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COMPARISON OF CROSS-SECTION CHANGES AND CLEANING OF CURVED CANALS PREPARED BY DIFFERENT SYSTEMS

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ABSTRACT

Aim: to evaluate the changes in the canal cross sectional area by using cone beam computed tomography (CBCT) and the cleaning ability of root canals by using stereo microscope and scanning electron microscope.

Materials and methods: a total of 40 extracted mandibular first molar teeth were collected. The curvature of each mesio-buccal canal in each root was determined according to Schneider's technique by using cone beam computed tomography and Roots with angles of curvature ranging from 25-45^{o} were selected. The samples were classified into four groups (10 each) according to the preparatory system used in the preparation. Evaluation of change in cross sectional area was done by using Cone beam computed tomography and Evaluation the cleaning ability of root canals was done by using stereo microscope and scanning electron microscope.

Results: One-shape and Revo-S Ni-Ti rotary systems produced more changes in the canal cross sectional area at all canal levels than Liberator Ni-Ti rotary system and K-file hand instruments. Regarding smear layer scores, all the tested systems were unable to produce dentin surface free from smear layer: Revo-S and Liberator Ni-Ti rotary systems produced less amount of smear layer than One-shape Ni-Ti rotary system and K-file hand instruments at the apical region.

Conclusions: The change in the canal cross sectional area is directly proportional to the amount of debris removal from the canal space with the four tested systems.

INTRODUCTION

Endodontics is defined by the American Association of Endodontics as a branch of dentistry which is concerned with the morphology, physiology and pathology of the human dental pulp and periradicular tissues.(1) When endodontically treating a tooth, the European Society of Endodontology states that root canal treatment success is dependent upon two major factors: cleaning and shaping. (2)

Cleaning pertains to the sufficient removal of debris, bacteria and smear layer from the root canal. (3) Debris is defined as dentin chips and

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residual vital or necrotic pulp tissue attached to the root canal wall. The smear layer is a surface film approximately 1 to 2 μm dentin particles, residual pulp tissue and bacterial components that remain on the root canal wall after instrumentation. Therefore, proper cleaning is essential in order to provide an adequate seal and prevent failure. (4)

Canal shaping remains to be one of the critical aspects of endodontic treatment, particularly when preparing curved canals. Currently, much research is being conducted into the shaping ability of various rotary nickel–titanium instruments when used with high torque and low speed electric motors which provide the precise control necessary with these systems. Initial results have been promising with reports describing the ability of nickel-titanium instruments to maintain canal shape and decrease the time taken for canal preparation compared to hand instruments. (5, 6)

Root canal curvature is an important factor affecting the technical quality of endodontic treatment. An excessive degree of root canal curvature can cause iatrogenic complications such as incomplete removal of pulp debris, instrument separation, post perforation and canal transportation.

Recently Cone beam computed tomography (CBCT) allows determination of root canal curvature and has been advocated for pre-and post-instrumentation evaluation of the changes in the canal cross sectional area. CBCT is a non-destructive technology which provides sub-millimeter high resolution three-dimensional image reconstruction that is highly accurate and quantifiable in axial, transverse and tangent planes. It also allows standardization of the results as it provides accurate repositioning of pre- and post-instrumented samples (7, 8).

So, the present study was conducted to compare the relation between the change in canal cross sectional area and cleaning of root canal system prepared by different systems.

MATERIALS AND METHODS

Selection of samples

Forty freshly extracted mandibular first molar teeth were collected. The teeth were cleaned from soft tissue fragments using scalpel No.15 and the calculus was removed by using ultra sonic scaler. Each tooth was examined radiographically from both buccal and mesial directions to exclude and replace any tooth having abnormalities such as internal resorption, obliteration, pulp stones, cracks and fractures.

The selected teeth were stored in normal saline (0.09%) during the procedures of the experiment.

Determination of root canal curvature

The curvature of mesio-buccal canal in each root was determined according to Schneider's(9) technique by using CBCT (Scanora3D, Soredex , Finland). Roots with angles of curvature ranging from 25-45^{o} were selected.

