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Research Paper

The self-adjusting file (SAF) system: Minimally Invasive 3D Endodontics- "LESS IS MORE"

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ABSTRACT

Current rotary file systems are effective tools. Nevertheless, they have two main shortcomings.

1) They are unable to effectively clean and shape oval canals and depend too much on the irrigant to do the cleaning, which is an unrealistic illusion.

2) They may jeopardize the long-term survival of the tooth via unnecessary, excessive removal of sound dentin and creation of micro-cracks in the remaining root dentin.

The new Self-adjusting File (SAF) technology uses a hollow, compressible NiTi file, with no central metal core, through which a continuous flow of irrigant is provided throughout the procedure. This technology uses a new concept of cleaning and shaping in which a uniform layer of dentin is removed from around the entire perimeter of the root canal, thus avoiding unnecessary excessive removal of sound dentin. Furthermore, the mode of action used by this file system does not apply the machining of all root canals to a circular bore, as do all other rotary file systems, and does not cause micro-cracks in the remaining root dentin.

KEYWORDS: *Cleaning and shaping, instrumentation, irrigation, minimally invasive, NiTi files, obturation, root filling, rotary files, SAF, self-adjusting file.*

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[Figure 1]

I. INTRODUCTION

Rotary nickel titanium (NiTi) files were first introduced clinically in 1993. Recently, innovative metallurgy and reciprocating movement were combined to allow for the creation of "single file" systems, such as Wave One (Maillefer-Dentsply, Ballaigues, Switzerland) and Reciproc (VDW, Munich, Germany). In all currently used systems, the files consist of a solid central metal shaft with a rotating blade and flutes to either contain or carry off the cut material. As long as the canals are simple, straight and narrow, with a round cross section, such instruments are likely to achieve the goals of root canal instrumentation and shaping. Nevertheless, rotary instruments, both new and old, may fail to meet the challenge of either oval or curved canals.[5-18]

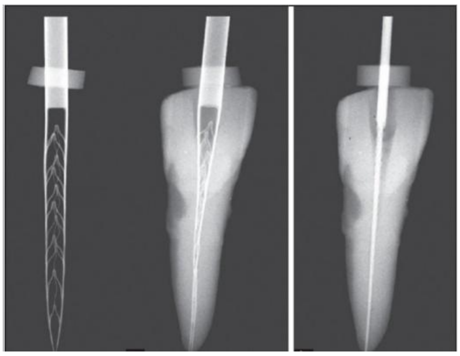
This need currently remains unmet due to

(a) The challenge of three-dimensional (3D) cleaning and shaping of oval and curved canals[5,8,9,12]
(b) The microbiological challenge of infected oval canals [10]
(c) The challenge of 3D obturation of oval canals. [11,13]
d) The challenge of maintaining the integrity of the remaining radicular dentin, was recently recognized.

The aim of this review is to introduce the reader to the SAF System and its mode of operation. The SAF System is a shaping and cleaning system designed for minimally invasive endodontic treatment. The system consists of a self-adjusting file operated with a special RDT handpiece-head and an irrigation that delivers a continuous flow of irrigant through the hollow file.

THE SELF-ADJUSTING FILE (SAF) SYSTEM

The SAF is designed as a hollow tube, the walls of which are made from a thin nickel titanium lattice with a rough outer surface [Figure 2]. The SAF system is extremely flexible and also extremely compressible, so that a 1.5-mm diameter SAF may be compressed into a root canal in which only a #20 K file could previously be inserted[10,18] [Figure 2]. This compressibility also enables the file to adapt to the cross-sectional shape of the canal. This will occur even if the operator is not aware that the canal is oval; hence, the name "self-adjusting file". Naturally, such a flattened file cannot rotate in the canal and is therefore operated with in-and-out vibrations created by the RDT handpiece-head.



[Figure 2]

The RDT handpiece- Head

The RDT handpiece-head [Figure 3] has a dual mechanical function. It turns the rotation of the micro-motor into a trans-line in-and-out vibration with an amplitude of 0.4 mm. It also contains a clutch mechanism that allows the SAF to rotate slowly when not engaged in the canal but completely stops the rotation once the file is engaged with the canal walls. The micromotor is operated at 5000 rpm, which results in 5000 vibrations/min, and the operator uses pecking motions when using the SAF.

[Figure 3]

The VATEA irrigation pump

The VATEA (ReDent) [Figure 4] is a self-contained peristaltic pump with a built-in irrigant reservoir of 500 mL operated using a foot switch and powered by a rechargeable battery.[20] The irrigant can be delivered into the tube at a rate ranging from 1-10 mL per minute, with the typical recommended setting of 4 mL per minute.

