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A Comparative Evaluation of Rotary and Hand Files on Working Length Changes in Curved Canals after Coronal Flaring: An In Vitro Study

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Introduction

The aim of root canal treatment is to eliminate microorganisms from the root canal system. This can be achieved by chemo-mechanical preparation of the canal, which consists of removing the infected pulp and shaping root canal system in order to facilitate irrigation and placement of a medicament or permanent filling material.[1] Root canal working length (WL) is defined as distance from a coronal reference point to the point at which canal preparation and obturation should terminate. A number of methods for determining WL have been described; including the use of radiographs, electronic apex locators, and tactile discrimination.[2]

In spite of improvements in instrument design and in various root canal preparation methods, stainless steel hand files still tend to create a number of aberrations in curved canals.[3, 4] In such canals, more flexible instruments made of nickel-titanium have been effective in minimizing complications during preparation. Niti-alloy (nitinol) has several advantages over stainless steel such as its greater flexibility due to super elasticity, the shape memory effect and a better resistance to torsional fracture.[5] In the last decade, many types of rotary root canal instruments have been introduced, varying in cross-section, blade and pitch design, and taper.[6] Nickel-titanium files were more effective in maintaining the original canal path of curved

root canal.[7,8] Different kinds of canal instrument and canal preparation technique may exert different effects on working length. If working length is shortened during the course of treatment, over instrumentation and overfilling may occur. This may cause error of canal shaping and delay healing of periapical lesion.[9,10]

Furthermore, an adequate coronal pre-enlargement accurately defines what initial apical instrument should be used and it results in a more precise anatomical diameter at the WL.[11] However, it is not known if determining WL after initial CF of root canal has been completed, but before apical preparation, will minimize the change in WL that occurs during the instrumentation of curved canals.[12]

Aim

Aim of this in vitro study was to compare pre and post instrumentation working length in curved root canals prepared by using stainless steel hand file, Hyflex CM, and Protaper next file.

Methodology-

Sixty extracted human maxillary and mandibular, first and second molar teeth were selected.

Preparation of Samples

Coronal access cavity preparation was made in each specimen by using a carbide bur and high speed air rotor hand piece. The distal roots of mandibular molars and palatal and distobuccal roots of maxillary molars were removed by using a diamond disc, so that the mesial root and the associated crown were separated from the remainder of the tooth.

Measurement of Canal Angulations

Canal curvature of the mesial root was determined by using the Schneider's method. Roots with mesial-distal curvature between 20° and 45° were selected for this study.

Measurement of Non-Flared WL (WLbefore Intracanal Instrumentation)

The occlusal surfaces of each tooth were flattened on a model trimmer to provide a consistent reference point for WL determination. A #10 K file was introduced into the mesiobuccal canal of each specimen. The location on the root where the file first appeared at the apical foramen when viewed through a surgical operative microscope was noted. The root end was resected at, or slightly coronal to the level of the apical foramen using a flat diamond abrasive disk. The root end was placed against a flat glass barrier. A file was placed into the canal until it reached the apical glass barrier. Using the fattened coronal surface as a reference point, WL measurement was determined with the help of a digital caliper in millimeters. This length was designated as non-flared WL. This measurement was recorded three times in succession for each canal, and a mean value for WL was calculated.

Division of Samples into Respective Groups

All the 60specimens were ranked by degree of maximum canal curvature and divided into three groups.

Group 1-The Roots Demonstrating the Smallest Curve

Group 2-The Next Smaller Curve

Group 3-The Next Smaller Curve

The mean canal curvature per group was calculated and compared to verify similarities in curvature.

Canal Instrumentation and Measurements in Each Group

Group 1- Instrumented With Stainless Steel Hand File

Specimens in group 1 were treated as follows: The root canal was flooded with a solution of 3% sodium hypochlorite Apical patency was verified using a #10 K file. The canal was irrigated with 1 ml of 3% sodium hypochlorite, and G. G. Drill no. 3, 2, and 1 were used for Coronal flaring, following the sequence recommended by the manufacturer.

The canal was irrigated and the distance to the apical glass barrier was determined as previously described. This length was designated the Group 1 Flared WL. The apical portion was prepared by step-back technique using hand instrument till #30 K file. Step-back instrumentation was initiated with a #35 K file placed 1 mm short of the flared WL. Each larger instrument was carried to a depth 1 mm short than previous file. Canal flaring was considered complete when the portion of the canal instrumented with hand blended with the portion instrumented with G. G. drills. After the step-back procedure, using #30 master apical file, group 1 Final WL was determined as described previously.