Classification of samples:

The selected teeth were randomly divided into 4 groups (10 each) according to the preparatory system used in the preparation:

- **Group A:** the mesio-buccal canals of the selected teeth in this group were prepared by One-shape Ni-Ti rotary system (Micro Méga, Besançon, France).
- **Group B:** the mesio-buccal canals of the selected teeth in this group were prepared by Liberator Ni-Ti rotary system (Miltex Inc, York, PA).
- **Group C:** the mesio-buccal canals of the selected teeth in this group were prepared by Revo-S Ni-Ti rotary system (Micro Méga, Besançon, France).
- **Group D:** the mesio-buccal canals of the selected teeth in this group were prepared by K-file hand instruments (Dentsply-Maillefer, Ballaigues,Switzerland).

Irrigation protocol

For irrigating the root canals, a freshly prepared 2.6% sodium hypochlorite solution was used in a 27-Gauge needle. Irrigation was performed by 2 ml of the solution at the start of the instrumentation, after each instrument and at the end of the biomechanical preparation. The penetration of the needle into the canals was adjusted with rubber stopper to 2 mm short of the working length. Finally the prepared canals were washed by 2 ml of distilled water.

Root canal preparation:

The preparation for all of the four systems was done according to the manufacturer's instructions by using 1:16 gear reduction hand piece powered by an electric torque control motor. Preparation of the glide path was done using #10 stainless steel K-type hand file. Removal of coronal constrictions was done using ENDOFLARE (Micro Méga, Besancon, France) and preparation was limited to 3 mm below the pulp chamber floor.

I-Evaluations of changes in the canal cross sectional area

Evaluation of change in cross sectional area was done by using CBCT scanning. Cross sectional area measurement were recorded on the pre-operative and post-operative images of cross-sectional area before and after instrumentation at 3 mm (apical), 6 mm (middle) and 9 mm (cervical), subtracting the pre-operative value from the corresponding post-operative value equals the change in canal cross sectional area.

II- Evaluation of cleaning ability (debris removal) using stereo microscope (Leica Micro system, Germany).

The amount of debris of each prepared root canal was evaluated at three regions (coronal, middle and apical regions) at magnification of x30. Microphotographs were taken for all the prepared canals and rated in double blind method by two trained operators and classified by means of modifications applied to the numerical evaluation scoring system of **Paque et al.** [10]

- Score (0) Clean root canal and only few small debris particles are present.
- Score (1) few small islets of debris covering less than 25% of the root canal wall.
- Score (2) many accumulations of debris covering 25-50% of the root canal wall.
- Score (3) More than 50% of the root canal wall is covered by debris.

III-Evaluation of cleaning ability (presence or absence of smear layer) using CBCT (JEOL, JSM-5300, Japan).

Scanning electron microscope (SEM) observations were obtained for statistical analysis, at magnification of x3500 and microphotographs were taken for all the samples of the four groups and rated in double blind method by two trained operators and classified by means the numerical evaluation scoring system of **Rome et al.** [11].

- Score (0) No smear layer and all dentinal tubules are open.
- Score (1) Minimum smear layer and more than 50% of dentinal tubules are open.
- Score (2) Moderate smear layer and less than 50% of dentinal tubules are open.
- Score (3) Heavy smear layer and the outline of dentinal tubules is obliterated.

RESULTS

I- Evaluation of cross sectional area changes at different regions of canals prepared by four different systems

1. One-shape Ni-Ti rotary system:

The difference between radicular regions was statistically significant as indicated by one way

ANOVA test ($p<0.05$). Pair-wise Tukey's post-hoc test showed no significant ($p>0.05$) difference between ***middle*** and ***apical*** regions, as shown in Fig. (1).

2. Liberator Ni-Ti rotary system:

The difference between radicular regions was statistically significant as indicated by one way ANOVA test ($p<0.05$). Pair-wise Tukey's post-hoc test showed no significant ($p>0.05$) difference between ***middle*** and ***apical*** regions, as shown in Fig. (1).

3. Revo-S Ni-Ti rotary system:

The difference between regions was statistically significant as indicated by one way ANOVA test ($p<0.05$). Pair-wise Tukey's post-hoc test showed non- significant ($p>0.05$) differences between ***apical*** and ***middle*** regions, as shown in Fig. (1).

