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Evaluation of the Efficacy of Self-Adjusting File Instrumenton Oval-shaped Root Canals

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Abstract: *Purpose;Oval-shaped canals are a challenge when using rotary files because buccal and/or lingual recesses are commonly left uninstrumented. The aim of this study was to evaluate root canal preparation in flat-oval canals treated with ProTaper, Reciproc or self-adjusting file (SAF) instruments. Methodology; 60 mandibular premolars were divided into three groups. After biomechanical preparation, teeth were embedded in acrylic blocks. Roots were then sectioned 4, 8, and 12 mm from the apex using a precise saw, and the cut surfaces in the apical, middle, and coronal thirds were observed under a stereomicroscope at ×40 magnification. Results;The areas of prepared canal walls were significantly higher with the SAF than the ProTaper or Reciproc instruments ($p<0.05$). The SAF removed the dentin layer from all around the canal, whereas the others left substantial untouched areas. The area in the apical third of the teeth prepared with the Reciproc was significantly higher than with the other techniques, likely due to the high taper of the Reciproc file ($p<0.01$).Conclusions;In the coronal third, mean increases in the area of the canal were significantly higher with the SAF than with ProTaper or Reciproc. Using the SAF instrument, flat-oval canals were prepared homogenously and circumferentially.*

Key words: *Oval canals, ProTaper, Reciproc, Self-adjusting file, Stereomicroscope.*

I. Introduction

Biomechanical preparation of root canals is a major step in achieving endodontic success; it enables bacterial elimination and the removal of debris, facilitating obturation [1]. The introduction of nickel-titanium (NiTi) rotary file systems resulted in significant progress being made in the mechanical preparation of the root canal space. Nevertheless, studies have underlined the still inadequate quality of mechanical preparation with current NiTi rotary systems. Indeed, it has been shown that the amount of mechanically prepared root canal surface is frequently below 60% [2, 3]. Thus, rotary NiTi techniques leave a substantial area of dentin untreated. The rotary motion of these files tends to prepare the main root canal space in a circular shape, leaving buccal and lingual extensions unprepared [4].

Proper mechanical instrumentation should uniformly cover the entire perimeter of the root canal, completely removing the inner layers of heavily contaminated dentin. This, in turn, will also ensure the removal of as much of the remaining soft tissue and bacterial biofilm as possible, because remaining soft tissue and bacterial biofilm may adhere to and cover large areas of the inner surface of the canal and may predispose to or cause and perpetuate disease [5]. Because of the limitations of current technologies, there is a continuing need for more effective preparation techniques to improve debridement of the root canal space.

Recently, the self-adjusting file (SAF; ReDent Nova, Ra'anana, Israel) was introduced, with a totally new design [6] (Fig. 1). The SAF is a hollow file, designed as a compressible, thin-walled, pointed cylinder, composed of a thin NiTi lattice. During operation, the file is designed to be compressed while inserted into a narrow root canal; then, it attempts to regain its original dimensions, thus applying constant delicate pressure to the canal walls. When inserted into a root canal, it adapts to the canal's shape, both longitudinally and also along the perimeter of the cross-section [6, 7].

Oval-shaped canals represent a critical challenge for any root canal cleaning and shaping protocol [8]. Thus, the present study was designed to evaluate the root canal preparation efficacy of the SAF protocol in oval-shaped canals and to compare those results with the performance of the ProTaper NiTi system (Dentsply-Maillefer, Balleigues, Switzerland) and the Reciproc instrument system (VDW, Munich, Germany; Fig. 2).

Figure 1.The SAF instrument system.

Figure 2. The ProTaper and Reciproc instrument systems.

II. Materials And Methods

In total, 65 mandibular premolars were selected and stored in purified filtered water. Teeth with curved roots were excluded. The coronal portions of all teeth were removed using a diamond-coated bur with water cooling, leaving roots approximately 14 mm in length. All roots were inspected to detect pre-existing cracks; teeth with such findings were excluded and replaced by similar teeth. Then, all roots were embedded in acrylic blocks. Five teeth were left unprepared and served as controls, and the remaining 60 teeth were divided randomly into three groups of 20 teeth each.

Canal patency was established with a #15 K-File (Dentsply-Maillefer, Balleigues, Switzerland). In the ProTaper group, canal preparation was performed with rotary files using a torque- and speed-controlled motor (X-Smart; Dentsply Tulsa Dental, Tulsa, OK) at the torque and speed recommended by the manufacturer. The following sequence of PT NiTi files was used to prepare the canals, at 300 rpm with 2 N/cm of torque. The SX file was used in coronal enlargement, the S1 file was used at one-third of the working length, the S2 file was used at two-thirds of the working length, and the F1, F2, and F3 files, which correspond to apical size 30, were used at the working length. Irrigation with 1 mL of 5.25% NaOCl solution was performed between each instrument.

