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INTRODUCTION

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Chemomechanical debridement of the root canal is required to completely clean, shape and disinfect the canal system from microorganisms, pulp tissue, necrotic debris and infected dentin. This could be achieved by enlarging and shaping the canal while preserving the canal anatomy and avoiding iatrogenic errors.

During the last decade root canal preparation with rotary nickel-titanium (Ni-Ti) instruments has become popular. More recently advanced instrument designs including non cutting tips, radial lands, different cross-sections and varying tapers have been developed to improve working safety, to shorten working time, and to create a tapered root canal.

Recently, new generation of NiTi instruments with higher flexibility and cutting efficiency had been introduced.

RaCe instruments have a triangular cross-sectional design with alternating cutting edge and electrochemically treated surface for improvement of cutting efficiency.

The Twisted file represent one of the advanced endodontic rotary files in the market, it has three unique features: it is manufactured by twisting of files and not grinding and has R-phase heat treatment and special surface conditioning that increase resistance to cyclic fatigue and increase flexibility.

Introduction

GTX, the new generation of profile GT is characterized by innovative M-wire technology, more blade angles, variable-width lands, and a 1-mm maximum shank diameter, the variable-width land are claim to minimize taper lock in the canal and produce larger chip space between the cutting flutes accordingly increasingly cutting efficiency without transportation.

However root canal transportation caused by excessive dentin removal in a single direction within the canal rather in all directions equidistantly from the main tooth axis leaving ~~uninstrumented~~ areas without instrumentation thus compromising treatment prognosis of the canal, while centering ability is the ability of file to be centered in the canal.

Hence studying the effect of this recent rotary NiTi system on canal transportation and canal centering ability is of great importance.~~Numerous studies have shown the ability of Rotary Ni-Ti systems to maintain original root canal curvature, to produce a well-tapered root canal form sufficient for obturation, and to Complete preparation in an acceptable time avoiding perforations, deviations, ledges, elbows, zips, transportation. Only a few studies have been published investigating the cleaning ability of rotary Ni-Ti files. Most of these studies have concluded that none of the automated instrumentation devices completely clean the root canal, in particular the apical region of curved canals. Additional~~

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concern has been expressed about the comparatively high incidence of fractures of rotary Ni-Ti instruments. The potential for endodontically treated teeth to fracture increases proportional to the amount of dentin removed.

During the last decade root canal preparation with rotary nickel-titanium (Ni-Ti) instruments has become popular. More recently advanced instrument designs including noncutting tips, radial lands, different cross-sections and varying tapers have been developed to improve working safety, to shorten working time, and to create a greater flare of preparations.

RaCe instruments (FKG Dentaire, La Chaux-de-Fonds, Switzerland) have a triangular cross-sectional design with alternating cutting edges (straight sector varies with twisted sector) and are claimed to prevent the instrument from screwing into the root canal thus reducing intraoperative torque values. Additionally, the surfaces of RaCe instruments are electrochemically treated for improvement of cutting efficacy. Some of the RaCe instruments for the initial steps of crown-down preparation are manufactured from stainless steel as well as from Ni-Ti alloy. Tapers range from 2 to 10%, sizes from 15 to 60. Different instrument sets for different types of curvature are available.

Previous concerns with rotary nickel titanium (RNT) files have centered on a desire to obtain both safety (preventing

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breakage) and cutting prowess (efficiency) in the same instrument. Previous file systems were generally either "safe" or they cut well, but they did not tend to do both. The future of endodontic canal preparation is here and it zis twisted, i.e. the Twisted File (TF) (SybronEndo, Orange, CA, USA).

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Although instruments for root canal preparation have been progressively developed and optimized, a complete mechanical debridement of the root canal system is rarely achievable. One of the main reasons is the geometrical dissymmetry between the root canal and preparation instruments. Rotary instruments regardless of their type and form produce a preparation with a round outline if they are used in a simple linear filing motion, which in most of the cases do not coincide with the outline of the root canal.

REVIEW OF LITERATURE

The objective of root canal preparation is to clean and shape the canal system in three dimensions while maintaining the original shape. Using stainless steel files showed tendency to cause canal transportation and other procedural problems, such as ledge formation, apical perforation, and mid-root strip perforation especially in narrow root canals. These complications may compromise the long-term success of the treatment.

