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ORIGINAL ARTICLE

Energy consumption of Twisted File instrument used with rotary or reciprocating adaptive motion

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ABSTRACT

Objective: The aim of this study was to compare the energy consumption of Twisted File (TF) instrument used with rotary or adaptive motion (AM). **Materials and Methods:** Forty S-shaped Endo Training Blocks (Dentsply Maillefer) were used. Twenty were prepared using TF 25.06 in rotary motion (RM) group, and 20 were prepared using TF Adaptive SM2 in AM group. While engine-driven endodontic motors were connected to a digital wattmeter, the required torque for root canal instrumentation was analyzed by evaluating the electrical power consumption of the endodontic engine. Electric power consumption (mW/h), elapsed time (s), and a number of pecking motions required to reach the full working length (WL) were calculated. The data was statistically analyzed using Mann–Whitney U-test ($P < 0.05$). **Results:** Electrical power consumption during the preparation was significantly different between the groups; RM group exerted less electric power than reciprocating AM group did ($P < 0.001$). The required time to reach the full WL was not statistically significant between groups ($P = 0.137$). **Conclusion:** Within the limitation of this study, RM group exerted less electric power than reciprocating AM group did.

Key words
Electric power consumption, nickel–titanium, nickel–titanium rotary preparation, Twisted File Adaptive

INTRODUCTION

Nickel–titanium (NiTi) instruments have been accepted as a significant improvement in endodontics in terms of reducing shaping time, producing a more centered shaping, and minimizing iatrogenic errors.[1-3] However, intracanal separation of NiTi instruments unexpectedly is not an uncommon problem in clinical practice.[4] NiTi instruments usually show no visible signs of permanent deformation and instrument separation occur unexpectedly.[5] The lifespan of a NiTi instrument has been correlated with its operational stress accumulation.[6] Bending and torsional stresses may contribute to instrument fatigue, which leads to mechanical failure.[7,8] Fatigues are usually begin with a microcrack formation originates from surface irregularities. These microcracks develop to produce inner defects, which will compromise the fracture strength of NiTi instruments.[9]

Manufacturers design new file systems in order to increase fracture resistance of NiTi instruments by changing the metallurgic properties of NiTi, manufacturing processes, making surface modifications, or selecting different kinematics during instrumentation.[10-12] NiTi endodontic instruments have been traditionally used with continuous rotation motion until the use of an F2 ProTaper file with reciprocation motion was proposed by Yared's study.[13] Reciprocating motion has been reported to extend cyclic fatigue resistance of NiTi instruments compared to continuous rotation motion.[14,15] Twisted File Adaptive system (TF Adaptive) has been introduced as a new instrumentation technique, combining reciprocation

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and rotation motions, thereby utilizes both techniques during instrumentation (http://www.sybronendo.com/cms-filesystem-action?file=/sybronendo-pdf/TF_Brochure.pdf). Elements Motor (SybronEndo, Orange, CA) automatically detects when the instrument is stressed and changes its motion. When the instrument is not stressed, it performs interrupted continuous rotation, but the moment instrumentation stress is increased, motion of instrument changes to reciprocation with specially designed clockwise and counterclockwise angles. Reciprocating motion also helps to prevent instruments to lock and/or thread (screw) into the canal. Screw effect, which happens when the instrument tip binds and shaft continues to rotate, causes high levels of stress on the instrument, thereby increasing the risk of separation.

The electric power consumption of an endodontic motor has been correlated with instrument stress state during instrumentation. The manufacturer claims that TF Adaptive system load less stress on the instrument. Therefore, the aim of this study was to compare the energy consumption of TF endodontic instrument used with rotary or adaptive motion (AM). The null hypothesis was that there would be no difference between rotation and AMs regarding electric power consumption.

MATERIALS AND METHODS

Forty standardized ISO 15, 0.02 taper, S-shaped Endo Training Blocks (Dentsply Maillefer) with 16-mm working length (WL) were used in this study. One expert operator, previously calibrated for pecking speed and pressure on the handpiece, performed all the instrumentation phases of this study. The Endo Training Block canals were scouted up to the WL with a #10 stainless steel K-File (Dentsply Maillefer) and randomly assigned to 1 of 2 groups:

- The TF rotary motion (RM) group (n = 20): After performing glide path with a #15 stainless steel K-File (Dentsply Maillefer), the 25 mm TF 25.06 was used to prepare the simulated canal until the WL. Each instrument was used with the Elements Motor; the speed of rotation was 500 rpm and torque was 4 Ncm
- The TF AM group (n = 20): After the performing glide path with a #15 stainless steel K-File, the 25 mm SM2 (25.06) was used to prepare the simulated canal until the WL. Each instrument was used with the TF Adaptive program of the Elements Motor.

In all samples, irrigation was performed with distilled water and a new instrument was used to prepare each simulated canal.

