Cyclic Fatigue Resistance of Three Different Rotary File Systems

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بسم الله الرحمن الرحيم

﴿رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ
الَّتِي أَنْعَمْتَ عَلَيَّ وَعَلَى وَالِدَيَّ
وَأَنْ أَعْمَلَ صَالِحاً تَرْضَاهُ
وَأَدْخِلْنِي بِرَحْمَتِكَ فِي عِبَادِكَ
الصَّالِحِينَ﴾

آية: ١٩ سورة النمل

Dedication

I would like to dedicate
this work to my parents,
and my wife

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Introduction

With the great breakthrough in dentistry rotary nickel titanium files are used instead of stainless- steel files, rotary nickel titanium files have super elasticity and shape memory which allows shaping of the root canal with low risk of canal transportation, zipping and other mishaps that might occurs with stainless steel files.

Nickel titanium files separation is one of the main unavoidable events with the continuous use of the file. Which can be classified according to mode of fracture into torsional failure or flexural failure. Torsional failure occurs when an instrument tip or any other part of the instrument is locked in the canal while the shank continues to rotate. Fracture occurs when the torque exerted is more than the elastic limit of the metal which always shows a sign of plastic deformation from the torsional loads.[1]

Flexural failure occurs with no specific pattern of fracture which is caused by fatigue of metal as the instrument does not bind in the canal, but it rotates freely in a curvature, generating tension and compression cycles and the point of maximum flexure fracture occurs, the different rotary instruments introduced into the market claiming to have better torsional strength and cyclic fatigue resistance.[1]

In the past, the only way to improve the performance of NiTi instruments was to change their design features. Also, the movement kinematics of NiTi instruments is another important factor, Rotary

instruments have been traditionally used in a continuous motion, but in the last years a reciprocating movement was also introduced.[2]

Also heat treatment, applied to instruments which modifies the phase transformation of the NiTi alloy, increasing its flexibility and flexural strength.[3]

Revo S system was introduced in 2008 with asymmetrical cross-section that facilitates penetration by a “snake-like” movement, While One Shape was introduced in 2012 which is a single file shaping system used in continuous rotation and had an asymmetrical cross-section. lately, Mani Silk file a heat-treated file was introduced in 2015 which can be used in continuous rotation or reciprocation with tear drop cross-sectional design.

With the different manufacture's claiming of their rotary files, cyclic fatigue testing for these three different file systems seems to be of great interest.

REVIEW OF LITERATURE

Rotation is a circular movement of an object around a center or point of rotation. When an endodontic instrument rotates within its elastic limit inside a curved canal, The instrument does not bind in the canal but it rotates freely in a curvature, every bent portion is subjected to mechanical loading, which is represented by alternate compressive and tensile stresses , as an instrument is held in a static position and continues to rotate, one half of the instrument shaft on the outside of the curve is in tension, while the half of the shaft on the inside of the curve is in compression, at the point of maximum flexure until the fracture occurs (Pruett et al. 1997)[4].the magnitude of the tensile and compressive forces imposed on the flexed area of an instrument depends on the geometry of the curved canal (i.e., radius length, arc length, and the position of the arc). The intensity of stress on the instrument increases as the curvature radius decreases, the arc length increases, and the arc is located in the coronal portion of the canal. [4]

Cyclic Fatigue resistance of different rotary files

Pruett et al (1997)[4] determined the effect of canal curvature and operating speed on the breakage of lightspeed instruments. a new method of canal curvature was simulated by constructing six curved stainless-steel guide tubes with angles of curvature of 30,40 or 60 degrees and radii of curvature of 2 or 5mm.size 30 and 40 light speed instruments were placed through the guide tubes and the heads secured in the magtrol

dynamometer. instruments rotate freely in the test apparatus at speed of 750,1300 or 2000 rpm until separation occurred. Instruments did not separate at the head, but rather at the point of maximum flexure of the shaft, corresponding to the midpoint of curvature within the guide tube. cycles to failure significantly decreased as the radius of curvature decreased from 5mm to 2mm and as the angle of curvature increased greater than 30 degrees. scanning electron microscopic evaluation revealed ductile fracture as the fatigue failure mode. these results indicate that the radius of curvature, angle of curvature and instruments size are more important than operating speed for predicting separation.

Peters et al (2004)[5] attempted to identify factors that influence shaping outcomes with these files, such as preoperative root-canal anatomy and instrument tip design. Other, less significant factors include operator experience, rotational speed, and specific instrument sequence. Implications of various working length definitions and desired apical widths are correlated with clinical results. Despite the existence of one ever-present risk factor, dental anatomy, shaping outcomes with nickel-titanium rotary instruments are mostly predictable. Current evidence indicates that wider apical preparations are feasible. Nickel-titanium rotary instruments require a preclinical training period to minimize separation risks and should be used to case-related working lengths and apical widths. However, and despite superior in vitro results, randomized, clinical trials are required to evaluate outcomes when using nickel-titanium instruments.

Parashos et al(2004)[6] examined used, discarded rotary nickel titanium instruments obtained from 14 endodontists in four countries and identified factors that may influence defects produced during clinical use. A total of 159 instruments were examined for the presence of defects. Unwinding occurred in 12% of instruments and fractures in 5% (1.5% torsional, 3.5% flexural). The defect rates varied significantly among endodontists. Instrument design factors also influenced defect rate, but to a lesser extent. The most important influence on defect rates was the operator, which may be related to clinical skill or a conscious decision to use instruments a specified number of times or until defects were evident.

Ullmann and Peters(2005)[7] evaluated static fracture loads of ProTaper Nickel Titanium instruments that had been subjected to various degrees of cyclic fatigue. Torque and angle at failure of new instruments and instruments that had been stressed to 30, 60, or 90% of their cyclic fatigue rotations in a simulated canal (90 degrees and 5 mm radius) were tested. With unused ProTaper instruments, resistance to cyclic fatigue decreased with diameter increase. Cyclic prestressing significantly reduced torsional resistance in finishing files, while shaping files were largely unaffected. In conclusion, build-up of tension within NiTi rotary instruments depends on instrument diameter. Clinically, larger instruments that have been subjected to some cyclic fatigue should be used with great care or discarded.