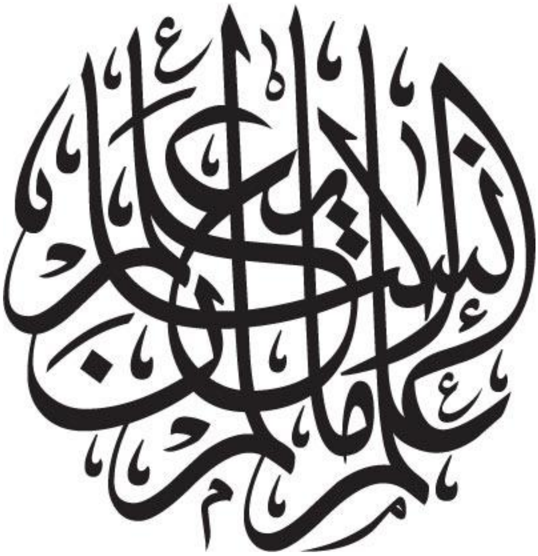

بسم الله الرحمن الرحيم

" علم الإنسان ما لم يعلم "

صدق الله العظيم

أية ٥ من سورة العلق

Incidence of Failure of Newly Introduced Nickel Titanium Files After Use in Severely Curved Simulated Canals

A
Thesis

Submitted to the Faculty of Dentistry,
Ain Shams University

In Partial Fulfillment of the Requirements of the Master's Degree in Endodontics

By

Wael Hamdy Seif El Nasr El Shater
B.D.S (2004)
(Ain Shams University)

Faculty of Dentistry
Ain Shams University
2012

Supervisors

Dr. Ehab El Sayed Hassanein

Head of department and Professor of
Endodontics, Endodontic department ,
Faculty of Dentistry, Ain Shams University.

Dr. Shehab El-Din Mohamed Saber

Associate professor of Endodontics,
Endodontic department,
Faculty of Dentistry, Ain Shams University.

To my family and to the soul of my late father,

thank you for all the sacrifices, love and support

To my wife and son,

For all the joy and motivation

Acknowledgement

I would like to express my deepest gratitude to ***Professor Doctor Ehab Hassanein*** Chairman of endodontic department, Faculty of Dentistry, Ain Shams University for his encouragement and effort during my academic and clinical work.

My sincere gratitude to ***Dr. Shehab El-Din Mohamed Saber***, Associate professor of Endodontics for his guidence throughout this study.

My deep appreciation to ***all the staff & members of the endodontic department***, Faculty of dentistry, Ain shams university for their continuous support.

Last but not least, special thanks to ***Dr. marwa Abou Seeda*** and ***Engineer Sabry Fangary*** for their sincere help and insightful ideas.

List of Contents

List of Tables

List of Figures

The manufacturing of a machined nickel titanium endodontic file goes back to 1988 [(1)]. The idea of using such an alloy was thought of to gain benefit of its properties; flexibility and superelasticity thus allowing preparation of curved root canals with less procedural errors than stainless steel files.

Although the more recently introduced rotary NiTi instruments fulfill that requirement, in addition to minimizing the operator's fatigue and saving time, they still have the disadvantage of unexpected fracture that mostly occurs without any visible signs of previous permanent deformation defects [(2)]. Failure of the rotary NiTi instruments has been attributed to; torsional failure, as when the instrument tip binds while it continues to rotate, flexural failure (cyclic fatigue); which occurs due to generation of compressive and tensile stresses at the point of flexure as in a curved canal, with eventual weakening and fracture, or a combination of torsion and flexion acting on the file.

In an attempt to overcome or minimize the instrument failure, rotary NiTi instruments are continuously being innovated with design features that would reduce their tendency to fail. More recently, not only was the design altered, but also the manufacturing technique itself has been changed. As an example of the manufacturing process modification, files are produced by twisting rather than machining. Since ground instruments are not resistant to fracture because grinding across the crystalline structure creates microfracture points along the length of the instruments, the new process aims at respecting the grain structure, thus increasing fracture resistance for maximum strength.

The number of canals that a rotary file can clean and shape before deterioration is controversial, as it depends on a number of variables, some of which are uncontrollable by the operator as the canal curvature and its abruptness. Since the canal curvature directly affects the instrument's fatigue life, the effect of the frequency of file use in a curved canal on the cyclic fatigue property is therefore considered an important factor to guard against file separation with its tedious consequences. Keeping the file from separation will also allow the operator to gain maximum economic benefit from the newly manufactured, thus expensive, files.

