Micro CT analysis of amount of dentin removal created by SAF vs. ProTaper systems

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ABSTRACT

Background: Dentin removed during root canal system instrumentation for creating adequate geometry for the canal and cleaning the canal. A new instrument had been marketed with the aim of optimum shaping of all parts of the canal system, however, no information present about the amount of dentin removal compared to conventional rotary system. This study investigated the amount of dentin removal when the canal instrumented by SAF compared with ProTaper by using high resolution computed tomography (micro CT).

Materials and Methods: Twenty extracted single canalled teeth were utilized for this study; and randomly divided into 2 groups. In the first group, the root canals were prepared by using protaper rotary system till F2 and the root canal irrigated with 1ml of normal saline after each instrument. The root canals in the second group were prepared using SAF for 2min, with continuous irrigation (normal saline). After rescanning, the amount of dentin removal was calculated.

Result: It was clear that the use of SAF system had increase the amount of dentin removal and in quantity larger than that did by ProTaper system & the mean of net difference was (0.288mm ± 0.051). By using t-independent test, there was highly significant difference between the two groups at (p=0.001), with in favor of the SAF system over ProTaper system at p< 0.01; in dentin removal quantity

Conclusion: Root canal preparation with SAF-system resulted in more and effectively removed dentin when compared with protaper rotary files.

Keywords: Root canal preparation, SAF-system, ProTaper rotary files, Micro CT, Amount of Dentin removal. (J Bagh Coll Dentistry 2014; 26(3):9-12).

INTRODUCTION

The purpose of root canal preparation is to shape the canals to an adequate geometry and clean the canal system by promoting access for disinfection solutions. This strategy has been termed chemico-mechanical canal preparation. The mechanical canal preparation supports disinfection first via disturbing biofilms that adhere to canal surface and second by removing a layer of infected dentin [1].

The important point in root canal preparation include preparation should be done without shaping errors such as transportation, elbow, zipping or perforation with more surface area prepared [2,3].

The micro computed tomography is a high resolution scanning image with several promising applications in different fields of dentistry. In a recent methodological study, the possibility to quantitative assess amount of dentin removal in teeth was presented.

A new developed Self-Adjusting File (SAF) was designed to address the shortcomings of traditional rotary file by adjusting itself to the canal cross section. This instrument consists of a compressible hallow Nickel-Titanium tube or placement into a root canal, will exert pressure against the canal wall and adjust itself three dimensionally. The SAF system used in an In and Out motion powered by a handpiece and under a constant irrigation.

The aim of this study is determining the amount of dentin removal when SAF applied to root canals of anterior teeth compared to ProTaper system.

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MATERIALS AND METHODS

Selection of teeth

Twenty extracted anterior teeth for the reasons unrelated to the current study were collected and stored in 0.1% thymol solution. Then all the teeth were scanned by micro CT unit at an isotropic resolution of 35 µm (Sc. Medical/ Switzerland). They were then accessed by using high –speed diamond burs, and patency of coronal canal was confirmed. Then coronal flaring was accomplished with #2 Gates Glidding burs (DentsplyMaillerfer, Switzerland).

Then canal length was determined with size 15 K files (12mm), specimens were then randomly allocated to two groups with n= 10 each.

Root canal instrumentation

- **SAF: Group -1-**

Ten samples were prepared by using SAF operated in a transline (In and Out) vibrating handpiece (GENTLE pomd, leavo. Germany) combined with a RDT3 head (Redent Nova) at a frequency of 83.3 H2 (5000 movements per minutes).

The 2 mm diameter SAF was inserted into the canal while vibrating and delicately advanced apically with an intermittent In and Out hand movements of 5mm amplitude until it reach the predetermined working length. It was operated with continuous irrigation 2mL/min. The preparation continued for 4 minutes, and then the teeth were kept in container during transport.

- **ProTaper: Group -2-**

For ten samples; the instrumentation was started with ProTper rotary file system according to the manufacturer instructions. The instruments were driven at 300 rpm with 2 N.cm of torque. After positioning of rubber stopper for all files, the sequence for preparation was, S1 file which was used for 1 minute 2mm shorter than the working length in a brushing motion for coronal one third with using a light coating Glyde File Prep that was applied to the file as a lubricant. Then S2 file which was used for 1 minute 2mm shorter than the working length in a brushing motion for coronal two thirds with using a light coating Glyde File Prep as a lubricant. Finally F2 file was used for full working length for 1 second using a light coating Glyde File Prep as a lubricant.

