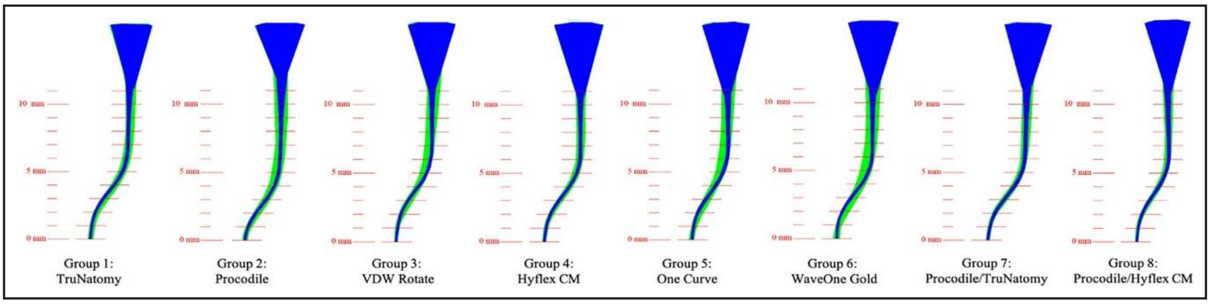

Figure 3. Superimposed pre-instrumentation and post-instrumentation images prepared using AutoCAD

Canal transportation

The TruNatomy systems displayed the smallest amount of negative canal transportation in the coronal third, whereas the VDW system of files indicated the lowest amount of positive canal transportation. The Hyflex CM system displayed the least amount of positive transportation in the middle third, while TruNatomy displayed the least amount of negative transportation in the apical third. All three-thirds of the root canal showed a significant difference between the categories: the apical ($p<0.001$), middle ($p<0.001$), and coronal ($p<0.006$). The apex transportation means and standard deviations, as well as the p-values for any statistically significant variations between groups.

TABLE 1. Diameter change within each third of S-shaped canals using different rotary systems

Diameter increase (Mean±SD)				
	TruNatomy	**Procodile**	**VDW**	**Hyflex CM**

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Coronal third (7–11 mm) 11 mm 10 mm 9 mm 8 mm	.15±0.07 0.28±0.03 0.31±0.03 0.32±0.03	0.27±0.03^{A}	0.40±0.13 0.47±0.05 0.52±0.05 0.52±0.05	0.48±0.05 B	0.39±0.12 0.50±0.05 0.50±0.03 0.49±0.03	0.47±0.04^{B}	0.12±0.09 0.31±0.05 0.30±0.02 0.30±0.03	0.27±0.02^{A}
Middle Third (3–7 mm) 7 mm 6 mm 5 mm 4 mm	.32±0.04 0.32±0.04 0.30±0.03 0.28±0.03	0.29±0.02^{A}	0.49±0.06 0.46±0.06 0.42±0.07 0.36±0.07	0.41±0.06 B	0.47±0.03 0.50±0.06 0.44±0.04 0.32±0.03	0.41±0.02B C	0.31±0.02 0.32±0.03 0.29±0.03 0.24±0.02	0.27±0.01^{A}
Apical Third (0–3 mm) 3 mm 2 mm 1 mm 0 mm	0.26±0.03 0.21±0.04 0.17±0.03 0.17±0.03	0.20±0.02^{A}	0.31±0.05 0.29±0.05 0.23±0.04 0.25±0.06	.27±0.05^{B}	0.34±0.04 0.36±0.10 0.19±0.04 0.15±0.05	0.26±0.05^{B}	0.22±0.03 0.20±0.05 0.12±0.03 0.12±0.05	0.16±0.02^{C}

