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SAF file: It's really three dimensional file

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The biological objectives of root canal treatment have not changed over the recent decades, but the methods to attain these goals have been greatly modified. The introduction of NiTi rotary files represents a major leap in the development of endodontic instruments, with a wide variety of sophisticated instruments presently available [1, 2].

Whatever their modification or improvement, all of these instruments have one thing in common: they consist of a metal core with some type of rotating blade that machines the canal with a circular motion using flutes to carry the dentin chips and debris coronally. Consequently, all rotary NiTi files will machine the root canal to a cylindrical bore with a circular cross-section if the clinician applies them in a strict boring manner [3].

Shortcomings of Rotary NiTi files

When operated in narrow canals or those with a round cross section, this mode of operation may be adequate. The situation is quite different for flat root canals that have an oval or even ribbon-shaped cross-section. Several reports have indicated that in oval or flat root canals, rotary files alone fail to perform adequate cleaning and shaping. Untreated ‘‘fins’’ may remain on the buccal and/or lingual aspects of the bore created by the rotary file (fig.1) [4-6].

Flat oval root canals are common in the distal roots of lower molars, upper and lower bicuspids, and lower incisors and canines. Asymmetrical, flat, tear-shaped cross-sections are another challenge. Such canals are common in most roots that contain two root canals in the same root and a potential isthmus. This includes anterior roots of lower molars, mesiobuccal roots of upper molars, first upper bicuspids, and some lower incisors (Fig.2). A systematic and comprehensive study by Wu et al [7] has shown that oval or flat root canal morphology is present in up to 25% of root canals, and in certain root groups it may exceed 50%. The flatness or asymmetry in these canals is usually in the buccolingual dimension; therefore, it fails to be recognized on clinical radiographs, which represent a buccolingual projection. The buccal and lingual areas of such flat root canals and the area facing the isthmus in tear-shaped ones cannot be adequately prepared by current rotary files.

All current rotary files have one or another type of spiral blade and helical formation that when rotating machines the root canal into a form that has a round cross-section [4].

General features of SAF file

The SAF is a hollow file designed as a compressible, thin-walled pointed cylinder either 1.5 or 2.0 mm in diameter composed of 120 µm-thick nickel-titanium lattice (Fig.3). The 1.5-mm file may easily be compressed to

the extent of being inserted into any canal previously prepared or negotiated with a # 20 K-file [8]. The 2.0-mm file will easily compress into a canal that was prepared with a #30 K-file. The file will then attempt to regain its original dimensions, thus applying a constant delicate pressure on the canal walls [8]. When inserted into a root canal, it adapts itself to the canal's shape, both longitudinally (as will any nickel titanium file) and along the cross-section (Fig.4). In a round canal, it will attain a round cross-section, whereas in an oval or flat canal it will attain a flat or oval cross-section, providing a three-dimensional adaptation. The surface of the lattice threads is lightly abrasive, which allows it to remove dentin with a back-and-forth grinding motion (Fig.5) [8].

The SAF is operated with trans line (in and out) vibrating handpieces with 3,000 to 5,000 vibrations per minute and an amplitude of 0.4mm. The vibrating movement combined with intimate contact along the entire circumference and length of the canal removes a layer of dentin with a grinding motion.

The SAF is inserted into the canal while vibrating and is delicately 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 will remove a uniform dentin layer 60-75 µm thick from the canal circumference [8]. The SAF file is designed for single use.

What about the irrigation?

The hollow design allows for continuous irrigation throughout the procedure. A special irrigation device is connected by a silicon tube to the irrigation hub on the file and provides continuous flow of the irrigant of choice at a low pressure and at flow rates of 1 to 10 mL/min.

Irrigation of the root canal with copious amounts of sodium hypochlorite during root canal treatment is widely recommended (Fig.6) [9, 10].

