Cyclic Fatigue Resistance and Shaping Ability of Two Different Nickel-Titanium Rotary File Systems

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Dedication

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INTRODUCTION

Nickel-titanium (NiTi) root canal files were first introduced in 1988 by Walia et al to overcome the rigidity of stainless steel instruments and thereby improve the instrumentation of curved canals , NiTi is far more flexible than stainless steel and its superelasticity reduces the restoring force thereby allowing improved canal shaping and reduced transportation. Despite the many advantages of NiTi instrumentation , unexpected fractures may occur during clinical use and the impairment of the outcome of root canal treatment results from the impossibility of removing the instrument.

Instruments separated by torsional stresses usually present macroscopic plastic deformation whereas instruments fractured by fatigue generally exhibit no specific macroscopic pattern.

Although several clinical and laboratory studies have investigated the cumulative effects of multiple tensile-compressive stresses on the incidence of cyclic fatigue and instrument separation for NiTi files, little is known on how surface and alloy features affect NiTi instrument fracture.

The use of nickel-titanium (NiTi) rotary instruments for root canal system preparation has increased due to their undeniably favorable qualities; however, unexpected fracture is an important disadvantage of these instruments.

Controversy remains regarding the contribution of torsional fracture, fatigue fracture and the combination of both to the separation of NiTi rotary instruments. Some have implicated fatigue fracture to be a main reason for the separation of endodontic files in the clinical setting. Fatigue fracture occurs due to repeated compressive and tensile stresses accumulated at the point of maximum flexure of an instrument rotating in a curved canal without the instrument being bind to the root canal.

Neoniti is a newly introduced NiTi rotary system with a non-homogeneous rectangular cross section and multiple taper in a single instrument; it consists of one C1 and three A1 (with #20, #25 and #40 tip sizes) files. The taper in the A1 #25 file is 0.08 from D0 up to D5; whereas from D5 to D16 the taper is 0.04. It is manufactured using a newly developed wirecut electrical discharge machining (WEDM) process. The manufacturer claims that this manufacturing process is highly precise down to the micron, oil-free and clean and stress is limited to the metal surface during this process.

Furthermore, it produces a rough surface, resulting in abrasive properties that enhance the speed of root canal preparation. Moreover, the manufacturer claims that these

files undergo appropriate heat treatment that results in high flexibility and shape memory of this system.

The aim of root canal shaping is to form a tapered funnel preparation with increased diameter from the apex to the orifice. Several nickel-titanium instruments have been developed with different design to improve the quality of root canal preparation, to allow for proper shaping and to maintain curvature in curved canals.

This urged the interest to compare the two systems with different geometrical designs in terms of cyclic fatigue, degree of transportation and maintenance of root canal curvature.

REVIEW OF LITERATURE

1. Cyclic Fatigue:

NiTi rotary instrument offer greater flexibility and more resistance to torsional separation than stainless steel files, a property that allows instrumentation of curved canals with minimal transportation. However, separation via torsional and cyclic fatigue is still possible with NiTi instruments. Cyclic fatigue occurs when a metal is subjected to repeated cycles of tension and compression that causes its structure to break down, ultimately leading to fracture because NiTi instruments may show no visible signs of permanent deformation during cyclic fatigue, instrument separation may occur unexpectedly. Increasing the resistance to file separation has been a focus in new NiTi rotary instrument design.

Gambarini et al (2008) [1] compared instruments produced using the twisted method (TF) and those using the M-wire alloy (GTX) with instruments produced by a traditional NiTi grinding process (K3). The results showed that K3 instruments showed no significant increase in the mean number of cycles to failure when compared with GT series X instruments. They concluded that cyclic fatigue resistance of nickel-titanium rotary files manufactured by twisting (TF) is significantly higher than instruments

produced with the traditional grinding process. However, instruments produced with M-wire (GTX) were not found to be more resistant to cyclic fatigue than instruments produced with the traditional NiTi grinding process.

Johnson et al (2008) [2] compared cyclic fatigue life of ProFile rotary instruments made from a novel Ni-Ti Alloy and 508 nitinol. Cyclic fatigue testing was performed by rotating instruments at 300 RPM in a simulated steel root canal with 5 mm radius and 90 degrees curve until instrument separation. Data were recorded for torque and angle at fracture. Torsion testing found differences between all 508 Nitinol groups and ProFile files manufactured from M-Wire NiTi have significantly greater resistance to cyclic fatigue while maintaining comparable torsional properties.

Kramkowski et al (2009) [3] compared the torsional stress and cyclic fatigue characteristics of ProFile GT and ProFile GT Series X. Cyclic fatigue was determined by recording the time until breakage of a file rotating in a simulated canal with an applied 45^{o} or 60^{o} curve. There was no statistical difference in cyclic fatigue failure for ProFile GT and ProFile GT Series X in a canal with curvature of 45^{o}. In the 60^{o} canal curvature, ProFile GT