Diameter increase (Mean±SD) Cont..						
	OneCurve		**WaveOne Gold**		**P Value**	
11 mm 10 mm 9 mm 8 mm	0.30±0.07 0.50±0.03 0.50±0.03 0.51±0.02	0.53±0.03^{C}	0.36±0.99 0.54±0.04 0.57±0.03 0.58±0.04	0.53±0.03^{C}	.00 0.00 0.00 0.00	<0.001
7 mm 6 mm 5 mm 4 mm	0.51±0.02 0.51±0.04 0.47±0.13 0.36±0.03	0.47±0.04^{D}	0.57±0.03 0.52±0.04 0.49±0.04 0.39±0.05	0.47±0.04^{D}	0.00 0.00 0.00 0.00	0.000
3 mm 2 mm 1 mm 0 mm	0.33±0.02 0.33±0.05 0.22±0.02 0.20±0.04	0.28±0.05^{B}	0.37±0.05 0.34±0.08 0.22±0.04 0.21±0.05	0.28±0.05^{B}	0.00 0.00 0.00 0.00	0.000

A, B, and C indicate a significant difference between the groups in multiple comparison test (*Tukey's* HSD for different types of rotary systems, $p<0.05$). SD: Standard deviation

Discussion

Since it is nearly impossible to gather standardised human teeth in S-shaped canals that have distinct parameters about canal diameter, length, level, and radius of both curvatures, the present investigation was conducted on simulated S-shaped canals in radiopaque thermosetting epoxy resin blocks.10 Resin blocks are the conventional substitute for real teeth despite the fact they are not as microhard as dentine and are prone to variations in resin consistency due to heat generated

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during instrumentation.[11,12,13] The reason AutoCAD was chosen in this study was because it could precisely scale the resin block images to the actual canal dimensions (16 mm), in contrast to Photoshop by Adobe. A further advantage of AutoCAD is its ability to provide two-dimensional quantitative measurements in an affordable and repeatable method by superimposing pre- and post-operative photographs.[14] The investigation's mechanical steps were all completed with files with a 25 ISO tip size. The reason for following the manufacturer's instructions was that this tip size was chosen specifically for intricate canal geometries.

Due to the reduction in file flexibility, an increase in tip size will increase the danger of canal transportation even if it may potentially lead to improved cleaning and better accessibility for the irrigation material.[15] It is not advised to use files with a taper greater than 0.04 for apical expansion in double-curved canals. Using a NiTi instrument with less taper and greater flexibility is therefore preferred.Six This study compared and examined the shaping skills of several popular and contemporary rotating systems using files from various tapers. Because the ta- per of the files was 0.07 and 0.06, respectively, canal straightening was seen in WOG and One Curve. Procodile performed better in contrast other larger tapered files like One Curve and WOG due to its unique double S-cross section and variable tapered core with a constant tapered cutting edge.

Because of its off-centric motion, the VDW rotated more resistance and debris than other file systems, disregarding the anatomy of the canal. Consequently, the canals treated with this technique exhibited increased canal diameter and straightened capillary curvatures. The controlled memory characteristic of Hyflex CM and TruNatomy files, which allows them to be pre-curved like conventional stainless-steel files and help preserve the canal's curvatures, may be the reason why these files in this investigation demonstrated the least diameter rise across all three sections of the canal.

In order to improve the files' fatigue resistance and flexibility, heat-treated NiTi alloys were used in the production of the most recent TruNat- omy files. The cross-sectional form of the new instruments is shaped like a parallelogram. Because a TruNato-my file can preserve structural dentin to assist preserve the tooth's strength, these files employ 0.8 mm NiTi wires rather than 1.2 mm. In cases of curved canals, the file's geometry permits a slim-flexible design and regressive taper root canal therapy.16 TruNatomy files remove the least amount of dentine clinically necessary to adequately irrigate the canal. Because both files provided cautious yet less aggressive outcomes, there was no discernible difference in diameter growth between Hyflex CM and TruNatomy for the reasons mentioned before.

Conclusion

Procodile and Hyflex CM hybridization produced remarkable outcomes in maintaining the canal diameter in all three sections, with the middle third of the canal exhibiting the least amount of canal transportation and the best centering ability. Nevertheless, physicians can employ a single file system (Hyflex CM or TruNatomy) as it exhibits good results in all parameters when compared with a combination of systems, if treatment cost and length limit the clinical application of the hybrid method.

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