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ORIGINAL RESEARCH

Evaluation of Root Canal Cleaning and Shaping Efficacy of Three Engine-driven Instruments: SafeSider, ProTaper Universal and Lightspeed LSX

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ABSTRACT

Aim: To compare the cleaning effectiveness and shaping ability of SafeSider, ProTaper Universal and Lightspeed rotary instruments during the preparation of curved root canals in extracted human teeth.

Materials and methods: A total of 63 roots with curved root canals were divided into three groups. Canals were prepared using SafeSider, ProTaper Universal or Lightspeed LSX. Using pre- and post-instrumentation radiographs, straightening of the canal curvatures and loss of working length were determined with a computer image analysis program.

The amounts of debris at the apical 5 mm were quantified on the basis of a numerical evaluation scale. The data were analyzed statistically using the two-way analysis of variance (ANOVA).

Results: There was significantly more transportation among the Lightspeed LSX group compared to the SafeSider and ProTaper Universal groups only at the 4 mm level ($p < 0.05$). The ProTaper Universal instruments performed significantly faster than other groups. No significant differences were observed between the three engine-driven instruments with regards to debris removal.

Conclusion: SafeSider, ProTaper Universal and Lightspeed LSX rotary instruments maintained the original canal curvature well at the apical 3 mm and were safe to use. No difference was found in cleaning efficacy and none rendered the apical part of the canal free of debris.

Clinical significance: SafeSider, ProTaper Universal and Lightspeed LSX rotary instruments are safe to use in curved root canals.

Keywords: Cleaning, LightSpeed LSX, ProTaper Universal, SafeSider, Shaping, Transportation.

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INTRODUCTION

The primary objective of root canal preparation is to completely remove pulp tissue and microorganisms from the root canal system while preserving the integrity and location of the canal and apical anatomy in preparation for adequate filling.[1-4]

Procedural errors may occur during mechanical instrumentation of the root canals. For example, canal transportation might lead to improper dentin removal, with a high risk of straightening the original canal curvature and forming ledges in the dentin wall.[5,6]

Various rotary systems for mechanical preparation have been introduced to the clinical endodontic practice. These systems vary in their design features which may significantly affect their clinical performance.[7]

ProTaper Universal (PTU) (Dentsply Maillefer, Ballaigues, Switzerland) is a series of NiTi (Nickel-Titanium) files with multiple tapers within the shaft of a single instrument with a convex triangular cross-sectional design, a changing helical angle and pitch and a non-cutting guiding tip.[8,9] Lightspeed LSX (LSX) (Discus Dental, Culver City, CA) is a series of NiTi files with a highly flexible nontapered shaft, and a short (2 mm) cutting spade-shaped blade.[10]

The EZ Fill SafeSider system (Essential Dental system, Hackensack, NJ, USA) is a series of stainless steel and NiTi files with a non-interrupted flat-sided design.[11] In contrast to PTU and LSX which are rotational files, SafeSider files rotate in a reciprocation motion.

The aim of this investigation was to compare the cleaning effectiveness and shaping ability of SafeSider, ProTaper Universal and Lightspeed rotary instruments during the preparation of curved root canals in extracted human teeth.

MATERIALS AND METHODS

Teeth Preparation

A total of 63 extracted maxillary molars with at least one curved buccal root were selected for this investigation from a random collection of extracted intact teeth that had been stored in 10% buffered formalin. All selected roots had a single curved root canal and were approximately of the same length (10 mm) from CEJ to apex.

The inclusion criteria were a fully developed apex, no caries and no root resorption.

The crowns were sectioned 3 mm coronal to the CEJ and access cavities were prepared using high-speed diamond burs. One root in each tooth was selected for the study, while the other roots were removed at the furcation level. All selected roots had a single canal and were approximately of the same length (10 mm) from CEJ to apex. Only roots in which a no. 10 K-file (Mani Inc., Takanezawa, Japan) could be inserted to full length until it emerged through the apical foramen were included. Roots in which this file passed freely through the apex were excluded. Working length (WL) was determined by subtracting 1 mm from the length at which the file first appeared through the apical foramen when viewed under 3.2× magnification (Carl Zeiss Meditac Inc., Dublin, CA, USA). Canals were prepared to WL using a stainless steel (SS) no. 15 K-file.