It has been well documented that when exposed to its target of bacteria and tissue debris, sodium hypochlorite loses its activity rather quickly [11]. Taking into account the extremely small volume of the root canal, the amount of sodium hypochlorite contained in the canal loses its activity within a very short time. Therefore, as frequent replacement of the irrigant as possible is mandatory for maintaining its optimal potency and effect [11].

The SAF operates with a continuous flow of the irrigant, thus allowing continuous fresh irrigant to be present in the canal at all times. The vibration of the file's metal lattice within the irrigant facilitates its cleaning and debridement effects [12, 13].

The effective replacement of irrigant in the apical part of the canal occurs with no clinically significant positive pressure. No pressure builds up in the canal during the SAF operation because the metal mesh allows free escape of the irrigant at all times. Even in the narrow apical part of a canal 200 µm in diameter (a canal prepared up to a #20 K-file), the SAF represents a very ineffective piston, with 38% of the canal cross-section area free for the irrigants backflow [8].

Safety in use (High durability)

Unexpected separation of rotary nickel titanium files was and still is the major drawback. Improvements in metallurgy, design, surface treatment, quality control, and, above all, the introduction of hands on training, have

significantly reduced the extent of this problem, nevertheless it is still with us. As opposed to stainless steel files that may give a ‘‘warning’’ by some distortion that appears in an abused file, usually no such macroscopic sign will appear in a rotary nickel titanium file. Furthermore, even in the era of microscope-assisted root canal treatment, a separated nickel-titanium file screwed in at the apical part of an even slightly curved canal is much more difficult to remove than a similar segment of a stainless steel file.

The SAF file is extremely durable and may go through rather severe abuse before a mechanical failure will occur. It does not have a core as do other nickel-titanium instruments. Any strain applied to it is distributed along many of its delicate parts, and the total endurance is a function of the accumulated endurance of each of these individual parts (Fig.7) [14].

Canal transportation

Another inherent problem with rotary-NiTi files is apical canal transportation in curved root canals [15, 16]. Most file systems will adequately maintain the apical part of a curved root canal in place as far as the thin instruments are concerned. However, the larger-diameter instruments are relatively stiffer and have a tendency to remove more dentin on the outer side of the curvature of the apical area, leading to apical canal transportation [17]. Rotary file manufacturers made many improvements, such as noncutting tips and more flexible alloys and designs, but the problem still exists.

Transportation of the canal at this critical point can have two major drawbacks: first, the apical part of the canal on the inner side of the curvature may remain untouched and full of debris, and, second, it may lead to ledging or even a subsequent perforation [18].

The SAF file is extremely flexible and pliable. It does not impose its shape on the canal but rather complies with its original shape. This is true both circumferentially and longitudinally. The long axis of the apical part of curved canals is kept closer to its original place than reported for rotary files: a mean center-of-mass shift of 68.8 - 77.7 µm compared with the shift of 120-135 µm previously reported by Peters et al with rotary files in similar canals [16]. In curved canals, the thicker rotary nickel-titanium files have a tendency to transport the canal to the outer side of the curvature [16]. When the SAF is used to enlarge the canal to similar dimensions, it tends to keep the apical part of curved canals closer to its original location.

Canal straightening

Another closely related problem is straightening of the root canal at the midroot section of curved root canals. Most file systems will straighten this part of the curvature to one extent or another by removing more dentin on the inner side of the curvature [16]. This may reduce the thickness of the remaining dentin on the inner side of the curvature to such an extent that it increases the risk of vertical root fracture [19] or even results in a strip perforation.

Accurate length measurement is an essential prerequisite for the use of any rotary file. The thin nickel-titanium rotary files are extremely flexible and may

negotiate even a canal with a rather sharp apical curve. When a rotary file accidentally passes the apical foramen of such a curved canal, because of either misleading length measurement or failure to keep the marker on the file in place, it may soon lacerate or zip the apical foramen and form an oval opening with potential loss of the apical constriction (Fig.8).

The SAF, on the other hand, may be operated in such conditions even for few minutes with no zipping whatsoever.

Obturation with what?

