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Changes in canal width and angle in curved canals in the resin blocks: pro taper next versus one shape instruments

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Abstract

Objective: To compare the effect of OneShape and ProTaper Next file on the change in canal width and angle of curvature in simulated curved canal in resin blocks.

Methods: The quasi-experimental study was conducted at the Aga Khan University, Karachi, from January to March 2018, and comprised endodontic resin blocks that had inbuilt curved canals. These were randomly divided into 2 equal groups and were subsequently prepared using OneShape in group A, and ProTaper Next rotary instrument in group B followed by staining with red and blue ink for comparison of pre- and post-operative images of canals. Standardised photographs were taken along with reference measuring scale. SPSS 22 was used for data analysis.

Results: Of the 60 blocks, 30(50%) were in each of the two groups. The mean pre-instrumentation angle of curvature was 32.3±2.13 and 31.0±3.28 degrees for groups A and B. The mean degree of canal straightening post-intervention was 1.5±0.5 and 3.6±1.38 degrees in groups A and B ($p<0.001$). In terms of canal width changes, OneShape file removed more resin material from the canal walls compared to the ProTaper Next system ($p<0.001$).

Conclusion: ProTaper Next file significantly altered the angle of curvature in the resin block compared to OneShape file, but the amount of material removed from the canal space was significantly higher with the OneShape file compared to ProTaper Next.

Key Words: ProTaper Next, OneShape, Nickel-titanium.

Introduction

The introduction of Nickel-titanium (NiTi) alloys in the late 1980s led to a revolution in endodontics.[1] Since then various technologic advancements have been made to minimise the procedural errors, and provide effective and predictable endodontic treatment.[2-4] These include the incorporation of M-Wire, R-phase and controlled memory wire technology to optimise the substructure of NiTi alloys.[5-7] Furthermore, different cross-sectional designs and new manufacturing processes have been employed to reduce the cyclic fatigue and torsional stresses.[8-10]

The fifth generation files, including OneShape (OS), ProTaper Next (PTN) rotary files etc., came into market as a result of these modifications.[3] The OS file, introduced by Micro-Mega (Besoncon, France), is one of the prominent single file NiTi instruments that work in continuous rotation for endodontic preparations. This unique file system is made up of conventional NiTi alloy comprising single file with 0.25mm tip diameter and 6% constant taper. OS instrument is characterised by a variable cross-section along the blade with triangular cross-section at the tip and double S-shaped throughout the shaft.[11] This asymmetrical design is speculated to eliminate threading and binding of the instrument in continuous rotation.[12]

PTN is the successor to the ProTaper Universal system. These files are the combination of three significant design features that includes M-Wire technology, offset and rectangular cross-section design.[13] This off-centre design generates a travelling mechanical wave of motion along the active portion of a file. This swaggering effect serves to reduce the engagement between dentine and file as opposed to one with centred mass of rotation. This reduction of engagement also limits any undesirable screw effect, taper lock and torque on any file. An off-centred file design also limits the probability of laterally compacting the debris and blocking the root canal system anatomy.[14]

These newly incorporated features in both OS and PTN files were claimed to provide safety during preparation of canals with adequate removal of tooth structure. Investigation of the shaping abilities of both these new NiTi files is necessary to understand the behaviour of these files. The current study was planned to evaluate and compare the effect of OSA and PTN files on the canal width changes and angle of curvature on simulated curved canal in resin blocks. The null hypothesis for the study was that there would be no difference in the shaping abilities of OS and PTN rotary files.

