The flaring efficiency of the Profile and Protaper on resin simulated root canals

Qussay A. Al-Jawhar , M.Sc.*

Abstract:

Forty resin simulated root canals with standardized curvature prepared for this study, divided into four groups ten canals for each group. Thirty canals were prepared with rotary endodontic instruments, profile 04, profile 04, 06 and protaper, ten canals for each type, with slow speed contra angle hand piece (300 rpm) using crown – down technique the other 10 canals were prepared with stainless steel k-flexo hand instrument using step – back technique. The total time required for preparation was calculated. The resin blocks were scanned; the pre-instrumented and post-instrumented images were stored in the computer and superimposed for two dimensional evaluation of canals preparation using Adobe photoshope 8.0 and Corel draw 9. For the coronal portion the amount of canal substance removed was calculated at 7mm, 9mm, 11mm levels from the working length. For the apical curvature the centering ratio was calculated at 2mm and 4mm level from the working length. The results showed that the amount of canal substance removed from the coronal portion by protaper was statistically higher than other groups with statistically less ability to stay center in the canal than profile rotary instruments but more ability to preserve apical curvature than k-flexo hand instruments with less time required for preparation. K-flexo files showed statistically less amount of canal substance removal at coronal portion and statistically higher centering ratio than other groups, and require more time for canals preparation.

Keywords:

Profile, protaper, apical curvature.

Introduction:

The main objectives of root canal preparation is to produce clean canal and shaping of the canal to form a continuously taper conical, funnel shape to receive the root canal filling and to provide space for endodontic instrument used during filling procedure, but the original configuration of the canal should be maintained.[1] The root canal shaping procedure is complex when relatively nontapered instruments are used to create tapered root canal shape.[2]

The use of stainless steel hand instruments found to cause canal aberrations (zip, ledge and perforation) [2], that is leads to the development of NiTi endodotic instruments. Since the end of 1980s files made from NiTi become available [3], which have more elastic flexibility and superior resistance to fracture, relatively maintaining original canal curvature and less aberrations in comparison with similar size stainless steel file [4].

The recent introduction of rotary instruments made from NiTi with different design and taper found to be effective to overcome problems associated with hand instruments like zipping, elbow, perforation and loss of working length [5,6].

Many types of rotary instruments is know available in the market like:

*Assistant Lecturer in the Department of Conservative, College of Dentistry, University of Al-Mustansiria.

profile taper 04 and taper 06, profile GT, Quantec and Protaper. In response to the problems associated with step back technique, The rotary instrument recommended to be used with crown – down technique which involve preparation of the canal from the cervical aspect to the apex rather than classical aspect from the apex to the crown. The main advantages of crown – down technique: 1- enhanced apical movement of instruments into the canal 2- increased space for irrigant penetration and debridement. 3-limination of coronally placed interferences 4-enhanced movement of debris coronally. [7,8]

There have been many reports about the effectiveness of rotary instruments when shaping either simulated resin blocks or extracted human teeth with curved root canal [5,9-11]

The aim of this study is to evaluate the efficiency of protaper and profile NiTi rotary instruments to prepare the resin simulated curved root canals through assessment of removal of canal substance in the coronal portion, the ability of the instrument to stay center in the canal and preserve the apical curvature, and total instrumentation time compared with stainless steel hand instruments.

Materials and Methods

Forty resin simulated root canals were constructed (Fig. 1) using #20 silver points as a mold this allowed the #15 endodontic file to fit to the working length. The total length of the canal is 14 mm long. A C-shape curvature was made and started 8 mm from the orifice (curved part 6 mm length) , with approximately 30 degree curvature determined by Pruett et al , modification of Schneider method [12]

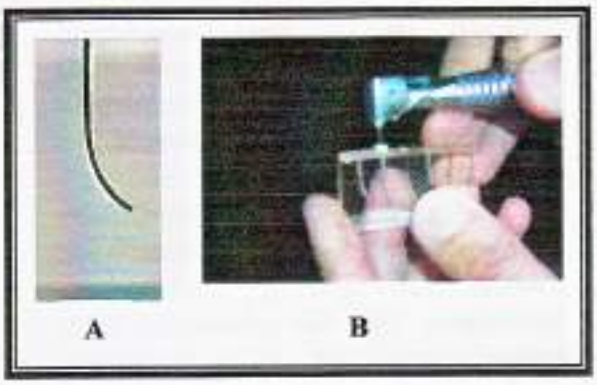

Fig. (1): (A) Composite image of the simulated resin canal , the blak line is the origianl canal , while the white line is the final preparation of the canal using protaper. (B) Resin Simulated canals.

