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Comparative evaluation of fracture resistance of hyflex edm, neolix neo niti, protaper next and protaper gold files- an in-vitro study

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Abstract--Aim: The purpose of the present research was to assess the comparison of the fracture resistance ability of various endodontic files like- Hyflex EDM, Neolix Neo NiTi, Protaper Next and Protaper Gold. Methodology: All the instruments were subjected to fracture test using a stainless-steel artificial canal. Time required for fracture as well as number of cycles to failure was calculated at 5 and 8 mm distance from the end of root canal tip. The fractured surfaces were then visualized using electron microscope. The data was analysed

using student t-test and Weibull reliability estimation. Results: Hyflex EDM OneFile instruments showed significantly greater cyclic fatigue resistance than protaper Gold Primary instruments as well as protaper next and neolix NiTi. A significant difference was found between the groups for the length of the fracture 5 mm from the tip ($P < 0.01$). No significant difference was found between the groups for the length of the fracture 8 mm from the tip ($P > 0.01$). Conclusion: Hyflex EDM OneFile demonstrated the highest performance in terms of cyclic fatigue resistance.

Keywords---Dental High-Speed Equipment, Fatigue, Torque, Reciprocation, continuous rotation.

Introduction

The introduction of nickel-titanium (NiTi) alloys enabled more favourable and safer root canal preparation due to the superior flexibility and mechanical strength of NiTi compared to stainless-steel hand instruments.¹ However, separation of NiTi instruments without a clinically detectable warning is an ongoing problem for endodontic practice.² Disposable use of the NiTi instruments is suggested for prevention of this problem and also cross contamination, however preparation of a molar tooth means that instrument would be used to prepare 3 to 4 root canals. Therefore, evaluation of mechanical properties of motor driven NiTi instruments is important.

Separation of NiTi instruments occurs via torsional failure, cyclic fatigue and their combination during clinical use. Torsional failure results when the instrument tip is screwed into the canal and its shank continuous to rotate producing a torque value exceeding the plastic limit of the material.³ Failure due to cyclic fatigue occurs by continuous stresses of tension and compression in the area of maximum root canal curvature.⁴ Cyclic fatigue resistance of a NiTi instrument depends on numerous factors related to design, kinematics and alloy of the instrument including taper, manufacturing process, cross-sectional shape and type of rotation.^{5,6} Recent studies emphasized that cyclic fatigue testing of an instrument should be conducted under body temperature to simulate clinical use as possible since the instruments show different behaviours under different conditions depending on their phase transformation temperatures.^{7,8} Hyflex EDM (HEDM)(Coltene/Whaledent, Altstätten, Switzerland) instruments are produced from controlled memory (CM) wires manufactured by electrical discharge machining (EDM) to improve mechanical properties.⁹ The instrument also shows variable cross-sectional shapes changing from triangular to rectangular from shaft to tip to optimize flexibility, cyclic and torsional resistance.¹⁰ Hyflex EDM OneFile has a tip diameter of 0.25 mm and variable taper from .08 at apical 4 mm decreasing to .04 along the remaining part.¹¹ Recently, many file systems introduced to the field that possess different material properties and designs including One curve (OC) (Micro-Mega, Besancon, France and Neolix (NE) (Neolix, châtres-la-Forêt, France). A wire-cut electrical discharge machining process is used to produce NE to improve cutting efficiency and result in faster root canal preparations. Previous studies showed the superior cyclic fatigue resistance of

HEDM and OC, against other NiTi files.¹² The Protaper Next (PTN) instruments have a rectangular cross-sectional design and using M-Wire to improve their flexibility and cyclic fatigue resistance. The improved fracture resistance might be the result of the nonuniform design and the reduction in the contact points between the file and the root canal wall.¹³ Although it is generally suggested that 6 instruments be used when preparing canals with a Protaper Universal (PTU) file, the first 3 in the coronal and middle third (Sx, S1, S2), and the remaining 3 in the apical preparation (F1, F2, F3), the instructions of PTN suggest using only 3 instruments (X1, X2, X3) to obtain similar shaped canals.¹⁴ Protaper Gold (PTG) rotary files (F1, F2 and F3) possess the same geometry as PTU files and have been developed with proprietary advanced metallurgy. Science advances, and single-use instrumentation systems have been created to prevent fracture from overuse. The files are used in a single tooth, in 1 to 4 root canals (as in molars) and are safe in narrow and curved canals. However, several studies have suggested that their traction and compression strengths are a disadvantage in the case of continuous rotation instruments. In relation to the assessment of the separated fragment lengths, it is preferable that the longest fragment should remain inside the tooth to make its removal easier.¹⁵ Therefore, this study was designed to evaluate the Hyflex EDM, Neolix Neo NiTi, Protaper Next and Protaper Gold files in terms of resistance to cyclic fatigue and separated fragment lengths.

