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Original Article

Comparative evaluation of the shaping ability of single-file system versus multi-file system in severely curved root canals

Guohua Yuan, Guobin Yang*

The State Key Laboratory Breeding Base of Basic Science of Stomatology, Key Laboratory for Oral Biomedicine of Ministry of Education, School and Hospital of Stomatology, Wuhan University, Wuhan, China

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ABSTRACT

Background/purpose: Reciprocating single-file systems are the latest nickel-titanium instruments and little information is available concerning the shaping ability of these new systems. Comparison of these single-file systems with well-known rotary multi-file systems is necessary. The purpose of this study was to compare the shaping ability of single-file system (WaveOne, WO) versus multiple-file system (ProTaper Next, PTN) in severely curved canals.

Materials and methods: A total of 20 severely curved canals were prepared with WO or PTN. Micro-computed tomography was used to scan the specimens before and after instrumentation. Differences between two groups in canal surface area, volume, Structure Model Index (SMI), thickness, straightening, the ratio of uninstrumented surface area and canal transportation were evaluated.

Results: The outline of the canals after preparation showed smooth taper in both groups. Canal surface area, volume, SMI, Thickness and canal curvature were significantly increased after preparation in both groups, and no significant difference was found between groups. At apical third, canals prepared with WO showed larger values of transportation compared with those in PTN group in the direction of main curvature. Approximately 29–34% of the root canal surface remained uninstrumented after preparation and no significant difference was noticed between groups.

Conclusion: Both of the two instrument systems maintained the original outline of the canals well. The canals prepared with PTN had less transportation and were better centered in the apical region.

1. Introduction

Canal preparation is one of the most important procedure in endodontic treatment and directly influences subsequent root canal disinfection and obturation.[1] A prepared root canal should have a continuously tapered funnel shape and maintain the original outline form of the canal.[2] These objectives are often difficult to achieve because of the highly variable root canal anatomy and canal curvature, especially when preparing severely curved canals.[3]

During shaping of severely curved canals, occurrence of iatrogenic errors, such as ledges, zips, perforations, and apical transportation is common.[4] To minimize these iatrogenic errors several preparation techniques and lots of instrument systems have been developed. However, the mechanical preparation of a curved root canal is still challenging because of the common factors, such as inflexibility of the canal preparation instruments, degree and radius of a canal curvature, unseen canal curvatures in the two-dimensional radiographs.[5]

The introduction of nickel-titanium (NiTi) rotary instruments brings well-tapered root canal preparations, reduced operator fatigue, and less time required for shaping, whilst also minimizes the risk of root canal transportation.[6] Since their first appearance, progress has been made on design, rotation motion, as well as in alloy processing.[7,8] Reciprocating single-file systems are the latest stage NiTi instruments for the preparation of root canals. The concept of reciprocating motion based on balanced force technique was introduced by Yared, and single F2 ProTaper instrument in a reciprocating motion was proposed to use for the preparation of curved root canals.[9] This was shown to be as effective as the full ProTaper system in cleaning around root canals. Reciprocating single-file systems are claimed to be able to completely prepare root canals with only one instrument and reduce the risk of

* Corresponding author. 237 Luoyu Road, Wuhan, 430079, China.
E-mail address: guobin.yang@whu.edu.cn (G. Yang).

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instrument failure and cross contamination.[10–12] Recently, a new reciprocating WaveOne (WO, Dentsply Maillefer) single-file system has been developed. The WO system consists of 3 single-use files: small (#21/.06) for small canals, primary (#25/.08) for majority of canals, and large (#40/.08) for large canals. These files are made of a special NiTi alloy called M-Wire that is created by an innovative thermal treatment process.[13] The M-Wire NiTi beneficially increased the flexibility of the instruments and improved the resistance to cyclin fatigue.[14]

Up to now, little information is available concerning the shaping ability of the reciprocating file. Hence, comparison of these single-file systems with well-known rotary multi-file (full-sequence) NiTi systems is necessary to assess the properties of these new files.

ProTaper Next (PTN, Dentsply Maillefer, Ballaigues, Switzerland) is a novel multi-file system incorporating a variable regressive taper design and an off-centered rectangular cross section, which are designed to reduce points of contact with the canal walls to generate less fatigue in the instrument during use.[15] This system is composed of 5 instruments with different tip size and taper (X1 #17/.04, X2 #25/.06, X3 #30/.07, X4 40/.06, and X5 50/.06), and is also made of M-Wire NiTi.