Preparation of simulated canals

The canals where divided into Four groups each group with 10 resin simulated canals. Thirty canals were prepared with rotary endodotic instruments profile taper.04 , profile taper .06 (Dentsply Maillefer, Switzerland) and protaper (Dentsply Maillefer, Switzerland) using high torque contra angle hand piece (INTRAsurg500, Kavo, Germany) (Fig.2) at speed of (300 rpm). Crown – down technique was used for canals preparation with rotary instruments according to the recommended sequences of the manufacturers until the apical portion of the canal achieve size 30. The profile and protaper instruments were coated with Glycerin as a lubricant (one rotary file is coated with 10-13 mg of lubricant).

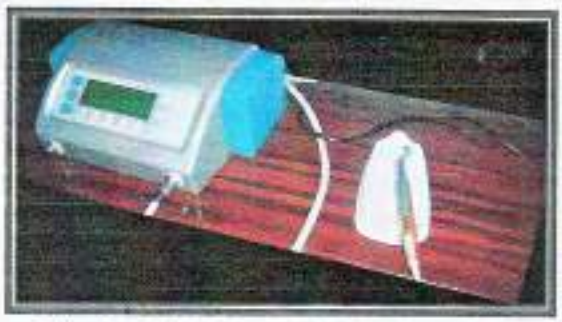

Fig (2): INTRAsurg500, device with contra-angle hand piece used in this study.

Each set of rotary instrument prepared 3 canals. The range for using rotary instruments properly without any defects was recorded between 3-5 canals. [13,14]

Ten canals was prepared with stainless steel K-flexofile (maillefer, Switzerland) using step-back technique. The file discarded after preparing one canal.

Irrigation was performed for all canals during preparation through the use of distilled water dispensed by insulin syringe with 27 gauge needle, 4ml of water dispensed after the use of each instrument.

Gates-Glidden drill were not used for all groups to see only the effect of files used.

After instrumentation the canal was dried with paper point.

The preparation of all canals started with k-flexo file size 15 with rubber stopper adjusted to full working using some filing action just to ensure all canals were opened.

Group 1

Ten resin simulated canals were prepared with profile 04 taper, with Crown – down technique, the first instrument introduce to the canal is #25 to about two third to half of the length using slow speed hand piece (300 rpm) with law pressure applied, till the resistance felt, then the profile instrument removed from the canal with force applied on the walls, after than size #30 instrument to the same length and with the same manner. This was for the preparation of coronal portion of the canal , for the apical portion #15 profile introduced to the full working length followed by #20 , #25 and size #30 used sequentially. If one instrument is failed to reach the working length the previous size was used.

Group 2

Ten resin simulated canals were prepared with profile 04 taper and 06 taper. Using a law speed hand piece (300 rpm) a profile #25 taper 06 is used to about 1/2 of the canal followed by #25 taper 04 to about 2/3 of the canal in crown - down manner, this is to prepare the coronal portion of the canal , for the apical portion, profile #15 taper 04 used to the working length followed by profile #20 taper 04 , #20 taper 06, #25 taper 04, #25 taper 06, #30 taper 04 , #30 taper 06 sequentially used to the full working length. All should be used with light apical pressure similar to the amount of pressure exerted when writing with a very sharp lead pencil. If one instrument is failed to reach the working length the previous size was used.