[Figure 4]

The EndoStation:

An all-in-one endodontic unit The EndoStation (ReDent and Acteon) is a compound machine specifically designed for the SAF that uses a special RDT handpiece. An external bottle is used as the irrigant container of the EndoStation, from which the irrigant is drawn by the peristaltic pump into the tube and through it to the attached file. When used in "SAF mode", both the micromotor and the irrigation pump are simultaneously operated using a single foot pedal.

No-pressure irrigation with scrubbing

This method uses positive pressure to get the irrigant to the WL and consequently involves the risk of a "sodium hypochlorite accident" in which the irrigant is passed beyond the apex. Negative pressure systems, such as EndoVac (SybronEndo), were designed to overcome this problem by using negative pressure to draw the irrigant to the apical part of the canal. [9-12] In both the concepts described above, the irrigation is applied intermittently, only when the file is withdrawn from the canal. When pulp tissue or bacteria is present, the sodium hypochlorite may thus be quickly consumed and inactivated. Therefore, simply flooding the canal with sodium hypochlorite during the procedure may be ineffective; frequent replacement of the irrigant is commonly suggested to maintain the desired activity. As long as the needle cannot be safely inserted to WL, no fully active sodium hypochlorite will be present at the apical part of the canal. The SAF System may be defined as a no-pressure irrigation system that is applied throughout the instrumentation process[15,16,18]. Once the irrigant enters the SAF, any pressure that may have existed in the delivery tube disappears due to the lattice structure of the file. The irrigant is continuously delivered into the root canal, and the vibrations of the file combined with the pecking motion applied by the operator result in the continuous mixing of the irrigant that is present in the root canal with fresh, fully active irrigant.

The scrubbing effect

All other irrigation systems rely on the chemical action of the sodium hypochlorite irrigant, the streaming motion of the irrigant, or both [15]. Nevertheless, there is a more effective way to clean surfaces of materials that are attached to them: Mechanical scrubbing. Either pulp tissue remnants or an established bacterial biofilm, tightly attached to the walls of the root canal are evident. In a canal that is subjected to retreatment, remnants of an old root filling may represent another material that is a challenging target for cleaning. Mechanical scrubbing of the surface is the most effective way to clean such a surface within a few minutes. The metal mesh of the SAF wall is intimately adapted to the canal wall and is continuously in motion, thus providing a scrubbing effect. The combination of scrubbing with the continuous flow of fresh, fully chemically active sodium hypochlorite results in highly effective cleaning of the canal walls from any attached materials.

The 3D cleaning and shaping challenge.

The challenge of oval canals

In most cases, rotary file systems will result in adequate instrumentation, as far as straight, narrow canals with round cross sections are concerned. In such canals, the rotary file will prepare a circular 'bore', leaving un instrumented buccal and/or lingual 'fin(s)'. This may result in the unnecessary removal of sound dentine while failing to reach the goals of cleaning and removal of the dentine layer all around the canal surface. When a SAF file is inserted into an oval canal, it is compressed so that it assumes the cross section of that canal. This spreading occurs even if the operator is unaware that the canal is flat, hence the name Self-Adjusting File. The SAF file will adapt itself to the walls of the canal and gradually remove a thin, uniform layer of dentine all around the circumference of the canal[12,14,16]. Consequently, a round canal will stay round with larger dimensions and an oval canal or one with a teardrop-like cross section will maintain that shape but with larger dimensions.

The challenge of CURVED canals

Canal straightening and canal transportation are two other procedural errors that may occur when using rotary instrumentation. In both canal straightening and canal transportation, vast areas of the canal wall are left uninstrumented, while excessive dentine removal occurs in some other areas that may be termed 'danger zones'[12].

The SAF file, which has no central metal core, is extremely flexible, which minimizes the risk for both canal straightening and canal transportation[10,11,13]. It adapts well to both longitudinal curvatures, as well as to the cross section of the canals and causes less canal transportation and canal straightening.

The challenge of ISTHMUSES

Roots that contain two canals in a single root may often contain an isthmus connecting the two canals[17]. Cleaning and obturating such isthmuses have been a major challenge that does not yet have a satisfactory solution.

Rotary instruments tend to actively pack the isthmus with dentine chips. This phenomenon may be easily understood when a rotating instrument removes dentine chips and tissue debris, it is much easier to push them sidewise into a non-resisting isthmus than to carry them coronally or pack them tightly within the instrument flutes.

The SAF file works in a totally different manner than rotary instruments[10,11,18]. The gentle abrasive action of the SAF file removes a dentine layer by converting it into thin powder that is continuously suspended and carried coronally by the flow of the irrigant. The SAF system produces no cut dentine chips, nor does it have the tendency to pack them into the isthmus.

