The Self-adjusting File (SAF). Part 3: Removal of Debris and Smear Layer—A Scanning Electron Microscope Study

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Abstract

Aim: The aim of this study was to evaluate the cleaning ability of the Self-Adjusting File (SAF) system in terms of removal of debris and smear layer. **Methodology:** Root canal preparations were performed in 20 root canals using an SAF operated with a continuous irrigation device. The glide path was initially established using a size 20 K-file followed by the SAF file that was operated in the root canal via a vibrating motion for a total of 4 minutes. Sodium hypochlorite (3%) and EDTA (17%) were used as continuous irrigants and were alternated every minute during this initial 4-minute period. This was followed by a 30-second rinse using EDTA applied through a nonactivated SAF and a final flush with sodium hypochlorite. The roots were split longitudinally and subjected to scanning electron microscopy (SEM). The presence of debris and a smear layer in the coronal, middle, and apical thirds of the canal were evaluated through the analysis of the SEM images using five-score evaluation systems based on reference photographs. **Results:** The SAF operation with continuous irrigation, using alternating irrigants, resulted in root canal walls that were free of debris in all thirds of the canal in all (100%) of the samples. In addition, smear layer–free surfaces were observed in 100% and 80% of the coronal and middle thirds of the canal, respectively. In the apical third of the canal, smear layer–free surfaces were found in 65% of the root canals. **Conclusions:** The operation of the SAF system with continuous irrigation coupled with alternating sodium hypochlorite and EDTA treatment resulted in a clean and mostly smear layer–free dentinal surface in all parts of the root canal. *(J Endod 2010;36:697–702)*

Key Words

Apical third of root canal, cleaning debris, irrigation, irrigation protocol, SAF, self-adjusting file, smear layer

The cleaning and shaping of root canals is a key step in root canal treatment procedures. Unless all tissue remnants and debris are removed, the subsequent stage of root canal obturation may also be jeopardized, leading to the potential failure of treatment (1, 2). Any material left between the canal wall and the root canal filling may prevent intimate adaptation between the two and may provide a space for bacterial leakage and bacterial proliferation.

Accordingly, the cleaning efficacy of any endodontic file system is of major importance and has been studied intensively (3, 4). The presence of a significant amount of debris is commonly encountered when either rotary or hand files are used in root canals with flat cross-sections. The debris accumulation in the uninstrumented "fins" may not allow for proper disinfection and may prevent the root canal filling from reaching these recesses, even when warm gutta-percha compaction is applied (1, 2). Such a gross accumulation of debris may readily be visualized even when using light microscopy at a magnification of $\times 50$ (1, 2).

Furthermore, the smear layer and some amounts of debris may be present on the walls of the root canals, even with the simplest morphology. A 5-μm-thick smear layer represents a potential gap between the root canal filling and the root canal wall that may be capable of accommodating approximately five layers of bacteria. Moreover, the smear layer may block or prevent the free access of antibacterial agents to the bacteria that may have penetrated into the dentinal tubules. The evaluation of fine debris and the presence of the smear layer require higher magnification levels ($200\times$-$1{,}000\times$) that are achievable only through the use of scanning electron microscopy (SEM).

SEM has been applied by numerous investigators to study the efficacy of various rinsing protocols and file systems in the removal of debris and smear layer (5–16). Every available file system generates a smear layer and leaves debris in the root canal, and rinsing with sodium hypochlorite alone is unable to render the canal free of debris and smear layers (5–13, 15, 16). In addition, the application of chelating agents such as EDTA may dramatically improve the overall efficiency of the procedure (8-13). Finally, even when the coronal and middle thirds of the canal are relatively clean, the apical third of the root canal always presents a problem in regard to the ability to achieve the same level of cleanliness (5, 6, 9, 12). This may be of great importance because the presence of a smear layer and debris may prevent sealer adaptation to the canal walls and allow penetration of irritants into the periradicular tissues, initiating or sustaining periradicular inflammation (17, 18).

The Self-Adjusting File system (SAF; ReDent-Nova, Ra'anana, Israel) is different from any available file system in two major respects (19). First, the SAF is a hollow and flexible file that adapts itself three-dimensionally to the shape of the root canal, including the ability to adapt to its cross-section (19). The SAF vibrates when

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operated and removes a uniform dentin layer from the canal walls even in oval, flat root canals (19). Rather than machining a central portion of the root canal into a round cross-section, the SAF allows for maintaining a flat canal as a flat canal with slightly larger dimensions. Second, this hollow file allows for the continuous irrigation of the root canal throughout the procedure, with additional activation of the irrigant by its vibrating motion that creates turbulence in the root canal. Irrigation may be provided by any physio-dispenser type of device (ie, NSK Surgic XT Micro Motor System, Kanuma, Japan, or W&H ImplantMed, Burmoos, Austria) or by a special rinsing unit such as the one used in the current study, which delivered the irrigant at a flow rate of 5 mL/min (VATEA, ReDent-Nova).

