ORIGINAL ARTICLE

An *in vitro* study of the shaping ability of two rotary endodontic instruments in curved roots canals

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ABSTRACT

The most appropriate canal shape for filling with Gutta Percha and Sealer is a continuously tapering funnel shape with smallest diameter at the apical limit and the largest at the orifice. This *in vitro* study evaluated the shaping ability of two rotary endodontic instruments in curved roots canals.

Keywords: Ni-Ti Instruments, Stainless steel, Rotary instruments

INTRODUCTION

Cleaning and shaping of the root canals constitutes the most important aspect of the endodontic treatment. Shaping of root canals is necessary to facilitate obturation. The most appropriate canal shape for filling with Gutta Percha and Sealer is a continuously tapering funnel shape with smallest diameter at the apical limit and the largest at the orifice.

Over the years, a number of instruments have been developed for shaping canals. With the advances in dental materials and dental technology, the market is flooded with newer flexible and effective cutting tools for preparation of the curved root canals. More flexible Nickel Titanium instruments for use in slow speed, high torque hand pieces has been developed. The rotary instrumentation is gaining more acceptance due to the ease and speed of preparation. Nickel Titanium instruments with increased taper have been developed in the hope that the greater flare along the instrument shaft would create the flare required in canal shape.

Stainless Steel rotary files have also been developed. However, the Stainless Steel hand files tend to create a number of aberrations including ledge formation, zipping, stripping or perforation in narrow curved canals. This is due to inherent stiffness of the metal.[4] Hence, probably the same drawback may be applicable to the rotary stainless steel instrument too.

Review indicates studies comparing hand with rotary instruments, and also the efficacy of various techniques of preparation.[1,12,14,17] A number of in vitro and in vivo studies have shown that, changes in working length commonly occur during cleaning and shaping of curved root canals.[4] However, there seems to be lacunae regarding shaping ability of different rotary endodontic instruments using the same technique. Hence this study was undertaken to;

1. Evaluate the efficacy of rotary Nickel Titanium instruments in curved root canals
2. Evaluate the efficacy of rotary Stainless Steel instruments in curved root canals.
3. Compare the ability of rotary Nickel Titanium non –ISO standardized Profile series and rotary Stainless Steel, ISO standardized Endoflash in preparing curved canals qualitatively.

MATERIAL & METHODS

Forty recently extracted human permanent mandibular first molars with fully formed apices were obtained for the present study. The teeth were stored in 10% formalin. Profile series Nickel Titanium files (dentsply**)** used in experiment were from the profile 0.04/0.06 and orifice shaper set. These instruments are made from Nickel Titanium alloy having a non cutting tip and U-shape cross section with 3 radial lands that keep the instrument centered in the root canal.

Endoflash rotary files (Kavo) are made from high –grade steel Stainless Steel being classified as K- type files and used in these experiments was in size 15-40 and 21 mm in length.

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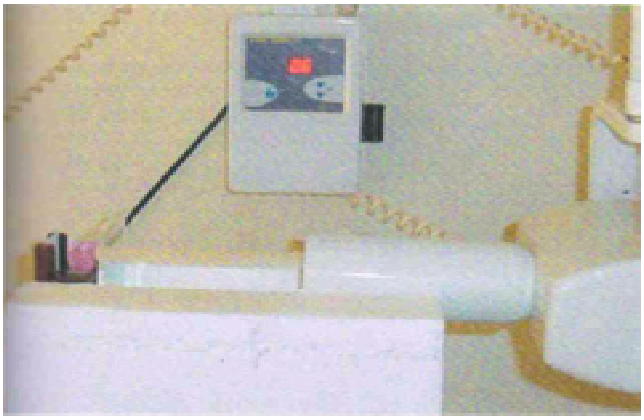
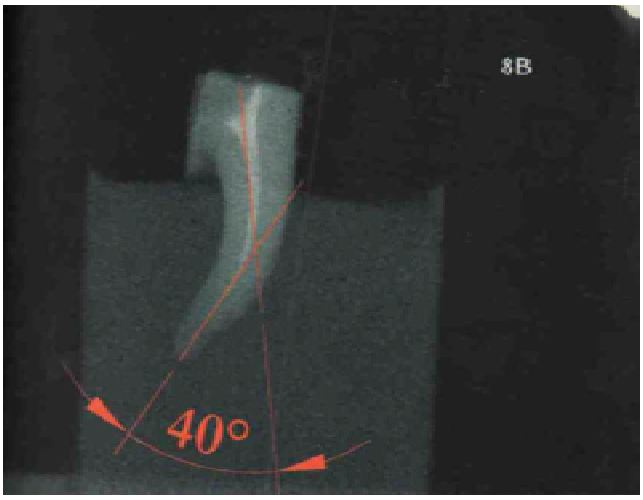
Materials used in the study



