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Comparison of the Cyclic Fatigue of Protaper Next, 2Shape and Hyflex EDM Using Glyde

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ABSTRACT

This study aimed to compare the resistance to cyclic fatigue of Protaper Next, 2Shape and HyFlex EDM and assess the effect of glyde. A total of 30 new Protaper Next, 2Shape and HyFlex EDM were tested. From each brand 10 files were tested with glyde. The cyclic fatigue test was performed using a specially designed endodontic motor. Resistance to fracture was determined by recording the time. The study concluded that HyFlex EDM recorded the highest value of resistance to cyclic fatigue than 2Shape and Protaper Next respectively. Glyde may reduce the resistance to cyclic fatigue in all brands of files also was concluded in this study.

Keywords: Cyclic fatigue, Glyde, Reciprocating instruments.

Introduction

Instrument separation is a serious concern in endodontics. Because stainless-steel instruments usually deform before they separate, dentists can inspect them for visible signs of instrument deformation. A deformed instrument usually shows severe bending or unwinding of the flutes, indicating that the elastic limit of the metal has been exceeded and that the instrument should be discarded. Nickel-titanium (NiTi) endodontic instruments were introduced to facilitate instrumentation of curved canals. Ni-Ti instruments are super elastic and will flex far more than stainless-steel instruments before exceeding their elastic limit^(1,2). This flexibility is an important property that allows preparation of curved canals while minimizing transportation⁽³⁾. Despite this increased flexibility separation is still a concern with NiTi instruments and they have been reported to undergo unexpected fracture⁽⁴⁾. Separation can occur

without any visible signs of previous permanent deformation, apparently within the elastic limit of the instrument. Cyclic fatigue of nickel-titanium engine-driven instruments was studied by determining the effect of canal curvature and operating speed on the breakage of Light-speed instruments. 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 degree. Scanning electron microscopic evaluation revealed ductile fracture as the fatigue failure mode. These results indicate that for nickel-titanium, engine-driven rotary instruments the radius of curvature, angle of curvature and the instrument size are more important than operating speed for predicting separation.

Materials and Method

Three brands of rotary instrument with tip size 0.25 were used. 10 instruments for each type were tested within the artificial canal. These instruments were tested with glyde.

Group 1 Protaper Next (NiTi rotary instrument tip size 0.25)

Group 2 2Shape (NiTi rotary instrument tip size 0.25)

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Group 3 HyFlex EDM (NiTi rotary instrument tip size 0.25)

Each instrument of these groups were subjected to cyclic fatigue testing device specially designed for the purpose that allowed a reproducible placement of the instrument in artificial canal. The instrument rotates freely in a curvature generating tension, compression cycles at the point of maximum flexure until the fracture occurs.

Instruments were tested within the canal (60° angle of curvature) with radius of curvature for all canals was 5 mm and the width of canal was 1.5 mm within a block made from stainless steel with a swiveling glass cover allowed for visualization of the file rotating in the canal and the removal of broken instrument among test. All the instruments were activated with endodontic motor that was connected to a cyclic fatigue test device using

(Recipro All) program design. The instance of fracture was based on visual observation of the fracture occurring in the instrument. The time (T) of fracture recorded in second (from starting reciprocating within a canal until fracture occur). An independent t-test was used to compare the cyclic fatigue resistance of Protaper Next, 2Shape and HyFlex in all groups.

Results

Descriptive statistic for each file are summarized in Table 1. The mean of cycle to fracture of all HyFlex EDM was greater than 2Shape and Protaper Next (p<0.00). There was a significant difference between Hyflex EDM and Protaper Next also there was a significant difference between Hyflex EDM and 2Shape, but there was no significant difference between Protaper Next and 2Shape when considering the irrigating media (Glyde) as the independent variable.

Table 1: Descriptive statistic for the cyclic fatigue resistance: TtF for each instrument in second (p<0.00)

	Number	Mean	Standard Deviation	Minimum	Maximum
Protaper Next	10	116.7	68.2	46.7	264.3
2 Shape	10	137.2	28.6	73.7	173.0
Hyflex Edm	10	425.9	72.7	337.6	542.5

Discussion

Fracturing of rotary nickel-titanium (NiTi) instruments occurs due to torsion or flexural fatigue⁽⁶⁾. Cyclic fatigue failure is reported to occur unexpectedly without any sign of previous permanent deformation. This occurs because of the alternating tension/compression cycles that instruments are subjected to when flexed in the region of maximum curvature of the canal^(6,7).

Several strategies have been incorporated in the manufacturing process to reduce the incidence of separation of NiTi instruments. These methods include (a) advanced surface treatment or electropolishing that finishes the surface and prevent crack propagation (b) varying the taper within one file and modifying the cross-section, thus reducing the contact area of the instrument with the canal walls (c) heat treatment or thermal processing the optimizes the microstructure of NiTi alloys.^(8,9,10,11,12) Using NiTi instruments in reciprocating motion can enhance the cyclic fatigue resistance⁽¹³⁾. Prptaper Next files (Dentsply Maillefer, Ballaigues, Switzerland) which have been recently

launched are designed in such a way that the center of mass or center of rotation is offset. This offset design minimizes the contact between file and dentine in addition it enhances augering debris out of the canal⁽¹⁴⁾. They are manufactured using M-Wire technology which in combination with the offset design improves the flexibility along the active portion of the file^(14,15) with considerably less iatrogenic error^(16,17).

The 2Shape file system consist of 2 shaping instruments in continuous rotation increased resistance to instrument fracture. Data from research reported that the resistance of 2shape to cyclic fatigue was 40%. The HyFlex EDM OneFile (HEDM; Coltene/Whaledent AG, Altstatten, Switzerland) is a novel instrument designed and marketed to shape root canals using a single file technique in continuous rotation.

HEDM is manufactured using the technique of electrical discharge machining (EDM). EDM can be used to manufacture all types of conductive materials (eg, metals, alloys, graphite, ceramics and so on) of any hardness with high precision.

The shape of a work piece is changed by building a potential between the work piece and the tools. The sparks initiated in this process are melting and vaporizing the material of the work piece in its top layer.

From the result of the present study it's clear that the mean cycle to fracture of HyFlex EDM is greater than that of 2Shape and Protaper Next, and that was due to it's properties as:

1. HyFlex EDM files are produced using an innovative manufacturing process called Electrical Discharge Machining. The EDM process results in a file that is extremely flexible and fracture resistant. In fact HyFlex EDM files are up to 700% more resistant to cyclic fatigue compared to traditional NiTi files⁽¹⁸⁾. While 2Shape files are up to 40% resistant to cyclic fatigue.
2. HyFlex EDM files follow the anatomy of the canal which can significantly reduce the risk of ledging, transportation and perforation.
3. The combination of flexibility, fracture resistance and cutting efficiency of the HyFlex EDM make it possible to reduce the number of files required for cleaning while preserving anatomy.

Finally HyFlex EDM owes its unique properties to a breakthrough technology called "Electrical Discharge Machining". This innovative manufacturing process uses spark erosion to harden the surface of the NiTi file resulting in superior fracture resistance and improved cutting efficiency. HyFlex EDM files offer trusted controlled memory effect and regenerative properties.

Conclusion

Cyclic fatigue resistance of HyFlex EDM was higher than that of 2Shape and Protaper Next respectively with the use of Glyde as irrigant solution.

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Conflict of Interest: None to declare.

Ethical Clearance: All experimental protocols were approved under the Department of Conservative and Cosmetic Dentistry, College of Dentistry, University of Baghdad, Baghdad, Iraq and all experiments were carried out in accordance with approved guidelines.

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