Materials and Methods

The quasi-experimental study was conducted at the Aga Khan University, Karachi, from January to March 2018, and comprised endodontic resin blocks with inbuilt curved canal over 30 degrees. . Exemption from the institutional ethics review committee was obtained prior to data collection, and the study was conducted using the Transparent Reporting of Evaluations with Nonrandomised Designs (TREND) statement of non-randomised trials.[15]

The estimation of sample size was done using the World Health Organisation (WHO) calculator[16] while keeping the mean difference in angle of curvatures as 2.75±0.43, level of significance (α) 1% and power of study (1-β) 99% in line with an earlier study[17]. Endodontic resin blocks made up of clear polyester resin with simulated canals having 30-35 degrees of curvature (Endo Training-Bloc, Dentsply Maillefer, Ballaigues, Switzerland) were included using non-probability consecutive sampling. Resin blocks which were damaged and/or had canal curvature <30 degrees or >35 degrees were excluded.

All preparations were made by single investigator. Resin block coding was done for identification purposes. Each block had simulated canal which was negotiated and prepared till ISO #20 size K-endodontic file reached the apex when the simulated canal exits the resin block. The working length was taken as 1mm short of the apex using direct visualisation. After preparation, the canals were irrigated with water using 5ml irrigating syringe with continuous in-and-out motion. The simulated canals of the resin blocks were then filled with green Indian ink and preoperative photographs of each block with reference measuring scale was taken with Nikon D7000 digital single lens reflex (DSLR) camera. For standardisation, all images were taken at the same distance from the resin block.

The blocks were then randomly divided into two equal groups. The blocks were numbered from 1-60; all even-numbered blocks were assigned to the OS group A, while all the odd-numbered blocks were allocated to the PTN group B. Both the OS and PTN rotary instruments were used as per the manufacturers' instructions. Ethylene diamine tetra acetic acid (EDTA) foam (RC-Prep) was used as a lubricant during instrumentation. After using each instrument, the canals were flushed with 5ml water using a plastic 27-gauge irrigating tip. PTN group was prepared till X2 (25/06 file) at the working length.

Standardised pre- and post-operative photographs, with the reference measuring scale, were then transferred to the Adobe Photoshop 7.0. Each image was then evaluated for angle of curvature, using Schneider's method[18] Twelve readings in millimetres on both outer and inner walls of each block were made (Figures 1-2). All assessments on the imaging software were carried out by a single assessor who was not involved in the canal preparation and was unaware of the group allocation of the resin blocks. Of the total, 12(20%) blocks were re-evaluated by the same assessor for intra-examiner reliability which turned out to be 93%.

SPSS 22 was used for data analysis. Independent sample t-test was used to compare the angle of curvature and canal width changes after using OS or PTN rotary files. Paired sample t-test was used to compare pre- and post-instrumentation changes in the blocks. The level of significance was set at $p<0.01$.

Results

Of the 60 blocks, 30(50%) were in each of the two groups. The mean pre-instrumentation angle of curvature was 32.3±2.13 and 31.0±3.28 degrees for groups A and B. There was a statistically significant difference between the mean degrees of straightening in both the groups, with PTN causing more straightening of the canal compared to OS (Table 1).

Also, there was statistically significant differences between the groups at each interval of 1mm on both the inner and outer walls from 1 to 12mm, and more canal material was removed from the outer wall compared to rthe inner wall of the block, with OS removing more material compared to PTN (Tables 2-3).

Discussion

The current study rejected its null hypothesis as the results suggested that OS rotary files showed superior maintenance of the canal curvature in the resin blocks compared to the PTN files. However, PTN files were found to be more conservative in terms of removal of resin material from the canal walls.

The methods used for the evaluation of shaping abilities in the current study included the evaluation of angle of curvature and canal width changes for both file systems. Schneider's method for measurement of canal curvature was used in the present study for comparison of canal curvature assessment. Among the other methods used for measurement of canal curvature, Schneider's method is the most widely used method owing to its simplicity, accuracy, reliability and less chances of error.[19] Schneider's method not only provided simple method to evaluate root canal curvature, but also classified the curvature into canals to be straight at 5 degrees or less, moderately curved at 10-20 degrees, and severely curved at 25-70 degrees.[19, 20]

The present study used resin blocks having simulated canals with curvature >30 degrees, therefore, they can be characterised as canals with severe curvature.[20] The results can be used to speculate the behaviour of rotary files in canals having severe curvature. The angle of curvature in the pre-operative resin blocks were similar for both the groups, therefore the selection bias is eliminated due to homogeneity in the sample population.