Esposito and Cunningham [1] compared the maintenance of the original canal path of curved root canals during instrumentation with stainless steel files (K-Flex), nickel titanium (NT) rotary files using the Ni-Ti-matic engine driven handpiece and Nickel Titanium (Mac) hand files. Canal path maintenance determined by superimposing instrumentation radiographs over an initial file radiograph and examining them for discrepancies. Nickel titanium hand and engine driven instruments maintained the original canal path in all cases. The difference between nickel titanium groups and stainless steel became statistically significant with instruments larger than size 30. In this study, Nickel titanium files were more effective in maintaining the original canal path of curved root canals when the apical preparation enlarged beyond size 30.

Isom et al. [2] evaluated the root thickness in curved canals after flaring. Root thickness in the mesial canals of lower

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first and second molars was compared before and after flaring by using a muffle system. Gates Glidden burs or M-Series Canal Openers were used with either a straight up-and-down motion or with an anticurvature motion. The muffle system was used to evaluate the root thickness between the canal and the closest point of the furcation before and after the use of rotary instruments. The teeth were mounted in the muffle, with the roots embedded in hobby casting resin. The resin was poured into the muffle around the roots of the teeth and allowed to set for 24 hours. It was found that Gates Glidden burs used straight up and down removed statistically more dentin at the level of the furcation than Canal Openers used straight up and down or in an anticurvature fashion. At a level 2 mm apical to the furcation, Gates Glidden burs used in an anticurvature fashion removed statistically more dentin than any other method tested.

Pilo and Tamse [3] evaluated the residual dentin thickness in mandibular premolars after preparation with Gates Glidden and Parapost drills. Twelve extracted single canal mandibular premolars were embedded in clear polyester resin to the cementoenamel junction (CEJ) in a muffle device. Three horizontal sections were made 1, 3, and 5 mm apical to the CEJ. Mesiodistal (MD) and faciolingual (FL) axes were carefully marked and the RDT was measured for each slice. Each tooth slice was reassembled in the muffle device with orientation pins, and then secured with stabilizing pins. This procedure was repeated after enlarging the root canal to K-40 file and preparing the coronal root canal space with Gates Glidden drills

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and ParaPost drills Nos. 3, 4, and 5. It was concluded that the average dentinal thickness 5 mm below the CEJ in the mesial and distal directions after post space preparation approached the accepted minimal 1 mm. Minimal or no reduction of residual dentinal thickness for post space is advisable in mandibular premolars with ribbon-shaped roots.

Jardine and Gulabivala [4] compared the efficacy of root canal preparation using two automated rotary nickel–titanium instrumentation techniques (McXIM instruments and Profile.04 Taper Series 29 instruments) with a double flared balanced forces hand preparation technique, using stainless steel files in extracted human teeth. Sixty root canals in extracted human teeth were used and divided evenly between the three groups. Pre and post instrumentation radiographs were made using mercury as a contrast medium to evaluate the canal shape before and after preparation. They concluded that the new rotary nickel titanium instrumentation techniques were as effective as the standard double flare hand preparation technique using stainless steel hand files. Canal curvatures were equally and well maintained following preparation in all the groups.

Deplazes et al. [5] compared apical preparations of root canals shaped by Nickel-Titanium rotary instruments and Nickel-Titanium hand instruments. This study measured displacement of canal centers in extracted human teeth after preparation by Lightspeed and nickel-titanium K-files. The

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specimens were divided into two groups (n = 11), after radiographing the roots from the buccolingual and mesiodistal planes with pathfinding files in situ. Displacements of root canal centers after preparation and increases in cross-sectional areas of the prepared root canals were evaluated at specific levels. There was no significant differences in displacement of canal centers or between the mean cross-sectional areas of the instrumented root canals were recorded between the Lightspeed and K-file groups. Both types of instruments produced similar displacement of canal centers after preparation.

Hülsmann et al. [6] compared several parameters of root canal preparation using two different rotary nickel–titanium instruments: HERO 642 and Quantec SC. A total of fifty extracted mandibular molars with root canal curvatures between 20 and 40 were embedded into a muffle system and prepared to size 45 (Quantec SC), or 40 (HERO 642). They evaluated the straightening of curved root canals, postoperative root canal diameter, and safety issues including file fractures, perforations, apical blockages, loss of working length, and working time. Evaluation was done using standardized radiographs and sectioning techniques. It was concluded that both systems respected original root canal curvature well and showed good cleaning ability. However, Quantec SC showed deficiencies in terms of safety.