4. k-file hand instruments:

The difference between regions was statistically significant as indicated by one way ANOVA test ($p<0.05$) followed by pair-wise Tukey's post-hoc test, shown in Fig. (1).

II-Evaluation of cleaning ability (debris removal) at different regions of canals prepared by four different systems

1. One-shape Ni-Ti rotary system:

The difference between regions was statistically non-significant as indicated by one way ANOVA test ($p>0.05$), as shown in Fig. (2).

2. Liberator Ni-Ti rotary system:

The difference between regions was statistically significant as indicated by one way ANOVA test ($p<0.05$). Pair-wise Tukey's post-hoc test showed non-significant ($p>0.05$) differences between (cervical and middle) regions, as shown in Fig. (2).

3. Revo-S Ni-Ti rotary system:

The difference between regions was statistically non-significant as indicated by one way ANOVA test ($p>0.05$), as as shown in Fig. (2).

4. k-file hand instruments:

The difference between regions was statistically significant as indicated by one way ANOVA test ($p<0.05$). Pair-wise Tukey's post-hoc test showed non-significant ($p>0.05$) differences between ***cervical*** and ***middle*** regions, as shown in Fig. (2).

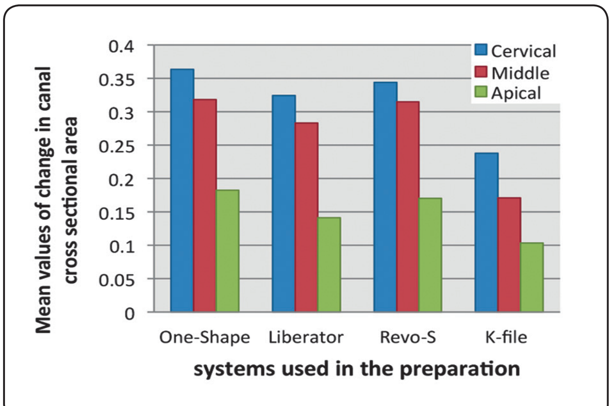

Fig. (1) A histogram of mean values of cross sectional area changes of different regions of the canals prepared by each tested systems.

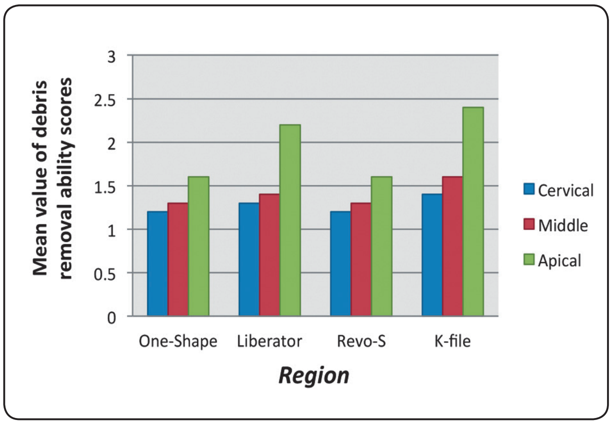

Fig. (2) A histogram of mean values of debris removal scores of different regions of the canals prepared by each tested systems.

III- Evaluation of cleaning ability (presence or absence of smear layer) at different regions of canals prepared by four different systems

1. One-shape Ni-Ti rotary system:

The difference between radicular regions was statistically significant as indicated by one way ANOVA test (p<0.05) followed by pair-wise Tukey's post-hoc test, as shown in Fig. (3,4).

2. Liberator Ni-Ti rotary system:

The difference between regions was statistically significant as indicated by one way ANOVA test (p<0.05). Pair-wise Tukey's post-hoc test showed non-significant (p>0.05) differences between ***cervical*** and ***middle*** regions, as shown in Fig. (3,5).

3. Revo-S Ni-Ti rotary system:

The difference between regions was statistically significant as indicated by one way ANOVA test (p<0.05). Pair-wise Tukey's post-hoc test showed non-significant (p>0.05) differences between ***apical*** and ***middle*** regions, as shown in Fig. (3,6).

4. k-file hand instruments:

The difference between regions was statistically significant as indicated by one way ANOVA test (p<0.05) followed by pair-wise Tukey's post-hoc test, as shown in Fig. (3,7).

