Cyclic Fatigue Resistance of Three Different Rotary Ni-Ti Instruments

Thesis

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Dedication

This work is dedicated to….

my great father and mother who have always been a major source of love and support throughout my whole life.

My sister and brother, who have been a constant source of emotional and moral support in every aspect of life.

My husband who has always been there to support and encourage me.

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Introduction

Root canal cleaning and shaping are important phases in endodontic therapy. Nickel-titanium (NiTi) root canal files were developed to overcome the rigidity of stainless-steel instruments and thereby improve the instrumentation of curved canals because of their super-elastic behavior and shape memory property.

However; intra canal instrument separation caused by cyclic fatigue has remained a primary concern in the practice of endodontics, especially for root canals with severe curvatures.

As a NiTi file bends around a curve, it is subjected to stresses along any part of the file; on the inside of the curve, the file is subjected to compressive stress. On the outside of the curve, the file is subjected to tensile stress. As the file rotates, every bent segment of the file experiences a cycle of both compressive and tensile stress.

The continuous cycle of compressive and tensile stresses leads to microfractures in the metal matrix of the file. This phenomenon is known as cyclic fatigue. Because the microfractures cannot be seen even with the aid of a surgical operating microscope, there is no warning preceding fracture. Therefore, clinicians should discard rotary NiTi files after a certain number of uses based on cyclic fatigue studies.

The mechanical performance of NiTi alloys is extremely sensitive to their microstructures and associated thermomechanical treatment history. Therefore, one of many promising solutions to improve fatigue resistance of rotary instruments is through novel thermomechanical processing or new manufacturing technologies.

Different parameters have been used to evaluate the fatigue resistance of endodontic instruments, such as angle and radius of curvature, single or double curvature, rotary speed, and geometry of the simulated canal. However ;these studies haven't considered the intracanal temperature during root canal preparation, newer alloys are believed to have transformation temperatures much higher than those of conventional austenitic materials used in previous generations of rotary instruments [1] and may in fact transform close to body temperature [2].

Sterilization of files is essential for aseptic procedure in case of new files and to prevent cross infection if files to be used for more than one patient. it has been reported in some studies that the additional heat treatment of NiTi instruments during autoclaving might affect their performance and physical properties negatively or positively. **Based on such evidence it was thought that the evaluation of effect of sterilization and different curvatures on cyclic fatigue resistance of different rotary NiTi systems at body temperature is of value.**

The causes of endodontic file fractures have been found to be torsional overload fracture, fatigue failure or combination of both[3,4]. Torsional overload occurs when the binding forces inside the canal locks part of the file while the motor continue to exert torque on the file. Fracture would occur when the torque exceeds the ultimate strength of the file. This type of fracture is usually accompanied by some sort of plastic deformation of the instrument[5]. Some authors have found this fracture to be the leading cause of instruments separation[3,6,7]. However ; Other studies have found cyclic fatigue to be the leading cause of endodontic instruments separation[8].Cyclic fatigue is induced by rotating endodontic instruments in curved canals[9]. This would create compression stresses on the inner curved area of the file and tensile stresses on the area of the file outside the curve. These areas would be changed simultaneously while the file continues to rotate inside the curve. These recurring stresses -even though they are below the elastic limit of the files- would lead to file separation after a number of cycles. A lot of research has been done to understand cyclic fatigue, its causes, factors modifying it and ways to avoid it in endodontic practice. Effect of size, taper, cross section design, rotation speed, motor torque, flutes number, chemical composition, alloy grain size, presence of precipitates in the alloy, operating temperature, effect of environment, curvature angle and radius,

surface treatments and modifications, autoclaving and heat treatment all have been studied to understand their effect on cyclic fatigue resistance.

- **Factors affecting cyclic fatigue resistance & Modes of file separation:**

A) Effect of autoclaving on cyclic fatigue resistance of NiTi Instruments:

Sterilization of files is essential for aseptic procedure in case of new files, and to prevent cross infection if files to be used for more than one patient. However autoclaving subjects' files to extreme environmental conditions and affect the mechanical properties of files. It has been suggested that NiTi shape memory and super elastic properties are strongly dependent on the thermomechanical processing history of the manufactured product, and consequently it has been reported that the additional heat treatment of NiTi instruments during autoclave sterilization might affect their performance and physical properties negatively or positively.

Silvaggio (1997)[10] examined the effect of heat sterilization on the torsional and flexural properties of rotary Nickel-Titanium endodontic files. They used nine hundred files: Profile Series 29,

from size 2 to size 10, taper 0.4, hundred files for each size. The files in each size group were divided into a control group (n=10) that were tested before being sterilized to establish baseline performance data, and nine experimental groups had 1, 5 or 9 sterilization cycles in dry heat sterilizer, steam autoclave. All the results for the groups were compared. 96.3% of torsional strength comparisons and 87% for rotational flexibility showed either significant increase or no change. The authors proved that heat sterilization of up to ten times does not increase the possibility of NiTi files fracture.

Yared et al (1999)[11] assessed the effect of simulated clinical use on the cyclic fatigue of Profile Nickel-Titanium rotary endodontic files. Total 45 sets Profile files sizes number 15-40/0.6 were used in the study. In the first group, fifteen sets were used in crown down technique to prepare 75 mesial root canals in mandibular molars. In the second group, another fifteen sets were used to prepare 150 root canals. The files were sterilized before each use in dry heat oven at 160°C for 2 hours. The files were then rotated in a metal tube (2 mm inner diameter) until fracture and the NCFs were obtained. In the control group 15 sets were tested in the artificial canals without any use (new out of box). The authors did not find statistical difference between the control and the two test groups. They concluded that simulated clinical use with dry heat sterilization have no effect on the NCF of NiTi files.