Root canal obturation of SAF-prepared root canals may be done by any of the common methods. Adaptation to the canal walls is possible even in flat canals because of the thorough cleaning of the otherwise difficult to clean recesses. Obturation using lateral compaction using chloroform-dipped customized master cones [(20)] is of particular interest because it allows the operator to actually visualize the shape of the SAF-treated root canal as reproduced on the customized master cone.

Thermoplasticized obturation or worm vertical obturation techniques also recommended to be used as a root canal obturation.

Conclusion

The SAF represents a new approach in endodontic file design and operation. Its main features are as follows:

1. A three-dimensional adaptation to the shape of the root canal, including adaptation to its cross-section.
2. One file is used throughout the procedure, during which it changes from an initially compressed form to larger dimensions.
3. Canal straightening and canal transportation of curved canals are largely avoided because of the lack of a rigid metal core. The file does not have ‘‘a will of its own.’’
4. High mechanical durability, thus overcoming the issue of separated nickel-titanium instruments.
5. Hollow design that allows continuous irrigation with constant refreshment of the irrigant throughout the procedure.

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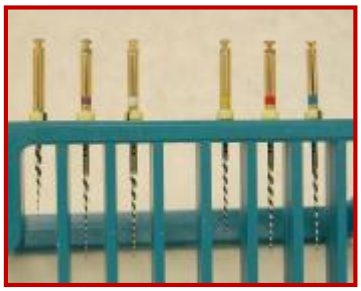

Fig.1

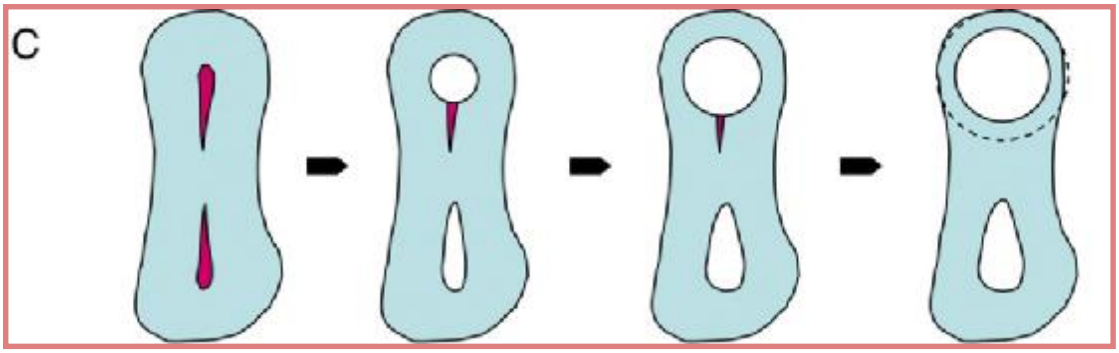

Fig.2

Fig.3

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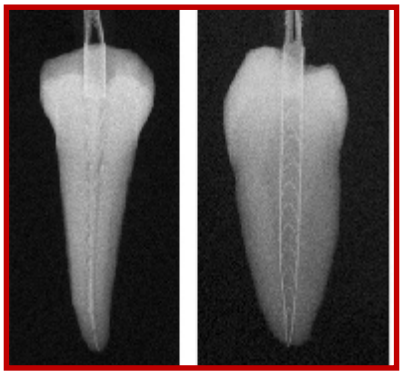

Fig.5

Fig.6

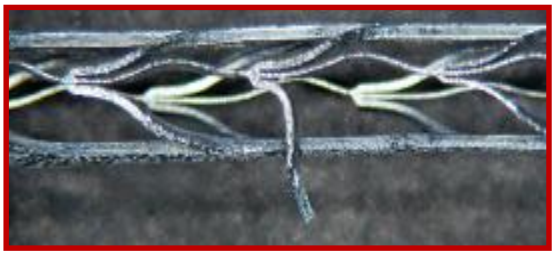

Fig. 7

Fig. 8