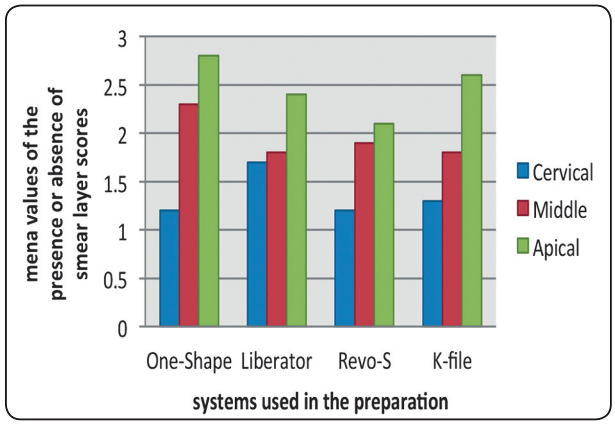

Fig. (3) A histogram of mean values of presence or absence of smear layer scores of different regions of the canals prepared by each tested systems.

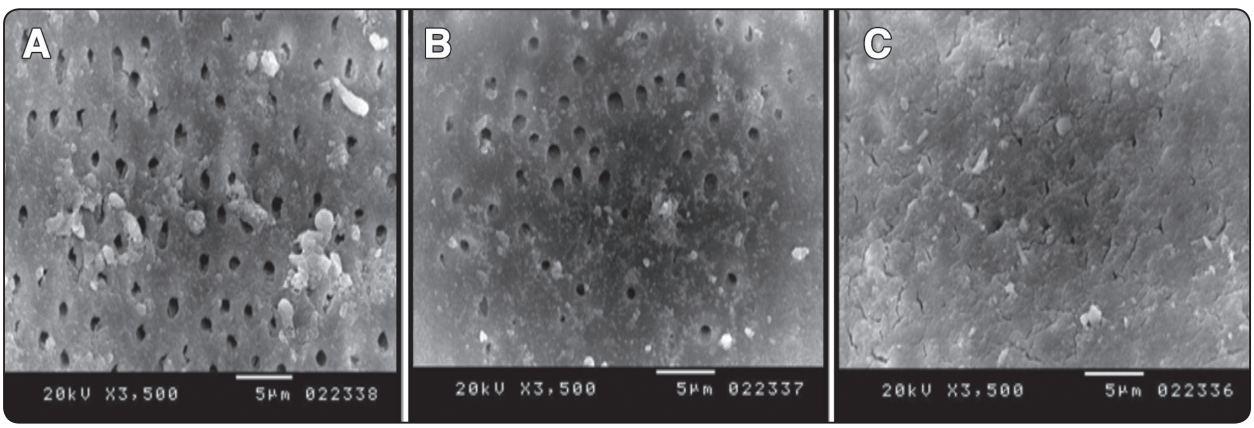

Fig. (4) SEM microphotographs for canals prepared by One-shape Ni-Ti rotary system at cervical third (A) showing score = 1, middle third (B) showing score = 2 and apical third (C) showing score = 3