A standard Plexiglas jig was designed according to Iqbal et al[12] (Fig. 1). Each tooth was inserted into a Plexiglass tube and secured with the help of cold-cured acrylic. Specimens were mounted on the angle-meter and a series of radiographs taken using a size 1 digital intraoral CCD sensor (Sopix, Sopro Imaging, Acteon Group, La Ciotat, France). The sensor of the digital radiographic unit was secured to the Plexiglas wall located behind the turntable. To obtain the initial radiographs, the specimens were rotated until the file appeared straight on the radiographs, and then rotated 90° to reveal the maximum curvature of the canal. The degree of rotation was measured using a protractor that was curved on the Plexiglas below the turntable. After canal preparation, final radiographs were taken at the same angle as the initial ones to allow direct comparison between images.

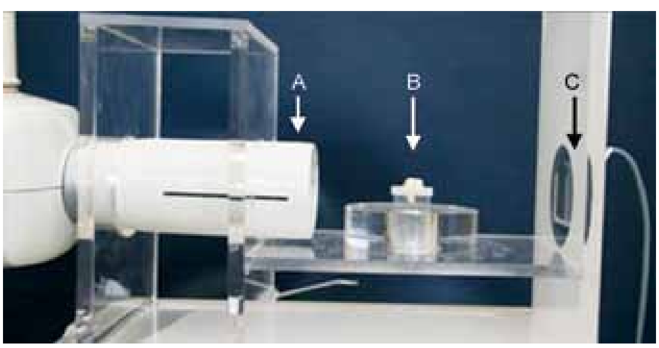

Fig. 1: Plexiglas jig holding X-ray tube head (A) at a fixed distance from turntable containing the specimen mounted in a Plexiglas tube (B) and digital radiographic sensor (C) secured to a Plexiglas wall located behind the turntable

The radius of curvature was calculated as described by Pruett et al.[13]

Specimens were divided into three experimental groups (21 canals each) so that the average radius of canal curvature in each group was similar to the other groups. The homogeneity of the three groups with was assessed and confirmed using analysis of variance (ANOVA) (Table 1).

Root Canal Instrumentation

All root canal preparations were completed by one operator (TK) proficient in all three file systems. Instruments were used to enlarge four canals only. RC-Prep (Premier, Norristown, PA, USA) was used with each file followed by 1 ml of 5.25% sodium hypochlorite (NaOCl) solution using a 25G needle inserted as deep as possible into the root canal without binding. Around 5 ml of 5.25% NaOCl followed by 5 ml of 17% EDTA were used as a final rinse. Root canals were prepared as follows:

SafeSider group: All instruments were used at a constant speed of 2500 rpm in a pecking motion with the Endo-Express reciprocating hand-piece according to the manufacturer's recommended protocol. A no. 20/02 file was used to the WL followed by a Pleezer reamer used to half of the WL. Then sizes 25/02, 30/02 and 30/04 files were used to the WL.

ProTaper Universal group: All instruments were used at a constant speed of 250 rpm with the X-Smart motor (Dentsply Maillefer, Ballaigues, Switzerland). The shaping files (S1 and S2) were used in a brushing motion and the finishing files (F1, F2 and F3) in an 'in and out' action. A no. 20 K-file followed by S1 file were used to two thirds of WL. Then the no. 20 K-file was used to WL followed by S1, S2, F1 (20/07), F2 (25/08) and F3 (30/09) files.

Table 1: Average values and standard deviation of radius of curvature between groups

Groups (n = 21)	*Mean radius of curvature (mm) ± SD*
SafeSider	182.20 (± 104.65)
ProTaper Universal	191.03 (± 103.18)
Lightspeed LSX	186.04 (± 91.80)

Lightspeed LSX group: All instruments were used at a constant speed of 2500 rpm in a continuous pushing motion with the Endo-Mate TC Cordless Handpiece (NSK Ltd., Tokyo, Japan) according to the manufacturer's recommended protocol. Gates Glidden drills 3, 2 and 1 were used to half of the WL followed by no. 20, 25 and 30 LSX files to WL.

