Removal of Debris and Smear Layer in Curved Root Canals Using Self-Adjusting File with Different Operation Times – A Scanning Electron Microscope Study

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Key Words
Apical third of root canal, curved root canal, debridement, self-adjusting file, smear layer

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Abstract

Aim: Debridement during root canal treatment is mandatory and it is provided by means of chemomechanical instrumentation and irrigation methods. This article analysis the debridement capacity of a novel system, SAF and its special irrigation device when used with different operation times in curved root canals.
Methodology: 30 mesiobuccal root canals of maxillary molars were instrumented using SAF. Teeth were divided into three groups. In Group 1, 10 new SAF files were used for operation for 4 minutes. In Group 2, the 4-min previously used SAF files were operated in the same manner. In Group 3, the 8-min previously used SAF files were operated. During SAF operation 2.6 % NaOCl and 17 % EDTA were used alternately in all groups. Debris and smear layer removal were evaluated for the apical thirds under scanning electron microscope.
Results: Non-used, 4-min preused, and 8-min preused SAF efficiently removed debris and smear layer in the apical thirds. There were no significant difference among the groups in terms of debridement.
Conclusions: When SAF is operated in curved root canals with continous flow of irrigation it results in debris and smear-free canal walls in the critical apical thirds within 12 minutes.
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Introduction

Root canal instrumentation produces smear layer. This amorphous structure is composed of dentin particles, necrotic debris, and odontoblastic processes that occlude the orifices of dentinal tubules (1). Smear layer is reported to prevent the penetration of irrigation solutions, medications, and filling materials into dentinal tubules and many researchers believe that it is detrimental (2). The literature reports generally show that regardless of the instrumentation and irrigation techniques, the effectiveness of irrigating solutions remains limited in the apical one third of a prepared canal. This is particularly true for curved root canals (3). Therefore, the improvement of irrigating protocols is essential during root canal treatment in order to achieve better cleaning efficiency especially in the very complex apical area.

Rotary nickel-titanium files are successful to clean and shape the straight and narrow canals,and completion of the file sequence may result in a clean canal with no tissue debris and with removal of all or most of the inner layer of the heavily contaminated dentin (4). Recently micro–computed tomographic studies by Peters et al (5) have extended the understanding of the limitations of rotary file systems reporting that inadequate preparation often occurs in curved root canals. In upper molars treated with a conventional rotary system, 49% of the canal walls were reported to be untouched, even in the larger palatal canals (6). To overcome this handicap, these common nickel-titanium file designs are being modified for a higher percent of the root canal surface to be prepared by the shaping procedure (7).

Self-Adjusting file (SAF) is a novel system among the nickel-titanium files operating in a different manner. It adapts itself longitudinally to a curved canal, as most rotary nickel-titanium files do, but differently adapts itself to the cross-section of the canal (7). It is a hollow file designed as a compressible, thin-walled, pointed cylinder, composed of a thin derivate of nickel-titanium lattice with high torsional and fatigue resistance. The lattice surface is slightly abrasive and it allows removing dentin with a back-and-forth grinding motion (8). This reciprocating file system is used with a specially designed irrigation device providing continuous flow of the irrigant.

During the operating procedure, SAF is inserted into the canal while vibrating and is lightly pushed in until it reaches the predetermined working length. It is then operated with in-and-out manual motion and with continuous irrigation using two cycles of 2 minutes each for a total of 4 minutes per canal. This procedure is reported to remove a uniform dentin layer 60- to 75-mm thick from the canal circumference (8).

Every available rotary file systems are reported to generate a smear layer leaving debris in the root canal (9) however a recent study by Metzger et al. (10), who used the SAF system with a 4-min application of 3% NaOCl and 17% EDTA reported clean and mostly smear layer–free dentinal surface in all parts of the root canal. However the evaluative tests showed the efficacy of the SAF file declined with time. A file that was preused for 30 minutes was found to be 40% less effective than a new file (8). Nevertheless, when used for 12 minutes, according to the manufacturer's instructions, the SAF efficacy was not reported to substantially reduce. However the ability to remove dentin is claimed to decrease if the file was reused (8).

Thus the aim of this present study was to evaluate the debridement capacity of SAF when used in curved root canals in an operation time as advised by the manufacturer. The null hypothesis is when SAF is used within 12 minutes it removes smear layer and debris efficiently in the apical thirds of curved root canals.

