Fatigue Life of ProTaper Gold^{RM} instruments

- An *in vitro* study -

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INTRODUCTION

Nickel-titanium instruments (NiTi) were introduced to facilitate root canal preparation in Endodontics. Despite its advantages, instrument separation remains a major concern [1,2,3].

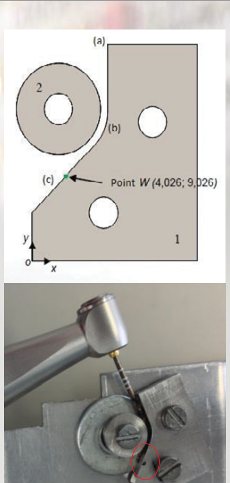
Fatigue life of a material is the number of cycles required to its failure. Fatigue behavior of instruments manufactured from NiTi alloy can be determined by cyclic fatigue testing, being a simple and reliable approach [4].

Several NiTi file systems are currently available with different clinical advantages [5]. ProTaper Gold^{RM} (PTG) instruments, for example, were recently introduced. These files have a design that features identical geometries as ProTaper® Universal (PTU), as well as the same instruments set and manufacturer's instructions for usage. Still, there is a differentiating heat-treatment : CM-Wire® technology [6,7].

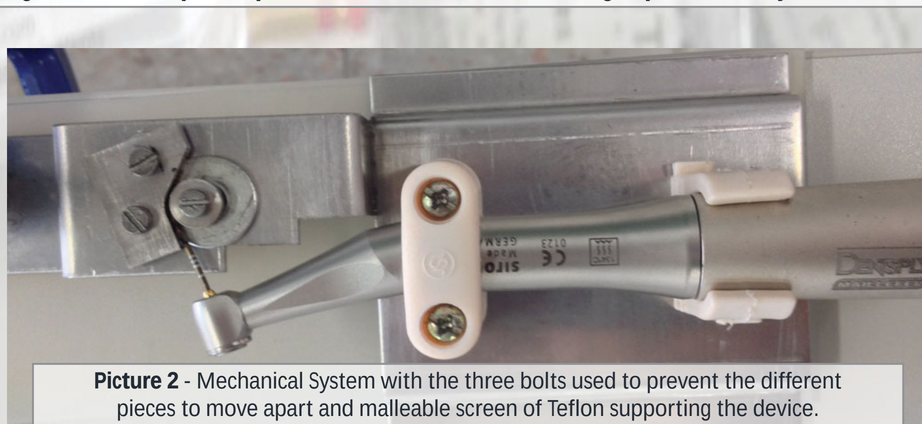
Since higher cyclic fatigue may lead to lower propensity for an instrument to break, the purpose of this study was to characterize the fatigue resistance of PTG system and to compare it with fatigue resistance of PTU and Protaper Next^{TM} (PTN) files, since little independent research is available.

MATERIALS AND METHODS

Seventy three sterile and new rotary files of PTG, PTU and PTN systems were experimentally tested in a mechanical device with a radius of curvature of 4.7 mm and an angle of curvature of 45˚. As seen in picture 1, a point with specific coordinates established the place where the tip of the instrument was in each test. **All parameters guaranteed equal experimental conditions ensuring reproducibility.**



Picture 1 – a) Schematic representation of the mechanical system. b) Mechanical device and respective W point.



Picture 2 - Mechanical System with the three bolts used to prevent the different pieces to move apart and malleable screen of Teflon supporting the device.

Time to failure (*t*) was recorded along the experimental testing and NCF was determined. This parameter have been used to assess cyclic fatigue resistance over time [8].

Statistical analyses was performed with IBM® SPSS® Statistics version 22.0.0 software.

The same operator was responsible for the fulfilment of required steps:

1. Place the instrument in the contra-angle and rotate the head of the contra-angle until the instrument be parallel to the part that simulate the canal;
2. Ensure that the instrument is perpendicular to the upper part of the block, it's well adjusted between the two pieces that impose radius of curvature and angle, and the extremity of the file is well positioned at the specific point;
3. Fix the position of the parts by tightening the bolts;
4. Turn on the WaveOne^{TM} motor equipment and select ProTaper Universal programme: 300 rpm and torque of 4 N.cm;
5. Step on the pedal initiating the digital chronometer;
6. Stop the chronometer when the tip of the instrument comes off.

RESULTS

Group	Type of file	Quantity	*t* (sec)	NCF
1	PTG F2	12	109,82 ± 23,03	549,1 ± 115,1
2	PTN X2	16	77,8 + 9,3	389,2 ± 46,7
3	PTU F2	12	56,70 ± 6,78	283,5 ± 33,9
4	PTG F3	12	58,18 ± 17,01	294,5 ± 88,0
5	PTN X3	13	88,62 ± 11,69	443,1 ± 58,5
6	PTU F3	12	31,70 ± 7,51	158,5 ± 37,57

Table 1 – Descriptive analysis: mean and standard deviation regarding time to fracture and NCF. Group 1 is the one with higher mean values; the lower values are present in Group 6.

The mean value of NCF between group 1 and group 4; group 3 and group 6 was found to have a significant statistical difference. Instruments with larger diameters (F3) had the tendency to present lower NCF than those with smaller diameters (F2). However, for system PTN the same tendency was not verified and Group 2 had a lower mean of NCF than Group 5.

When comparing data between different systems of files and considering F2/X2 instruments, mean NCF of PTG instruments was higher than PTN. In addition, mean NCF of PTN was higher than PTU instruments ($p<0,05$).

As far as it concerns instruments F3/X3, the statistics showed a significant difference among all groups, being PTN system the one with the higher mean of NCF, followed by PTG and PTU.

DISCUSSION AND CONCLUSIONS

According to our results, instruments of smaller size have a higher NCF. These findings corroborate with current literature, since resistance to cyclic fatigue decreases when instrument sizes and respective diameter increases [9-15].

When comparing PTG and PTU instruments, PTG system has proven to be more fatigue resistant than PTU. Despite the identical architecture and operation of PTG and PTU systems, different manufacturing process affects their fatigue resistance behaviour. A higher proportion of martensite and changes in the phase transformation behaviour may be the reason [6,7,9,16,17]. However, when PTN fatigue resistance concerns, it depends on the type of instruments and its diameter.

During clinical practice, clinicians should be aware of this property when it comes to the moment of choosing the mechanical system to use.

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