In the Reciproc group, the Reciproc R25 instrument, which had an ISO size 25 at the tip and a taper of 0.08 in the apical 3 mm, was used for canal preparation. The R25 instrument was operated with a VDW.SILVER motor (VDW, Munich, Germany) at 300 rpm, as recommended by the manufacturer. The R25 file was used with a continuous up-and-down pecking, reciprocating movement, which is claimed to rotate 150° counter clockwise, then 30° clockwise.

In the SAF group, the SAF was used to enlarge the canals. For this procedure, canals were first prepared with a #20 K-File. Then, a 1.5-mm diameter SAF, which corresponds to an apical size of 20, was used with an in-and-out vibrating handpiece head (RDT3, ReDent Nova) at an amplitude of 0.4 mm and at 5000 vibrations per minute. SAF was applied with a pecking motion to the working length for 4 min in each canal. In-

and-out manual motion was also performed continuously by the operator. Continuous irrigation with 2.5% NaOCl was applied with a pump (VATEA, ReDent Nova) at a rate of 4 mL/min.

In all groups, the smear layer was removed with 3 mL of 17% EDTA for 3 min. Bi-distilled water (3 mL) was then used for 3 min as a final rinse.

All roots were sectioned perpendicular to the long axis at 12, 8, and 4 mm from the apex using a diamond-coated precision saw (IsoMet 1000, Buehler, Dusseldorf, Germany) under water cooling. Images of each section were captured at 40× magnification using a stereomicroscope (Leica MZ75, Meyer Instruments, Langham Creek, Houston). The results are expressed as the cross-sectional area, roundness, and diameter of the root canal prepared. The cross-sectional areaanddiameter of the root canal werecalculated as a percentage of thearea of the canal lumen. TheresultswereanalyzedbyusingtheOnewayAnova test (Table 1).

	Pixel (%)		p
	Mean±SD	Median	
Self-Adjusting File	2,18±0,79	***2,05***	
ProTaper	1,32±0,36	**0,75**	***0,03*** **
Reciproc	1,62±0,31	**0,97**	

OnewayAnova test *** p<0.05*

Table 1: Evaluation of thepixelpercentagesaccordingtothecross-sectional areaanddiameter of the root canal

III. Results

Overall, in terms of roundness and diameter, there was no difference between the groups. However, in the coronal third, the areas of the root canal walls prepared were significantly higher with the SAF than the ProTaper or Reciproc instruments (Fig. 3). The SAF removed the dentin layer from all around the canal, whereas the ProTaper and Reciproc instruments left substantial areas untouched (Fig. 4, 5). The SAF-treated canals had more evident preparation of the buccal and/or lingual recesses. There was no significant difference between the Protaper and Reciproc groups for the cut surfaces in the apical, middle, or coronal thirds. The area in the apical third of the teeth prepared with the Reciproc was significantly higher than the other preparation techniques, likely due to the high taper of the Reciproc file.

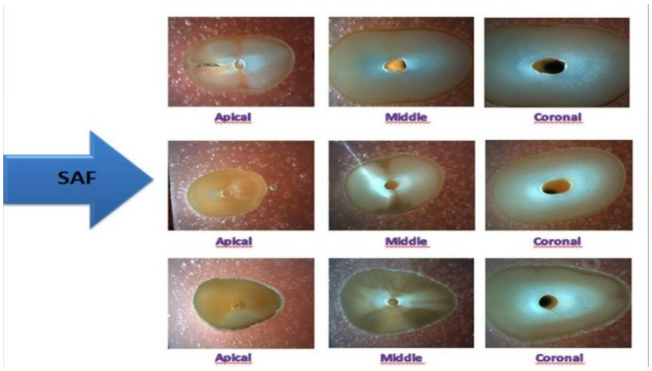

Figure 3. Apical, middle and coronal section images of roots prepared with the SAF system.

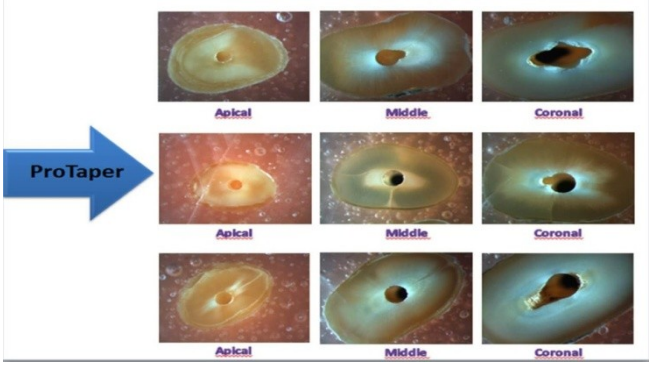

Figure 4. Apical, middle and coronal section images of roots prepared with the ProTaper system.

