ABSTRACT

The present study compared the efficacy of two newly introduced rotary Ni-Ti instruments, HeroShaper and NRT in preparation of curved canals. A total of sixty mesiobuccal root canals of human mandibular molars were equally divided into the two experimental groups. Crown-down technique was used with applying manufacturer instructions. Each instrument prepared ten canals. Irrigation was done using normal saline and commercially available soap was used for lubrication. Pre- and postoperative radiographs were taken, and then digitally processed. Shaping ability was assessed by measuring the change in canal curvature. Centering ability was determined by measuring the change in dentin thickness at five fixed levels, change in working length was evaluated by technical measurement pre- and postoperatively and durability was recorded by inspection of files after each use for any sign of permanent deformation or instrument separation.

Both rotary systems achieved good results regarding the assessed criteria with no significant difference; however HeroShaper saved more dentin especially in the mid-root area. Inspection of the used HeroShaper and NRT instruments showed some incidence of overtwisting, unwinding and separation. It was concluded that both Ni-Ti rotary systems were efficient in shaping curved root canals regarding maintaining canal curvature, position of angle of curvature, working length and canal centering. The usage of digital radiographic technique in assessment of shaping ability was an effective technique.

KEY WORDS: Rotary NiTi instrumentation, Hero Shaper, NRT, shaping ability, instrument durability, Digital radiography.
INTRODUCTION

Thorough root canal preparation and debridment present the most significant segment of endodontic treatment. The ability to enlarge the canal without canal deviation, apical transportation or instrument separation is the primary objective in endodontology[1]. Stainless steel hand instruments are being used for cleaning and shaping of root canals, but they are not efficient enough in preparation of narrow and curved canals due to the instruments inherent stiffness. Larger sizes of stainless steel hand instruments aids in safe preparation of curved canals (6,7). These mishaps urged the development of a new generation of rotary endodontic instruments made of nickel-titanium (Ni-Ti) alloy. The increased flexibility of Ni-Ti instruments aids in safe preparation of curved canals[6,7]. These instruments differ in geometric construction[2-5]. These instruments were carried out to evaluate shaping abilities and mechanical properties of these newly introduced rotary Ni-Ti to get maximum benefit of their clinical performance[11]. Two of the newly developed Ni-Ti rotary instruments are NRT® having a quasi rectangular cross section and HERO SHAPER® having a triple helix cross section in shaping of curved root canals.

This study was thus directed to compare the efficacy of the two newly introduced rotary nickel titanium instruments (HeroShaper® and NRT®) during preparation of curved root canals with respect to: ability of instruments to maintain original canal curvature, centering ability of the instrument during canal preparation and its ability to preserve dentin thickness at dangerous zones, ability of the instrument to maintain working length and finally durability of the instrument and incidence of separation.

MATERIALS AND METHODS

1) Selection of teeth and preliminary preparation

Sixty extracted human mandibular first permanent molars were collected. After gross tissue debridment, they were disinfected in 5.25% NaOCl for 5-10 minutes then stored in 0.1% thymol solution. The selected teeth had completely formed roots. Mesibuccal canals had range of canal curvature (0°- 69°) either in mesiodistal or buccolingual directions according to Schneider [12]. A standard occlusal access cavity was performed. File size 10 stainless-steel K-file (Mani, 743 Nakaakutsu, Japan) was used to negotiate mesiobuccal canals and when it flushed with apical foramen it was removed and its length was measured to record the tooth length. Working length was determined by substracting 0.5 millimeter from the recorded tooth length.

2) Teeth embedding in polyester blocks

Clear polyester (Salah el din chemicals, Cairo, Egypt) was mixed according to the manufacturer directions, and poured in a standardized rubber mold. Thirty ml of cobalt was added to one liter of clear polyester and mixed until the color became pink then peroxide compound was added to initiate setting. Each tooth was then embedded in the mold till the cemento-enamel junction. Elapse time of one hour was allowed for the polyester to set completely. Five horizontal grooves (two apical, two middle and one cervical), corresponding to levels at which dentin wall thickness would be measured, were made with a fine disc on axial line angle of each block. Thin metal wires 2 mm in length were glued in each groove to form radiopaque marks.