Materials and Methods

Selection of Teeth

The study sample consisted of 30 maxillary molars with fully formed apices that had been extracted for periodontal and/or prosthetic reasons. The teeth were stored in 10% buffered formalin until they were used. The mesiobuccal (MB) root canals of maxillary molars were instrumented using SAF. Curvature of the MB canals was measured according to the protocoldescribed previously by Estrela et al. (11). The 30 canals showed curvatures ranging from 32 to 45°. This sample was equally divided into 3 groups of 10 teeth for instrumentation with SAF. The working length of each canal was determined by subtracting 1mm from the observed length of protrusion of the number 10 file through the apical foramen.

Root Canal Instrumentation and Irrigation with the SAF

After endodontic accesss cavity, the root canal was negotiated using a size 10 K-file. The working lengths were set 1 mm shorter than the apical foramen. A glide path was established by manual instrumentation up to a size 20 K-file. The 10 SAF files were operated using an in-and-out vibrating handpiece as described by Metzger et al. (6) with 5000 vibrations/min and a 0.4-mm amplitude, with the irrigation device (VATEA; ReDent-Nova) that provided flow of the irrigation solution at a flow rate of 5 mL/min until it reached the predetermined working length for 4 minutes. The irrigation solution flowed into the file and freely escaped into the root canal through the lattice wall to backflow coronally without positive pressure. Because a flow rate of 5 mL/min was chosen, 15 mL of NaOCl (2.6%) and 5 mL of EDTA (17%) were used. NaOCl was used as the initial irrigant during the first 3 min of the operation, followed by 1 min of irrigation with EDTA. A final flush with 5 mL NaOCl was used to remove the EDTA, and distilled water was used in the last step. The canals were dried using paper points.

In Group 1, 10 new SAF files were used for operation for 4 minutes. In Group 2, the 4-min previously used SAF files were operated in the same manner. In Group 3, the 8-min previously used SAF files were operated.

SEM Evaluation

Two longitudinal grooves were prepared on the buccal and lingual surfaces of each root using a diamond disc, avoiding penetration into the canal. The roots were then split into 2 halves with a chisel and coded. The coded specimens were mounted on metallic stubs, gold sputtered, and examined independently by two observers using SEM (Leo Stereoscan S440, Leica, Wetzlar, Germany). After general evaluation of the canal wall, 2 SEM photomicrographs were taken at magnifications of 2000× at the apical (2 mm to apex) thirds of each specimen for the smear layer and 200× for debris. Cleanliness was evaluated using a 5-point scoring system introduced by Hülsmann et al (12). (1) score 1: no smear layer, and all dentinal tubules were open; (2) score 2: a small amount of smear layer, and some dentinal tubules were open; (3) score 3: homogenous smear layer covering the root canal wall, and only a few dentinal tubules open; (4) score 4: complete root canal wall covered by a homogeneous smear layer, and no open dentinal tubules were observed; and (5) score 5: heavy, homogeneous smear layer covering the complete root canal wall.

The presence of debris was evaluated from images at 200X magnification using a scale of 5 scores (12) as follows: (1) score 1: clean root canal wall and only a few small debris particles, (2) score 2: a few small agglomerations of debris, (3) score 3: many agglomerations of debris covering less than 50% of the root canal wall, (4) score 4: more than 50% of the root canal walls were covered with debris, and (5) score 5: complete or nearly complete root canal wall coverage with debris.

All results were then grouped into "clean canal wall" that included scores 1 and 2 or "smear layer and debris present" that included scores of 3, 4, and 5.

Two examiners independently scored each of these images, which were coded and randomly mixed so that the examiners were blinded to the area from which a given sample originated.

When two examiners independently agreed on a score, it was recorded. When disagreement occurred, both two discussed the sample and its scoring, and an agreed score was reached.

Statistical Analysis

Statistical analysis was performed by using nonparametric analysis of variance. Results were regarded as significant if $p < .05$. Multiple comparisons were adjusted by using the Bonferroni correction.

Results

Debris

Root canal preparation using the SAF for three groups rendered all root canals clean of debris. Debris evaluation of the root canal dentinal surfaces usually resulted in debris scores of 1 or 2, representing a clean root canal surface (Figure 1). In the new SAF group 90% of the apical thirds of the roots were free of debris, this ratio was 87% in the 8-min used group. Finally 12-min group was 74% . Statistically there was no difference between the experimental groups ($P > .05$).

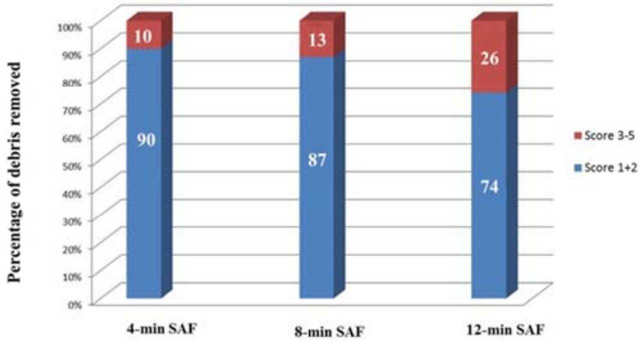

Figure 1. Distribution of debris scores at apical levels. Data were dichotomized for graphic illustration: scores 1–2 (clean canal wall) versus 3–5 (debris present).