Irrigation with 1ml normal saline was used after each instrument and 1ml after completing the instrumentation with disposable syringe and an open-end 27 gauge needle. After each instrument the needle was inserted until it reached the predetermined working length and retracted 2mm before irrigation was applied. Total instrumentation time was measured with timer that was equal to 2 minutes and the total irrigation volume was 4ml. After canal instrumentation the specimens directly send for post operative Micro-CT scans.

MicroCT Measurements

The tooth samples were measured before and after preparation with a commercially available cabinet cone-beam microCT, (µCT 35, SCANCO Medical AG, Brüttisellen, Switzerland). It operates with a cone beam originating from a 7 µm focal-spot X-ray tube. The x-rays are detected by a digital cooled charged coupled device (CCD) camera based area detector and the projection data are computer-reconstructed into a 1024 x 1024 image matrix. The chosen voxel size was 20 µm in all three spatial dimensions. For each sample, 600 to 750 slices were scanned, covering a total of 12.00 mm to 15.00 mm, X-ray voltage was 70 kVp, Intensity 114 µA, Integration Time 1600 ms.

Evaluation

The mounting device ensured almost exact repositioning of the samples for both pre and post scanning procedure. Superimposition was calculated subsequently with the software package IPL V5.15 (SCANCO Medical AG). The two three dimensional scans were co registered with each other by three dimensional rotation and translation determined by maximizing the cross-correlation of the two overlaid three –dimensional datasets of the outer hull of the tooth, which is unchanged by the root canal treatment. Then by varying the relative translation in all three directions, we automatically detected the best superimposition of the outer root contour, with a precision better than one voxel. The matched root canals were then evaluated as follows:

Maximum diameters of the canals were determined by means of a distance transformation technique related to canal length. In their technique, the volumes of interest were filled with spheres sized to accommodate the maximum diameter within the structure. Each voxel was assigned a local (thickness) value, which represented the diameter of the largest sphere in which that specific voxel was located. Then pre and post thickness diameter was evaluated and the change between the pre and post thickness considered an amount of dentin removal in (mm).

RESULTS

ProTaper system

The descriptive statistics for the mean values & the standard deviations of the quantitative dentin removal (QDR) in mm (pre-preparation versus post-preparation) for the ProTaper system used for preparation of the root canal samples had been shown in the table (1) (fig. 1). From the table (1), it was clear that the use of ProTaper system had increase the amount of dentin removal & the mean of net difference was (0.213mm ± 0.034).

Table 1: The descriptive statistics of the QDR in mm for ProTaper system used for preparation of the root canal samples

ProTaper	N	Min.	Max.	Mean	S.E.	S.D.	Variance
Pre-	10	0.546	1.294	0.802	0.061	±.193	0.037
Post-	10	0.703	1.533	1.014	0.068	±.215	0.046

SAF system

The descriptive statistics for the mean values & the standard deviations of the QDR in mm (pre-preparation versus post-preparation) for the SAF system used for preparation of the root canal samples had been shown in the table (2) (fig.1). From the table (2), it was clear that the use of SAF system had increase the amount of dentin removal and in quantity larger than that did by ProTaper system & the mean of net difference was (0.288mm ± 0.051). By using t-independent test, there was highly significant difference between the two groups at (p=0.001) (table 3), with in favor of the SAF system over ProTaper system at p< 0.01; in dentin removal quantity, (fig1)

Table 2: The descriptive statistics of the QDR in mm for SAF system used for preparation of the root canal samples

SAF	N	Min.	Max.	Mean	S.E.	S.D.	Variance
Pre-	10	0.479	0.965	0.681	0.046	±.146	0.021
Post-	10	0.838	1.265	0.969	0.042	±.131	0.017

Table 3: t-test for the difference between the two instruments used for preparation of the root canal samples in QDR