Device for localizing and stabilizing the specimen (Front view)



Preparation of the specimen

The extracted teeth that were stored in 10% formalin were taken and the crowns were sectioned till the roof of the pulp chamber. The patency of mesio buccal canals was checked using # 10 Stainless Steel H-files. The distal root of mandibular molars were resected using a carborandum disc. The length of all the specimens were kept constant at 14 mm by grinding occlusal surface. The teeth were embedded in an acrylic block of length 1.6 x 1.6 cm in width and 2 cm in height. A plastic assembly with a length of 1.6 x 1.6 cm in with and 0.6 cm in height was made to fit and stabilize the acrylic block for localization.

Standardization was achieved by fixing the orientation of the X ray holding device, plastic assembly and X ray cone. The source to the object distance was kept constant 40 cm and object to the film distance was kept 2.5 cm.

The teeth were radiographed using Ekta speed dental intra oral periapical X ray films. The exposed films were processed using Periomat Autoprocessor with readymade Kodak developer and fixer solutions. The exposure time was kept 0.6 second for all the specimens.

The radiographs were scanned using a Umax Scanner and transferred to an Auto Cad software system to measure the canal angulation using Schneider method. Forty mesio buccal canals from 40 mandibular first molars were selected using the following criteria.

1. Root canals having Type 1 configuration i.e. separate from the orifice to the apical foramen.
2. 20-45° curvature of the canal in the mesio distal plane.
3. Patent canal i.e. No. 10 K file could be seen through the apical foramen.

The contrast medium was flushed out of the canals using water prior to instrumentation.

Groups

The canal curvature of all the specimens were first assessed that they were arranged in an ascending sequence starting from the smallest curvature to the largest curvature and these specimens were numbered accordingly (1-40). The specimens with odd number were kept in Group I and specimen with even number kept in Group II. Each group consist of 20 teeth each (n=20).

Method

Group I: The mesio buccal canal was shaped using Profile file in an Anthogyr Ni'T'I control gear reduction hand piece 128:1 with torque control coupled to an electronic micro-motor with speed of (40,000rpm). The final rotational speed obtained was 312 rpm. Crown down technique was used to prepare the canals.

An estimate of the provisional working length was made on basis of the pre-operative radiographs. 3mm was reduced from these provisional working length. The main objective of the Crown down was to flare the root canal till the provisional working length. The main objective of the crown down was

to flare the root canal till the provisional working length i.e. less 3mm. Profile orifice sharper #3 (.06/.04) was the first instrument used for the Crown down sequence. Profile orifice –sharper#2 (.06/30) was the second instrument used in the crown down sequence. Profile .06/25 was the third instrument used in the sequence. Profile .06/20 was used in similar fashion and it was worked more apically. Profile .04/20, .04/20 were used in similar fashion to reach the estimated working length less 3mm The exact working length was determined after the Crown down phase was completed. The working length was determined by inserting a conventional #10 K-file (2% taper) .Apical preparation was done using the;Profile .04/20 till the exact working length Profile .4/25 till the exact working length .Final flaring was done using the; Profile .06/20 till the exact working length.

