بسم الله الرحمن الرحيم

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Cyclic Fatigue Resistance of Three Different Rotary File Systems

Thesis

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

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Dedication

✍This work is dedicated to

*To **my parents** the reason for what I become today.*

Thanks for your great support and continuous care.

***To my wife and my family** who has been a constant source of emotional and moral support in every aspect of my life, this thesis would certainly not have existed without them.*

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Introduction

With the great breakthrough in dentistry rotary nickel titanium files are used instead of stainless steel files due to its super elasticity which allows shaping of the root canal with low risk of canal transportation, zipping and other mishaps might with stainless steel files. However it still has some drawbacks like file separation with the continuous use which can be classified according to mode of fracture into torsional failure or flexural failure.

Torsional failure occurs when a Plastic deformation happens near its cutting edge while 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 to beat on this drawbacks to have better torsional strength and cyclic fatigue resistance by some modifications like heat treatment, alloy modification.

Nitishaper system was introduced in 2018 with asymmetrical cross-section that facilitates penetration by a "snake-like" movement, claiming good cyclic fatigue resistance, While Hyflex EDM was introduced in 2016 which is a single file shaping system of continuous rotation with asymmetrical cross-section used in a full clockwise rotation, according to manufacture made of a conventional austenite NiTi alloy, the cross section at the tip has three cutting edges while in. middle of the cross-sectional design progressively changes from a three-cutting-edge design to two cutting edges, the shank, has S-shaped cross section shows two cutting edges, resembling the cross-sectional design of Reciproc instruments. This design is alleged to eliminate threading and binding of the instrument in continuous rotation and limits the risk of instrument breakage, lately, M-Pro was introduced to market with convex triangular cross section which is main three file system with continuous rotation.

Review of literature

Rotation is a circular movement of an object around a center or point of rotation. The endodontic 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.

Cyclic fatigue occurred due to one half of the instrument shaft on the outside of the curve is in tension, while the other half on the inside of the curve is in compression, at the point of maximum flexure until the fracture occurs ***(Pruett et al., 1997[1]).*** The magnitude of the tensile and compressive forces imposed on the flexed area of an instrument depends on the geometry of the curved canal (ie, radius length, arc length, and the position of the arc). The intensity of stress on the instrument will increase if the curvature radius decreases. The arc is located in the coronal portion of the canal, when it increase the stress will increase.

Pruett et al.[1] determined the effect of canal curvature and operating speed on the breakage of light speed instruments. He constructed 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 collet of a magtrol dynamometer. Instruments rotate freely in the test apparatus at speed of 750, 1300 or 2000 rpm until separation occurred. Cycles to failure were not affected by rpm. 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. The instrument with larger diameter shafts, #40, failed after significantly fewer cycles than did #30 instruments under identical test condition. 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 ($p < 0.05$). These results indicate that the radius of curvature, angle of curvature and instruments size are more important than operating speed for predicting separation.

Yared et al.[2] evaluated cyclic fatigue of. 06 ProFile Ni-Ti rotary instruments after clinical use in molar teeth. In group 1, instruments size 40-15 were used in a crown-down technique using 2.5% NaOCl as an irrigant. Fifty-two molars were included and 13 sets of Profile Ni-Ti rotary instruments were used. Each set of instruments was used in four molars, and was steam autoclaved before each use. Group 2 (10 sets of new ProFile Ni-Ti rotary instruments) was the control group. Cyclic fatigue was tested by rotating the instruments in a 90 degrees metallic tube until they broke. One-way analysis of variance did not show any statistically significant differences amongst the files from both groups regarding cyclic fatigue. It was concluded that sterilization and clinical use in the presence of NaOCl did not lead to a decrease in the number of rotations to breakage of the files.

Peters et al.[3] 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. [4] 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 7,159 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 et al. [5] 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