Smear Layer

Operating SAF with 4, 8, and 12-min applications resulted in a root canal surface clean of smear layer (Fig. 2). In the apical thirds, 15 out of 30 were scored as either 1 or 2, respectively, representing a clean dentin surface. 4-min group represented 64%, 8-min group represented 61%, and 12-min group represented 57% in smear layer scores of 1 or 2, respectively. Different operation time of SAF within 12 minutes removed smear layer almost equally in the apical thirds. No differences between groups were detected statistically ($P > .05$).

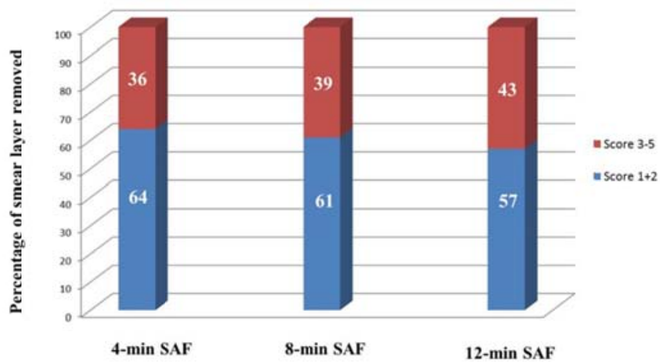

Figure 2. Distribution of smear layer scores at apical levels. Data were dichotomized for graphic illustration: scores 1–2 (clean canal wall) versus 3–5 (smear layer present).

