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INFLUENCE OF BRUSHING ACTION — on torsional and fatigue resistance of TF Adaptive instruments

Nickel-titanium (NiTi) alloy was introduced in endodontics more than 20 years ago, to make shaping procedures easier, more rapid and predictable. Since 1993, manufacturers have mainly changed cross-sectional designs and geometrical traits of instruments to improve intracanal resistance to fracture. In 2007, another strategy to achieve this goal was proposed: the use of new manufacturing processes to optimize the microstructure of NiTi through innovative thermomechanical processing. NiTi instruments produced with these technologies (M-Wire, CM wire, Twisted Files, etc.) showed better properties for endodontic use, in terms of flexibility and resistance to mechanical stress, compared with the traditional NiTi alloy and processing.

More recently, a third factor (the use of reciprocating motion instead of continuous rotation) has become very important in this search for safer instrumentation techniques. Current literature data show that reciprocating motion can extend both torsional and cyclic fatigue resistance of NiTi instruments compared with continuous motion, mainly because it reduces instrumentation stress. In fact, in one movement of rotation, the instrument cuts and is engaged into the canal, while in the other (usually with a smaller angle), the instrument is disengaged and stresses are reduced. Following these concepts, new motors with specific reciprocating movements were developed, and single-file techniques were proposed for clinical use. Despite this improvement, however, the accumulation of all instrumentation stress on one single file was still felt to be dangerous; consequently, a new reciprocating motion was developed to be used according to a sequence to optimize performance and safety.

Released in 2013, TF Adaptive (TFA; Axis|SybronEndo) uses an innovative motion, different from any other motion previously used in endodontics, that combines the advantages of both continuous rotation and reciprocation. When the TFA instrument is not (or very lightly) stressed, the movement can be described as an interrupted continuous rotation, allowing optimal cutting efficiency and removal of debris, since the cross-sectional and flute designs are meant to perform at their best in a clockwise motion. In contrast, while negotiating the canal, owing to increased instrumentation stress and metal fatigue, the motion of the TFA instrument changes into reciprocation, with specifically designed clockwise and counterclockwise angles. Moreover, these angles are not constant, but vary depending on the anatomical complexities and the intracanal stress. This adaptive motion is therefore meant to reduce the risk of intracanal failure without affecting performance, by the Elements Motor automatically selecting the best movement for each clinical situation (Fig. 1).

Other clinical factors can significantly affect the clinical resistance of NiTi instruments: the anatomical challenges, the use of torque control motors, the applied pressure, and the differences in use among various clinicians in terms of sequence, the creation of a glide path, and the amount of brushing action (for coronal flaring). All these differences are very difficult to evaluate, since they are mostly related to individual skills, sensitivity and operative choice. It would be interesting to assess the extent to which fatigue resistance is affected by different clinical usage, such as performing or not performing a brushing action. The brushing action (or circumferential filing) is meant to increase coronal flaring and, consequently, make apical progression of the next instrument in the sequence easier with less stress placed on it. Therefore, the goal of this study was to compare the torsional and cyclic fatigue resistance of TFA instruments after clinical use, in order to evaluate the clinical advantages of brushing action, if any.

Methodology
Twenty packages of TFA small (SM) files were selected for this study (Fig. 2) and randomly divided into two groups of ten each. Each instrument was used once in sequence to prepare a mandibular molar with three canals (Fig. 3). Following the manufacturer’s guidelines for the TFA SM sequence, a manual glide path up to an ISO size 15 was established using the K-file stainless-steel instruments contained in the package. According to the traffic light concept, it was decided to stop at yellow and use only the first two instruments in the sequence: the SM1 (green, #20.04) followed by the SM2 (yellow, #25.06). All instruments were used with the patented TFA Elements Motor, which automatically selects the best kinematics (continuous rotation or reciprocation) according to intracanal stress. All instruments reached working length in incremental steps (1 mm), without being forced apically and with flutes being cleaned after each 1 mm apical progression. Irrigation with sodium hypochlorite was performed with the use of each instrument.

