Alternating versus Continuous Rotation: A Comparative Study of the Effect on Instrument Life

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Abstract

Introduction: Rotary nickel-titanium instruments have multiple advantages but with the risk of more fractures because of flexure or torsion. Alternating rotation appears to be an alternative to continuous rotary movement. The objective of this study was to determine the influence of the type of instrument rotation on the frequency of fractures or deformation. **Methods:** Instrumentation was performed on 120 molar root canals with an angle of curvature greater than 30° using alternating rotation (group A: 60° clockwise, 45° counterclockwise) and continuous rotation (group B). **Results:** The results indicate that instruments used with alternating rotation have a higher mean number of uses (13.0) compared with the continuous rotation group (10.05); this difference was statistically significant ($p < 0.05$). **Conclusions:** The ProTaper shaping instruments (S1 and S2) are those that achieved the greatest difference in use with alternating rotation, with S2 being the most resistant to fracture or deformation with the two types of movement used. *(J Endod 2010;36:157–159)*

Key Words

Alternating rotation, continuous rotation, fracture, nickel-titanium file

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Fracture of rotary nickel-titanium (NiTi) instruments is a problem in endodontic practice (1). Instrument design (2), the use of new alloys (3), variations of torque (4) and speed (5), and manual preflaring (4, 6) have been studied by several authors since the introduction of NiTi instruments (7), aiming to reduce the risk of fracture.

During the preparation of root canals, rotary NiTi instruments suffer because of torsion and flexion. Torsional fatigue occurs when the tip of the instrument binds in the root canal while the file continues turning. If the elastic limit is exceeded, the instrument deforms until it fractures (8). Flexural fatigue develops when the instrument rotates inside a curved root canal and is subjected to an excessive number of tension-compression strain cycles in the region of maximum root canal curvature (9).

Stress increases when instruments are used in curved root canals. When the instrument rotates, it is subjected alternately to compression and flexion, which can produce microfractures and can finally lead to instrument fracture (10). In recent publications, alternating rotary movement has been proposed as an alternative to continuous rotation in order to reduce the risk of instrument fracture and root canal deformity (11, 12).

NiTi instrument binding decreases with the use of an alternating movement (11), reducing instrument block, and the torsional stress is thus induced. Furthermore, on reducing the number of cycles within a root canal, flexural stress will be lower (9). The objective of this study was to evaluate the different risk of deformation or fracture of NiTi instruments when using continuous or alternating rotary movements.

Material and Methods

Instrumentation was performed on 120 root canals obtained from freshly extracted human mandibular and maxillary molars, the apices of which were fully formed and had an angle of curvature greater than 30° (6). ProTaper NiTi instruments (Dentsply Maillefer, Ballaigues, Switzerland) were used with the Tecnika digital motor (ATR, Pistoia, Italy) and a W&H WD-75 M 16:1 reduction contra-angle handpiece (W&H, Bürmoos, Austria) in order to investigate the fracture frequency with two types of rotary movement.

The sample was randomly divided into two groups according to the rotary movement used: group A, alternating rotation (clockwise [CW] 60° and counterclockwise [CCW] 45°), and group B, continuous rotation (CW). Each instrument was used until it fractured or became deformed; the instrument was then substituted by another of the same characteristics but without changing the rest of the set. Each tooth was held in a muffle system to ensure manipulation in the same position. After obtaining a radiographic record, the chamber was opened, and patency of the root canal was established using a size 08 K-type file (Dentsply Maillefer); the working length and the radius and angle of curvature of the root canal were determined (13).

The sequence used for both techniques was as follows: (1) determination of the working length using a K-type file (Flexofile #10, Dentsply Maillefer); (2) manual preflaring of the working length of the root canals using hand instruments (Flexofiles #10, #15, and #20, Dentsply Maillefer); and (3) continuous or alternating rotary instrumentation performed with ProTaper files (Dentsply Maillefer) using an S1, S2, F1, F2, and F3 sequence (14), with speed and torque settings in accordance with the manufacturer's instructions.