In the current study, PTN files caused significantly more straightening of severely curved canal. Caper et al.[21] compared various NiTi rotary systems, including OS and PTN files, and provided a contrasting result, with OS files causing straightening of 4.9 degrees compared to 3.7 degrees by PTN. However, that difference was not statistically significant. Furthermore, they had taken initial curvature of 28 degrees for both files in extracted mandibular molars. They had used Cone beam computed tomography (CBCT) imaging for data collection and measured the angle of curvature using the method devised by Estrela et al.[22] Their study further concluded that other rotary files, including WaveOne, Twisted Adaptive and ProTaper Universal, demonstrated a similar trend of straightening of >3 degrees. Celikten et al.[23] used CBCT for the evaluation of shaping abilities of OS and PTN files. They had taken roots with canal curvature of 24 degrees for both PTN and OS. The resultant straightening caused by these files turned out to be of 1.8 and 1.9 degrees for PTN and OS respectively, and the difference was was not statistically significant.

D'Amario et al.[24] evaluated the effects of various single-file systems, including OS file, on the severely curved canal >40 degrees. After the use of single files, the mean change in curvature was 2.7 degrees for OS. Similar trend was followed by other file systems and that was also not statistically different. They further declared these file systems to be efficient and safe to use because despite having severely curved pre-operative canals, only few degrees of straightening was observed.

Yuan and Yang[25] compared PTN with WaveOne files, and found that PTN file caused 10.8 degrees of straightening of canal compared to 13.1 degrees by WaveOne file. Although, PTN caused less straightening of canal, the difference was not statistically significant.

Ferrara et al.[26] compared PTN with ProTaper Universal files in severely curved root canals. Although the initial canal curvature for both the groups was around 21 degrees, the straightening these files caused in clinical view was 4.5 degrees for both the files which means that both files caused more straightening even in curvatures that were moderate in magnitude pre-operatively.

It is evident that PTN caused more straightening of canal regardless of initial canal curvature compared to OS files which showed a variable trend among different studies. However, it appears that OS instrument showed less straightening in canals with pre-operative curvature >40 degrees. This trend was also followed in the present study that clearly showed that OS, despite being made up of conventional NiTi, clearly surpassed the M-Wire technology-based PTN files.

Both PTN and OS systems were compared for the removal of canal material from the resin block. Both files with same apical diameter and constant taper from tip to shaft of file i.e. 0.25mm tip diameter with 6 degrees constant taper were selected in order to exclude the effect of file size on canal preparation.[23] However, it is evident from the preparations that OS file was significantly more aggressive in terms of removing canal material from the resin block at each interval from apical to coronal region of the canal. This is in contrast with the findings of Alrahabi et al.[27] who reported PTN to be more aggressive in terms of canal width changes and ultimately causing more canal transportation than with OS in extracted teeth. Dhingra et al.[28] compared OS with WaveOne in extracted molars using CBCT, and also concluded that OS was less aggressive in the removal of canal dentine. Despite having similar apical diameter and taper, this behaviour can be attributed to the differences in the physical properties of both these files.

Since PTN file prepares canal in a swaggering manner, it can be anticipated that it poses less stresses on the canal wall, and, in turn, removes less material as opposed to files that engages all the walls of the canal simultaneously which is OS file in our case.[21] The other possible explanation to the mentioned result can be the physical property of resin block used itself. Endondontic resin blocks have the tendency to melt when more stresses are generated on its surface. There is a possibility that because of the aggressive nature of OS file with centred preparation engaging all the walls of the canal, it posed more stress, leading to the removal of more material compared to off centred preparation by PTN.