Group II: The Mesio buccal canals was shaped using Endoflash Stainless Steel K- Files. Crown down technique was used to prepare the canals. Conventional .35 size K file was inserted into the root canals to its point of first resistance. The file was taken out and its length was measured and compared with the radiograph if whether the resistance was because of the curvature, the canal was prepared till the beginning of the curve with Gates Glidden #2 and 3. If the resistance was because of dentin the root canal was prepared till that length using gates Gildden # 2 and 3 # 35, 30,25 were used in Crown down manner to prepare canal till the estimated working length less 3mm. The exact working length was determined after the Crown down phase was completed. Apical preparation was done using the; 15 K file till the working length, 20K file till the working length ,25 K file till the working length .

Assessment of canal preparation

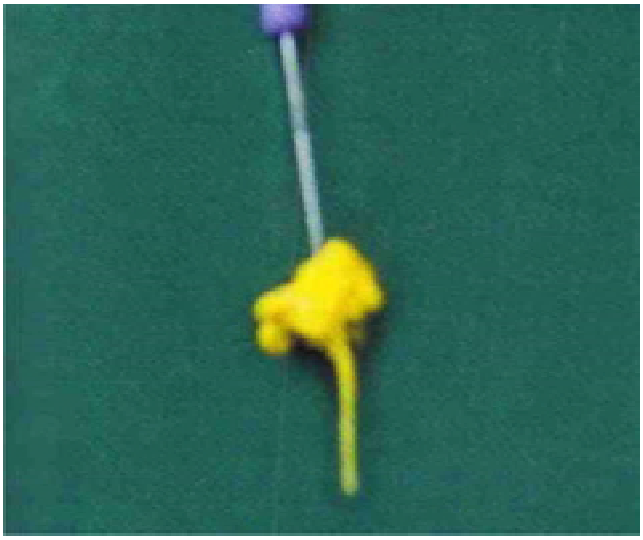
The assessment of root canal preparation was broadly classified as Qualitative assessment.The following were the criteria employed (1) Smoothness of the coronal half (2) Smoothness of the apical half (3) Horizontal and longitudinal grooves (4) Flow (5) Taper to assess the quality of the root canal preparation. The root canal form of the instrumented canals were reproduced by making an accurate impression.

Method of Assessment

Root canal impressions were made by lubricating the canal with glycerin. Light bodied poly vinyl siloxane impression material was carefully injected into each canal followed by the introduction of barbed broach, to act as a support for the coronal part of the impression and to facilitate removal.

Parameters for Assessment Smoothness of coronal half of the canal – categorized as poor or good

Smoothness of the apical half of the canal – categorized as poor or good



Root canal impression – Poly vinyl siloxane light body addition type

Horizontal or longitudinal grooves – categorized as absent or present.

RESULTS

The results presented below relate to total of 36 specimens (18 specimens in each group). Four specimens were discarded as canal impression could not be retrieved. Impression were made by injecting poly vinyl siloxane light body addition type impression material into root canal.

The majority the canal had smooth apical canal walls in both the groups. Smoothness of the apical half of the canal was good in 16 canal impressions in both the groups. Smoothness of the coronal half of the canal impression was good in 17 specimens prepared by profile series instruments and 16 specimens prepared by Gates Glidden drills and Endoflash rotary files had good smoothness of the coronal half of the canal. The majority of canal impression had longitudinal grooves in the coronal portion. Longitudinal grooves were present in 15 specimens in Group I. in group II, 8 specimens showed only longitudinal grooves. The majority of canal impression had good flow characteristics. In group I, 16 specimens were rated good. In group II, 14 specimens showed good flow characteristics. Most of the canal impressions exhibited good taper in Group I. Sixteen specimens in Group I exhibited good taper. In Group II, only 10 specimens exhibited good taper.

DISCUSSION

Current endodontic instrumentation techniques recognize the inherent problems associated with cleaning and shaping curved root canals. Techniques for manually shaping the root canals are well established.[6,9] Since a long time, research has

been directed towards inventing an ideal automated device, which would be easy to use, save time, and render ideal preparation of root canals. A major advantage the automated devices offer the clinicians is reduction in fatigue and time. Treating many teeth in a session, or narrow and curved canals, is bound to incur strain on the instruments and cause fatigue to the clinicians. However, with the introduction of flexible instruments and rotary instrumentation, overall strain is lessened and fatigue is reduced.

