Canal centering ability of two Nickel-Titanium rotary systems compared with SS hand instrumentation in curved canals using Kuttler's endodontic cube - An in vitro study.

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ABSTRACT

Cleaning and shaping of root canal system is an important phase in endodontic therapy for achieving success. Since some degree of canal curvature is present in most of the teeth of human dentition, endodontic preparation of the root canal system becomes difficult. Nickel Titanium instruments were introduced as they were more flexible for use in curved canals. The aim of the study was to compare the canal centering ability of two rotary Nickel Titanium systems (Hero 642 & Profile 0.04 & 0.06 series) with stainless steel K-files using Kuttler's endodontic cube method.

Key words : Kutller's endodontic case, canal centering ability, Ni-Ti rotary instruments, Profile, Hero 642

Introduction

Cleaning and shaping is an important phase in endodontic therapy. Some degree of canal curvature is present in most of the teeth of human dentition. This curvature makes endodontic preparation of the root canal system difficult. Nickel Titanium instruments, which are more flexible, were introduced for use specially in curved canals. Profile series and Hero 642 system are some of the commonly employed rotary Nickel Titanium instruments.

Different methods have been used to evaluate the efficiency and deficiency that instruments used for root canal preparation can produce. These methods include use of radiographs[1,2], microscopic investigation[3,4], resin blocks[5,6] and computed tomography[7,8]. But all the techniques have their own limitations. The major difficulty was to provide an accurate comparative analysis between pre and post instrumentation features of the same root canal system. Bramante et al[9] in 1987 addressed this issue with introduction of a model that consisted of a tooth embedded in resin, which could be sectioned horizontally into a number of slices before instrumentation and then held together by an external muffle system which was made up of plaster during instrumentation. Many modifications of this system were done later. Tames et al[10] in 1998 introduced a new system composed of a metal stand, four metal pins and a Teflon mold. According to Kuttler[11], this model had tendency of change in working length of the root after sectioning of the specimen. He then introduced a new model called

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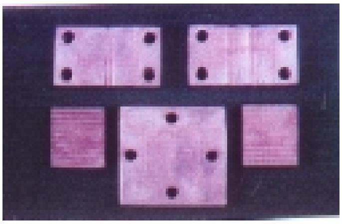

Fig. 1. Five sections of the cube

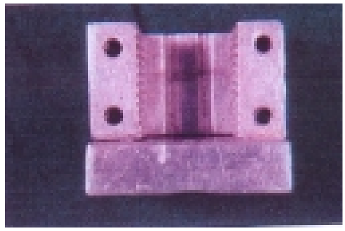

Fig. 2. Vertical and horizontal grooves

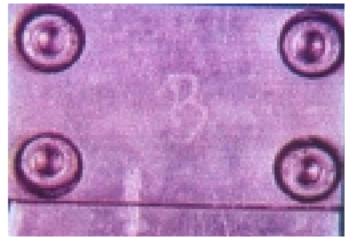

Fig. 3. External fixation screws

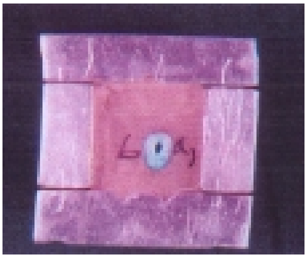

Fig. 4. Tooth embedded in acrylic

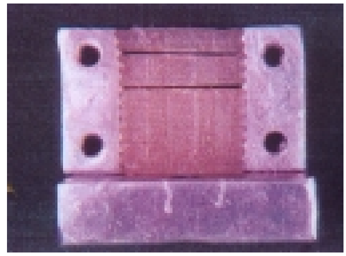

Fig. 5. Acrylic block sectioned at two levels.

Endodontic Cube for determining the canal centering ability of instruments in 2001. The aim of the present study was to compare the canal centering ability of two rotary Nickel Titanium systems (Hero 642 & Profile 0.04 & 0.06 series) with stainless steel K-file using Kuttler's endodontic cube method.