The use of micro-CT (μCT) imaging has been recommended to evaluate the effectiveness of NiTi rotary instruments in respecting and maintaining the original anatomy of root canals and to measure the possible transportation produced.[16,17] μCT can be used for qualitative and quantitative assessments of root canals in three dimensions.[18] Furthermore, with the development of software, algorithms allow measurement of geometrical parameters such as volume, surface area, structure model index (SMI), straightening, and thickness.[16,19,20]

Although there have been several studies about shaping ability of PTN and WO up to now, the results differ from each other in separate studies. Thus, the purpose of this study was to evaluate and compare the shaping ability of single-file reciprocating system and multi-file rotary system, using WO and PTN as their representative products respectively, in severely curved root canals of extracted human molar teeth by μCT. The null hypothesis is that there is no difference between two systems.

2. Materials and methods

2.1. Preparation of specimens

All the procedures of the present investigation were approved by Research Ethics Committee of Wuhan University. A total of ten extracted mandibular first molars were selected from a pool of extracted teeth for this study. Only the tooth that had a curved mesial root (20°−35°) according to Schneider's method[21] and 2 separated mesial canals with width near the apex at approximately size 15 was selected. The standard access cavities were prepared, and then the crowns of teeth were sectioned slightly above the cementoenamel junction. The mounting of each specimen on scanning electron microscopy stubs was performed as described previously.[16]

2.2. Root canal preparation

The canals were localized and explored with #10 K-file (Dentsply Maillefer). The working length (WL) was determined by inserting a #10 K-file to the root canal terminus and subtracting 0.5 mm from this measurement under 8 × magnification of a surgical microscope. The buccal and lingual canals in each mesial root were randomly assigned to WO or PTN group.

In the WO group, the primary file #25/.08 was used in a programmed reciprocating motion generated by the X-Smart motor (Dentsply Maillefer) in the “WaveOne” mode. File was used in a slow in-and-out pecking motion (amplitude less than 3 mm, 3 pecks) according to the manufacture's instruction. The flutes of the instruments were cleaned after 3 pecks.

In the PTN group, PTN instruments were used in a crown-down fashion with brushing motion at a speed of 300 rpm generated by the X-Smart motor. The ProTaper Universal SX was used to enlarge the coronal aspect of the canal. This was followed by using the X1 to full WL, and canal finishing was performed with the X2 to full WL.

Apical patency was checked with a size #15 K-file between two instruments. Before the use, each instrument was lubricated with Glyde (Dentsply Maillefer). Irrigation was performed with copious 5.25% NaOCl after the use of each file and when root canal instrumentation was complete.

2.3. Micro-CT measurements and evaluation

A μCT system (μCT-20; Scanco Medical, Bassersdorf, Switzerland) with a resolution of 36 μm was used to scan the specimens before and after instrumentation. Three-dimensional images were reconstructed and the volume of interest was selected extending from the furcation region to the apex of the root for the evaluation of root canal geometry. The following measurements were performed by using proprietary software supplied by Scanco. Volume and surface area of the root canals before and after instrumentation were evaluated from the triangulated data by using the “Marching Cubes” algorithm, which was described previously.[20] Increases in volume and surface area were calculated by subtracting the scores for the pre-instrumented canals from those recorded for the post-instrumented canals. Structure Model Index (SMI) and thickness of the canals were also determined from the triangulated data. SMI was originally used to characterize trabecular bone with a structure as being ribbon-shaped versus cylindrical, which ranges from 0 (parallel flat planes) to 4 (an ideal ball).[20] The thickness of the canal was measured by using Distance Transformation Techniques as described previously.[22]

Then, exact superimposing two sets of three-dimensional root canals (pre- and post-instrumentation) was performed to obtain reproducible results for “centers of mass”. Each scanning slice was defined by a series of paratactic data for the x-, y- and z-axes. The “centers of mass” of the canals were connected along the z-axis of each slice by a fitted line.[22] This fitted line was further used to evaluate canal curvature mathematically. Straightening (%) was expressed as difference in canal curvature in relation to initial scores. The mean canal transportation was also calculated by comparing the “centers of mass” before and after instrumentation at the apical, middle, and coronal thirds of the canals.[22] The canal transportation was measured in two directions: the direction of main curvature (DC) and the tangential direction to main curvature (TC, a side shift). Finally, matched images of the surface area voxels of the canals before and after preparation were analyzed to evaluate the amount of uninstrumented surface area, which was determined by calculating the number of static voxels (voxels present in the same position on the canal surface before and after instrumentation). The uninstrumented area were expressed as a percentage of the total number of voxels present on the canal surface.

2.4. Statistical analysis

Mean scores were calculated, and differences between groups or within groups were analyzed statistically by using *t*-test or analysis

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