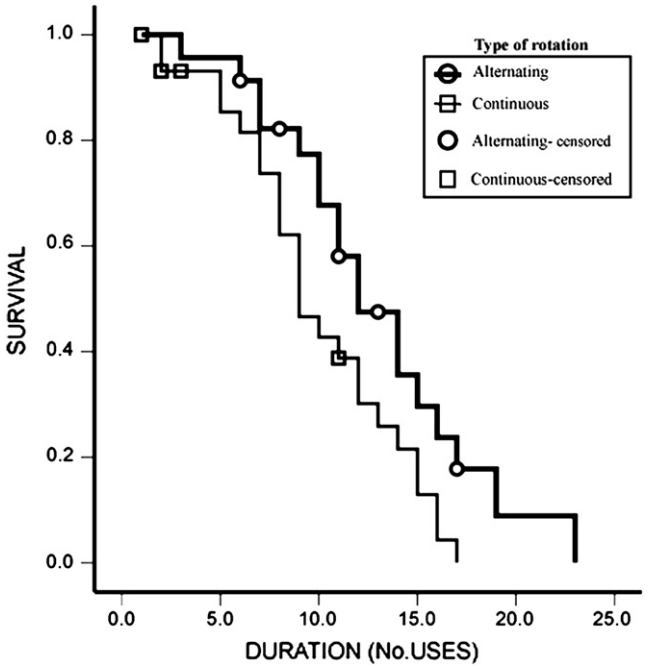

Figure 1. Survival curves (duration) of the instruments with the two types of movement.

In both groups, irrigation of the root canals was performed with 2 mL 5.25% NaOCl after the use of each instrument. All root canals were instrumented by the same operator. All instruments were examined for signs of deformation or separation by three endodontists using an operating microscope with 20× magnification (15).

Statistical Analysis

The distributions of continuous variables are expressed as means ± standard errors. A comparative analysis was performed of the lifespan of the instruments based on the following variable: the number of uses of each file before withdrawal because of deformation or fracture. The survival curves were constructed by using the Kaplan-Meier method, and these curves were used to estimate the mean and standard error of the lifespan. The log-rank test was used to compare the lifespan between the different groups of files.

Results

The means ± standard errors of the radius and angle of curvature of the root canals in group A were 2.5 ± 0.17 mm and 59.1° ± 2.48°, and in group B they were 2.5 ± 0.23 mm and 56.6° ± 2.61°. There were no statistically significant differences in these variables between the two groups.

A total of 53 instruments were used: 23 in group A and 30 in group B. A comparative analysis of the cause of withdrawal of each type of instrument showed that 18 files were withdrawn in group A (14 for fracture [77.8%] and 4 for deformation [22.2%]), and 25 instruments were withdrawn in group B (17 for fracture [68%] and 8 for deformation [32%]). Fracture was found to be the main cause for withdrawal in both groups. Deformation was more common in group B than in group A, although the difference was not significant.

The total number of uses was 11.36, with a standard error of ±0.712. On comparison of the two types of movement, the mean lifespan with alternating rotation was 13.0 ± 1.17 uses, and with continuous rotation it was 10.05 ± 0.82 uses. Figure 1 shows the survival curves of the instruments with the two types of movement using the log-rank test. The instruments used with alternating rotation presented a significantly longer survival ($p < 0.05$).

TABLE 1. The Mean Number of Uses in Alternating Movement by the Type of Instrument

Instrument	Total used	Uses
S1	4	16.33 ± 1.45
S2	3	21.00 ± 2.30
F1	6	10.08 ± 1.73
F2	5	10.20 ± 1.11
F3	5	10.60 ± 1.59

The results obtained according to the type of instrument and movement are shown in Tables 1 and 2. When analyzed individually, the behavior of the different instruments showed that both S1 and S2 achieved a greater number of uses with the alternating movement. With continuous rotation, S1 showed a similar number of deformations and fractures to the finishing instruments.

Discussion

For this study, it was necessary to choose rotary instruments that cut in both directions of rotation (11). In alternating rotation, instruments without this characteristic have greater difficulty progressing along the root canal (11). Instruments that cut in both directions have a design that provides a uniform and low-intensity distribution of torsional stress, enabling work in the transformation phase (16), although they have high levels of residual stress localized, particularly in the area corresponding to the curvature of the canal (17). Compared with constant taper instruments, the variable taper of these instruments is less likely to cause taper lock (18).

