Original Article

Comparison of shaping ability of three different rotary instruments in simulated root canals using computer image analysis: An *in vitro* study

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ABSTRACT

Aim: This in vitro study was done to compare the shaping ability of ProTaper, K3, and Hero Shapers in clear resin blocks with simulated root canals using computer image software analysis. **Materials and Methods:** 45 clear resin blocks with simulated root canals were divided into three groups of 15 each. Preinstrumentation digitalized images of the blocks were made and stored. Each group was instrumented with ProTaper, K3, and Hero Shapers, respectively. Postinstrumentation images of the blocks were made after injecting a contrast medium to improve the outlines of the root canals. Pre- and post-instrumentation images were magnified, superimposed, and assessed using computer image analysis program (pattern matching analysis). Material removal was measured at nine points in the inner wall and outer wall ending 1 cm from the apical terminus. **Statistical Analysis:** Student's t-test and one-way analysis of variance were used to compare the overall change in the width in the mesial view by using ProTaper, K3, and Hero Shapers. **Results:** ProTaper showed more change in width, followed by K3 and Hero Shapers. **Conclusion:** ProTaper and K3 showed significant removal of material in the outer wall of the coronal and apical 3rd, followed by inner wall of the middle 3rd. Hero Shapers showed significant removal of material in the outer wall of coronal 3rd, with less significant changes in the middle 3rd and even material removal in the apical 3rd.

Key words: Cleaning and shaping, computer image analysis, rotary instruments, simulated root canals

INTRODUCTION

Biomechanical preparation of the root canal is one of the most important steps in root canal treatment. Obtaining a continuously tapered shape canal with the smallest diameter at the apical foramen and the largest at the orifice that permits effective irrigation, filling without changing the original curvature, and hence the removal of infected dentin and organic tissue by shaping and dissolution. Various instruments have been used to prepare the root canal.

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When using the traditional rigid stainless steel hand instruments, it is difficult to achieve desired root canal shape, especially in narrow and curved canals. It is time-consuming as well as there is more chance of getting canal aberrations such as zips, elbows, ledges, and perforations. Nickel–titanium (NiTi) instruments have been developed with new design features such as varying tapers, noncutting safety tips, with varying length of cutting blades and combination of metallurgical properties of NiTi alloy.[1]

All NiTi rotary systems incorporate instruments with tapers ranging from 0.04 to 0.12. In order to improve the relatively low cutting efficiency of NiTi instruments, greater tapering instruments has been introduced to enhance the canal shaping ability and to reduce the incidence of instrument failures.[2]

ProTaper, K3, and Hero shapers instruments have different cross-sections such as convex triangular cross-section with advanced flute design, asymmetric triple fluted cross-section safe ended tip, and triple helix cross-section combines multiple tapers within the shaft[3] with safe ended tip.[4] The recently innovated rotary systems such as Mtwo, RaCe, and Revo-S result in minimal canal transportation similar to ProTaper Universal system, which has been manufactured through conventional nitinol.[5] Numerous studies have demonstrated that NiTi rotary instruments show more rapid, centered, rounder, and conservative canal preparations.[6] The purpose of this *in vitro* study is to compare the shaping ability of ProTaper, K3, and Hero Shapers in simulated root canals using computer image software analysis.

MATERIALS AND METHODS

Specimen preparation

Forty-five simulated root canals in clear resin blocks with the diameter and the taper were equivalent to an ISO 10 size k-file, with the standardized length of 18 mm, and with the straight part of 11 mm and curved part of 7 mm.

The samples were randomly divided into three groups namely 1, 2, and 3 and were prepared with ProTaper (Dentsply-Maillefer, Asia), K3 (SybronEndo, Mexico), and Hero Shapers (MicroMega, France), respectively.

Instruments and preparation technique

ProTaper file system with a convex triangular cross-section and its variable tapering design provides flexibility and cutting efficiency. The torque can be adjusted depending upon the type of files being used such as orifice shapers, shaping files, and finishing files.

K3 files with its variable core diameter make them flexible. Series of three radial lands with a relief behind two of the three radial lands reduces friction on the canal wall. Body shapers are available in taper 0.08, 0.10 with tip size 25 and are used to prepare the coronal third of the canal. Hero Shapers' files have 0.04 and 0.06 taper with ISO tip sizes and a noncutting tip, triple helix cross-section with three cutting edges. Helix angle and pitch increases from tip to shank so that attaining more flexibility and efficiency. Instrumentation of canals was done with an electric motor in a crown down manner at a rotational speed range of 250-400 rpm, through 1:16 torque control handpiece (Anthogyr, Dentsply). To check the patency of the canal before the root preparation, ISO 10 size k-file was introduced into the simulated canal to working length.