Aim Of The Present Study

The purpose of the present research was to assess the comparison of the fracture resistance ability of various endodontic files like- Hyflex EDM, Neolix Neo NiTi, Protaper Next and Protaper Gold.

Methodology

A stainless-steel artificial canal with an inner diameter of 1.5 mm showing an angle of curvature 90° and radius of curvature of 2 mm was immersed in a water bath, which temperature was maintained at 37°C by a submersible heater and thermostats. All instruments were used until fracture, which was detected both audibly and visually. Time required for fracture (TF) was measured by 1/100 seconds chronometer and fractured fragment length was measured by a digital calliper with 10-2 accuracy. Number of cycles to failure (NCF) values were calculated by multiplying the TF value with recommended speed of each instrument and dividing the result by 60. The curvature started at the following two distances from the canal terminus: 5 and 8 mm. The artificial canal wall was coated with synthetic oil prior to each file insertion to reduce friction. The canals were covered with a glass plate to stop the file from escaping. All files were rotated until failure occurred, which was recorded in seconds.

Fractured surfaces of two instruments were visualized with scanning electron microscope. Since Shapiro-Wilk test revealed that the data showed normal distribution ($P > 0.05$), Student t-test was used to analyse TF and fragment length data with 5% significance threshold using SPSS. TF data was also analysed using Weibull reliability estimation for the calculation of 99% survival probability.

Results

Hyflex EDM OneFile instruments showed significantly greater cyclic fatigue resistance than Protaper Gold Primary instruments ($p < 0.05$). Weibull analysis indicated that Hyflex EDM OneFile instruments also exhibited higher reliability and Weibull modulus than Protaper Gold Primary. (Table 1). When comparing PTG with PTN files, the PTG files had the greater CF resistance and the PTN files. At 8 mm from the tip, no significant difference was found between the PTG and PTN files ($P > 0.01$); however, the PTG files demonstrated a higher resistance than the PTN files. A significant difference was found between the groups for the length of the fracture 5 mm from the tip ($P < 0.01$). No significant difference was found between the groups for the length of the fracture 8 mm from the tip ($P > 0.01$). (Table 2)

Discussion

One of the most common complications during root canal preparation is the fracture of the NiTi rotary file during the procedure.¹⁶ It was reported that the fracture of the file during clinical use, mainly related to cyclic fatigue.^{17,18} The present study evaluated and compares the cyclic fatigue resistance of the different NiTi file systems manufactured from different alloys and after different heat treatment in simulated single curvature canals.

The HEDM file showed the highest resistance to cyclic fatigue compared to other NiTi files, where Spark-machined peculiar surface is the main feature of HEDM, the cyclic fatigue resistance of HEDM files was higher than Hyflex CM file (HCM, Coltene/Whaledent).¹⁹ Also, HEDM resists cyclic fatigue significantly better than ProTaper Universal and Pro-Taper Gold files.²⁰ HEDM was the first instrument manufactured with EDM technology, which is a noncontact thermal erosion process. EDM causes local melting and partial evaporation of minor portions of the materials by generated electrical sparks, leaving surface finish with a typical crater-like.²¹

Alloy properties have been reported to influence the cyclic fatigue resistance of NiTi instruments primarily. Hyflex EDM instruments are manufactured from CM wire that underwent a unique treatment termed electric discharge machining that improves the cutting ability and fatigue resistance, whereas Protaper Gold instruments are manufactured from advanced metallurgy technique that received a thermomechanical treatment after machining. Post-machining thermomechanical treatment of both CM and NiTi wires resulted in a mixed phase which consists mainly of martensite providing increased flexibility and cyclic fatigue resistance. Hyflex EDM instruments have been compared with Protaper Gold and reported to show superior cyclic fatigue resistance of Hyflex EDM instruments.²²

Reciprocating movement has been developed to prevent screw in effect to improve torsional resistance of instruments, and then it was reported to increase cyclic fatigue resistance also.²³ However, in the present study Hyflex EDM OneFile instrument operated with continuous rotation movement showed significantly greater cyclic fatigue resistance. At 8 mm from the root tip, the PTG instruments

had the highest performance in terms of the cyclic fatigue resistance, but no significant difference was found between the PTG and PTN instruments.

The Weibull analysis presents the capacity of tested instruments in extreme-value distribution and the lower values that might be clinically important for operators.²⁴ Hyflex EDM OneFile instruments showed a higher Weibull modulus, which is an indicative of a higher reliability of the material.²⁵ The lengths of fractured fragments were similar between groups, which indicated the correct position of the instruments within artificial blocks and formation of similar stresses during testing.

Conclusion

Hyflex EDM OneFile demonstrated the highest performance in terms of cyclic fatigue resistance. PTG also showed good performance in terms of the cyclic fatigue resistance.

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