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ORIGINAL ARTICLE/ARTICOLO ORIGINALE

Conditioning of root canal anatomy on static and dynamics of nickel-titanium rotary instruments

Condizionamento dell'anatomia canalare sulla statica e la dinamica degli strumenti rotanti in Nichel-Titanio

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KEYWORDS
Ni-Ti rotary instruments;
Rotary translation;
Roughness;
Torque;
Torsional stress.

Abstract
Aim: Aim of this study is to analyze the real movement, influenced by anatomical difficulties, of nickel-titanium rotary instruments within root canal systems; then the objective is to point out the physical and geometrical characteristics of an ideal instrument, able to overcome the most complex anatomies.
Methodology: At first, observation of the behavior of nickel-titanium rotary instruments within root canal systems and of the influence on them of root canal anatomy. Then, attempt to avoid the anatomical obstructions exploiting, with manual rotation, the advantages of a zero/low torque.

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Results: Given that, in some root canals the severity of the curves prevents instruments to advance in rotation, we obtained significant results by manually advancing and rotating NiTi rotary instruments.
Conclusions: Therefore, in some cases, we would need an instrument that can reconcile efficiency with a reduction of mass and torque; the ideal instrument should have a very contained working part, combining efficiency with the decrease of mass and, consequently, of torsional stresses too.

PAROLE CHIAVE
Roto-traslazione;
Rugosità;
Stress torsionale;
Strumenti rotanti in Ni-Ti;
Torque.

Riassunto
Obiettivi: obiettivo di questo studio è di registrare il reale movimento degli strumenti, condizionato dalle difficoltà anatomiche, all'interno dei sistemi endocanalari, per poi tentare di evidenziare le caratteristiche fisiche e geometriche dello strumento ideale, impegnato ad affrontare le anatomie più complesse.
Materiali e Metodi: in un primo momento: osservazione del comportamento delle lime endodontiche meccaniche in Ni-Ti all'interno dei sistemi canalari e del condizionamento che l'anatomia canalare ha su di esse. In seguito: tentativo di eludere l'impedimento anatomico sfruttando, con la rotazione manuale, i vantaggi di un torque nullo-basso.
Risultati: premesso che in alcuni canali la severità delle curve impedisce agli strumenti di avanzare in rotazione, si sono ottenuti risultati significativi facendo avanzare e ruotare gli strumenti manualmente.
Conclusioni: alla luce di queste considerazioni, in alcuni casi avremmo bisogno di uno strumento che possa conciliare l'efficienza con una diminuzione di massa e torque. L'ideale sarebbe trovare uno strumento con parte lavorante molto contenuta e che coniughi, quindi, l'efficienza alla diminuzione della massa e di conseguenza anche dello stress torsionale.

Introduction

Anatomical complexities submit nickel-titanium (Ni-Ti) rotary instruments to stresses that often undermine their structural integrity. Despite an extraordinary development of Ni-Ti in more than 20 years of utilization, the increased risk of a separation remains a significant problem for many clinicians.[1] Many variable might contribute to this fracture, but the two main causes are cyclic fatigue and torsional fatigue, both of which might contribute to fracture, depending on canal curvature, instrument geometry and manufacturing method.[2–4] Torsional fracture occurs when an instrument tip or another part of the instrument is locked in a canal, while the shank continues to rotate and the elastic limit of the metal is exceeded[1,5]; instruments fractured by fatigue do not bind in the canal but they rotate freely around a curve, generating tension/compression cycles at the point of maximum flexure until fracture occurs.[6] Many fracture simulation studies on Ni-Ti instruments have been conducted separately from cyclic fatigue and torsional failure tests.[7,8] Only a few studies have tried to correlate these two factors of fracture.[9–12]

The endodontic handpiece imparts to the instruments a rotary motion around an axis (axis of the handpiece). When the apical portion of an instrument is inserted into a curvature, this portion will rotate around a new and different axis (axis of the canal after the curvature); this rotational motion around a new axis is the result of two actions; the first due to the structural continuity of the instrument which tends to transfer, to its portion inserted into the curvature, the same rotary motion imprinted by the endodontic handpiece to the portion of instrument in direct contact with the endodontic handpiece itself (rotation motion around the axis of the handpiece); the second due to the root canal walls, which, opposing the penetration of the instrument inserted into the curvature, exert on it pressing forces (this portion of instrument, in fact, attempts to rotate around the axis of the handpiece, but "slams" on root canal walls). The resultant of these two actions will rotate the portion of instrument inserted into the curvature around a new axis (axis of the canal after the curvature). To appreciate this rotation around a new and different axis, a rotary instrument can be put in rotation on a glass plate, in order to simulate a true rotation in a root canal with a high degree of curvature; a rotary-translation of the bent portion of the instrument can be observed; this would be impossible to value if root canal walls were present.[1]

Even when on the handpiece is not set any torque, once the instrument is inserted in the root canal, on it act forces (conditioning of the root canal walls) that flex it and give it the same root canal's shape.

Pressing forces exerted by root canal walls, if on one hand deviate the axis of rotation of the portion on instrument inserted in the curvature, on the other cause the increasing of friction forces that oppose the rotation and the advancement of the instrument. In vivo, when the curvatures are more than one, this phenomenon happens at every curve. Pressing forces (frictional forces), increase, up to the result of the inability to rotate and/or advance the endodontic file.

Today we have particularly efficient instruments that, cutting a lot, advance until reaching the apical foramen

[1] https://www.youtube.com/watch?v=RkGOftLEv1g.