Group 3

Ten resin simulated canals were prepared with protaper rotary instrument using a low speed hand piece (300 rpm) with crown – down technique. For coronal portion of the canal start with shaping file S1 (Purple colored) to achieve straight line access with brushing movement once resistance felt remove the file and force against the canal walls on its removal this action performed just to removed any cervical interference. A stainless steel k-flexo file #15 is used to working length to break up any debris and to re-confirm the working length, after that Shaping file SX is used with the same manner. When the canal is patent and working length is confirmed shaping file S1 is reused to the working length with brushing motion, followed by shaping file S2 (with white colored ring) used with the same manner till it reached the working length , followed by irrigation and recapitulation.

The apical portion is prepared with finishing files , first start with F1 file

(with yellow ring) to working length its tip size equal to #20 file followed by F2 file (with red ring) to the working length . finally use F3 file (with blue ring) is used to working length its tip size equal to #30 file, with that instrument the preparation of the apical portion is completed. (Fig.1)

Group 4

Ten resin simulated canals were prepared with K-flexo files using ordinary step – back technique, all the files used to prepare the apical portion precurved before use, started with #15 hand file to the working length with filing action till it fits loosely to the canal, this procedure is repeated with #20, #25 till #30 is used to prepare the apical part of the canal. Step back filing was performed by using one size of file larger then the previous size adjusted to 1mm shorted than the previous size until #60 is used to approximately the middle of the canal length. Always #30 is used to working length to recapitulate the canal.

Methods used for Evaluation of Canals Preparation

1- Preparation Time

The total time of canal preparation was recorded in minutes. This included the active instrumentation, irrigation and time used to exchange the instruments.

2- Evaluation of apical and coronal portion preparation

Before preparation the resin canals were filled with drawing ink with 27 gauge needle and syringe, the resin blocks were labeled and scanned with high resolution scanner (GenX) and the images were stored in computer hard disk. After preparation of the canals, they were filed with ink and scanned again with the same resolution and same size and stored in the hard disk.

Image analyis using Adobe photoshope 8.0, Raster Vector 6.8, Corel draw 9 softwares.

The pre-instrumented and post-instrumented images were superimposed this depends on a label put on each resin block to act as a guide for that purpose.

For coronal portion preparation assessment of the amount of coronal substance removed in all canals was calculated two-dimensionally using corel draw software measuring the greatest distance between the edge of each instrumented canal and the corresponding edge of uninstrumented canal on both sides at three levels 7mm, 9mm, 11mm from the working length (from the apex of the canal) after using Raster Vector software to convert the canal image to Vectors to facilitate measurement by magnification of the image 10 times without affecting the resolution.

For the apical curvature the mean centering ratio (which is the ability of the instrument to stay centered in the canal) is calculated to compare the shaping ability of four groups at 2mm ,4mm from the working length, , the smaller the ratio the better the instrument to stay centered in the canal.

The centering ratio was calculated at each level by this formula (X1-X2/Y). X1 is the maximum extend of canal preparation on one direction, X2 canal extend in opposite direction , Y is the diameter of final canal preparation. [15]

Results:

Preparation Time

The mean instrumentation time showed in table (1). There were no significant difference between profile taper 04 (group1), and profile taper 04, 06 (group 2) ($P>0.05$). Protaper showed statistically less preparation time than other groups ($P<001$), while

step back with k-flexo files (group 4) showed statistically highest time required for preparation of canals than other groups (P<0.001).

Table (1): total canal preparation mean time required for all groups.

Groups		Mean time (Minutes)
1	Profile .04 taper	6.27
2	Profile .04, .06 taper	6.51
3	Protaper	5.12
4	Step back (k-flexo)	12.57

Preparation of canals coronally

The mean, standard deviation, minimum and maximum values of the amount of coronal substance removed by four types of endodontic instruments used in this study are shown in table (2) Fig. (3), at 7mm, 9mm and 11 mm from the working length. Using one way ANOVA revealed that at 7mm the mean differences between the four groups was statistically significant (P<0.05), while at 9mm, 11m , the mean differences between groups were very highly significant (P<0.001). Paired t-test was used to compare the mean between each pair of groups, table (3).

Table (2): Descriptive statistics for the amount of canal substance removed by four groups at 7mm, 9mm and 11mm.