Bertrand et al. [7] evaluated curved root canal preparations using Hero 642 rotary nickel–titanium instruments

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by the Bramante method. Twenty-four canals were used with an angle of curvature greater than 20. Roots were embedded in clear resin using a plaster mould and cross-sectional cuts were made in the apical, middle and coronal thirds of each root. The control group was prepared using stainless steel hand instruments and the step-back technique. The second group was instrumented using the Hero system. The canal centering and shape was evaluated using image analysis software. The results showed that no significant difference occurred in the amount of dentine removed, or canal centre displacement in the coronal and middle thirds of the curved canals. In the apical third, transportation was significantly higher with stainless steel hand instruments than with the Hero system. They concluded that when using the Hero system, the original canal shape was maintained better in the apical third of curved canals compared to a hand preparation technique with stainless steel instruments.

Ponti et al. [8] compared the canal centering ability of two rotary file systems using a new split-mold design (the endodontic cube). The mesial roots of ten mandibular molar teeth were embedded in composite resin by using the endodontic cube as a mold and sectioned into five pieces. Canals were prepared using ProFile Ni-Ti .06 taper Series 29 and ProFile GT rotary instrumentation techniques. Canal centering was evaluated using computer software by superimposing the pre and post instrumentation images. They concluded that both systems remained centered within the canal with minimal deviation from the original canal path and they

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also concluded that the endodontic cube was an effective tool for studying and comparing instrumentation techniques.

Weiger et al. [9] studied the efficiency of hand and rotary instruments in shaping oval root canals. This study was designed to determine the efficiency of hand and rotary instruments in shaping oval root canals. Seventy-five oval canals were equally divided into three groups. The apical third was prepared with rotary LightSpeed instruments either to size 52.5 (mandibular incisors) or to size 57.5 (distal root of mandibular molars). The middle third with an oval cross-section was shaped with Hedström hand files using circumferential technique, with 6% taper rotary Hero files in a circumferential filing movement or with rotary LightSpeed instruments in a step-back technique. It was found that there was no instrumentation technique was capable of completely preparing dentin walls of oval root canals. Circumferential filing of the middle third of oval root canals with either 6% taper Hero files or conventional Hedström hand files gave comparable results.

Versümer et al. [10] studied root canal preparation using ProFile .04 and Lightspeed rotary Ni–Ti instruments. They used fifty extracted mandibular molars with root canal curvatures ranging from 20 and 40. The teeth were then embedded into a muffle system (modified Bramante technique). All root canals were prepared using ProFile .04 or Lightspeed Ni–Ti instruments to size 45 following the manufacturers'

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recommendations. Pre and post instrumentation radiographs were superimposed and the same for pre and post instrumentation images for evaluation of canals straightening, root canal diameter, and safety issues (file fractures, perforations, apical blockages, loss of working length). It was concluded that both systems maintained the original root canal curvature and were safe to use.

Weiger et al. [(11)] compared the rotary FlexMaster instruments with Lightspeed instruments and NiTi hand files in preparing curved root canals. They used a total of one hundred and thirty six root canals of extracted molars, which were prepared with rotary FlexMaster instruments, Lightspeed and NiTi hand files. A re-assembly technique according to Bramante technique was used. It allowed sectioning the root into two halves and reassembly again for comparison of the canal outline before and after preparation. They concluded that rotary Flexmaster instruments are suitable for preparing curved root canals. They provided results similar to Lightspeed instruments with minimal risk of instrument fracture but increased risk of root canal transportation.

Bergmans et al. [(12)] evaluated the influence of a smooth flexible versus active tapered shaft design on canal preparation by NiTi rotary techniques. A XMCT-scanner and developed software were used to nondestructively analyze the mesial canals of 10 extracted mandibular molars in 3D with a spatial resolution of 30 µm. Specimens (n = 10 per group) were

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scanned before (PRE) and after (POST) preparation using Lightspeed or GT-rotary files. Numerical values for volumes, dentine removal transportation and centering ability were obtained in addition to a visual inspection on canal aberrations. It was resulted that the active tapered shaft removed significantly more dentine in the middle to apical portion of the root compared to the smooth flexible design. Both groups demonstrated some straightening, but no significant differences were found with respect to instrument types. However, absolute values for net transportation and centering ratio were small and no canal aberrations could be found.