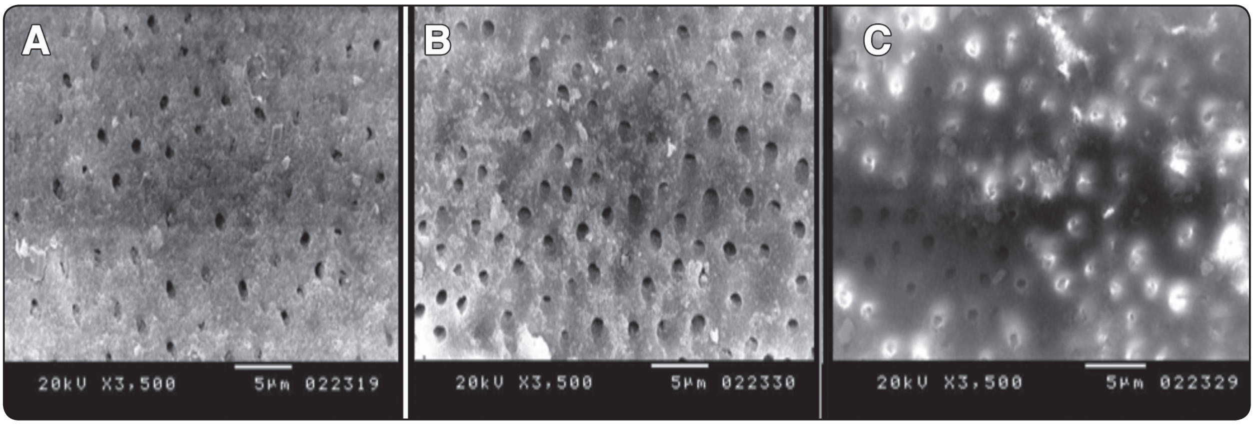

Fig. (5): SEM microphotographs for canals prepared by Liberator Ni-Ti rotary system at cervical third (A) showing score = 2, middle third (B) showing score = 2 and apical third (C) showing score = 3

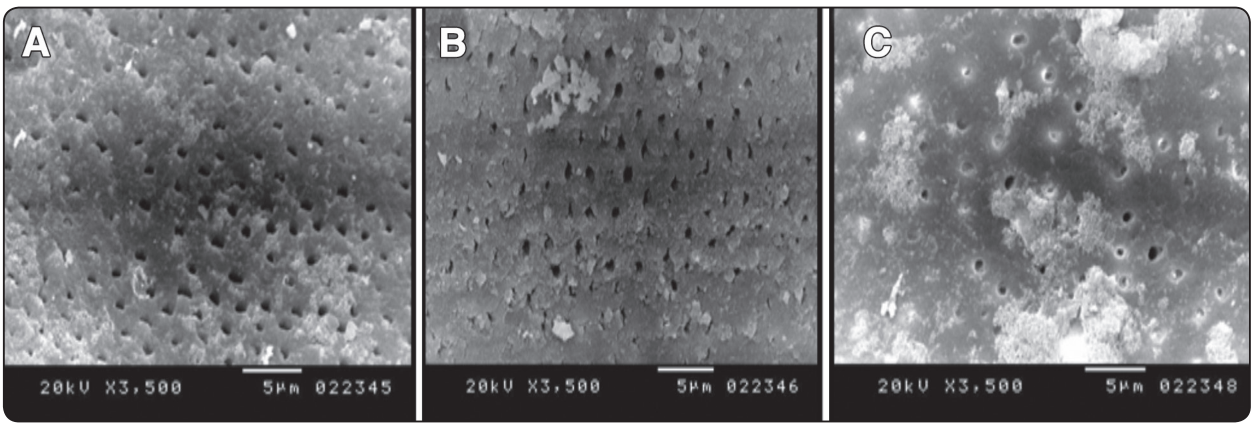

Fig. (6): SEM microphotographs for canals prepared by Revo-S Ni-Ti rotary system at cervical third (A) showing score = 1, middle third (B) showing score = 2 and apical third (C) showing score = 3

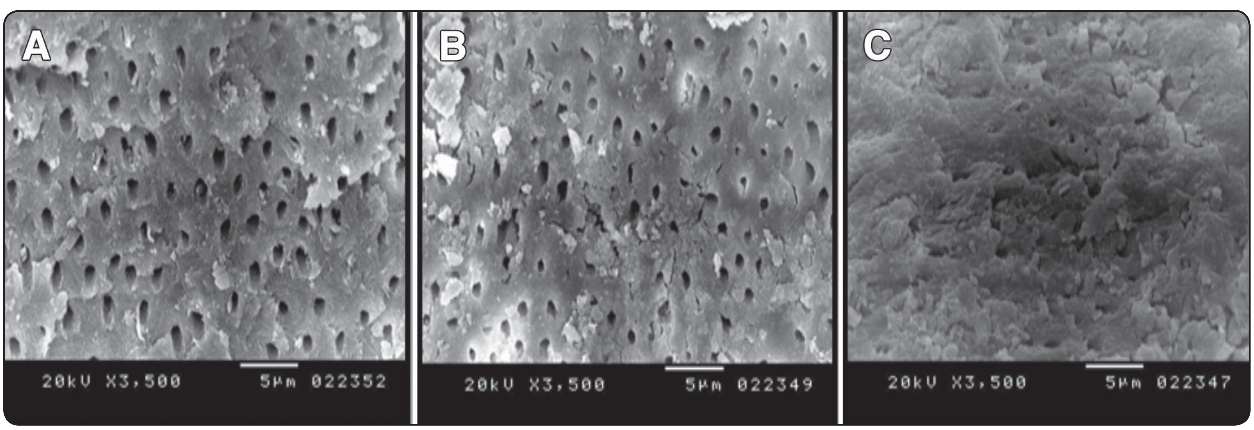

Fig. (7): SEM microphotographs for canals prepared by K-file hand instruments at cervical third (A) showing score = 1, middle third (B) showing score = 2 and apical third (C) showing score = 3

