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ORIGINAL ARTICLE/ARTICOLO ORIGINALE

Evaluation of cyclic fatigue resistance of modern Nickel—Titanium rotary instruments with continuous rotation

Valutazione della resistenza alla fatica ciclica di strumenti rotanti a rotazione continua prodotti con moderne leghe Nickel-Titanio

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KEYWORDS
Cyclic fatigue;
Nickel-Titanium;
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Abstract
Aim: The aim of present study was to compare cyclic fatigue resistance of three modern Ni—Ti instruments used with continuous rotation.
Materials and methods: For this study 3 groups of rotating instruments with continuous rotation (HyFlex EDM, Twisted File Adaptive, Revo S SU) have been used, each group consisted of 20 files. The various groups were subjected to cyclic fatigue testing through an artificial metal device. A statistical analysis with Kruskal—Wallis test and Mann—Whitney test was performed.
Results: There were statistically significant differences between the three groups. The HyFlex EDM instruments have a fracture resistance slightly higher than the Twisted file and far higher than Revo S SU.

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Conclusions: Modern Ni—Ti alloys increase resistance of the rotating instruments to cyclic fatigue.

PAROLE CHIAVE
Fatica ciclica;
Nickel-Titanio;
Rotazione continua;
Strumenti rotanti.

Riassunto
Obiettivo: Lo scopo di questa ricerca è stato valutare la resistenza alla fatica ciclica di tre differenti Files rotanti prodotti con nuove leghe Ni-Ti con movimento di rotazione continua.
Materiali e Metodi: Per la verifica di questo studio sono stati utilizzati 3 gruppi di strumenti rotanti a rotazione continua (HyFlex EDM, Twisted File Adaptive, Revo S SU), ogni gruppo comprendeva 20 files. I vari gruppi sono stati sottoposti a test di fatica ciclica attraverso un dispositivo metallico artificiale. E' stata effettuata una analisi statistica con test di Kruskal-Wallis e test di Mann-Whitney.
Risultati: Sono state rilevate differenze statisticamente significative tra i vari gruppi. Gli strumenti HyFlex EDM hanno mostrato una resistenza alla frattura leggermente superiore ai Twisted file e nettamente superiore ai Revo S Su.
Conclusioni: Le moderne leghe Ni-Ti determinano una maggiore resistenza dello strumento rotante alla fatica ciclica.

Introduction

The use of Ni-Ti represented a turning point in the history of Endodontics, in fact it allowed the production of new endodontic instruments both manual and rotating with higher features than stainless steel one, achieving more effective and reproducible results.[1—3]

Ni—Ti alloys used in dentistry have a fair atomic composition of Ni and Ti, corresponding to 55% of Ni and 45% of Ti.[4,5]

In the past the only way to improve performance of Ni—Ti instruments was to change their dimensions, tip, cross-sectional and flutes design.[6,7] With the development of M-wire and Twisted File technology the instruments have been commercialized aiming at improving safety.[8] The movement kinematics is another important factor.[9] Ni—Ti instruments have been traditionally used with a continuous motion, but in the last years a reciprocating movement has been introduced.[10,11]

Some authors demonstrated that the reciprocating motion can extend cyclic fatigue resistance of Ni—Ti instruments when compared to continuous rotation, but these are only preliminary results.[12,13]

Although the use of Ni—Ti alloy involves a series of advantages, the use of these rotating instruments in Endodontics involves a possible and increased risk of fracture compared to steel files use.[14—16]

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.[17] Torsional fatigue is the twisting of a metal about its longitudinal axis at one end, while the other end is in a fixed position.[18,19]

The resistance to cyclic fatigue of Ni—Ti rotary instruments can be increased via improvements in the manufacturing process or by the use of new alloys with superior mechanical properties.[20,21] There have been many studies on the cyclic resistance of different Ni—Ti rotary instruments with different designs or compositions.[22—24]

Therefore, the aim of this study was to compare cyclic fatigue resistance of new rotating files produced with modified Ni—Ti alloys with rotating files produced with common Ni—Ti alloy.

Materials and methods

Three Ni—Ti rotary instruments — HyFlex EDM (Coltene/Whaledent, Langenau, Germany), Twisted file Adaptive (Kerr, Orange, CA, USA), Revo S SU(Micro-Mega, Besancon Cedex, France) — were selected for the cyclic resistance test. Each group included 20 unused instruments, the size of instruments in Group 1 and 2 was 25/08 and 25/06 for Group 3.

Group 1 was composed by HyFlex EDM Ni—Ti, instruments with complete new properties due to their innovative manufacturing process using electric discharge machining that create unique surface of the new Ni—Ti files and makes the HyFlex EDM files stronger and more fracture resistant.[25] Group 2 was composed by Twisted Files Adaptive, these are formed by twisting a triangular blank in combination with heat treatment and special surface conditioning, which conserves the natural grain structure.[26] Group 3 was composed by Revo S SU, Ni—Ti instruments with asymmetrical cross-section that provides less stress on the instrument and more flexibility.[27]

To evaluate the resistance to cyclic fatigue testing of all instruments, a metal device has been created. The device was composed by a support base to which a rigid locking system for the handpiece was connected. At the head of the handpiece cubes with artificial canals have been set. The entrance of the cubes artificial canal was set in axis with the tools inserted in the handpiece head (Fig. 1).