Instruments	Mean	S.D.	S.E.	95% Confidence Interval of the Difference		t-test	d.f.	p-value
				Lower	Upper			
SAF - ProTaper	-0.075	.0437	0.02	-0.116	-0.034	-3.831	18	.001

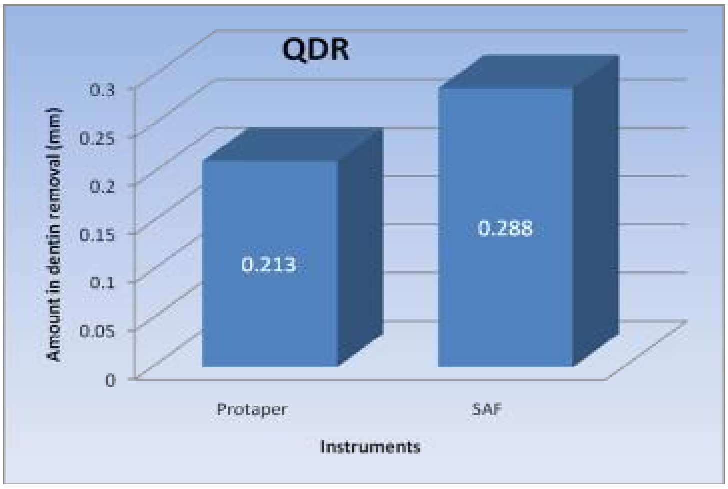

Figure 1: Bar chart representing difference between the two instruments for QDR (Mean net difference)

DISCUSSION

During root canal preparation, the most time consuming and demanding phase of endodontic therapy, the operators skills and the pathological conditions, which depend on dental anatomy and set limitations to the treatment, should be carefully evaluated. It is important that operators have thorough knowledge of dental anatomy and instrumentation techniques, know how to adapt the available instruments and materials to each case and develop satisfactory tactile sensation to control dentin removal by the action of endodontic files. All these factors are closely related with the root structure in different situations [4,5].

It is generally accepted that the amount of remaining dentine is directly related to the strength of the tooth [6,7].

Lateral forces result in high stress concentrations in radicular dentine at the coronal one third of the root [8,9]. The rotational axis of the tooth is located at the crest of the alveolar bone, and most of the applied force is concentrated around the circumference of the tooth where the crown diameter is the smallest, corresponding to the cervical region of the tooth at the cemento-enamel junction (CEJ) [8,9], whereas the concentration of the forces is the lowest within the root canal [10]. The centre of the root canal, representing the central axis of the tooth, is a neutral area with regard to force concentration

[8,9]. This force distribution may explain the susceptibility of teeth to fracture at the CEJ area when lateral forces are exerted on the coronal portion of the tooth during occlusal loading [8-10]. From the point of view of stress concentration, the thickness of the dentinal wall between the root canal and its external circumference assumes great significance. There is a direct correlation between the root thickness and the ability of the tooth to resist lateral forces and avoid fracture [10,11]. The thickness of the dentine wall is directly proportional to the ability of the tooth to withstand lateral forces. Therefore, treatment that causes indiscriminate removal of tooth structure from the canal walls during endodontic treatment should be avoided [10].

The present study evaluated two active NiTi systems. The design of this study was such that an analysis of areas before and after the root canal preparation to determine the increasing of area by mm, mean by increasing the area the more surface touched and more dentin removed. By this method there is significant difference between the two systems. This result might be explained by the single SAF file is intended to be used throughout the procedure, starting as a compressed file that gradually enlarges in size during dentine removal with close, three dimensional adaptations to the canal walls with continuous irrigation [12].

Such mechanical preparation can be attributed to the 3-D stress building up in the lattice skeleton of the file when working compressed while removing dentine. Furthermore, with the vibrating motion of the file, dentin was gradually and uniformly removed resulting in smooth surface that looks as if it were sandblasted. The surface of the SAF is delicately rough with 3 μm peak-to-bottom dimensions. This rough surface is present on every thin element of the NiTi lattice. The compression of the file generates circumferential pressure on the canal walls. The pressure is greatest when the file is inserted into the root canal and declines with the gradual enlargement of the canal. This change in pressure in turn affects the amount of dentin removed, increased it [12,13].

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