Material and Methods

Forty-five extracted human first mandibular premolars were selected. Standard access openings were made with a # 2 round bur and working length was measured 1 mm short of apex. Curvature of the tooth was measured according to Schilder's technique[12]. Teeth with a canal curvature of 100 to 250 were randomly divided into 3 groups of fifteen teeth each. The teeth were sectioned occlusally to maintain a standard length of 12mm for all the specimens. The teeth were embedded into acrylic resin using the Kuttler's endodontic cube.

An endodontic cube (20mm) was fabricated for this study to embed the teeth in acrylic resin. The endodontic cube consists of five sections, which are held together by external fixation to form a roofless cube (Fig. 1-5). The vertical walls have horizontal grooves projecting internally by 1mm that are machined at precise intervals of 1.5mm. They provide the internal indexing in the horizontal plane and the guides for the site at which the resin tooth model will be sectioned. The open cube is completed by two vertical sections that have longitudinal grooves to correctly orient the sections after image capture and increase the ease of reassembly. The outer sections are held together by external fixation screws. Each tooth was embedded in acrylic resin using endodontic cube. The resin was flowed into the endodontic cube, which was placed on a laboratory vibrator. The tooth to be sectioned was correctly oriented in the acrylic resin in the endodontic cube and was held in position using rope wax on the occlusal surface. After the acrylic had set, the endodontic cube was disassembled and the embedded tooth was removed from the cube. The acrylic block demonstrated equidistant horizontal grooves on opposite surfaces, whereas the remaining two opposite walls had vertical surface projections.

Using the horizontal grooves on opposing surfaces as a guide, the tooth in resin was sectioned using diamond disk of 0.3mm thickness at levels 4.5mm (middle third) and 9mm (apical third) from coronal orifice. This created three distinct areas of analysis namely:

a. Coronal third - Canal orifice
b. Middle third - 4.5mm from canal orifice
c. Apical third - 9mm from canal orifice.

Each tooth was placed in a silicon impression material and photographed using camera (Nikon fm2)

The test group comprised of:

Group I - Specimens prepared with stainless steel K- files and Gates Glidden drills

Group II - Specimens prepared with hero 642

Group III- Specimens prepared with profile 0.04 & 0.06 series.

Group I

Group I was prepared by hand instrumentation with step back technique with anti curvature filling using stainless steel K-files (Mani Inc, Japan). These instruments were precurved before their introduction in canal because of their rigidity. The canals were instrumented to working length with a size 20 file. Gates Glidden drills (Mani Inc, Japan) sizes 2, 3 and 4 were used in coronal half of the canal without applying apical pressure. Hand instrumentation was continued to a size 30 at working length. The following files sizes were used to flare the canal-using step back technique 30, 35, 30, 40, 30, 45 and 30. Each file size larger than 30 was used 1mm short of the proceeding file. Recapitulation was performed with the size 30 to working length.

Group II

Group II was prepared with Hero instruments (MicroMega, Switzerland), following the full sequence recommended by the manufacturer. The Hero instruments are handpiece driven (300-600 rpm) and have graduating taper that ranged from 0.02 to 0.04 taper and three apical sizes 20, 25 and 30. The first wave of instruments were size 25, first a file of 0.6 taper was used at half the working length, then a file of 0.04 taper was used 2mm short of working length, finally a file of 0.02 taper was used at working length for the apical third preparation up to the working length. The second wave of instruments were size 30, a file of 0.04 taper was used at three quarters of the working length, then a file of 0.02 taper used at working length for the apical third preparation. The instruments were used using a 64:1 gear reduction handpiece (Anthogyr, France) powered by an electric motor at a constant speed of 350 rpm.

Group III

In-group III, the specimens were prepared with profile 0.04 and 0.06 taper (Dentsply Maillefer, Switzerland) following the full sequence recommended by the manufacturer. The Profile instruments are handpiece driven (150-350 rpm) and have taper of 0.04 and 0.06 and orifice shapers of no. 3 and 2. First the orifice shapers of #3 and #2 were used for coronal shaping followed by profile #25 / .06 and profile #20 / 0.6 to one half of the root and profile #25 / .04 and profile #20 / .04 to the two third of the canal in a crown down manner.

For apical shaping, profile #15 / .04, #20 / .04, #20 / .06, #25 / .04, #25 / .06 and #30 / .04 were sequentially used to the working length. Profile instruments were also used using 64:1 gear reduction handpiece (Anthogyr, France) at a constant speed of 250 rpm.