3) Classification of samples and root canal preparation

Teeth embedded in the blocks were divided randomly into two experimental groups as follows: Group(A): thirty samples, prepared with rotary Ni-Ti files, HERO shaper® (Micro-Mega, France). Group(B): thirty samples, prepared with rotary Ni-Ti files, NRT (Mani, 743 Nakaakutsu, Japan)
Initially, Gates-Glidden drills #3, #2, #1 (Mani, 743 Nakaakutsu, Japan) were used for coronal flaring. Samples were prepared in a crown down process according to the manufacturer instructions. For group (A) four Hero shaper® Ni-Ti rotary file sizes were used in four steps as follows: # 20 taper 0.06 till 2/3 of working length. Then # 20, #25 and #30 having taper 0.04 were used till full working length. For group (B) four NRT® file sizes were used in six steps as follows: initially # 20, then # 30 both having taper 0.06 were used till 2/3 of the working length. The next four sequences were used till the full working length, # 20, # 30 both 0.04 taper, followed by # 20, # 30 both 0.06 taper. Files were used with short strokes and minimal apical pressure. Each set prepared ten canals i.e. three sets/group.

Endomate DT® endodontic motor was used with speed 400 rpm for Hero shaper, 200 rpm for NRT, torque 1.6 Ncm, with Gear reduction 1:16 contra angle. The canal was irrigated with 5-ml of normal saline after each file use and each file was coated with commercially available liquid soap (Pril®, Henkel Portsaid for detergents and chemicals, Egypt) as a lubricating agent during canal instrumentation. Files were autoclaved after instrumentation of four canals.

4) Imaging of pre- and post instrumented samples

Pre-and post-instrumentation radiographs were taken for each sample from buccal and mesial aspects giving a total of 240 radiographs for each instrument type. A trophy x-ray machine) Trophy Radiology, 94300 Vin Cennes, Type 6510, France) with exposure parameters 60 Kvp, 10 mA and 0.02 second exposure time was used. Digital images were captured by Digora sensor (phosphor plate 2 cm x 3cm) placed in its pack. To assure consistency of angulation and distance among all radiographs, Digora sensor was used in conjunction with Endex alignment system for paralling technique, (Dunvale Corporation, Gilberts IL 600136, USA). To obtain a repeatable position for the sample, vertical and horizontal stainless-steel wires were glued on the sensor pack to form a right angle corner to aid in adapting the block. A double sided adhesive tape was used to stick to block. During imaging of the samples, a file was inserted in the canal, to enhance the appearance of canal curvature.

5) Digital processing and Geometric measurements

A total of 240 digital radiographs were obtained (120 for each experimental group representing 60 images for buccal aspect and 60 for mesial aspect, 30 pre-instrumentation and 30 post-instrumentation). For each image the following measurements were recorded pre- and postoperatively: degree of curvature, position of the angle representing the degree of curvature, dentin wall thickness. Each measurement was repeated three times. The average was calculated for later statistical analysis.

5.1) The degree of curvature

Pre-and post-instrumentation canal curvatures were measured according to Schneider’s technique as shown in Fig. 1: The coronal 1/3 direction of the canal was traced by a straight line. Another oblique straight line was traced through the outline of the canal in the apical 2-3 mm. The intersection of these two lines forms an interior angle whose value was recorded.

FIG. (1) Technique of measurement of the degree of curvature

5.2) Position of the angle representing the degree of canal curvature

After determining the value of interior angle, the position of angle was determined by constructing a vertical line starting from the angle perpendicular down to root apex. The value of the distance was recorded.
5.3) **Dentin wall thickness**

For buccal view, the dentin wall thickness was measured at five levels: one cervical, two middle and two apical as identified by radiopaque marks. A line was constructed between the external root surface and the external canal wall representing mesial dentin thickness, another line was constructed from interior root surface to inner canal wall, representing distal dentin thickness (Fig. 2a). For mesial view, starting at the level of the radiopaque mark, a line was constructed between the buccal root surface and the buccal canal wall, representing buccal dentin thickness; another was constructed from lingual root surface to lingual canal wall, representing lingual dentin thickness (Fig. 2b).