The choice of asymmetric alternating rotation (65 °CW-45 °CCW) is based on results obtained in other studies (12) in which it was shown that symmetrical sequences make progression along the canal more laborious. Torque was established in accordance with the manufacturer's specifications. In motors with controlled torque, it is individualized for each instrument so that each one works within its elastic limit. The design and taper of each instrument must be evaluated in order to achieve torque values within this limit (19). Test systems are now available that allow for the analysis of the forces, torque, and file displacement during each phase of root canal preparation (20). However, other authors propose to work at higher torque in order to avoid instrument binding and the continuous use of the auto-reverse mechanism, which is described as more stressful for the instrument, finding a significant reduction in the incidence of instrument fractures (4).

In the study by Varela-Patiño et al (11), the incidence of instrument fracture in blocks of resin was lower with alternating rotation than with continuous rotation (27.1% with continuous rotation vs 12.5% with alternating rotation, $p < 0.001$), with a mean of between nine and 10 uses with alternating movement compared with four to

TABLE 2. The Mean Number of Uses in Continuous Movement by the Type of Instrument

Instrument	Total used	Uses
S1	7	9.50 ± 0.84
S2	4	15.00 ± 1.15
F1	7	8.50 ± 2.21
F2	6	9.60 ± 1.80
F3	6	9.08 ± 1.99

five uses with continuous movement. The lifespan of an instrument is directly proportional to the stress accumulated during work in the root canal (16). Although no definitive guidelines have been published on the number of times an NiTi file may be used, the recommendation is to discard an instrument once plastic deformation is detected in order to avoid separation (21). Many authors have accepted that the failure of NiTi files is influenced more by technique than by the number of uses (22). With this technique, although the instrument would frequently engage dentine at its tip, the CCW rotation would immediately disengage the instrument. Theoretically, the CW and CCW movements should reduce the incidence of torsional fracture caused by taper lock (12). Alternating rotation could contribute to reducing the phenomenon of overinstrumentation caused by the tendency of these instruments to taper lock. Overinstrumentation causes deformation of the original shape of the root canal, particularly in its apical third (23). In addition, cyclical fatigue and the apical extrusion of debris are reduced using a CW movement of 65° and CCW movement of 45° (11).

The present study was performed on natural teeth with a mean radius of curvature of 2.58 mm (range, 0-5 mm) and a mean angle of curvature of 57.48° (range, 30°-105°); therefore, these were teeth with marked curvatures and pronounced angles. When the behavior of the different instruments was analyzed individually, we found that the greatest number of uses with alternating rotation was achieved with both S1 and S2 instruments. When using continuous rotation, the number of deformations and fractures presented by the S1 instruments was similar to finishing instruments (Table 1). This could be caused by performing preflaring up to #20 to protect the tip, which is the most delicate part of these files. Also it explains the high usage number of the S2 instruments; in addition to the preflaring that protects the tip of the S1 instrument, work with S2 instruments is performed when the S1 instrument has already eliminated coronal interferences, thus reducing flexural stress. The risk of taper lock is reduced by incomplete rotation. However, Diop et al (20) found that the highest levels of apical torque were observed with the S2 instrument and the first two finishing files, indicating that these instruments are mainly involved in apical progression. The S1 and S2 files have a safety quotient that qualifies them as safe (14). In the present study, all instruments were used until they deformed or fractured. Deformation of the NiTi instruments occurred more frequently in the continuous rotation group (26.7%) than in the alternating rotation group (17.4%). These results may be explained by the greater tendency to taper lock (11, 12).

The combination of the removal of coronal interferences and preflaring produces an access that is free of obstacles for instruments, reducing the stress that instruments suffer and their tendency to fracture (4, 6). Based on the available data, the type of rotary movement also has a direct influence on the stress suffered by instruments. In 1985, Roane et al (24) applied the law of physics of action and reaction (Newton) to the instrumentation of curved canals, suggesting the concept of balanced force. The application of this concept can now be seen in alternating rotation. Although in the present technique the instrument would frequently engage dentine at its tip, the CCW rotation would immediately disengage the instrument. Theoretically, CW-CCW movement should reduce the incidence of torsional fracture caused by taper lock (12).

The mechanics of instrumentation are important and are directly related to the performance of endodontic instruments. This is an area in which there is still a great deal of research to be performed. In conclusion, instrumentation with alternating rotation clinically appears to be a path that will optimize endodontic instrumentation. The ProTaper shaping instruments (S1 and S2) achieved the greatest difference in the number of uses with alternating rotation, with S2 being the most resistant to fracture or deformation in the two movements used.

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