Group 1

The simulated root canals were instrumented with ProTaper instruments in the following sequence. S1; used up to ¾ of estimated working length, Sx; used for coronal shaping, S2; used up to working length, and F1 and F2; used up to working length.

Group 2

The simulated root canals were instrumented with K3 instruments in the following sequence. Coronal preparation: Size 25; 0.10 taper — Orifice shaper, size 25; 0.08 taper — Orifice shaper, can be used up to 1/3 to 2/3 of working length.

Group 3

The simulated root canals were instrumented with Hero Shapers in the following sequence: Size 20; 0.06 taper up to 2/3 of working length, size 20; 0.04 taper up to working length, size 25; 0.04 taper up to full working length.

Each resin block was mounted in a vise before instrumentation. Each instrument was coated with RC Help (Prime Dental) as a lubricant and 1 ml of 3% sodium hypochlorite was used after each instrumentation step for irrigation. The canals were recapitulated using ISO size 10 k-file.

Assessment of preparation

Preinstrumentation images were taken using a digital camera (Nikon — D-40, 6 megapixels, SLR, ED 18-55 mm 1:3.5-5, 6GII) at a standardized camera object, at a distance of 1 feet, and were stored as JPEG file in a computer. Postinstrumentation images were taken after injecting a contrast medium to improve the outlines of root canals. They were photographed at the above-mentioned standardized distance and were stored as JPEG file in a computer. Pre- and post-instrumentation images were magnified for 5 times using Adobe Photoshop 7.0 and were superimposed.

Obturating material was removed, that is, difference between canal configuration before and after instrumentation was measured one dimensionally both for inner and outer wall of the curvature at measuring points, marked at a distance of 1 cm between them to the working length, perpendicular to the surface of the canal, reducing 1 cm from the apical terminus. This resulted in 9 inner and 9 outer measuring points for each simulated canal. The amount of material removed from each wall of curvature was measured using pattern matching

analysis by subtracting the preinstrumentation image from the postinstrumentation images. In the mesial view also, pre- and post-instrumentation width at each level was calculated.

Pre- and post-instrumentation images were superimposed for the assessment of canal width change [Figures 1-3].

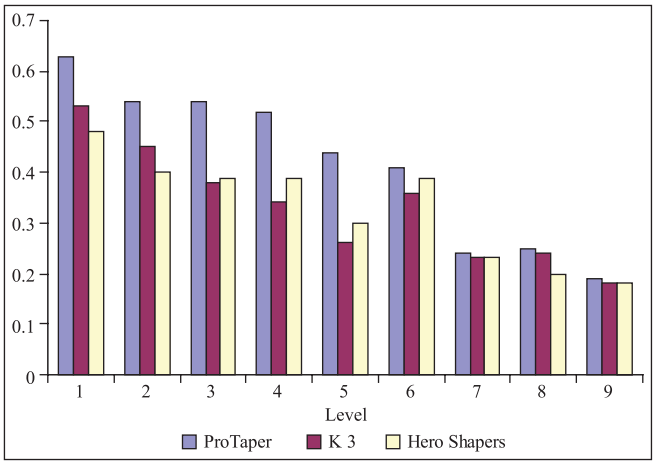
RESULTS

All the values were tabulated and statistically analyzed using Student's *t*-test and analysis of variance (ANOVA) using SPSS version 10.0. ProTaper showed more change in the width of the coronal and apical third portion of the outer wall and in the middle third region of the inner wall. K3 showed a significant change in the width of the coronal and apical third of outer wall and in the middle third of the inner wall. Hero Shapers showed more material removal in the outer wall of coronal 3rd with less significant changes in the middle 3rd and an even preparation in the apical 3rd.

When using ProTaper, more amount of material was removed in the coronal and apical portion of the outer wall and while using K3 more change in the width of the middle third of the inner wall. Hero Shapers showed less material removal overall when compared with the other group instruments.

Statistical analysis was done using one-way ANOVA to compare the overall change in the width in the mesial view by using ProTaper, K3, and Hero Shapers [Graph 1]. Results show that ProTaper showed more change in width, followed by K3 and Hero Shapers.

Data were analyzed using computer software, Statistical Package for Social Sciences, SPSS version 10. Data were expressed in its mean and standard deviation. One-way ANOVA was performed as a parametric test to compare the different variables when instrument and regions were taken individually. For all statistical evaluations, a two-tailed $P < 0.05$ was considered as significant.