6) **Change in working length**

After mechanical preparation was completed, the working length of each tooth was re-measured clinically by introducing the master apical rotary until the apical stop, and then file was removed and measured to detect the change in working length in millimeters with 0.5 mm precision.

7) **Instrument permanent deformation and separation**

Each rotary file was visually inspected for any sign of permanent deformation or instrument separation after use in each canal. Files were then examined under stereomicroscope at 40X magnifications after cleaning within ultrasonic cleaner after ten canal usage or at the event of fracture or deformation.

8) **Statistical analysis**

Data collected from the two experimental groups were tabulated and statistically analyzed using t-test and Chi-square test. Level of significance was set at P<0.05.

**RESULTS**

1) **Comparing change in canal angle of curvature**

Overall in both groups 64.15% showed no change in canal curvature, which was more obvious in HeroShaper group (68.5%), than with NRT group (59.6%). Fig.3 shows that the mean value of change in both views combined and in mesial view or buccal view alone. The general trend was that HeroShaper group had less mean canal curvature change than in NRT group. There was no statistical significant difference between both groups where P value = 0.3, 0.4, 0.5, respectively.

2) **Comparing the change in the position of angle of curvature**

That position of angle representing apical curvature moved towards the apex in 92.6% prepared with HeroShaper versus 90.4% in NRT (Fig. 4). The position remained the same 7.5%, equally divided between both groups. In only one image the position moved in cervical direction and was prepared with NRT.
3) Change in outer (O) and inner (I) dentin thickness at five levels cervico-apically

Generally, Hero shaper group presented lower values than the NRT group (Fig. 5). Both instruments produced the highest change in dentin thickness coronally and decreased towards the apical level, presenting the least change. Except for the two apical levels, the mean of change in outer dentin thickness was more than that of the inner dentin thickness for both groups. Statistically there was significant difference between the two instruments, in only the two middle levels. In middle 1 level; P-value was 0.004 and 0.014 for outer and inner change in dentin thickness, respectively. In middle 2 level; P-value was 0.00 and 0.001 for outer and inner dentin thickness, respectively.

4) Change in canal centering position:

The mean values of canal deviation were determined by subtracting the inner dentin thickness from outer change in dentin thickness. Positive values indicated deviation towards outer side and negative values indicated deviation towards inner side. Figs. 6a,b,c shows that in both groups canals were mostly centered in the middle level 3. Canals were mostly deviated towards outer side in the cervical two levels and they were mostly deviated towards inner side in the apical two levels. There was no statistical significance between two groups; P=0.615, 0.48, 0.58, 0.6, and 0.53 at the five levels, respectively.

5) Comparing change in working length

HeroShaper and NRT groups kept working length with no change in 74.1% and 73.1%, respectively. There was no significant difference between both groups regarding this change. The mean of change in working length in both groups were 0.33mm and 0.31mm, respectively. There were no significant difference between both groups where P-value was 0.9.
6) Instrument permanent deformation and separation

In HeroShaper group only one file #30 .04 separated in the 10th canal. In NRT group instrument separation occurred in two files: #20 .04 in the 8th canal and #30 .04 in the 9th canal. Signs of permanent deformation (over twisting and unwinding), occurred in four files in HeroShaper (three files #20 .04 and one file #25 .04), in NRT group these signs occurred in two files #20, .04 (Fig 7).
DISCUSSION