Evaluations

Digital radiographic images were exported to Adobe Photoshop (Adobe Systems Inc., San Jose, CA, USA) and artistic filters were applied to posterize the edges to improve contrast. AutoCad software (Autodesk, San Refael, CA, USA) was used to draw the central axis of the pre- and post-instrumentation file.

Apical transportation was evaluated by superimposing the pre- and post-instrumentation images and measuring the distance between the two central axes at 0, 1, 2, 3 and 4 mm from the WL. The loss of WL was evaluated by measuring the distance between 0 mm from the WL in the pre-instrumentation radiograph and the tip of the file in the post-instrumentation radiograph.

In order to ensure blinded assessment, the evaluator was not aware of the particular group when measuring the degree of apical transportation and loss of WL.

Working time was measured using a stopwatch, from application of the first instrument used for preparation of the canal until the last instrument reached the WL.

In order to evaluate canal cleanliness, the roots were horizontally sectioned at 5 mm from the apex to attain the same length for all specimens. These specimens were then sectioned as follows: two shallow longitudinal grooves were cut on each root following its curvature; care was taken to ensure that the grooves did not penetrate the canal. The roots were then split with a mallet and chisel resulting in two halves of the root.[1]

During this procedure four teeth were lost and were excluded from further evaluation. The apical section (5 mm) of the root canal wall was photographed at 20× magnification using a Nikon Coolpix 4500 camera (Nikon, Chiyoda-ku, Tokyo) and a Zeiss microscope (Carl Zeiss Meditac Inc., Dublin, CA, USA). Photomicrographs of each specimen were projected onto a screen, enlarged by 40 times the original size with a superimposed grid with squares measuring 5 × 5 mm each. The total number of squares covering 5 mm of the apex of the canal space and the total number of squares which contained debris were counted for each tooth; particles or chips of any structure on the surface of the root canal were considered debris.[1,14,15] The total amount of debris was expressed as a percentage of squares containing debris of the total number of squares in 5 mm of the apex of the root canal in both halves of a specimen.

The assessment of the canal cleanliness was carried out by a second examiner who was blind in respect to all experimental groups.

Results were subjected to statistical analysis using two-way ANOVA ($p < 0.05$).

RESULTS

Instrumentation

During preparation of the canals no instrument separated and no instrument was permanently deformed.

No significant differences concerning loss of WL were found between the groups ($p > 0.05$, Table 2). No significant differences in apical transportation were recorded at the 0 to 3 mm levels from the WL ($p > 0.05$, Table 2). A significant difference was found at the 4 mm level ($p < 0.05$, Table 2). More transportation was demonstrated with the LSX than with the other instruments.

Mean WT was significantly shorter with the PTU than with the SafeSider and LSX instruments (105.29 ± 27.41, 229.58 ± 90.59 and 205.45 ± 58.38 seconds respectively) ($p < 0.05$).

Canal Cleanliness

Four roots were lost during the splitting procedure and excluded from the study. Consequently, statistical analysis for the debris score was performed on the remaining 59 split roots. No difference was found in the amount of remaining debris between the three devices. None of the instruments reproducibly rendered the apical part of the canal free of debris ($p > 0.05$, Table 3).

Table 2: Mean loss of WL and mean transportation (mm) at different apical levels. Mean transportation (mm) at different apical levels ± SD

Groups (n = 21)	*Mean loss of working length ± SD*	*0 mm*	*1 mm*	*2 mm*	*3 mm*	*4 mm*
SafeSider	0.39 (± 0.83)	0.19 (± 0.20)	0.13 (± 0.16)	0.10 (± 0.06)	0.11 (± 0.06)	0.10 (± 0.06)
ProTaper Universal	0.27 (± 0.35)	0.08 (± 0.12)	0.06 (± 0.06)	0.07 (± 0.07)	0.08 (± 0.07)	0.10 (± 0.10)
Lightspeed LSX	0.50 (± 0.82)	0.17 (± 0.18)	0.15 (± 0.16)	0.12 (± 0.08)	0.15 (± 0.11)	0.19 (± 0.15)

Table 3: Mean debris score percentage

Groups	*Mean debris score percentage ± SD*
SafeSider (n = 20)	6.04 (± 4.13)
ProTaper Universal (n = 19)	3.75 (± 3.53)
Lightspeed LSX (n = 20)	4.79 (± 4.56)

DISCUSSION

Alteration in the canal shape following preparation has been evaluated using various methods. Bramante et al[16] proposed to re-assemble cross-sectioned teeth. The drawback of this technique is the loss of many teeth due to 'ledges' caused by gaps between the sections of the roots.