DISCUSSION

The results of this study were greatly attributed to the design, taper and cross section of the instruments used. The idea of an instrument able to improve this upward removal of debris and to optimize the root canal cleaning is motivated by the development of new Ni-Ti files thus upgrading the feature of the previous instrument designs. The upward removal of dentinal debris depends on the characteristics of the main cutting edges on the active part of the instrument, the spacing between two edges (pitch length), the depth of the grooves and the orientation of the edges (helix and cutting angles) [(12)].

The results of One-shape may be attributed to its unique design which incorporates a variety of different cross sections along the active length of the file which offers an optimal and improved cutting action in three zones of the root canal and also its electro-polishing enhanced cutting efficiency[(13)] or to the 2-cutting-edge zone on the instrument coronal portion which offers optimal cutting and extricating action for upward debris removal and the variability in pitch and helix angle as claimed by the manufacturer.

The slight difference between One-shape and Revo-s is greatly attributed to the similarities between their designs especially at the coronal part of the canal [(14)]. But the lower results of smear layer formation by Revo-S may be due to the additional innovating parameters which are the asymmetrical cross-section and the 0% taper of 13 mm in coronal and middle of the working part of AS30 and AS35 decreasing the area of contact between the instrument and the canal , therefore decreasing amount of smear layer formed.

The results of cleaning ability were in agreement with ***Poggio et al*** [(15)] who found that Revo-S both presented very low smear layer scores and open tubules scores, with no significant difference among coronal, middle and apical thirds and ***Celik et al*** [(16)] who stated that there was statistically significant difference found between the coronal third and the middle thirds while higher amount of debris and smear layer were found in apical third.

Liberator showed the least change in canal cross sectional area and debris removal ability among Ni-Ti instruments and this may be attributed to the non fluted (straight-fluted) instrument that decreases its ability to cut dentin and engage debris to remove it in a coronal direction [(17)]. Also it rotates in higher rpm (1000-2000) rpm according to the manufacturer's instructions) in which it can't push the debris from the apical region and may pack smear layer.

The results were in agreement with ***Vazhiyodan et al*** [(18)] who found that Liberator was unable to produce clean surfaces form debris.

Stainless steel hand k-files showed the least amount of change in CSA aiming to its small taper and the hindered cutting ability of manual systems in comparison with rotary systems and consequently the least amount of debris removal.

The cleaning results were in agreement with ***Ashutosh et al*** [(19)] who found that Ni-Ti ProTaper showed lower smear layer scores than K-file in the coronal and middle thirds, ***Huang et al*** [(20)] who found that the results regarding the amount of debris and smear layer remaining in the middle and coronal thirds for both ProTaper groups achieved better results than the k-file groups and there was no significant difference between the two ProTaper groups , while in the apical region there was no significant difference in debris and smear layer among the three groups and ***Rao et al*** [(21)] who found that there was no significant difference between k-files and hand ProTaper regarding smear layer removal but, there was significant difference between rotary ProTaper and both k-files and hand ProTaper.

CONCLUSIONS

1) One-shape and Revo-S Ni-Ti rotary systems produced more changes in the canal cross sectional area at all canal levels than Liberator Ni-Ti rotary system and K-file hand instruments. The change in canal cross sectional area is directly proportional to the amount of debris removal from the canal space with the four tested systems.

2) All the tested systems were unable to produce dentin surface free from smear layer: Revo-S and Liberator Ni-Ti rotary systems produced less amount of smear layer than One-shape Ni-Ti rotary system and K-file hand instruments at the apical region.