Ni-Ti rotary files’ usage is increasing widely in the endodontic field. A working knowledge of the instrument properties related to its behavior in preparation of curved canals is important, to ensure safe preparation. This study compared HeroShaper and NRT Ni-Ti rotary files which have different design features and metallurgical properties. According to the manufacturer description HeroShaper files are the new generation of Hero 642 and have innovative adapted pitch that avoids screwing effect and increase instrument performance. Furthermore the triple helix cross section allows a positive cutting. The tip is innovative to follow the canal anatomy. While NRT Ni-Ti rotary files combine two important characteristics: shape memory effect and super elasticity. Its unique metallurgy produces a 4-5mm of shape memory file tip and a super elastic file body. The shape-memory tip allows precuring of the file to aid in following the canal pathway. The tip returns to its original shape when autoclaved. The superelastic body allows for a continuous taper of the canal preparation. They have quasi rectangle cross-section that allows improved file flexibility and cutting ability. The file has deep spaces between the cutting blades, minimizing the possibility of apically extruding debris.

The current study utilized natural root canals in agreement with many authors (2,3), rather than simulated root canals made within resin blocks (2,3). Natural root canals were preferred because dentin texture, stiffness, and hardness differ from those of resin from which simulated canals are made. Hence the behavior of the instrument and its cutting efficiency will differ. Furthermore, the internal natural teeth canal anatomy is more complex than the completely smooth in simulated ones, which doesn’t simulate the clinical condition. It was found that rate of instrument deformation of Ni-Ti rotary files was six times less in natural teeth (4), when compared to a similar study utilizing simulated teeth (5).

The present stud used separate measurements from pre- and postoperative digital radiographs to evaluate shaping ability of both examined systems. This allowed easy assessment of the changes from buccal and proximal aspects. The specially designed setup using Endex alignment system was used during radiography to obtain standardized parallel radiographs as previously advocated (6), where a specially designed apparatus was used to obtain standardized parallel radiographs. The use of digital radiography was applied differently by other authors in terms of digital subtraction (2) or images superimposition (5) to compare pre- and postoperative radiographs. Others (7) used high-resolution computed tomography to assess geometric changes in three dimensions and at different levels.

Five short thin metal wires were used in this study to act as fixed points to identify certain reproducible levels for pre- and postoperative measurements as previously advocated (8). Other authors (7) sectioned the roots horizontally to specify certain levels, followed by reassembling the teeth and their instrumentation. Although, the latter facilitated evaluation of dentin thickness and centering, however, there is loss of tooth structure relative to the cutting disc thickness.

Torque controlled endodontic motor (Endomate DT) with torque 1.6Ncm (according to manufacturers instructions) was used during preparation. This helped to avoid instrument locking into the canal and its subjection to high levels of torsional stresses and fracture (9). HeroShaper files were operated at speed 400 rpm. The effect of different rotational speeds within the manufacturer range was studied. On using Hero 642 there was no significant difference between these speeds (200,400, and 600) regarding file breakage, canal curvature and working length alterations (10).

Some authors (20) recommended usage of EDTA with rotary instruments. However, EDTA was not used in the present study, as it was shown to cause softening of dentin and hence deviation of the canal or loss of curvature as proposed by some authors (21). Commercially available liquid soap was used instead; it was generously placed on each file before use to provide lubrication and debris suspension. This facilitated canal negotiation and instrumentation (22).
Before instrumentation, coronal flaring was performed with Gates Glidden drills to help establishing straight line access and reduce the strain on the instrument and its failure as proposed by some authors. Instrumentation was done utilizing crown-down technique to reduce intracanal friction and thus to minimize the risk of instrument separation.

Ni-Ti rotary instruments were properly cleaned and sterilized using autoclave after every four canals (resembling one molar tooth with four root canals). It was found that changes in mechanical properties (microhardness, tensile strength and fatigue resistance) of rotary Ni-Ti endodontic instruments after five cycles of common sterilization procedures were insignificant. Also removal of dentin deposits adhering to instrument surface was important. These lodged dentin chips might cause a wedging action on the machining cracks leading to their propagation from localized tensile stress during clinical use and eventually result in instrument fracture.