Irrigation was performed with 1ml of 2.5% NaOCl after each instrument use. A final flush of 5ml of NaOCl was used after instrumentation completion.

After instrumentation, the sections were disassembled and placed back into their customized forms and photographed as previously described. The preinstrumentation tracings were aligned with that of the post instrumentation images and the post instrumentation canal outline was traced.

Image analysis

The traced outlines of the canals were scanned and were transferred to VixWin 2000 software. This software program was used to compare the uninstrumented canal images to instrumented canal images. This software allowed measuring the distance between two points by one tenth of a millimeter. Two parameters were compared for coronal, middle and apical sections:

— Canal Centre Displacement

— Canal Centering Ratio

The canal centre displacement was calculated in mm by [(X2-X1)2 + (Y2-Y1)2]½ where X1Y1 were the coordinates of pre instrumentation centre of gravity, X2Y2 were the coordinates of post instrumentation centre of the canal gravity.

The canal centering ratio was calculated by (X1-X2)/X3 where X1 was the greatest deviation, X2 was the deviation in the opposite direction and X3 was the final diameter of the canal.

Results obtained were tabulated and statistically analysed. The statistical package SPSS PC + (Statistical package for social service, Version 4.01) was used for analysis. The mean values were compared by one-way ANOVA. Multiple range test by Tukey-HSD (Honestly Significant Difference) procedures was employed to identify the significant groups. In the present study, $p < 0.05$ was considered as the level of significance.

Canal centering ratio

Canal centering ratio is calculated and results are shown in Table 1 & 2. At the coronal level, Group I (0.38 ± 0.05) showed highest canal centering ratio followed by Group II (0.35 ± 0.04) and Group III (0.34 ± 0.04). There was no statistically significant difference between the three groups at the coronal third of the canal p>0.05). One specimen from Group I and one specimen from Group II and III each showed perfect canal centering with canal centering ratio of 0.

At the middle level, Group I (0.41 ± 0.03) showed highest canal centering ratio followed by Group II (0.28 ± 0.02) and Group III (0.16 ± 0.03). There was statistically significant difference between the groups (p value of < 0.01). Tukey - HSD test showed that statistically Group I was significantly different compared to Group II and Group III. There was also statistically significant difference between Group II and Group III.

At the apical level, Group I (0.40 ± 0.03) showed highest canal centering ratio followed by Group II (0.17 ± 0.01) and Group III (0.15 ± 0.01). There was statistically significant difference between the groups (p value of < 0.03). Tukey - HSD test showed that statistically Group I was significantly different compared to Group II and Group III. There was no statistically significant difference between Group II and Group III.

Canal center displacement

At the coronal level, Group I (0.12 ± 0.05) showed highest canal center displacement followed by Group II (0.11 ± 0.02) and Group III (0.10 ± 0.04). There was no statistically significant difference between the three groups ($p > 0.05$).

At the middle level, Group I (0.15 ± 0.04) showed highest canal centre displacement followed by Group II (0.10 ± 0.01) and Group III (0.08 ± 0.02). There was statistically significant difference between the groups ($p < 0.02$). Tukey - HSD test showed that Group I was statistically significantly different compared to Group II and Group III. There was also statistically significant difference between Group II and Group III.

At the apical level, Group I (0.17 ± 0.02) showed highest canal centre displacement followed by Group II (0.06 ± 0.0004) and Group III (0.05 ± 0.0003). There was statistically significant difference between the groups ($p < 0.03$). Tukey - HSD test showed that Group I was statistically significantly different compared to Group II and Group III. There was no statistically significant difference between Group II and Group III.

Discussion

Many problems were encountered using stainless steel instruments in curved canal. Parameswaran et al[13], Al-Omari et al[14] and Chris Coleman et al[15] reported incidence of transportation, zipping and straightening of the canal using stainless steel instruments. The attention was then shifted to change of instrument design to make it more flexible. Stainless steel files e.g. flexofiles, K-flex files and flex R files[16], decreased the prevalence of these defects, however, they were not completely eliminated[17].