The adaptation of the file to the root canal's cross-section is expected to limit the potential gross debris accumulation in untreated areas of oval, flat canals. The continuous flow of the irrigant through the file combined with the vibrating motion may have an effect on the cleaning ability of the file in the root canal at large and particularly in its difficult-to-clean cul de sac region, the apical third of the root canal (20). This challenging portion of the root canal may benefit from the unique mode of action of the SAF file.

The present study was designed to evaluate the cleaning ability of the SAF in terms of removal of debris and smear layer, using SEM.

Figure 1. The SAF file with its irrigation tube. The file was operated with a KaVo (Biberach Riss, Germany) vibrating handpiece. An irrigation tube with an on-off switch (white) was attached to a continuous-flow source (VATEA, ReDent-Nova, [19]) that provided either 3% sodium hypochlorite or 17% EDTA at 5 mL/min.

Materials and Methods

Selection of Teeth

Twenty-three single-rooted teeth were selected from a random collection of human teeth that were extracted within the last 3 months and stored in 10% buffered formalin until they were used. Each root was radiographed in buccolingual and mesiodistal projections to evaluate the shape of the root canal and to detect any possible obstruction. The inclusion criteria were single-rooted teeth with straight root canal and an intact pulp chamber, whereas the exclusion criteria were previous root canal treatment and teeth with an irregular root canal anatomy.

Root Canal Treatment

An endodontic access cavity was prepared in each tooth, and the root canal was negotiated using a size 15 K-file. The working length was determined to be 1 mm short of the apical foramen that was sealed from the outside using an impression compound (Kerr, Orange, CA).

A glide path was established by manual instrumentation up to a size 20 K-file using 3% sodium hypochlorite and RC-Prep paste (Premiere, Philadelphia, PA) as a lubricant.

An SAF file (ReDent-Nova) was used for cleaning and shaping the root canal using an in-and-out vibrating handpiece as described by Metzger et al (19). The hollow SAF file allowed for continuous irrigation throughout the procedure. Irrigation was performed via a silicon tube (inner and outer diameters of 1.587×3.175 mm, respectively; Degania-Silicone, Degania, Israel) that was attached to a rotating hub on the shaft of the file (Fig. 1). The irrigant went into the file and freely escaped into the canal through the lattice wall to backflow coronally and escape through the access cavity. No positive pressure was generated in the root canal.

The irrigation was performed continuously during the operation using a special irrigation apparatus (VATEA Irrigation Device). This apparatus contained two separate irrigation fluid reservoirs, each with its own irrigation tubing, which was attached to the hollow SAF file via a dual silicone tube with a Y-type ending that allowed each irrigant to be separated from the other until the delivery point.

The SAF file was operated in two cycles of 2 minutes each for a total of 4 minutes. The SAF was removed for inspection after each cycle. During the first minute of each cycle, sodium hypochlorite (3%) was used as the irrigant, wheras EDTA (17%) was used during the second minute. The flow rate of the irrigants was set at 5 mL/min, resulting in a total volume of 10 mL of each irrigant used during the procedure. After completion of the two cycles, an additional irrigation with EDTA (17%) was performed for 0.5 minutes with the vibrational mechanism turned off followed by a final flush with sodium hypochlorite (3%, 5 mL) in order to remove the remaining EDTA. The root canal was dried using paper points, and the tooth was left to dry at room temperature for 24 hours before being prepared for the SEM examination. The experimental group was composed of 20 roots, which were subjected to the protocol described previously. Three roots were used as a positive control for the smear layer in which only sodium hypochlorite (no application of EDTA) was used as an irrigant through the total 4-minute period of the SAF operation.

SEM

Each root was split longitudinally and subjected to SEM processing and examination. The samples were dried and coated with gold (Polaron SEM Coating Unit E5100; Quorum Technologies, East Sussex, UK) and examined using a JEOL JSM 840A scanning electron microscope (JEOL, Tokyo, Japan). Representative sections of the coronal, middle, and apical thirds of the canal were used for evaluation at a magnification of 200× and 1,000×.

Selection of Representative Sections

After the central beam of the SEM had been directed to the center of the object by the SEM operator at 10× magnification, the magnification was increased to 200× and subsequently 1,000×, respectively, and the canal wall region appearing on the screen was photographed (5).

SEM Image Analysis and Scoring

The cleaning ability of the SAF file was evaluated using the debris and smear layer score systems introduced by Hülsmann et al (5). These