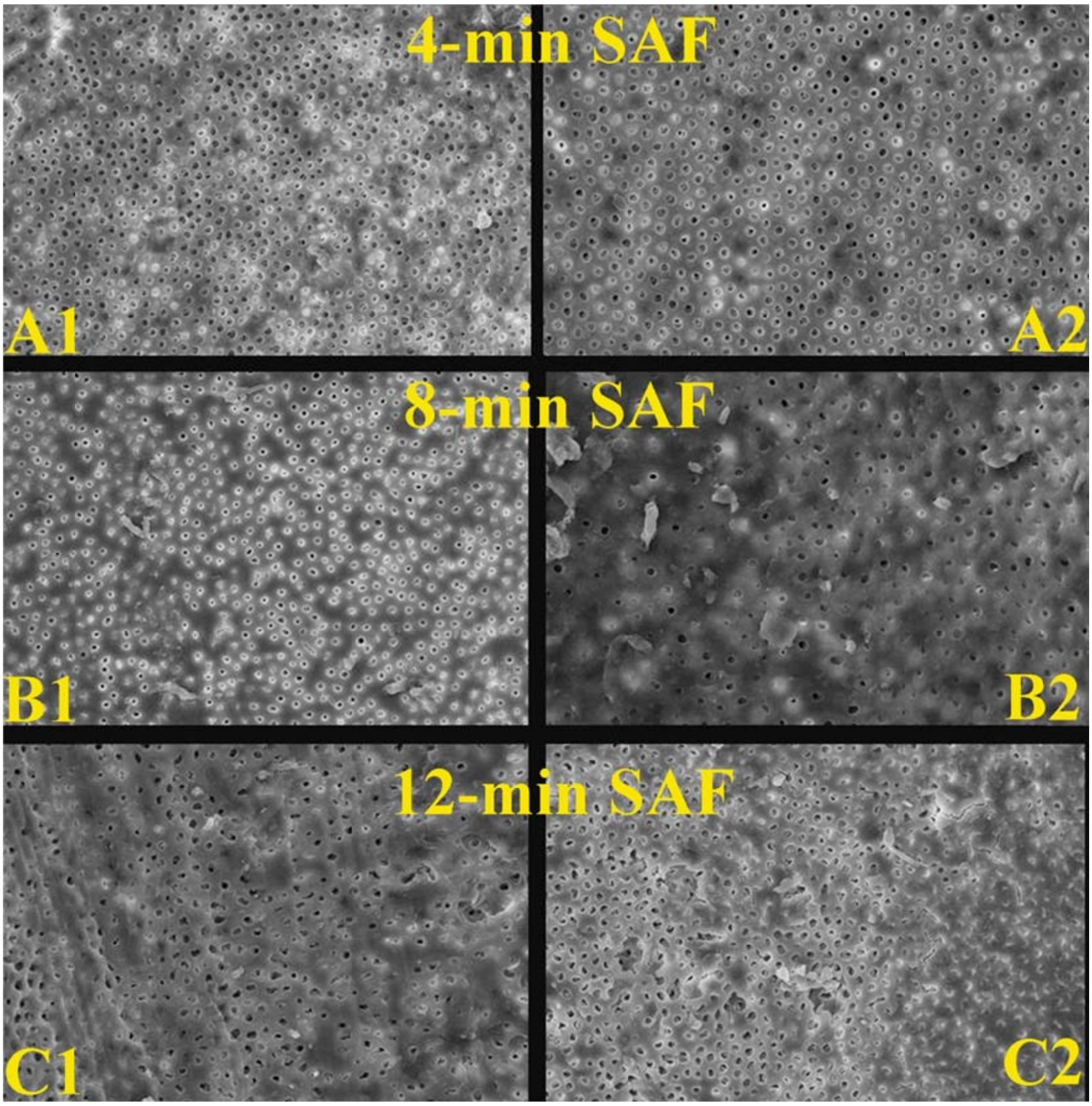

Figure 3. The smear layer in the apical third of curved root canal **(A1-2)** After 4-min operation of new SAF + dual-irrigation regime the root canal surface is free of debris and smear layer leaving the dentinal tubules open; **(B1-2)** the 4-min preused SAF were used with the dual-irrigation regime. Most of the dentinal tubules were open with a score 1-2; **(C1-2)** the 8-min preused SAF + dual-irrigation regime representing score 2-3.

Discussion

Debridement of the root canal system is a major concern for endodontic success and irrigation is an important part of root canal debridement especially in curved root canals (13). Unfortunately, many studies have reported that currently used methods of root canal preparation and irrigation do not effectively debride the entire root canal system (9). Ideally, root canal irrigants should flush out debris, dissolve organic tissue, destroy microbial byproducts, and remove the smear layer. Past studies have shown that current canal preparation and irrigation methods may be effective at cleaning the coronal portions of root canals but much less effective in the apical portions of canals (14,15). Although several studies indicate that achieving this goal in the apical third of the root canal may be difficult if not impossible, the use of the SAF in combination with a dual-irrigation regime of NaOCl and EDTA is reported to result in clean dentin surfaces in the apical portion of most root canals (10). Recently the study results of Metzger et al. (10) represented 65% root canal wall free of smear layer for the apical thirds of the root canal. Our results are in line with this previous study. In the 4-min used SAF smear layer was removed 64 %, 8-min used SAF 61%, and 12-min used SAF 57%, respectively.

Sodium hypochlorite has the ability to dissolve organic debris, and destroy microbial byproducts

(16). EDTA is a chelating agent used to remove the smear layer (17). This dual combination of irrigants has been shown to be effective in debriding and disinfecting root canals as well as other irrigants (18-21). Studies have shown an increased efficacy of canal debridement with increased apical size preparations and increased taper of instruments (14,22). As reported recently by Peters et al (5) the resulting apical size is usually at least equivalent to a #40 file when SAF is used during preparation in 5-minutes. Several studies confirmed that larger apical preparation reduces the bacterial count (23,24) and enhances the effectiveness of irrigation (25). Probably apical preparation performed using SAF and vibrating motion of the file's delicate mesh within the fluid that is continuously replaced had synergist effect for debridement and resulted with clean root canals almost free of smear layer on the critical apical region.

In addition, the role of chlorine should not be overlooked. It is known that chlorine is responsible for the dissolution of organic tissue and the antimicrobial effect of NaOCl (26). However, chlorine is consumed rapidly during the first phase of tissue dissolution, probably within 2 min (26,27). Therefore regular replenishment and large volumes of NaOCl are required for successful debridement. During SAF operation with continous irrigation, one should consider that NaOCl is refreshed every second making it possible for sufficient free chlorine to be present in the root canal to dissolve the organic component of dentine debris. It could be possible that NaOCl contains enough free chlorine to dissolve the organic component of the dentine debris and despite the increased operation time with the used files NaOCl had enough flushing effect on debridement especially at the apical portions of the curved root canals. NaOCl entering the file through a free-rotating hub is continuously replaced during the procedure, thus providing a fresh and totally active irrigation solution. Because positive pressure is absent throughout the root canal system, the solution can easily escape through openings in the lattice of the file (8). The success in removing the smear layer in the apical third, may be due to the vibrating motion of the file's delicate mesh within the fluid that is continuously replaced.

Conclusions

When SAF is operated in curved root canals with continous flow of irrigation it results in debris and smear-free canal walls in the critical apical thirds within 12 minutes. Thus our null hypothesis is accepted.

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