REFERENCES

1. Guelzow A., Stamm O., Martus P. and Kielbassa A.M.: Comparative study of six rotary nickel-titanium systems and hand instrumentation for root canal preparation, Int. Endo. J., 38: 743-52, 2005.

2. Bechelli C., Zecchi S. and Colafranceschi M.: Scanning electron microscope study on the efficacy of root canal wall debridement of hand versus Lightspeed and #153; instrumentation,Int. Endo. J., 32:484-93, 1999.

3. Tronstad L.: Clinical Endodontics, Thieme Medical Publication, 2002.

4. Weine F.S.: Endodontic Therapy (6th edition), Mosby Publishing, 2003.

5. Esposito P.T. and Cunningham C.J.: A comparison of canal preparation with nickel–titanium and stainless steel instruments, J. of Endo. , 21: 173–6, 1995.

6. Glosson C.R., Haller R.H., Dove S.B. and Delrio C.E. .: A comparison of root canal preparations using Ni–Ti hand, Ni–Ti engine-driven and K-Flex endodontic instruments, J. of Endo., 21:146–51, 1995.

7. Yu X., Guo B., Zhang R., Tian YY. and Wang H.: Cone-beam computed tomography study of root and canal morphology of mandibular premolars in a western Chinese population. BMC Med Imaging, 12:18, 2012.

8. Weng XL., Yu SB., Zhao SL., Wang HG., Mu T. and Tang RY.: Root canal morphology of permanent maxillary teeth in the Han nationality in Chinese Guanzhong area: a new modified root canal staining technique. J. Endod., 35:651-6, 2009.

9. Schneider SW., Austin and Texas: A comparison of canal preparations in straight and curved root canals. Oral Surg. Oral Med. Oral Pathol., 32:271-5, 1971.

10. Paque F., Musch U. and Hulsmann M.: Comparison of root canal preparation using RaCe and ProTaper rotary Ni-Ti instruments. Int. Endod. J., 38:8-16, 2005.

11. Rome WJ., Doran JE. And Walker WA.: The effectiveness of Gly-Oxide and NaOCl in preventing smear layer formation. J. Endod., 11: 281-8, 1985.

12. Mallet J.P.: An Instrument Innovation for primary endodontic treatment: the Revo-S Sequence. Smile Dent. J., 2009.

13. Gernhardt C. R.: One-shape - a single file Ni-Ti system for root canal instrumentation used in continuous rotation. Endod. Pract. Tod., 7: 211-16, 2013.

14. Ruiz HE., Gutman JL. and Wagner MJ.: A quantitative assessment of canal debris forced periapically during root canal instrumentation using two different techniques. J. Endod., 12:554-58, 1987.

15. Poggio C., Dagna A., Chiesa M., Beltrami R. and Colombo M.: Ultra-structural analysis of the root canal walls after preparation with two rotary nickel-titanium endodontic instruments. Cont. Clin. Dent., 5:357-60, 2014.

16. Celik D., Taşdemir T. and Er K.: Comparison of influence of different manufacturing methods on the cleaning efficiency of rotary nickel-titanium files. Mic. Res. Tech., 76:231-6, 2013.

17. De Oliveira DP., Barbizam JV. , Trope M. and Teixeira FB.: Comparison between gutta-percha and resilon removal using two different techniques in endodontic retreatment. J Endod., 32:362-4, 2006.

18. Vazhiyodan A., Rao SR., Padmanabhan P., Pragada NL. and Lata DA.: comparison of root canal cleaning ability of protaper and liberator rotary Ni-Ti instrument systems. Int. J. of Cont. Dent., 2, 2011.

19. Ashutosh, Aseem P., Tikku, Anil C., Promila V. and Rakesh KY.: In vitro evaluation of root canal preparation with plastic endodontic rotary finishing file. A.J. instit. of dent. Sci. mang., 24:30-34,2012.

20. Huang QL., Zhang XQ. , Deng GZ. and Huang SG. : SEM evaluation of canal cleanliness following use of protaper hand-operated rotary instruments and stainless steel k-files, the Chin. J. of dent. Res., 2009.

21. Rao A., Kamath P., Kundabala M. and Shetty K.: Smear Layer evaluation after root canal instrumentation with manual and rotary techniques. Int. J. of Adv. Res., 2: 447-453, 2014.