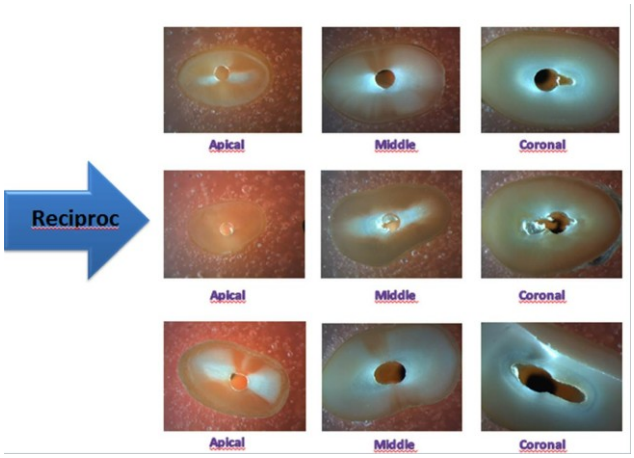

Figure 5. Apical, middle and coronal section images of roots prepared with the Reciproc system.

IV. Discussion

Variations in canal geometry before shaping and cleaning procedures seem to have more influence on the changes that occur during preparation than the instrumentation techniques themselves [9]. Nonetheless, one potential limitation of this study is the relatively small sample size of 20 teeth per group; however, this is similar to other recent studies [2, 10, 11, 12, 13].

Effective cleaning and shaping of the root canal system is the most important factor for achieving the biological and mechanical objectives of root canal treatment. Over the years, various instrumentation techniques and flexible instruments have been developed and introduced for this purpose [9, 14, 15].

Recently, new systems that use reciprocating motion have been introduced to the market that claim to shape root canals with only one file. As a result of technique simplification, according to the various claims clinicians can save time and cost in endodontic treatments [14].

The new concept of reciprocating instruments and the use of only one instrument to enlarge the canal, regardless of the pre-existing canal condition (such as dimension and curvature), into a final size and taper seems to go against current instrumentation protocols that require the gradual enlargement of the canal with a series of instruments until the desired size and shape is obtained. However, this new concept of using a single (reciprocating) instrument may be cost-effective and may shorten the learning curve for practitioners in adopting the new technique [14, 16].

When compared with rotary NiTi instrumentation, SAF has been reported to leave less unprepared area [12] and is significantly more effective in disinfecting oval canals *in vitro*[17]. In the present study, the SAF resulted in a higher area than the rotary groups only in the coronal third. This may be explained by the relative softness of dentin near the pulp chamber as a result of the higher dentinal diameter and density [18] compared with the other canal regions.

In the middle third, although no differences in area among the groups were observed, the SAF system did show a significantly higher area of prepared root canal wall than the rotary instruments. This may have been due mainly to the anatomical features of the flat-oval-shaped canal of the mandibular premolars [19].

The preparation of the apical section remains a challenge. In this region, previous studies of root canal preparation with the SAF have shown uninstrumented areas in mandibular premolar root canals [13]. We also found no difference in the unprepared areas of root canal walls using the SAF or the rotary instruments. This may be explained by the root canals of mandibular premolars tending to have a rounder cross section in this region, which favours the action of rotary instruments [20].

It is worth noting the compressibility of the SAF instrument because this mechanical feature allows the SAF to adapt itself to the cross-sectional shape of oval canals [6]. If the lattice cylinder of the file, which has a 1.5 mm diameter, is compressed mesiodistally up to 0.2 mm, it may spread buccolingually by up to 2.4 mm. This may explain how it spreads to form closer contact with the canal walls, even in the buccal and lingual recesses that were commonly unaffected by the rotary files.

In the samples evaluated, it is noteworthy that NiTi instruments made a round cross-section, but the SAF made a teardrop-shaped cross-section, similar to the original shape of the canal. Metzger *et al.* [6] emphasised that most rotary file systems would find the widest part of the canal and gradually machine it, using several files of increasing diameter, to a still wider canal with a round cross-section. If the canal happens to be relatively narrow, the whole original canal may be included in the preparation. If the canal, however, is flat, oval, teardrop- shaped, or simply large, this mode of preparation may leave untreated recesses, mainly buccally or lingually to the machined part of the canal [6, 7]. The SAF touches the inner canal wall at all points, as a result of the compressible and expansive structure of its lattice.

The current results indicate that, in addition to its previously reported greater efficiency for circumferentially removing dentin from all canal walls [7, 8, 12, 13], the SAF system also has improved debriding and cleaning efficacy in oval-shaped canals. This may, in turn, also aid in explaining the recently reported improved disinfection of the SAF system in oval canals [17].

As demonstrated previously, the present results suggest that rotary NiTi instruments alone were unable to adequately prepare the root canal [2, 9, 21], and the SAF did indeed result in more homogenous preparation and circumferential removal of a layer of hard tissue, favouring root canal disinfection and the accommodation of the root canal filling material [12, 17]. Further studies should compare the cleaning efficacy of the SAF system with a combination of rotary files and a passive ultrasonic irrigation method in flat-oval-shaped canals.

Within the limitations of this study, it can be concluded that in the coronal third, the mean increase in the area of the canal was significantly higher with the SAF than with the ProTaper or Reciproc instruments. Using the SAF instrument, flat-oval-shaped canals of mandibular premolars were prepared homogenously and circumferentially.

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