Group 2- Instrumented With Hyflex Rotary System

Each specimen in group 2 was instrumented using hyflex group following the full sequence recommended by the manufacturer. The coronal portion of the canal was prepared with orifice shaper 25-8%, the canal was irrigated, and the distance to the apical glass barrier was determine as described previously. This length was designated as group 2 flared WL. 15-4%, 20-4%, 25-4% and 20-6%, 30-4% were then taken to full length. After irrigation with 3% sodium hypochlorite and verifying apical patency, WL was measured as previously described and was designated as group 2 final WL.

Group 3- Instrumented With Protaper Next Rotary System

Each specimen in group 3 was instrumented using protaper next file following the full sequence recommended by the manufacturer. The coronal portion of the canal was prepared with orifice opener (sx), the canal was irrigated, and the distance to the apical glass barrier was determined as described previously. This length designated as group 2 flared WL. X1 and X2 then taken to full length. Final finishing was done by finishing file X3. After irrigation with 3% sodium hypochlorite and verifying apical patency, WL was measured as previously described and was designated as group 3 final WL.

Statistical Analysis: A repeated measures analysis of variance (ANOVA) test and a Tukey's multiple Post Hoc tests were used for this study.

Result

Three WL readings were noted for each sample: (1) Non-flared WL (WL before intracanal preparation). (2) Flared WL (WL after CF preparation). (3) Final WL (WL after complete canal preparation). In table 1 One way analysis of variance (ANOVA) test was done which showed no statistically significant difference between the three groups. Table 2 showed statistically significant difference ($P < 0.05$) between all the groups. But greater change in WL at all stages of canal preparation with stainless steel instruments. Within each group, a repeated measures analysis of variance test and a Tukey's multiple Post Hoc test was used to determine the presence of statistically significant differences between (a) the non-flared WL versus the flared WL; (b) the nonflared WL versus the flaredWL; and (c) the flared WL versus the final WL. Change in WL due to early CF and late CF was calculated. Tukey's multiple Post Hoc test showed that statistically group 1 was significantly different compared to group 2 and 3 ($P < 0.05$). There was no statistically significant difference between group 2 and 3 ($P > 0.05$).

One way ANOVA

WL	Groups	N	Mean	S.D.	F-value	P-value	NS/S
NON- FLARED WL	STAINLESS STEEL	20	17.77	1.90	0.001	0.999	NS
	HYFLEX CM	20	17.77	0.82			
	PROTAPER NEXT	20	17.79	1.03			
FLARED WL	STAINLESS STEEL	20	17.56	1.99	0.096	0.909	NS
	HYFLEX CM	20	17.72	0.81			
	PROTAPER NEXT	20	17.73	1.04			
FINAL WL	STAINLESS STEEL	20	17.41	1.95	0.362	0.698	NS
	HYFLEX CM	20	17.73	0.80			
	PROTAPER NEXT	20	17.73	1.04			

Table 1: Comparison between the Non-flared WL, Flared WL and Final WL for each group.

One way ANOVA							
WL	Groups	N	Mean	S.D.	F-value	P-value	NS/S
NON-FLARED WL TO FLARED WL	STAINLESS STEEL	20	0.21	0.35	3.869	0.027	S
	HYFLEX CM	20	0.05	0.07			
	PROTAPER NEXT	20	0.05	0.06			
NON-FLARED WL TO FINAL WL	STAINLESS STEEL	20	0.36	0.40	11.562	0.000	S
	HYFLEX CM	20	0.05	0.07			
	PROTAPER NEXT	20	0.06	0.06			
FLARED WL TO FINAL WL	STAINLESS STEEL	20	0.15	0.29	5.129	0.009	S
	HYFLEX CM	20	0.00	0.05			
	PROTAPER NEXT	20	0.00	0.02			

Table 2: Comparison of non flared WL to flared WL, Non flared WL to final WL and Flared WL to final WL for all three groups.

Discussion

In the curved canals the determination of the accurate working length is a challenging task.[13] Until and unless correct working length is not determined, other steps of the root canal therapy like cleaning, shaping and obturation of the root canal system cannot be accomplished accurately.[14] Once the working length has been determined accurately in the curved canals it is extremely important to monitor the working length periodically during the rest of procedure, since the working length changes as a curved canal is straightened.