Resin blocks were used in the present study because they are standardisaed, easy to obtain, and eliminate the use of natural teeth for experimental procedures.[29] Studies have shown that preparation in resin block had similar outcome to that of preparation in a natural tooth.[30,31] However, concerns are also present for using them as a replacement of teeth for endodontic training purposes.[32]

Since the last decade or so, the world is shifting towards single-file systems for root canal preparations with efficient cutting potential while maintaining the original canal anatomy. No file system up till now is considered perfect in terms of these requirements. The quest for the ideal file system continues. PTN, despite its disadvantages, if used judiciously, can preserve the canal anatomy better and produce good results. Further studies on extracted teeth using three-dimensional (3D) imaging are required to obtain more precise results.

Conclusions

There was a significant difference in the angle of canal curvature pre- and post-instrumentation in both OS and PTN files. PTN files significantly altered the angle of curvature in the resin block compared to OS files. The amount of material removed from the canal space was significantly high with OS files compared to PTN at the apical, middle and coronal parts.

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Table 1: Comparison of angle of curvature in resin block OneShape versus ProTaper Next file systems.

	Pre instrumentation (degrees) Mean ±SD	**Post instrumentation (degrees)** Mean ±SD	**Mean difference (degrees)** Mean±SD	***p-value***
OneShape	32.30 ± 2.13	33.80 ± 2.12	1.5 ± 0.5	*<0.001*
ProTaper Next	31 ± 3.28	34.6 ± 3.3	3.6 ± 1.38	*<0.001*
***p*-value**	0.07	0.27	<0.001	

- *Paired sample t test (in rows italic)*
- Independent sample t test (in column)
- SD= Standard deviation
- *p*-value <0.01 is considered as significant

Table 2: Canal width changes on inner wall after using OneShape and ProTaper Next files.

Distance from apex	**OneShape Mean ± S.D. mm**	**ProTaper Next Mean ± S.D. mm**	***p*-value**

Inner wall at 1 mm	0.84 ± 0.38	0.42 ± 0.36	<0.001
Inner wall at 2 mm	0.88 ± 0.43	0.51 ± 0.4	0.001
Inner wall at 3 mm	0.87 ± 0.41	0.36 ± 0.28	<0.001
Inner wall at 4 mm	0.94 ± 0.34	0.42 ± 0.29	<0.001
Inner wall at 5 mm	0.89 ± 0.31	0.54 ± 0.39	<0.001
Inner wall at 6 mm	0.93 ± 0.33	0.57 ± 0.37	<0.001
Inner wall at 7 mm	0.94 ± 0.33	0.61 ± 0.36	0.001
Inner wall at 8 mm	0.92 ± 0.29	0.59 ± 0.38	<0.001
Inner wall at 9 mm	0.96 ± 0.31	0.57 ± 0.39	<0.001
Inner wall at 10 mm	0.93 ± 0.32	0.61 ± 0.38	0.001
Inner wall at 11 mm	0.98 ± 0.36	0.61 ± 0.43	0.001
Inner wall at 12 mm	0.97 ± 0.32	0.68 ± 0.44	0.006

- n=30 each group
- Independent sample t test
- *p*-value <0.01 is significant
- SD= Standard deviation

Table 3: Canal width changes on outer canal wall after using One Shape and ProTaper Next files.

Distance from apex	**OneShape Mean ± S.D. mm**	**ProTaper Next Mean ± S.D. mm**	***p*-value**
Outer wall at 1 mm	1.8 ± 1.5	1.01 ± 0.66	0.012
Outer wall at 2 mm	1.7 ± 1.2	0.98 ± 0.67	0.006
Outer wall at 3 mm	1.68 ± 1.11	0.94 ± 0.60	0.002
Outer wall at 4 mm	1.68 ± 0.93	0.92 ± 0.59	<0.001