Groups	Levels	Min. /mm	Max./mm	Mean	S.D
Group 1 Profile 04	7mm	0.109	0.348	0.270	0.075
	9mm	0.211	0.358	0.290	0.050
	11mm	0.211	0.422	0.309	0.063
Group 2 Profile 04,06	7mm	0.118	0.412	0.295	0.098
	9mm	0.195	0.555	0.374	0.117
	11mm	0.264	0.580	0.397	0.100
Group 3 Protaper	7mm	0.219	0.589	0.417	0.135
	9mm	0.298	0.679	0.540	0.133
	11mm	0.378	0.688	0.579	0.097
Group 4 K-flexo	7mm	0.000	0.328	0.181	0.134
	9mm	0.060	0.334	0.195	0.106
	11mm	0.067	0.423	0.212	0.126

Preparation of the canal apically

The centering ratio was measured for all groups at two levels 2mm and 4mm from the working length. The mean, standard deviation, minimum and maximum values are seen in table (4) Fig (4). ANOVA test showed statistically very highly significant differences between all groups at both levels (P<0.001). Paired t-test was performed to compare the mean centering ratio between each pair of groups Table (5).

Table (3): Paired t-test to compare the mean of the amount of canal substance removed by the four groups at 7mm, 9mm and 11mm levels between each pair of groups.

Groups		7mm	9mm	11mm
Group 1 vs. group 2	t value	-0.525	2.547	-2.373
	Significance	NS	*	*
Group 1 vs. group 3	t value	-2.895	-5.332	-9.003
	Significance	*	***	***
Group 1 vs. group 4	t value	2.109	2.642	2.160
	Significance	NS	*	NS
Group 2 vs. group 3	t value	-2.024	-2.299	-3.592
	Significance	NS	*	**
Group 2 vs. group 4	t value	2.699	5.065	4.087
	Significance	*	**	**
Group 3 vs. group 4	t value	3.323	5.639	7.272
	Significance	**	***	***

NS: Non significant difference (P>0.05),
*significant difference (P<0.05),
**highly significant difference (P<0.01),
*** : very highly significant difference (P<0.001).

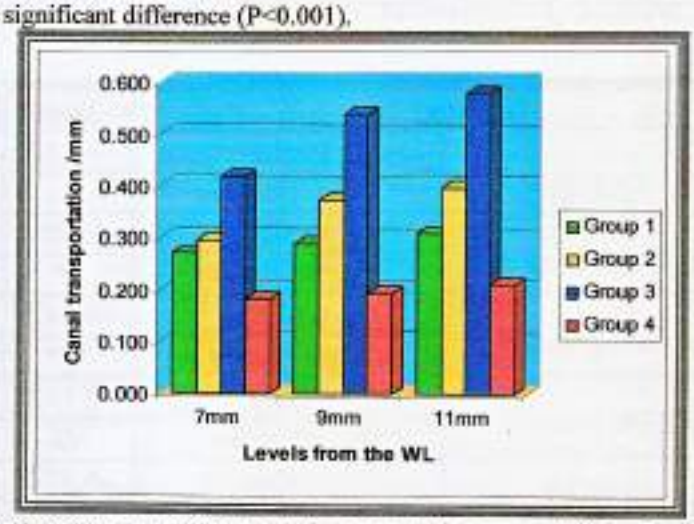

Fig. (3): Bar chart showing the differences in mean of the amount of canal substance removed by four groups at 7mm, 9mm and 11mm.