The method used in this study to assess shaping ability of used instruments, was done by subtracting the measured curvature of root canal and position of curvature in pre- and postoperative radiographs. When the difference between both angles increased, this meant that the used instrument had a tendency to straighten the canal. The method used to assess centering ability and preservation of dentin thickness was done by measuring mesial and distal dentin thickness in buccal views, and buccal and lingual dentin thickness in mesial views at five different levels as previously described. When dentin thickness change was not the same on both sides of the canal, this meant that there was a tendency for canal center to shift. To assess change in working length, it was measured clinically pre- and postoperatively by the operator in millimeters as done by Davis et al.

The results of both rotary Ni-Ti systems showed adequacy regarding maintenance of root canal curvature in agreement with previous studies that investigated Hero 642. The shaping ability studies of ProTaper and Hero 642 revealed that both systems prepared curved canals rapidly, maintained working length and without creation of perforations, but Hero 642 was better in maintaining canal curvature and had better centering ability.

Both studied systems prepared canals preserving centering in mid root areas, removing more dentin from the outer side of the curve above the curvature, and removing more dentin from inner side of the curve below the curvature. There was no significant difference between the two systems regarding these criteria. This was in agreement with previous studies which found that canals prepared with Ni-Ti rotary instruments showed minimal transportation.

Regarding position of curvature beginning, in most images the position of curvature beginning moved towards apex or remained the same after instrumentation. The used Ni-Ti instruments caused minimal change in canal curvature, giving an indication that dentin was removed equally on both sides of the canal, while when the position moved apically, this confirmed that dentin was removed more from the outer side of the curve (safe zone) above the curvature beginning and more from the inner side of the curve (safe zone) below curvature beginning.

Concerning change in dentin thickness, it was shown that except for the two apical levels, the mean of change in outer dentin thickness was more than that of the inner dentin thickness for both groups. There were significant difference between HeroShaper and NRT at the two middle levels, which indicated that HeroShaper files removed less dentin than NRT at these two levels. This could be attributed to difference in instrument size reaching the full working length; NRT had #30 taper 6% versus Hero shaper #30 taper 4%.

Both systems had good results regarding maintenance of working length. This was similarly reported, where decrease in working length was minimal with Ni-Ti rotary files.

With respect to durability of the used Ni-Ti instruments, only three files were separated, one HeroShaper file #30 .04, and two NRT files #20 .04 and #30 .04. Permanent
deformation occurred in six instruments, four HeroShaper #20 .04 and #25 .04 and two NRT #20 .04. It was evident that permanent deformation occurred in relatively small sizes denoting probability of torsional failure, while those fractured without any signs of permanent deformation were of large sizes denoting probability of fatigue failure. It was reported that fatigue resistance decreased as instrument diameter increased, while torsional resistance increased with increasing instrument diameter (4). The broken HeroShaper file separated after preparation of nine canals, while the broken NRT files; were after preparation of seven and eight canals. These results revealed that there is no definite safe minimal number of canals to be prepared by NiTi rotary files as advocated by previous studies(29,30), where they recommended usage of rotary Ni-Ti instruments in clinical practice up to 10 times. The influence of operator on instrument breakage was also demonstrated (43) where the operator had to master this rotary canal preparation technique through learning and experience. Instrument separation during preparation seems to be multifactorial and needs specific further investigations.

Regarding permanent deformation its incidence was higher with HeroShaper, which could bear advantage as it might give an indication when to discard the instrument before separation. Abrupt instrument separation that occurred with NRT may complicate endodontic treatment. Increased incidence of instrument separation with NRT system could be also attributed to inherent surface defects denoting their poor manufacturing quality which was previously reported (42). The three fractured instruments were separated in the apical portions of the canals in agreement with some authors where they reported that instrument separation occurred mostly in instruments used to full working length, in molar teeth, narrow canals and in apical thirds (30).

Thus within the scope of the present in vitro study the following can be concluded: Both Ni-Ti rotary systems were efficient in shaping of curved root canals regarding maintaining canal curvature, position of angle of curvature, working length and canal centering. It is, however, recommended to decrease number of prepared canals than that advised by the manufacturer for safety. The usage of digital radiographic technique in assessment of shaping ability was an effective technique.

**REFERENCES**