Outer wall at 5 mm	1.69 ± 0.84	0.99 ± 0.59	0.001
Outer wall at 6 mm	1.5 ± 0.87	0.96 ± 0.59	0.005
Outer wall at 7 mm	1.64 ± 0.79	1.03 ± 0.63	0.002
Outer wall at 8 mm	1.66 ± 0.78	1.05 ± 0.63	0.002
Outer wall at 9 mm	1.65 ± 0.76	1.10 ± 0.60	0.003
Outer wall at 10 mm	1.63 ± 0.77	1.03 ± 0.68	0.002
Outer wall at 11 mm	1.62 ± 0.73	0.99 ± 0.69	0.001
Outer wall at 12 mm	1.59 ± 0.72	0.92 ± 0.66	<0.001

- n=30 each group
- Independent sample t test
- *p*-value <0.01 is significant
- SD= Standard deviation

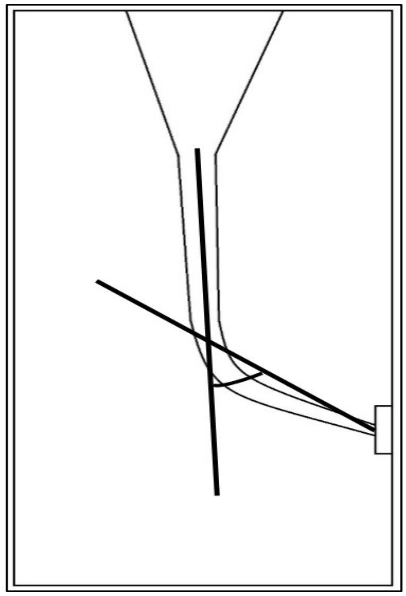

Figure 1: Measurement of angle of curvature on resin block using Schneider's method.

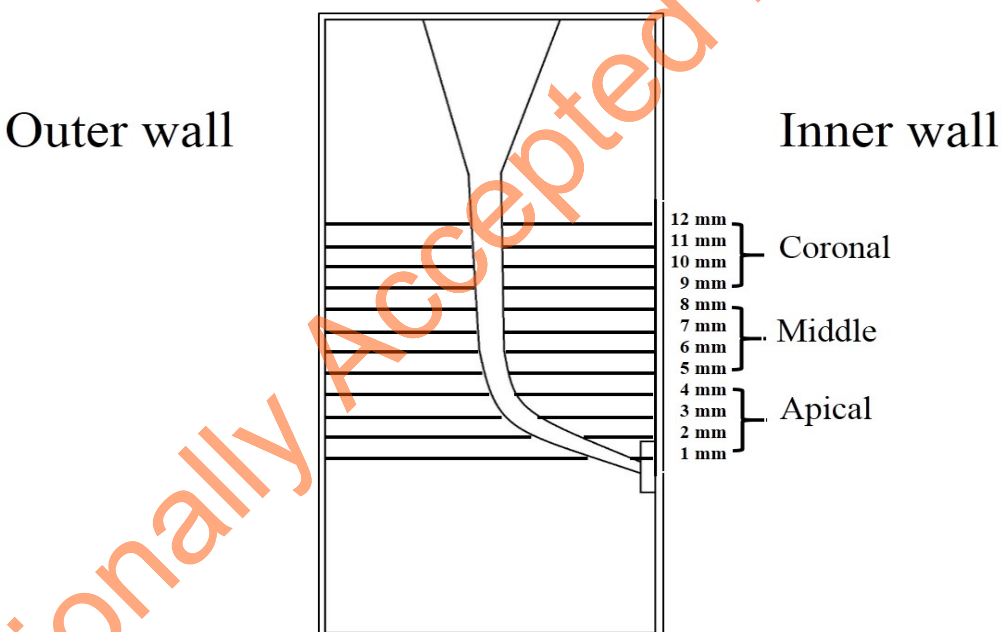

Figure 2: Description of measuring points on both inner and outer walls of resin block with simulated canal.