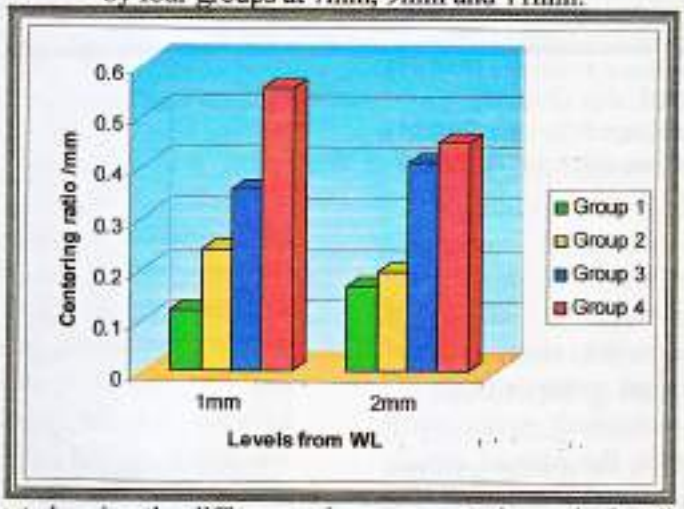

Fig. (5): Bar chart showing the differences in mean centering ratio for all groups at 2mm and 4mm.

Table (4): Descriptive statistics of centering ratio for all groups at 2mm and 4mm.

Groups	Levels	Min. /mm	Max./mm	Mean	S.D
Group 1 Profile 04	2mm	0.101	0.142	0.118	0.0112
	4mm	0.010	0.310	0.165	0.0920
Group 2 Profile 04,06	2mm	0.109	0.418	0.238	0.1192
	4mm	0.112	0.381	0.194	0.1006
Group 3 Protaper	2mm	0.187	0.631	0.356	0.1563
	4mm	0.139	0.629	0.410	0.1793
Group 4 K-flexo	2mm	0.287	0.748	0.554	0.1641
	4mm	0.221	0.638	0.448	0.1411

Table (5): Paired t-test to compare the centering ratio for the four groups at 2mm, and 4mm between each pair of groups.

Groups		2mm	4mm
Group 1 vs. group 2	t value	-3.142	-0.319
	Significance	*	NS
Group 1 vs. group 3	t value	-5028	-3.880
	Significance	**	**
Group 1 vs. group 4	t value	-8.382	-4.910
	Significance	***	*
Group 2 vs. group 3	t value	-2.167	-4.152
	Significance	NS	**
Group 2 vs. group 4	t value	-5.377	-6.716
	Significance	***	***
Group 3 vs. group 4	t value	-2.441	0.538
	Significance	*	NS

NS: Non significant difference (P>0.05),
*significant difference (P<0.05),
**highly significant difference (P<0.01),
***very highly significant difference (P<0.001).

Discussion:

The main objective of canal preparation to create clean tapered canals without apical transportation [16] ,this could be achieved easily with straight canal ,with the curved canals the preparation should enlarge the canal, while maintaining the original path without apical zipping , ledge and/or perforation., this study was to compare the ability of two endodontic rotary instruments, profile and protaper and one hand instrument stainless steel k-flexo file in preparing the resin simulated curved canals by assessment the coronal substance removed to reflect the cleanness and taper of

prepared canal ,and the centering ratio was calculated to give idea about the ability of the instrument to remove canal substance equally on both sides in the apical one third of the canal to preserve the curvature while enlarging of the canal.

Resin simulated root canals were used in this study to produce standardized simulation of root canal with shape, size , taper and curvature, which have been used by other studies[4,17].

The evaluation of the shaping ability in the coronal and apical portion by using image analysis method was used by different studies [4,18], through scanning of the canals, convert them to vectors, and calculation the transportation of the canal after superimposition of pre-instrumented over post-instrumented canals using image analysis software (Adobe photoshope, Corel draw).

Preparation of the canals with most rotary instruments using contra angle hand piece at low speed ranged between 150 – 350 rpm [16], in this study the resin canals were prepared at 300 rpm speed with crown – down technique as recommended from the manufacturer.

The results of this study showed that the time used to prepare the canal with rotary instrument is less than with hand instrument and the protaper required statistically less time and effort to prepare the canals than profile rotary instrument this findings is agreed with other findings [16,19] while k-flexo file exhibited statistically higher time of canal preparation because it needs more effort and pressure exerted during preparation [5].

Removal of canal substance in the coronal portion compared between all groups at three selected levels (7mm, 9mm, 11mm) from the working length. The result showed that protaper and profile rotary instruments produced more canal enlargement coronally than stainless steel k-flexo hand file (group 4), this due to the design of rotary instrument with large taper (0.02 – 0.19) for protaper, (0.04 – 0.06 for profile) than the k-flexo file which has a fixed taper over the working area of the file, but there was statistically non significant difference between group 1 (profile 04) and group 4 (k-flexo file) at 7mm and 11mm.