Graph 1: Overall comparison of change in width in mesial view

DISCUSSION

The biological aspects of cleaning and shaping of root canal system are to remove the infected soft and hard tissue and for creating access for irrigants, intracanal medicaments to the apical canal space, and retaining the integrity of radicular structures.

Cleaning and shaping were done by using carbon steel and stainless steel instruments with 0.02 taper. The access for irrigation solution to reach the apical region was insufficient because of the rigidity of the stainless steel instruments and

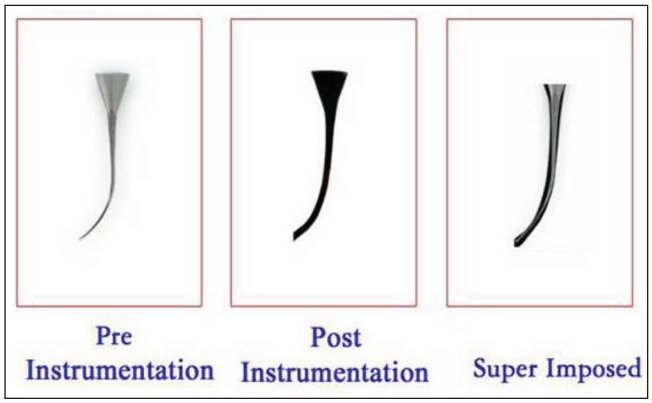


Figure 1: Group I-Protaper buccolingual view

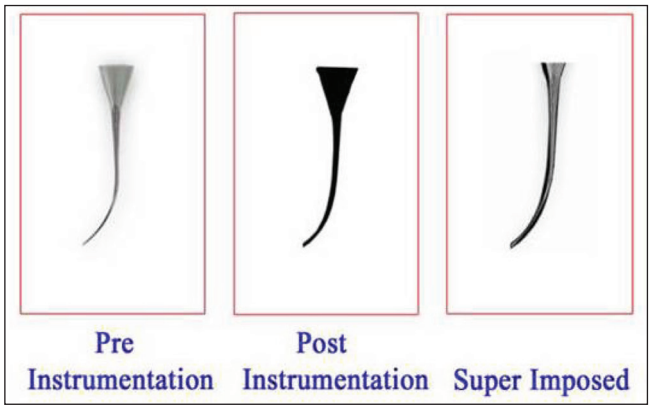


Figure 2: group II-K3 buccolingual view

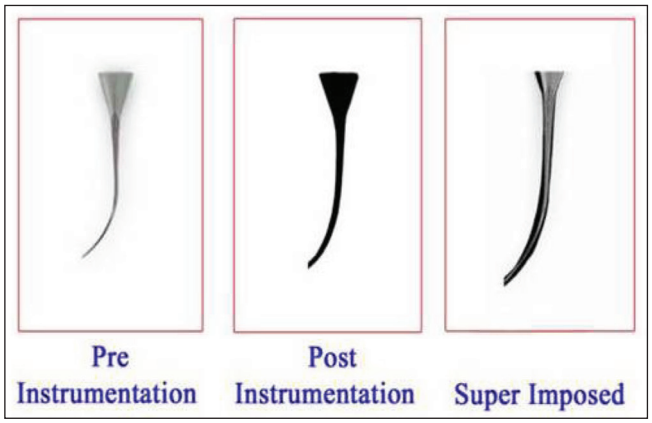


Figure 3: Group III-Hero shapers buccolingual view

it creates canal irregularities while proceeding the shaping procedure with the bigger size instrument. There are more chances for procedural errors as the root becomes more curved and when instrument size increases.

NiTi files were introduced by Walia *et al*. and concluded that NiTi files have greater flexibility and resistance to torsional fracture than stainless steel files. These exhibit shape memory effect and super elasticity. However, the lesser cutting efficiency is the main drawback of NiTi instruments. Canal transportation is rare while using NiTi instrument.[7]

The designs, tips, and tapers of the rotary NiTi have been modified so that it shows superior quality to that of the stainless steel instruments. These instruments maintain the patency of the canal and are more convenient for the operator as well as for the patient because of reduced treatment time.[7]

The greater the tapering, more the accessibility for the irrigants to reach the apical third region so that there will be complete removal of remnant pulp tissue, necrotic root dentin, and microorganisms from the pulp canal space.

Recently, there are so many rotary systems available in the market. Among them ProTaper, Hero shapers, and K3 system have been selected in this study because of its different cross-sectional configuration and cutting efficiency.