Walia et al [1] initially investigated the bending and torsional properties of nitinol root canal files. Root canal files in size # 15 with triangular cross-sections were fabricated from 0.020-inch diameter arch wires of Nitinol, a nickel-titanium orthodontic alloy with a very low modulus of elasticity. A unique manufacturing process was used in which the fluted structure of a K-type file was machined directly on the starting wire blanks. The Nitinol files were found to have two to three times more elastic flexibility in bending and torsion, as well as superior resistance to torsional fracture compared with size # 15 stainless steel files manufactured by the same process. The fracture surfaces for clockwise and counterclockwise torsion were observed with the scanning electron microscope and exhibited a largely flat morphology for files of both alloy types and torsional testing modes. It was possible to permanently precurve the Nitinol files in the manner often used by clinicians with stainless steel files. These results suggested that the Nitinol files may be promising for the instrumentation of curved canals.

Pruett et al [3] studied cyclic fatigue of nickel-titanium, engine-driven instruments by determining the effect of canal curvature and operating speed on the breakage of Lightspeed instruments. A new method of canal curvature evaluation that addressed both angle and abruptness of curvature was introduced. Canal curvature was simulated by constructing six curved stainless-steel guide tubes with angles of curvature of 30, 45, or 60 degrees, and radii of curvature of 2 or 5 mm. A simulated operating load of 10 g-cm was applied. Instruments were able to rotate freely in the test apparatus at speeds of 750, 1300, or 2000 rpm until separation occurred. Cycles to failure were determined. 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 instruments with larger diameter shafts (#40) failed after significantly fewer cycles than did #30 instruments under identical test conditions. Multivariable analysis of variance indicated that cycles to failure significantly decreased as the radius of curvature decreased from 5 mm to 2 mm 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 indicated that, for nickel-titanium engine-driven rotary instruments, the radius of curvature, angle of curvature, and instrument size were more important than operating speed for predicting separation. The results also suggested that standardized fatigue tests of nickel-titanium rotary instruments should include dynamic operation, and that the effect of the radius of curvature as an independent variable should be considered when evaluating studies of root canal instrumentation.

Ha'ikel et al [4] examined three groups of engine driven rotary NiTi endodontic instruments (Profile, Hero, and Quantec) and assessed the times for dynamic fracture in relation to the radius of curvature to which the instruments were subjected to during preparation. The instruments were rotated at 350 rpm and introduced into a tempered steel curve that simulated a canal. Two radii of curvature of canals were used: 5 and 10 mm. Time at fracture was noted for all files, and the fracture faces of each file were analyzed with scanning electron microscopy. Radius of curvature was found to be the most significant factor in determining the fatigue resistance of the files. As radius of curvature decreased, fracture time decreased. Taper of files was found to be significant in determining fracture time. As diameter increased, fracture time decreased. In all cases, fracture was found to be of a ductile nature, thus implicating cyclic fatigue as a major cause of failure.

Yared et al [5] evaluated the cyclic fatigue of .06 ProFile NiTi rotary instruments after clinical use in molar teeth.

Group1 included 13 sets of Profile NiTi rotary instruments, each set used onto four molar teeth (a total of 52 molars) instrumented in a crown down manner by sizes 15-40 and using 2.5% NaOCl as an irrigant. Group 2 was the control group and included 10 sets of new ProFile NiTi rotary instruments. Cyclic fatigue was tested by rotating all the instruments in a 90˚ metallic tube until fracture. The results showed no statistically significant differences amongst the files from both groups regarding cyclic fatigue. It was concluded that ProFile NiTi rotary instruments taper 0.06, sizes 15-40 could be used safely in crown down instrumentation of canals in up to four human molars. The use of 2.5% NaOCl and steam autoclave sterilization did not alter the cyclic fatigue of these instruments.

Sattapan et al (6) analyzed the type and frequency of defects in nickel-titanium rotary endodontic files after routine clinical use. A total of 378 Quantec Series 2000 rotary NiTi instruments discarded after normal use from a specialist endodontic practice over 6 months were analyzed. Almost 50% of the files showed some visible defects; 21% were fractured and 28% showed other defects without fracture. Fractured files could be divided into two groups according to the characteristics of the defects observed. Torsional fracture