The result showed that protaper (group 3) produced more canal enlargement coronally than profile 04 (group 1) and profile 04,06 (group 2) which was statistically significant, except at 7mm level it was non significant difference between protaper and profile 04, 06. The cutting efficiency of protaper is more than profile rotary instrument, the reason is the presence of variable helical angle in protaper and constant helical angle in profile the *helical angle* is the angle that the cutting edge makes with long access of the file [20]. The cutting efficiency is more with this angle is variable along the file than if it is constant [21]. Also the convex triangular cross section design of the cutting blade of the protaper file increases the cutting efficiency [19]. The taper of protaper found to be 0.02 to 0.19%[22] and this greater than other file to the same level of the root canal, which result in greater increase in canal width.

Profile 04, 06 (group 2) remove more form coronal substance at all selected level than profile 04 (group 1) but statistical analysis exhibited a non significant difference between both groups only at 7mm level. This due to the use of profile instrument with larger taper 06 in the coronal portion.

The centering ratio was calculated at 2mm and 4mm level from the working length to evaluate the ability of the instrument to stay center in the canal at apical portion the smaller the

ratio the better the ability to remove from the canal substance on both side preserving the apical curvature. According to the result of this study the hand instrument with step back technique exhibited a statistically largest centering ratio than other groups (rotary instruments) this because the rotary nickel titanium files have greater flexibility than stainless steel k-flexo hand file, this may cause the k-flexo file to remove excessive resin from the outer aspect of the canal at the apex of the curve which was often associated with irregular widened areas [23]. The statistical analysis revealed that there was non significant difference in centering ratio between protaper (group 3) and k-flexo file (group 4) at 4mm level but significantly higher centering ratio for k-flexo file than protaper at 2mm. This result was concord with other reports[5,24].

Comparing profile and protaper rotary instrument, profile showed statistically less centering ratio than protaper which means the ability of profile to stay center in the canal is better than protaper at 2mm and 4 mm level, the reason for that is the presence of radial land (three land) and the non cutting tip in the profile and the absence of radial land for protaper, the radial land is the surface that project axially from the central axis, between flutes as far as the cutting edge, Radial land when combined with non cutting tip is believed to keep the file centered in the canal which in turn lead to minimal canal transportation. [20]. This result is agreed with other report[19]. The statistical analysis show that the difference was significant between protaper (group 3) and profile 04 (group 1) at both levels, but no significant difference was found between protaper (group 3) and profile 04, 06 (group 2) at 2mm.

The result also showed that the use of profile 06 with taper 04 (group 2) affect the centering ratio which was statistically higher than for profile 04 (group 1) at 2mm level and non significant difference was found at 4mm level. This due to the use of additional stiffer profile 06 with profile 04 taper than using more flexible 04 profile alone [25,26].

This study was conducted to give an idea about the quantitative analysis of the shaping ability of profile and protaper rotary instruments using simulated canals calculated in two dimensions on digitized image. Those instruments should be further tested quantitatively and qualitatively using three dimension evaluations.

Conclusions:

Under the condition of this study it was concluded that:

1-Protaper rotary instrument has more cutting efficacy than profile rotary instrument in the coronal portion of the canal, with less time and effort required for canal preparation.

2-Profile .04 rotary instruments have more ability to stay center in the apical portion of the canal preserving the canal shape in curved canal than protaper.

3-The use of profile taper .06 with 0.4 in the apical portion affects the original curvature of the canal.

4-The use of stainless steel hand instrument removes less canal substance in the coronal portion and has less ability to stay center in the canal in apical curvature with more time and effort required during preparation compared with profile and protaper groups.