There are many recent methods to assess the quality of the cleaning and shaping techniques, among them commonly used techniques are radiographic techniques such as subtraction radiography, electron microscopic technique, digital imaging, computed tomography scan, silicone model method, and canal impression study using rubber base impression material. Computer image analysis method has been chosen because it is a nondestructive technique and allows pre- and post-instrumentation changes at several parameters using a special software program such as AutoCAD or Photoshop.[8]

In the current study, to obtain good quality images, digital camera l (Nikon- D-40, 6 megapixels, SLR) was used at a standard distance of 1 feet and stored as a JPEG file in a computer. JPEG was used to reduce the file size of natural, photographic-like true-color images without affecting the quality of the image.

To compare the pre- and post-instrumentation images, computer-assisted image analysis has been done. The samples outlines were clearly seen with the help of (blue ink) contrast medium. The pre- and post-instrumentation images were superimposed over one another to compare the canal shaping ability. This was assessed by a computer software image analysis program.

In the present study, 9 measuring points were marked at a distance of 1 cm on the inner and outer side of the canal curvature within the standardized working length for all the groups. The change in the root canal width was measured one-dimensionally at both pre- and post-instrumentation images.

The image analysis was done with computer-assisted method for this study because of its accuracy on quality assessment. Canals were viewed buccolingually and change in width was measured at various points. In the mesial view, pre- and post-instrumentation width at each level was calculated.

In group 1, there was a significant change in the width of the coronal, apical region of the outer wall of root canal whereas the inner wall of the middle third of root showed a significant change in the width.

Reasons could be:

- Due to increased taper of shaping files of up to 19%.[3]
- The larger instruments are stiffer and may cause a higher lateral force in curved canals. These restoring forces attempt to return the file to its original shape and act on the outer side of canal wall during preparation, especially with progressive taper instruments.[1] With the brushing technique, the file is lightly pressed against the walls to prepare the entire root canal surfaces, while respecting the original canal anatomy.
- The least centered preparation with ProTaper could be due to its reduced flexibility, increased tip stiffness, and progressive taper of the instrument as compared to fixed tapers of others. The results are in accordance with Gergi *et al*.[9]

In group 2, there was a significant change in the width in the outer wall of coronal 3rd, inner wall of middle 3rd, and the outer wall of apical 3rd.

Reasons could be K3 body shapers files with enhanced taper of 0.08, 0.10, and 0.12 can act as both canal shaping files orifice openers and deep body shaping files.[10] Constantly tapered K3 instruments showed more material removal toward the outer aspect at the apical level.[11] Results obtained with K3 may be due to larger apical preparation with greater taper and stiffer instruments compared with those of ISO taper.[12] Good shaping ability for constant tapered K3 instruments in simulated root canals may be due to the asymmetrical, active file design with variable helical flute and variable core diameter. K3 with its unique cross-section design, which has a positive angle of inclination, relief at the posterior extremity of the blade, U-shaped file design with three radial lands, and the relatively higher number of instruments used in the shaping sequences may be responsible for the above observation.[13] The reason behind K3 instrument having positive rake angle will work like a shaver on the dentin surface, could be one of the reasons

for the above-mentioned results.[14] Ersev *et al.* evaluated the shaping efficacy of five NiTi rotary instruments with different cross-sectional designs, they found K3 to be a better choice in preparing curved canals.[15]

Group 3: There was a significant change in the width of coronal 3rd region of outer wall of the root canal, minimal change in the inner wall of middle 3rd, and an even preparation in both the outer and inner wall in the apical region.

Reason could be while using Hero Shapers in a crown down manner a file with greater taper is used first followed by file with smaller taper in order to progressively shape the canal. The risk for fracture is reduced because of its maximum flexibility and its smaller core diameter.[4] The width on the mesial side both before and after the instrumentation, when measured at 9 measuring points were highly significant with significant change in the width for all the groups.

All the instruments in the present study produced a more centered continuously tapering canal shape and maintained the original curvature with minimal apical transportation.

In the clinical situation, care should be exercised in the extrapolation of the present results to the use of these instruments. However, further studies will be required to confirm the findings of the present study with varying canal curvature. The efficiency of tooth structure removal in the presence of chelating agents may also influence the shaping ability of NiTi rotary instruments.

CONCLUSION

From the present study it can be concluded that:

- ProTaper and K3 showed a significant change in the width of the outer wall of the coronal and apical 3rd, followed by inner wall of the middle 3rd.
- Hero Shapers showed more change in the outer coronal 3rd, with less significant changes in the middle 3rd, and even material removal in the apical 3rd region of the root canal.
- All the instruments maintained original canal curvature, enlarged the canals three dimensionally, and were safe to use with limited applications.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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