Walia et al[18] in 1988 introduced a new generation of instruments wherein stainless steel was replaced by nickel-titanium alloy. They reported that files made from nickel titanium alloy were two to three times more elastic, and had superior resistance to fracture in clockwise and counter clockwise torsion when compared with similarly manufactured stainless steel files.

To reduce the operator's fatigue and save time many rotary nickel titanium systems were developed. The profile series and Hero 642 are two of the most commonly employed rotary nickel titanium systems. These instruments are available with 0.04 and 0.06 taper. The profile instruments have a triple helical configuration. Hero 642 instruments are available in 0.02, 0.04 and 0.06 tapers. The instruments are sized in the ISO & ANSI standards. The Hero instruments have a trihelical Hedstrom design with sharp flutes. They have larger central core that provides extra strength with cutting edges of a slightly positive rake angle[16].

The canal centering ability was calculated by 2 parameters: (a) The canal center displacement, (b) canal centering ratio at the coronal, middle and apical levels. The canal center displacement was calculated using the formula given by Bertrand[19] and the canal centering ratio was calculated by the method proposed by Roig Cayon et al[20].

At the coronal level, there was no statistically significant difference for both centering ratio and canal center displacement amongst the three groups. At the middle level there was a statistically significant difference between all the three groups for canal centering ratio as well as canal center displacement. In the apical level, there was a statistically significant difference between the stainless steel file group and both Profile and Hero 642 group. But there was no statistically significant difference between the Profile and Hero 642 group.

The overall performance of NiTi systems was better than stainless steel files. Several studies have confirmed that rotary NiTi files maintain the original canal curvature better than stainless steel files[21-24]. The stainless steel files produced larger extent of movement because of their hardness that was shown to be three to four times harder than Nickel Titanium. Carvalho[25] reported that even after precurving and anti-curvature filing, a small amount of transportation could be expected from stainless steel instruments.

At the coronal level, all the three groups showed results that were not significantly different. This showed that in straighter portion of the canal both stainless steel and nickel titanium systems could perform equally well. Studies[25,26] have reported similar results comparing different NiTi systems and stainless steel files.

The canal transportation formula is a function of the difference between the maximum deviation and the deviation seen on its opposite side divided by the final canal diameter. Hence, if the original canal configuration is irregular in shape, then coronal flaring using Gates Glidden or orifice shaper changes the canal shape from irregular to a more uniform rounded shape. This roundening of irregular shaped canals is interpreted as canal transportation at the coronal level. This fact has been validated by Bertand et al[19].

In the middle level, all the three groups showed results that were statistically significant. The stainless steel files transported the canal as expected. But there was also a significant difference between the Profile and Hero 642 systems. Although both of them are nickel titanium system, the reason could be the cross sectional design of both the instruments. The Profile system have triple helical configuration whereas Hero system has trihelical Hedstrom design, which has got a thicker inner core. Turpin et al[27] in their study on torsional and bending stresses of two cross sections of nickel titanium stated that trihelical Hedstrom design are less flexible and resistant to bending. This could have caused the Hero 642 system to cause more transportation than the Profile system.

Our result was in contrast with the study of Bertrand et al[19], who reported Hero and stainless steel files to have the same amount of transportation in the middle level. But the stainless steel files used in their study was flexofile, which is more flexible than the standard K-files used in our study.

In the apical level, the stainless steel files caused more transportation than both the NiTi rotary system. This result is also expected because of the rigidity of the stainless steel[25]. But even though the inner core of Hero 642 is thick, its performance was not significantly different from that of Profile. The possible reason for obtaining this result could be that the apical third of canal was prepared by 0.04 taper instrument of Profile whereas 0.02 taper instruments were used for Hero system.Thompson & Dummer[28] in their study stated that transportation by an instrument might reflect the instrument design and tendency of instrument to straighten within the canal. They further stated that this appears to be more evident in canals prepared using instruments with greater taper which are stiffer. The lesser taper of Hero 642 used in apical third preparation could be the reason for it to perform as well as Profile series instruments.