The Elements Motor was connected to a digital wattmeter (Energy-measuring tool; Rev Ritter GmbH, Frankfurt, Germany) and an electronic schedule in order to evaluate the electric power consumption required to reach the full WL. The electronic schedule was designed to quantify and subtract the electrical and mechanical power disturbances. The electrical power consumption (mW/h), number of pecking motions, and time (s) required to reach the full WL with a TF 25.06 or SM2 file were calculated for every specimen belonging to the 2 groups (RM and AM). The Shapiro–Wilk test showed that data were not distributed normally thus differences between groups were statistically analyzed using the Mann–Whitney U-test. The significance level was set at P = 0.05. All statistical analyses were performed using the SPSS for Windows 21.0 software package (SPSS, Inc., Chicago, IL, USA).

RESULTS

In an experimental procedure, any TF 25.06 or SM2 file was not damaged or separated in both groups. In both groups, pecking motion required to reach apex was same (n = 5). Electrical power consumption during the preparation was significantly different between the groups; RM group exerted less electric power than reciprocating AM group (P < 0.001). The Elements Motor consumed 5.09 mW/h (standard deviation = 0.45) and 6.56 mW/h (standard deviation = 0.4) in the RM and AM groups, respectively [Table 1]. RM group took less time (48.34 ± 17.07) to reach the full WL than AM group (51.71 ± 9.28), but this was not statistically significant (P = 0.137). A ledge formation occurred in one sample in RM group.

DISCUSSION

Literature review has shown that fracture incidence for stainless steel files ranges from 2% to 6%.[16,17] In 1980, NiTi instruments were invented to facilitate root canal preparation and thereby to reduce procedural errors such as apical transportation and file separation. NiTi instruments are 2–3 times more resistant to elastic and torsional fracture than stainless steel files.[18] However, fracture incidence of instruments increased, as NiTi rotary instruments were developed.[4] By modifying NiTi files' mechanical features such as diameter, cross section,

Table 1: Electric power consumption (mW/h), time (s), and number of pecking motions required to reach the full working length with rotary motion or adaptive motion

Group	Electric power consumption	Number of pecking motion	Time
RM	5.09±0.45[a]	5	48.34±17.07[a]
AM	6.56±0.4[b]	5	51.71±9.28[a]
P	<0.001		0.137

*Different superscript letters indicate a significant difference between groups. RM - Rotary motion, AM - Adaptive motion and tip, fracture incidence for NiTi files was sought to be decreased and mechanical features were tired to be improved. For the same purpose, mechanical features of NiTi alloys were modified and new alloys such as M-Wire were obtained. Furthermore, movement kinematics was considered to decrease fracture incidence of NiTi files.[19] For over a decade, NiTi instruments had been used in continuous RM when Yared[20] proposed the use of NiTi instruments in reciprocating motion. Studies have demonstrated that reciprocating motion increases cyclic fatigue resistance of NiTi files, compared to continuous RM.[14,21] Recently released TF instruments operating with Elements Motor combine both reciprocating motion and continuous RM. The manufacturer claims that this "adaptive motion" minimalizes the stress on the file and allows it to perform root canal preparation more easily and safely.[22]

In this study, we calculated the energy consumed by both TF NiTi files in continuous RM and in AM to reach WL in S-shaped resin blocks. Since resin blocks cannot simulate the root dentin, studies performed on these blocks do not reflect the clinical condition. However, it is a frequently used method, as the use of simulated canals in resin blocks allows standardization and replication of studies.[17,23,24] Another purpose of the use of S-shaped resin blocks is to enable Elements Motor to perform reciprocating motion in AM mode by exposing TF files to stress in the canal.

The manufacturing company proposes the use of SM1, SM2, and if necessary SM3 files at WL for TF adaptive system, respectively. It is also suggested that conventional TF files should be used in crown-down technique (http://www.sybronendo.com/cms-filesystem-action?file=/sybronendo-pdf/TF_Brochure.pdf). There is no difference between conventional TF files and TF files using adaptive system in terms of manufacturing. Both files were manufactured by being twisted in R-phase. In our study, in order to obtain standardization, resin blocks were shaped by using TF 25.06 and SM2 files according to a single-file principle. During shaping procedures, ledge formation was observed in 1 resin block in RM group and it was replaced by a new sample. However, there were no procedural errors in AM group. Franco *et al*.[25] proved in their study that reciprocating motion offers better shaping ability compared to continuous RM.

The results of this study revealed that TF NiTi files used in continuous RM consume significantly less energy than those used in AM. Thus, the null hypothesis was rejected. On the other hand, no difference was found between two motion types in terms of time taken to reach WL and the times of pecking motion. There is no study comparing electric consumption of TF NiTi files in the literature. In a study, Berutti *et al*.[22] compared glide path formation capability of two different path file NiTi rotary files using an energy consumption calculation method. Following the comparison of two different path files, the researchers calculated the energy consumption for the same NiTi file during shaping procedure. They have claimed that root canal preparation procedure results in stress on files and the stress increases electric consumption.[22] The results of this study revealed that increase in electric consumption during shaping procedure performed by using AM may not be associated with the fact that AM in canal causes more stress on the file compared to continuous RM, since previous studies have reported that reciprocating motion increases the resistance of NiTi instruments to cyclic and torsional fatigue when compared to continuous RM.[14,21,26,27]

CONCLUSION

Within the limitation of this study, RM group exerted less electric power than reciprocating AM group did.

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Conflicts of interest

There are no conflicts of interest.

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