The challenge of C-shaped root canals

C-shaped canals represent a most complicated and challenging case of flat-oval canals. Rotary instrumentation has great limitations in these challenging root canal systems[16]. However, the SAF system may handle such extreme cases of flat-oval canals with greater efficacy[16].

The challenge of retreatment

Complete removal of the previous root canal filling material is important to allow or an effective disinfection of the canal[12]. Larger diameter instruments may be used to complete the cleaning process, but one must consider the risks of damaging the root by either canal transportation[16] or by the increased creation of microcracks and full thickness fractures[14,17] which may be caused by the thicker rotary instruments.

The SAF file cannot remove the bulk of the root canal filling material. Nevertheless, Abramovitz et al showed that once this bulk is removed with rotary instruments, the material remaining on the canal walls can be effectively removed with the SAF system[18].

The microbiological challenge

Long oval canals are rather common[16], and the challenge of reducing bacterial counts as much as possible is quite different in such canals[10,16]. Areas of the canal that were not instrumented could serve as sanctuaries for viable bacteria. It is likely that such areas were blocked with dentine chips, as in the case of the isthmus which would protect the inner layers of the bacterial biofilm in these areas from the action of sodium hypochlorite.

Lin and Hapassalo recently demonstrated that the SAF system is also more effective than either rotary or hand files in the removal of biofilm located in recesses (grooves) of the root canal, thus providing additional explanation for the antibacterial efficacy of the SAF system[15]. Therefore, it seems that the introduction of the SAF system may have advanced the above definition of the elimination of bacteria as much as possible one notch farther, at least in oval and irregular canals.

The challenge of 3D OBTURATION

Effective three-dimensional obturation is expected to provide an adequate sealing of the root canal, which has always been a major target in root canal treatment[16]. However, Schilder stated long ago that if the canal is not clean, it cannot be adequately obturated[16]. The quality of root canal fillings is usually clinically evaluated by their radiographic images.

Debris that remains or is packed into uninstrumented buccal and/or lingual recesses or 'fins' often prevents the root canal filling from achieving 3D contact with the canal wall. Such obturation failures, despite the acceptable radio- graphs they produce, may later be discovered during periapical surgery or during a microscope- assisted retreatment procedure. The scrubbing action of the SAF file, combined with the activation of the irrigant by the vibration, resulted in a smooth and uniform clean surface that allowed for better adaptation of the root canal filling.

The challenge of file separation

File separation is one of the major drawbacks of nickel- titanium rotary files[17]. The separated fragment is usually screwed-in in the canal and may block access to its apical portion. Removal of the fragment requires expertise, is time consuming, and may lead to the loss of sound dentine with the danger of perforation or predisposing the tooth to vertical root fracture[14].

The SAF file is extremely flexible, to the extent of bending upon itself. It looks delicate, but it is rather resistant to mechanical damage. Even it gets completely detached, it is usually easily washed out of the canal because, contrary to a separated rotary file fragment, the detached arch is not screwed-in in the canal.

Clinical implementation of the SAF system

The SAF system is substantially different from all current rotary file systems. Consequently, when starting to use this system the operator has to change certain habits and should expect a certain learning curve. This is first of all because the SAF file is not a penetrating instrument, as per all current rotary files. Furthermore, the endpoint of treatment is defined by operating time rather than by reaching a working length with a given size of instrument.

Minimally invasive endodontics

The SAF technology allows for a new concept in endodontics: minimally invasive endodontics. Minimally invasive procedures in medicine at large are procedures designed to achieve all the goals of the traditional, more invasive procedures, while causing only minimal damage to the patient. Such procedures do not represent a compromise but, rather, attempts to reduce the destructive 'price tag' attached to the more invasive traditional approach[6,7,14,15].

The SAF system allows for such a change in endodontics; it allows for:

(i) More complete instrumentation of the canal walls[11,12,17]

(ii) Cleaner oval canals[12,13]

(iii) Cleaner apical portion of the canal[17]

(iv) Better adaptation of the root canal filling to the canal walls, especially in oval canals[11,17].

All of these results are achieved:

(i) Without the excessive removal of dentine in all parts of the canal[11,12]

(ii) Without straightening and/ or transportation of the canal[10,13] or the risks associated with these phenomena

(iii) Without the inherent risk of creating microcracks in the radicular dentine[15,18].

II. CONCLUSION

The basic concepts and principles of endodontics indicate to allow success, the canal should be clean of debris, free of bacteria and sealed adequately by the root canal filling[8].

The SAF system opens up a new era and new horizons for those practitioners who are not content with just faster and easier root canal treatment, but who additionally strive for the best 3D root canal treatment. The new concept of 'minimally invasive endodontics' that has been made possible by the new SAF technology represents a potential paradigm shift. As such, it requires an open mind for new ways of thinking about endodontics.

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