Another difference between the stainless steel files, Profile and Hero 642 was the tip design. The K file has got a cutting tip. This standard cutting tip can be too aggressive because the first flute makes the initial cut in canal transportation[29] whereas both the rotary systems have modified non-cutting tips. Powel et al[30] reported less canal transportation in apical third and ledging was minimized while using instruments with non-cutting tips. Kuhn et al[31] stated that type of alloy used for making the instrument, tip design, instrument design and instrumentation technique used, are the major factors for getting a more centered canal preparation.

In this study, the non-cutting tip, their cross sectional design along with their flexibility could be the reasons for the NiTi system to remain more centered than the stainless steel file.

Maintaining the original canal curvature, continuous taper and conical forms are ideal requirements of endodontic instrumentation. But certain deviations from canal anatomy have been reported with use of stainless steel instruments. The recent manufacturing of endodontic instrument from nickel titanium alloy which has a low modulus of elasticity, superior resistance to fracture or increased flexibility have lead to a new generation of instruments that may overcome some of the limitations of stainless steel instruments[28]. Both Hero 642 and Profile series instruments performed good in this study when compared to stainless steel instruments. But Profile system with its non-cutting tip and radial land design performed superior to Hero 642 in our study.

Conclusions

- The endodontic cube can be used as an effective method for analyzing the canal centering ability of difference endodontic instruments.
- Both the Nickel Titanium system (Profile series and Hero 642) showed superior canal centering ability than stainless steel hand instruments.

- In the coronal level, there was no significant difference between the groups, thereby implying that both stainless steel and Nickel Titanium system can perform equally well in straighter part of the canal.
- In middle level, Profile series instruments showed superior canal centering ability than Hero 642 and stainless steel K-files. The difference between all the three groups was statistically significant.
- In apical level both Profile series and Hero 642 instruments performed equally well and there was no statistically significant difference between these 2 groups. The stainless steel K-flies showed significantly more transportation than both Hero 642 and Profile series instruments at the apical level.
- Overall, profile series instruments showed superior canal centering ability and performed better than both Hero 642 system and stainless steel K files.
- All the test specimens irrespective of the instrumentation technique employed could not demonstrate perfect canal centering ability.

References

1. Knowles KI et al Assessing apical deformation and transportation following the use of light speed root canal instruments. Int Endod J 1996;29:113

2. Nagy CD et al A comparative study of seven instruments in shaping the root canal in-vitro. Int Endod J 1997;30:124.

3. Crambarani C Shaping and cleaning the root canal system a scanning electron microscopic evaluation of a new instrument and irrigation technique. J Endod 1999; 25:800.

4. Schafer E, Zapke K. A comparative scanning electron microscopic investigation of the efficiency of manual and automated instrumentation of the canal. J Endod 2000; 26:660-64.

5. Schafer E. Effects of four instrumentation techniques on curved canals; A comparative study. J Endod 1996; 22:685-89.

6. Thompson SA, Dummer PMH. Shaping ability of profile 0.04 taper series 29 rotary nickel titanium instruments in simulated root canals . Part II Int Endod J 1997; 30:8-15.

7. Peters OA, Schohenberger K, Laib S. Effects of four NiTi preparation techniques on root canal geometry assessed by micro computed tomography. Int Endod J 2001; 34:221-30.

8. Garip Y, Gunday M. The use of computed tomography when comparing NiTi and stainless steel files during preparation of simulated root canals. Int Endod J 2001; 34:457-57.

9. Bramante CM, Berbert A, Borger RP. A methodology for the evaluation of root canal instrumentation. J.Endodon1987; 14:273-77.

10. Tamse A, Pilo R A new muffle model system to study root canal morphology and instrumentation techniques. J Endod 1998; 24:540-42.

11. Kuttler S, Garala Mand.Dorn RPSO. The endodontic cube: A system desibned for evaluation of root canal anatomy and canal preparation. J.Endodon 2001;27:533-36.

12. Schneider SW. A comparison of canal preparation in straight and curved canals. Oral Surg 1971; 32:271-75.

13. LoddTharuni S, Parameswaran A, Sukumar VG. A comparison of canal preparation using the K-file and light speed in resin blocks. J Endod 1996; 22:474-76.

14. AlOmari MAO, Bryant S, Dummer PMH. Comparison of two stainless files to shape simulated root canals. Int Endod J 1997; 300:35-45.