In the curved canal the loss of accurate working length can also be related to the accumulation of the dentinal debris and pulpal debris in the apical 2 to 3 mm of the canal due to constricted coronal portions of the canals.[15] Sadeghi and Doagoand Ibarrola *et al*. compared WL changes after SLA (Straight-line access) and different CF methods. They found that it is better to establish WL after SLA (Straight-line access). Least changes in WL occurred with Ni-Ti rotary orifice shapers after CF.[16, 17]

In the present study, the effect of early coronal flaring (CF) and late CF on the working length (WL) in curved root canals were measured. It was found that for each specimen, there was a difference between the non-flared WL, flared WL, and final WL. There was no statistically significant difference between the three groups. But greater change showed in WL at all stages of canal preparation with stainless steel instruments. When comparing group 1 to group 2 and 3 there was statistically significant difference ($P < 0.05$) and between group 2 and 3 ($P > 0.05$) there was no statistically significant difference.

In this study; group 1, 2, and 3 differed in the relative amounts of WL change that occurred as a result of CF. CF in the stainless steel group was accomplished with Gates Glidden (G. G.) drills, in the Ni-Ti ProTaper Next group with Sx and in the Ni-Ti Hyflex CM group with orifice shaper (25/8 %) . Coronal flaring using Gates Glidden drills in hand instrument groups and whole canal instrumentation in stainless steel hand file group caused significantly more working length change than in other rotary instrumented group.

In the present study, the canal curvature determined using Schneider method, Schneider angle, when used in combination with the radius and length of the curve, provide a more precise method for describing the apical geometry of canal curvature while canal access angle and its related parameters provide more information about the coronal geometry of curvature.[18] The results of this study indicate that Ni-Ti rotary files can be expected to consistently produce a small decrease in WL, whereas the combination of G. G. Drills and stainless steel files causes more than twice as much decrease in WL. Thus, the clinical impact of length changes that occur during instrumentation may be reduced if WL is verified as the canal preparation around curved portion of the canal progresses. Even if WL is shortened during cleaning and shaping procedures, length verification would permit

adjustments to obturation material, and reduce the risk of overfill. Also, subsequent instrumentation should be done using the altered WL. The observed loss of working length can be caused by a variety of factors. The WL may change as a curved canal is straightened.[19,20] The loss may also be related to the accumulation of dentinal and pulpal debris in the apical 2 to 3 mm of the canal, or other factors such as failing to maintain foramen patency, skipping instrument sizes or failing to irrigate the apical 1/3 adequately. The working length is lost owing to ledge formation or to instrument separation and blockage of the canal.[21] In the study where the shaping ability of ProTaper Next and Hyflex CM were compared, the loss of the WL was observed, and was smaller for canals which were prepared using ProTaper Next with the difference statistically significant. Saber *et al*. compared the shaping ability of ProTaper Next, iRaCe® and Hyflex CM rotary NiTi files maintained that the use of ProTaper Next resulted in significantly greater canal straightening than other files. Greater canal straightening results in bigger change of the working length. In present study, a significantly greater change took place after use of ProTaper Next.[22]

In the present study, canal curvature was determined by measuring curvature of file. There was significantly smaller decrease in curvature observed in Hyflex CM group than in stainless steel K-file group and ProTaper next group. ProTaper next is a Ni-Ti rotary file with high taper and high cutting ability. ProTaper next removed more material from the inner side of canal before the initiation of curve, but in the apical third area, they removed more material from the outer side of canal, which resulted in a decrease in curvature. ProTaper next removed more root dentin. The preparation of the canal with Hyflex CM Files resulted in more centric canal preparation. It was noticed especially in apical part of the canal, where the amount of removed resin in outer and inner curvature were quite similar.[23] In the study by Davis *et al*. similar results were obtained where in mean decrease in WL was significantly greater for stainless steel group (−0.48 ± 0mm) than for the Ni-Ti group (−0.22 ± 0.26 mm).[7] Change in WL due to preparation of coronal portion of the canal was significantly more by stainless steel instruments (*P* values < 0.05). The relatively large length change produced by the G. G. drills in group 1 may be due to the removal of the cervical bulge of dentin. CF with G. G. drills tends to create a straight line access to the mid root canal. Flaring in group 2 and 3 with ProTaper next Sx and Hyflex CM orifice opener (25/8%) tends to follow the original canal contour and did not create the same type of straight-line access to the mid root canal.

Conclusion: When rotary Ni-Ti files were used, the reduction in WL, although statistically significant, was much smaller. The clinician should know that the WL subsequently decreases during canal instrumentation. Keeping this factor in mind the cleaning and shaping should be done so as to provide better treatment outcome.

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