This study was undertaken to evaluate the efficacy of rotary Nickel Titanium and rotary Stainless Steel instruments by the Crown down instrumentation technique, and to compare, the shaping ability of rotary Nickel Titanium non ISO standardize profile series and rotary ISO standardized Endoflash Stainless Steel files, in preparing curved canals qualitatively.

The profile series of instruments are made of Nickel Titanium alloy and also vary in their construction and does not conform to the ISO guidelines. Nickel Titanium alloy are flexible extremely elastic resistant and bio compatible. Because of their elastic nature they can be manufactured only by machining which result in formation of Burrs.[19] The cutting efficiency of the Nickel Titanium instrument is lower as compared to that of Stainless Steel due to lack of rigidity.[16] The greater taper incorporated in the design although decreases the flexibility of the Nickel Titanium instruments is highly favorable in producing root canal and with increased taper which provides for convenience of cleansing of root canal by preventing the packing of dentin mud, permitting better circulation of the irrigants in the root canal system and also debriding the coronal aspect of the canal to greater extent compared to more minimal preparation apically which confirms to the greater degree of infected dentin walls in the coronal as compared to the apical portion and better facilitation of a more thorough obturation,[15] as the continuously tapering root canal allows hydraulic principles to operate by the restricted flow principle. As the flow is restricted during the compacting procedures, it causes the Gutta Precha and sealer to take the path of least resistance, namely apical and lateral foramina

The Endoflash rotary files are made of Stainless Steel and their construction conforms to the ISO guidelines. Stainless Steel is time tested material, but rigid in nature and biologically acceptable even through, it has a greater quantity of free Nickel atoms than the Nickel Titanium alloys. These files have a higher cutting efficacy then Nickel Titanium files, but because of their rigidity are prone to procedural accidents.[4] However, because these instruments have only 2% taper, it permits some degree of flexibility.

To evaluate the quality and quantity of root canal preparation, a study design is desirable that allows good standardization, as well as good simulation of the clinical situation. Simulated root canals in resin blocks[4,8] allows an optimal standardization of root canal diameter and curvature and can provide good experimental controls, but, are not representative of clinical conditions as extracted teeth. On the other hand, extracted teeth are much closer to clinical reality in terms of dentin hardness, three -dimensional variation of root canal curvature, and irregularities of the root canal system[5]. Hence, extracted teeth were chosen for the study. The only drawback is that, the length and curvature of the root canals could not be standardized. Hence, certain parameters in the selection like only the mesio -buccal root canal of permanent mandibular first molars with mesiodistal curvature of a range 20 to 45^{o} were employed in the study to minimize the variables. Mesio-buccal root canals of the mesial roots of permanent manidbular first molars were used in the study because they are usually curved in mesio –distal direction. Barium sulfate powder and Diatrizoate Megulmine radio opaque dye was used as a contrast medium because, it could be easily be injected into and flushed out of the canals. Also, it did not affect the original anatomy.

The radiographs were scanned in a Umax scanner and transferred to an Autocad Software system to measure the canal curvature in mesio distal direction using Schineider's methods. Root canals having moderate to severe curvature (20-45^{o}) were assessed in the study. Crown down technique is indicated for preparing root canal with such curvatures. Hence, Crown down technique was used to prepare the root canals in both the groups.

26% sodium hypochlorite was used as root canal irrigant to simulate the clinical condition, which is consistent with other invitro studies.[13]

Torque control hand piece was used to prepare the root canals. This hand piece could be used at four different torque levels. The profile series instruments had their specific torque limit and are to be used according to the limit. Orifice shaper # 3and # 2 were used at torque level of N/Cm. profile .06/.04 instruments were used at a torques level of 2 N/Cm and 0.9 N/Cm respectively.[20]

The Nickel Titanium instruments are highly flexible and have elastic memory. However, this property has its negative aspect in that a strained instrument is not visualized readily, resulting in breakage of instrument.[19] To prevent this eventuality the Profile series of instruments are to be used for only 10 clinical (one canal for each use).[11,17] In conforming to the instructions, only 10 mesio –buccal canals were instrumented with a set of instruments. Regimen was followed for the Kavo Endoflash rotary files too, to maintain uniformity during the study.