In the first group (A), no brushing action was performed. In the second group (B, with brushing action), once the SM1 instruments had reached working length, cir-
cumferential filing for approximately 20 seconds was performed in each canal to increase coronal flaring. The brushing action was performed using the TFA motion and by disengaging the instrument 1 mm from working length to allow lateral cutting with minimal stress.

After the shaping procedures had been completed, the used TFA instruments (SM1 and SM2) were first inspected under the microscope at 20× magnification to detect any sign of torsional failure (flute elongation or deformation). All deformed instruments were discarded, while the rest were subjected to a cyclic fatigue test. The fatigue test was performed using a device validated in a number of previous studies conducted by the author.1-5 The instruments were rotated into a curved canal using TFA motion until fracture occurred. The time to failure was recorded, and the mean values and standard deviation were then calculated. In order to determine any statistical difference among the subgroups, the data were subjected to a one-way analysis of variance, with significance set at the 95% confidence level.

Results
The results of the cyclic fatigue tests of used TFA instruments showed no statistically significant differences between the SM1 instruments of both groups. The brushing action performed for 60 seconds did not negatively affect the instruments’ resistance. Group A SM1 instruments had a mean time to failure of 207 seconds, while Group B SM1 instruments had a mean time of 198 seconds.

In contrast, a statistically significant difference was found between the SM2 instruments of the two groups. The Group B SM2 instruments showed a significantly higher resistance to cyclic fatigue (a mean time of 139 seconds) compared with the Group A SM2 instruments (a mean time of 111 seconds). The reason for this is that the coronal flaring previously provided by the brushing action of the SM1 file reduced the instrumentation stress on the SM2 file.

Deformation of flutes was recorded only in Group A SM2 files. The reason for this might be that the coronal flaring due to the brushing action of the SM1 file reduced the torsional stress of the SM2 file.

Discussion
The present study shows that the clinical performance of rotary and reciprocating NiTi instruments can be related to operative techniques. It has been suggested that any NiTi instrument may be used both as a reamer while working towards the apex and with a brushing action as a Hedstrom file while exiting the canal, to improve coronal flaring and/or circumferential filing. The benefit of the brushing action is not only to enhance the extent of the canal walls touched by the file and tapered preparations, but also to provide greater coronal enlargement for safer progression of the instruments in a sequence.

The suggested brushing/circumferential filing technique is therefore needed to perform better preparation of an oval canal, as shown in the clinical case. Instruments are indeed designed to shape a round canal while progressing to working length, but a significant amount of cutting/touching of canal walls on the lateral side can be performed while instruments are exiting the canal, especially in oval canals.

The author demonstrated in a previous study that the brushing action can be performed for up to 30–60 seconds with minimal or no risk of increasing instrument fatigue. The findings of the present study, which concerns TFA instruments used with TFA motion, are consistent with previously published results.6

Moreover, in the present study, it has been demonstrated that the brushing action with an SM1 file allowed safer progression to the final working length of the next (SM2) NiTi instrument in the sequence. Group A SM2 instruments (no brushing) showed a significant reduction in resistance to cyclic fatigue, and this can be attributed to greater instrumentation stress compared with Group B (in which brushing had been performed with the previous instrument). Deformation of flutes was recorded only in Group A SM2 files. The reason for this might be that the coronal flaring due to the brushing action of the SM1 file reduced the torsional stress of the SM2 file.

Conclusion
The coronal flaring provided by the brushing action of the first instrument (SM1) reduced the instrumentation stress on the second instrument (SM2) in the TFA sequence, both in terms of torsional and flexural stress. The brushing action (circumferential filing) performed in the present study (prolonged use for 60 seconds) did not adversely affect the mechanical resistance of the instruments.

Editorial note: A complete list of references is available from the publisher.