15. Coleman CL, Suel TA. Analysis of NiTi versus stainless steel instrumentation in resin simulated canals. J Endod1997; 23:32-35

16. Cohen S, Burns RC. Pathways of the pulp, & 7th edition. St. Louis USA, C.V. Mosby Co.

17. Roane JB, Sabala CL, Manville C. The balanced force concept for instrumentation of curved canals. J Endod 1985; 11:203-11.

18. Walia H, Brantly WA, Gerstein M. An investigation of the bending and torsional properties of Nitinol root canal files. J Endod 1988; 14:346-51.

19. Bertrand MF, Pergurier L, Medionio E. Curved molar root canal preparation using Hero 643 rotary NiTi instruments. Int EndodJ 2001; 34:631-36.

20. Roig-Cayon M, Brau-Aguade E, Canalda-Sahli C. A comparison of molar root canal preparation using flexo file, canal master U and Heliapical instruments. J Endod 1994; 20:495-99.

21. Glossen CR, Hller RH, Dove B, del Rio C. A comparison of root canal preparation using NiTi hand, NiTi engine driven and K flex endodontic instruments. J Endod1995; 21:146-51.

22. Thompson SA, Dummer PMR. Shaping ability of light speed rotary NiTi instruments in simulated root canals. Part II. J Endod 1997; 23:742-47.

23. Hulsman M, Schade M., Schabis F. A comparative study of root canal preparation with Hero 642 and Quantec SC rotary NiTi instruments. Int Endod J 2001; 34:538-46.

24. Park H. A comparison of greater taper files, profiles and stainless steel files to shape curved root canals. Oral Surg 2001; 91:715-18.

25. Carvalho LAP, Bonetti I, Aurilis M. A comparison of molar root canal preparation using stainless steel and NiTi instruments. J Endod 1999; 25:807-10.

26. Ottosen SR, Nicholis JI, Steiner JC. A comparison of instrumentation using Naviflex and profile NiTi engine driven rotary instruments. J Endod 1999; 25:457-60.

27. Trupin YL, Changneau F, Vuleain JM. Impact of two theoretical cross section on torsional and bending stresses of NiTi root canal instruments model. J Endod 2000; 26:414-17.

28. Thompson A, Dummer PMH. Shaping ability of Hero 642 rotary NiTi instruments in simulated root canals. Part II. Int Endod J 2001; 33:255-61

29. Wildly WL, Semia ES. Montogomery another look at root canal instrumentation Oral Surg 1992;74:499-507.

30. Powell SE, Simon JHS, Maze BB. A comparison of the effect of modified and non- modified instrument tips on apical canal configuration. J. Endod 1986; 12:293-300.

31. Kuhn WG, Carnes DL, Clement DJ. Effect of tip design of NiTi and stainless files on root canal preparation. J Endod 1997; 23:735-38.

Congratulations

Congratulations to Dr. Anil Kohli for being elected as The President, Dental Council of India, which is the highest regulatory body for Dental Education and Practice in the Country.

Dr. Kohli is the President-elect of Indian Endodontic Society, of which he was earlier the Hon. General Secretary as well as the Past-President. He is also the Dental Advisor to the Ministry of Health and Family Welfare, Govt. of India. Dr. Kohli is consultant to several prestigious institutions, such as Armed Forces Medical Services, Border Security Force (BSF), Escorts & Malhotra Heart Institutes, Pushpawati Singhania Research Institute and President Estate clinic to name a few. He is also the Honarary Dental Surgeon to the President of India. He is a Padmashree awardee.

It is a rare honor for Dr. Anil Kohli as the person as well as to the IES, to which he belongs, that he has reached the highest office anybody could hold in the Dental Profession. He assumes the charge when Dental Profession is going through a difficult period. There are the problems of unchecked growth of private dental colleges, falling standards of dental education, non-uniformity in graduate and post-graduate curricula across the country, lack of adequate and well-qualified faculty and eroding of ethics and values in the dental professionals. The profession has high expectations from Dr. Kohli that some of these problems will be tackled to some extent. The IES extends him all the support and wishes him all the Best towards his endeavor to improve the profession and its image.