Incidentally, it was observed that, when Nickel Titanium Profile series instruments were used according to their torque limits none of the instrument separated in the canal, unlike in case of the Endoflash rotary files most of the instrument deformed. A possible solution to this problem is to use a

torque value that operates below the maximum permissible torque limit of each rotary instrument.Recently Barthel et al[2] demonstrated that it is possible to use poly vinyl siloxane impression material (low viscosity addition type)which is currently the most elastic and dimensionally stable dental impression material,[5] to take repeated impressions of the root canal without destruction of tooth structure.

Successful canal impressions were taken from the 18 specimens in both the groups. The results showed that smoothness of the coronal half of the canal was good for 17 specimens prepared by profile series instruments. The smoothness of the coronal half was good for 16 specimen prepared by Gates Glidden drills and Endoflash rotary files. Smoothness of the apical half of the canal was good for both the group in 16 specimens. Hence, we can conclude that both the instruments were effective in preparing the coronal and apical portion of the canal.

Contrary to the result of Bryant *et al*[3,4] specimens prepared by Nickel Titanium and eight specimens prepared by Gates Glidden drill and Endoflash rotary files showed longitudinal grooves on the coronal part of the impression.

In previous studies, simulated root canals in resin blocks were used[4]. These blocks were made by using size 20 annealed silver points as templates. In this study, extracted teeth were used to prepared root canals. The anatomy of natural tooth is different from simulated canals. The coronal and middle third of natural tooth is different from simulated canals. The coronal and middle third of the root canal in natural tooth is oval in shape in bucco lingual direction and as it progress apically, it becomes more rounded. This variation in morphology of the extracted tooth may be reason for the presence of longitudinal grooves because initial cutting was done at the narrowest portion of canal that is in the mesio-distal direction. The specimens prepared by Profile series instruments showed more longitudinal grooves as compared to the group prepared by Gates Glidden drills and Endoflash rotary file. This could be because of the smaller size and length of cutting blade of the orifice shapers. The orifice shaper had a tip diameter equivalent to ISO standardized instrument 30 and 40 and length of the cutting blade was 10 mm. due to this smaller diameter and greater taper along the length of the cutting blade, the instrument bypass the coronal portion of the canal without excessive cutting at the tip. The gates Glidden drill used in the study had a tip diameter equivalent to ISO standardized instruments 70 and 90. This larger diameter of the instrument was able to engage the coronal portion of the canal more effectively from the start of the preparation.

Flow was good for 16 specimens prepared by Profile series instrument and in specimens prepare by Endoflash rotary files. The results in this study were similar to study done by Barthel et al[2] who did not find any difference between the performance of Profile instruments and Stainless Steel K type files in molars. The chances of procedural errors. (ledge,elbow formation) were similar for the both the groups in this study. Other studies have demonstrated that Profile instruments remained better centered in the canal than Stainless Steel hand files[10] There could be two reason for the good flow characteristics in the group prepared by Stainless Steel Endoflash rotary files.

Firstly, Crown down technique was used for both the groups. Flaring the coronal portion of root canal before instrumenting the apical region may facilitate the placement of files into apical portion of curved root[7] canals. After Crown down phase there is always some straightening of the curved root canals. This may further reduce the chances of procedural errors (ledge, elbow formation)

Taper was good in 16 canal impressions for Group I which was prepared by profile series instrument and only 10 canal impressions in Group II showed good taper. This positive characteristics for Profile instruments was presumably a reflection of the increased taper of the instruments which tend to produce a conical preparation. Such canal shapes would facilitate obturation. This finding was similar to the study down by Thomas *et al*.[18]

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