Bergmans et al. [13] compared the preparation of canals using Protaper and K3.Twenty extracted mandibular molars were used in this study. Specimens were scanned using an X-ray microfocus CT scanner before and after preparation. Images were analyzed for evaluation of canal volume, dentin removal and centering ratio. In addition, canal aberrations were recorded. Results showed that there was no statistically significant difference between the two groups in the increase of the total canal volume. Both groups showed significantly higher dentine removal toward the furcation with no difference between them. K3 showed significantly higher dentin removal towards the outer aspect of the curve than towards the inner aspect at the middle and apical level. It was concluded that both Protaper and K3 instruments were capable of acceptable preparation of the canals, the progressive taper design was less influenced by the mid root curvature providing a good centered

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apical preparation. However coronally, caution is indicated for the progressive design of protaper regarding the center displacement towards the furcation.

Garala et al. [14] compared the effect of Profile and Hero 642 on the remaining canal wall thickness after the preparation. The anatomy of 26 mandibular mesial roots with separate buccal and lingual canals was evaluated before and after instrumentation using the endodontic cube (modified Bramante technique). Canal cross sections were subsequently prepared. Samples were then instrumented within the cube. Pre and post instrumentation images of the sections were compared to determine the minimum canal wall thickness remaining after preparation. Buccal and lingual canals within the sections from each level (coronal to apical) showed a reduction in minimum canal wall thickness but without statistically significant difference between the two systems. It was concluded that instrumentation with either of the two systems did not compromise canal wall thickness. Preoperative canal wall thickness was found to be the most significant factor determining the minimum canal wall thickness after preparation.

Hulsmann et al. [15] compared root canal preparation using two rotary Nickel Titanium systems; Light speed and Quantec SC. A total of fifty extracted mandibular molars with root canal curvature between 20 and 40 were prepared using both systems. They evaluated straightening of the canals,

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incidence of canal aberration and working time. Preparation was evaluated using modified Bramante technique. They concluded that both systems maintained root canal curvature, performed canal aberrations with no statistically significant difference between them.

Karagöz-Kücükay et al. [16] evaluated the effect of rotational speed on root canal preparation with Hero 642 Rotary Ni-Ti Instruments in terms of canal straightening, loss of working length, and instrument breakage. They used a total of sixty mesial root canals from extracted human mandibular molars. Pre- and postoperative radiographs were analyzed using computer software. The results showed that there was a significant reduction in the final canal curvatures and working lengths between pre and postoperative images, however, there was no significant difference between preparations at different speeds.

Song et al. [17] studied and compared Great Taper (GT) hand files using a reversed balanced force technique, nickel-titanium (NiTi) flex files with a balanced force technique and stainless steel (SS) K-type files using a step-back technique. Forty-eight extracted mandibular premolar teeth ~~with single root canals~~ having curvatures between 15 and 45° were prepared using a modified Bramante mode. The teeth were cross-sectioned at 2, 6 and 10 mm from the working length. Preoperative images of canals at three levels were captured at 20x magnification using a stereomicroscope. ~~Canals in each~~

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group were, respectively, prepared to an apical size .10 GT file with 0.2 mm tip diameter, size 30 NiTiflex file and size 30 SS K-fileRoot canals were prepared and , the postoperative images were superimposed over the preoperative images using software PHOTOSHOP 6.0. The ability to maintain the instrument in the central axis of the canal and the deviation from the central canal axis were determined. with the assessment of the amount of dentine removed. It was resulted Results showed that at apical level, the centering ratio, the distance of transportation and the dentine removed in GT and NiTiflex- groups- were significantly less than those in SS group, but no statistical differences were found between the two NiTi groups. At other levels, there were no substantial differences amongst the groups.

Iqbal et al. [18] used a newly developed radiographic technique to compare apical transportation and loss of working length (WL) between .06 taper ProFile-Series 29 and ProTaper nickel–titanium (NiTi) rotary instruments in vitro. Mesio-buccal canals of 40 extracted mandibular molars were randomly divided into two groups. Group 1 was instrumented with ProFile and group 2 with ProTaper instruments according to the manufacturers' directions. A specially constructed radiographic jig with a Schick digital radiographic system was used to take pre- and postoperative radiographs of the samples that were at predetermined angulations. Using AutoCAD 2000, the central axes of initial and final instruments were radiographically superimposed to determine the loss of WL and degree of transportation at D0, D1, D2, and D4 from the WL. A statistically

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