References:

1. Schnilder H: Cleaning and shaping the root canal. Dent Clin North Am 1974;18:269-296.

2. Buchanan LS: The standardized-taper root canal preparation-part 1: concepts for variably tapered shaping instruments. Int Endod J 2000; 33:516-529.
3. Walia H, Brantly WA, Gerstein H: An initial investigation of bending and torsion properties of nitinol root canal files. J Endod 1988; 14: 346-351.
4. Esposito PT, Cunningham CJ: A comparison of canals preparation with nickel –titanium and stainless steel instruments. J Endod 1995; 21:173-176.
5. Ki-Yon Kum et al: Shaping Ability of Three ProFile Rotary Instrumentation Techniques in Simulated Resin Root Canals. J Endod 2000; 26(12): 719-723.
6. Sonntag D, Delschen S, Stachniss V: Root-canal shaping with manual and rotary Ni-Ti files performed by students. Int Endod J 2003; 36(11):715-718.
7. Arens DE et al: The crown – down technique: a paradigam shift (interview). Dent Today 1996; 15: 38-47.
8. Regan J D, Gutmann J L: Preparation of the root canal system. HARTY'S ENDODONTICS IN CLINICAL PRACTICE, Internet site "www. fleshandbones. com/ readingroom/pdf/862.pdf "77-94
9. Gin-ichiro et al: A Comparison of Shaping Ability Using ProFile, GT File, and Flex-R :Endodontic Instruments in Simulated Canals. J Endod 2002; 28 (4): 316-321.
10. Kosa DA, et al: An analysis of canal centering using mechanical instrumentation techniques. J endod 1999; 25:441-445.
11. Jardine SJ, Gulabivala K: An inVitro comparison of canal preparation using two automated rotary nickel – titanium instrumentation techniques. Int Endod J 2000; 33;381-391.
12. Pruett J, Clement D, Carnes D: Cyclic Fatique testing of nickel-titanium endodontic instruments. J endod 1997; 23(2): 77-85.
13. Buchanan LS: The standardized-taper root canal preparation--Part 2. GT file selection and safe handpiece-driven file use. Int Endod J 2001; 34(1):63-67.
14. Peter Parashos, Ian Gordon, Harold H Messer: Factors Influencing Defects of Rotary Nickel-Titanium Endodontic Instruments after Clinical Use. J Endod 2004; 30(10): 722-725.
15. Galhoun G and Montgomery S: The effects of four instrumentation techniques on root canal shape. J Endod 1998; 14(6): 273-277.
16. Ruddle C: Shaping the future of endodotics, the protaper geometries, features, and guidelines for use: Newsletter Denstply Maillefer, Ballaigues, Switzerland 2002, June: 6-14.
17. Bryant ST et al: Shaping ability of Profile rotary nickel – titanium instruments with ISO sized tips in simulated root canals. Part 2. Int Endod J 1998; 31:282-289.
18. Tony M Ponti et al: Canal-Centering Ability of Two Rotary File Systems. J Endod 2002; 28(4): 283-286.
19. Hyung HH, Kim SK: A comparison of the shaping abilities of 4 nickel-titanium rotary instruments in simulated root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003; 95:228-233.
20. Koch k, Brave D, Real World Endo: Design features of rotary files and how they affect clinical performance. Oral health 2002; Feb: 39-49.
21. Ghanim Almannai: The efficacy of different rotary instrumentation techniques on the canal cleanliness, a comparative electron microscope study. Published Ph.D thesis, 2004; Odontologiska Institutionen. Stockholm Nr 67.
22. West JD: Introduction of a new rotary endodotic system: progressively tapering files. Dent Today 2001; 20: 50-57.
23. Thompson SA, Dummer PM: Shaping ability of ProFile.04 Taper Series 29 rotary nickel-titanium instruments in simulated root canals. Part 2. Int Endod J 1997 Jan; 30(1):8-15.
24. Braun A et al: Straightening of the root canals following preparation with NiTi Systems. Dtsch Zahnarzti Z 2003; 58: 42-45.
25. Edgar Schäfer.Comparison of hand stainless steel and nickel titanium rotary instrumentation: A clinical study. J Endod 2004; 30 (6) : 432 – 435.
26. Bryant ST et al: Shaping ability of .04,.06 taper profile rotary nickel – titanium instruments in simulated root canals. Int Endod J 1999; 32:155-164.