The use of high-resolution computed tomography (micro-CT) to study root canal anatomy is a promising tool, but there are few difficulties that need to be overcome concerning the structure of tomographic experiments and the reconstruction and analysis of the 3D data configuration obtained.[12,17-19] Furthermore, micro-CT scans can only detect the inorganic aspects of accumulated debris and not the organic counterparts.[20,21]

In the present study, the setup combined with digital images and use of computer software enabled precise evaluation of even minor changes in the canal geometry. Furthermore, no teeth were lost during this evaluation and the technique was simple and easily reproduced. Nevertheless, this technique is not suitable for root canals exhibiting double curvatures or more, since maximum curvatures in these canals usually exist in multiple planes.[22]

The main parameters included in the evaluation of any technique or device is the ability to clean and shape the root canal space while maintaining the canal's original curvature.[22] The present study demonstrated that the three different mechanical designs of rotary instruments produced similar results with minimal transportation and minimal loss of WL. While more transportation occurred with LSX at the 4 mm level, the clinical significance of this finding is not clear. Iqbal et al[8] used a similar technique to compare apical transportation between ProFile (Dentsply Tulsa Dental, Tulsa, OK, USA) and PTU, and found significantly more transportation at the 4 mm level in root canals instrumented with ProFile. They questioned the clinical significance of greater transportation at the this level due to the fact that no statistically significant differences were found at the critically important level of 3 mm from the apex.[8]

In the present study, mean WT was significantly shorter for PTU system. According to the manufacturer, PTU instruments have convex, triangular cross-section, which enhances the cutting action while decreasing the rotational friction between the blade of the file and dentin.[23,24] Enhanced cutting with less friction and screwing might be the reason the mean WT was significantly shorter.

Evaluation of Postoperative Root Canal Cleanliness

Mechanical preparation of the root canal may result in a significant debris reduction but usually will not result in debris-free root canals.[4,25,26]

Longitudinal and horizontal sections of extracted teeth have been used in previous studies to evaluate root canal cleanliness.[4,14,25-28] In the present study, the roots were split longitudinally and the apical 5 mm were photomicrographed under a light microscope. The use of horizontal sections enables adequate investigation of isthmuses and recesses but loose debris that was present inside the canal may be lost during sectioning. Furthermore, great care must be taken to avoid contamination during the sectioning process due to dust from the sawing blades.[4]

Hülsmann et al[4] suggested that the standard technique for the evaluation of postoperative root canal cleanliness should employ a scanning electron microscope (SEM). When using an SEM, observer bias may occur when working with higher magnifications, as only a small area of the root canal wall can be observed at a given time. It is a common finding that most SEM operators tend to select fields with a clean canal surface with open dentinal tubules rather than areas with a large bulk of debris.[4] Compared to SEM, light microscopy has much lower magnification which in turn facilitates a more reliable sampling of fields to be measured.

In the present study, no difference was found in cleaning efficacy between the three systems and no completely cleaned root canals could be found regardless of the instruments applied. Cleanliness was determined using a debris scoring method similar to that described by Suffridge et al,[15] Jensen et al.[14] and Wu and Wesselink et al.[1] Other previously used methods require a subjective assessment by an examiner to collect the nominal or ordinal data using indexes or criteria ranging from no debris to heavy amounts of debris. The grid method of scoring seems to provide a less subjective and more accurate method to quantify remaining debris and potentially permit the use of more sensitive parametric statistical analysis.[14,15]

Further studies are required to find better methods and systems for more adequate root canal debridement.

CONCLUSION

With the limitation of this *in vitro* study, SafeSider, ProTaper Universal and Lightspeed LSX rotary instruments maintained the original canal curvature well at the apical 3 mm and were safe to use. No difference was found in cleaning efficacy between the three engine-driven instruments, and none rendered the apical part of the canal free of debris.

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