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Comparison of Cyclic Fatigue Resistance of Two Different Rotary NiTi Instruments (An In-Vitro Study)

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Aim: The aim of this study was to compare the dynamic CFR of M3-ProGold instruments and Pepsi Gold instruments.
Material and methods: Eighty files of size 25/.06 of M3 Pro Gold files and Pepsi Gold files (each n = 40) were evaluated for dynamic cyclic fatigue resistance inside two artificial stainless-steel canals with 2 different radii [(60̊ curvature, 3 and 5 mm curvature radii) at body temperature and immersed in distilled water at 37° ± 1°C. The NCF (number of cycles to failure) was documented. The data was analysed by the use of ANOVA and Tukey post hoc tests (P ≤ 0 .05).
Results: The Pepsi Gold instruments had a significantly greater NCF than the M3 Pro Gold files in both canal radii at body temperature.
Conclusion: Pepsi Gold instruments have higher CFR than M3 Pro Gold instruments.

Keywords: CF, controlled memory Alloy, M3 Pro Gold files, Pepsi Gold files.

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Introduction

Cleaning and shaping of root canals are very important steps in endodontic treatment process.[1] In curved canals, apical foramen transportation and ledge formation are complications commonly found during canal preparation.[2] To overcome these problems, nickel-titanium (Ni-Ti) rotary instruments have been developed. Endodontic rotary instruments have accomplished nonstopping improvement.[3] The alloy enhanced the strength and flexibility of endodontic rotary instruments in comparison with the traditional stainless-steel endodontic files. While non stopping improvements in the design and construction of Ni-Ti endodontic instruments[4] to decrease the incidence of the problems through RCT, rotary files separation because of cyclic fatigue (CF) remained an important issue. CF fractures occur as a result of rotation of the instruments continuously in a canal curvature with the lack of binding.[5] The files subjected to elastic deformation are exposed to mechanical loads represented by the alternation between tension and compression.[6,7] The continuous cycles of the load lead to file fracture through CF. CFR is the number of cycles to failure (NCF) that a file can resist under a definite situation till fracture happens.

Rotary files do not display noticeable marks of permanent deformation through CF so file fracture can happen suddenly.[8] The newly introduced alloys have transformation temperatures higher than conventional austenitic alloys used in the old generations of rotary instruments[9] and the transformations may happen near to body temperature[10] and the thermal treatment of the Ni-Ti alloy improves its microstructure and maximizes its flexibility and CFR.[11-13] The instruments manufactured of controlled memory (CM) wires are more resistant to CF than the traditional Ni-Ti alloy.

The M3 pro Gold files (United Dental, Shanghai, China) are NiTi files that are designed to be used in continuous rotation motion with an inactive tip and a convex triangular cross-section size 25/.06 taper. The manufacturer claimed that these files provide fast and safe preparation in curved canals due to the high flexibility. M3 pro Gold files are manufactured with a CM wire associated with an innovative triple surface coating, which allows greater flexibility and CFR to the files.[14]

The Pepsi Gold files (Fanta Dental Material Co., Shanghai, China) are newly introduced NiTi files that is designed to be used in continuous rotation motion with an inactive tip and a flat surface design 25/.06 taper. The manufacturer claimed that these files provide quick and safe preparation in curved canals due to the high flexibility. Pepsi Gold files are manufactured with a CM wire associated with a surface treatment, which allows better flexibility, hardness and resistance to CF.[15]

So, this study was conducted to evaluate the CFR of these instruments at body temperature (BT). The null hypothesis was that there is no significant difference between the instruments regarding their CFR and that the CF isn't affected by the body temperature.

Materials and Methods

1-Sample selection:

A total of eighty files of the two types were used (Fanta Pepsi Gold files and M3 Pro Gold files). Files with tip size (0.25 mm) #25 were used. The files were examined under 8X digital microscope for any marks of noticeable defects and none were rejected.

2-Sample size calculation:

The statistical sample size calculation was performed using the G power version 3.1.9.7 [16]. The predicted sample size (n) was found to be a total of (80) file (40 file each

group). An alpha type error of 0.05, a beta power of 0,95 and an N2/N1 ratio of 1, while mean and standard deviation obtained from previous study.[17]

3-Sample Classification:

Instruments used was categorized into two main groups (n=40) according to the instrument type:

- Group I (40 files) Fanta Pepsi Gold files (25,6%) were tested.
- Group II (40 files) M3 Pro Gold files (25,6%) were tested.

Each group was divided into two equal subgroups:

- Subgroup A = 20 files were tested in 3mm radius artificial canal.
- Subgroup B = 20 files were tested in 5mm radius artificial canal.

4-Dynamic Cyclic Fatigue resistance test:

A custom made dynamic CF testing device was used fig(1).[18] The files were rotated using endodontic motor (Econnect) with speed 350 rpm and torque 2.5 Ncm (according to the manufacture's recommendations) with up and down motion in the artificial canal. The artificial canal was designed using AutoCAD software. The canals were done the exact dimension and taperness of the file examined (25,6%) plus 0.1 mm relief for the whole instrument. Each canal has a 16 mm length. According to Schneider canal curvature description technique[19], the canal has 60° curvature and 5,3mm curvature radii.[20]

Instruments were rotated and immersed in distilled water at 37 ° ± 1 ° BT.[21] The temperature of the water was controlled via aquastic thermostatic control linked to the heat control and measured by digital thermometer. When starting the test the device was adjusted to allow the instruments to enter the canal perpendicularly. The file was attached to the endodontic motor and was inserted 16mm in the canal (the full length of the canal). The whole assembly was submerged below water level in the water bath container. The water temperature was adjusted by the heat control to be 37°±1°C.

The instruments were observed by the operator while rotating in the canal until the instrument was fractured. The stopwatch was stopped once instrument fracture was occurred. Time till fracture (Ttf) in seconds was documented. The glass cover was removed. The file was removed, wiped with a clean tissue and put in a pouch. File number, group and subgroup are written on the pouch. The canal was wiped thoroughly. The device was ready for a new test. The number of cycles to fracture was calculated by this formulation[22] (NCF= revolution per minute (rpm) x Ttf (sec)/60).

5-Statistical Analysis

Statistical analysis was performed using statistical package for social sciences, version 21.0. The recorded data followed normal distribution. Data was displayed as means and standard deviation (S.D) values. Unpaired t test was used for statistical analysis. P- value < 0.05 was considered to be statistically significant.

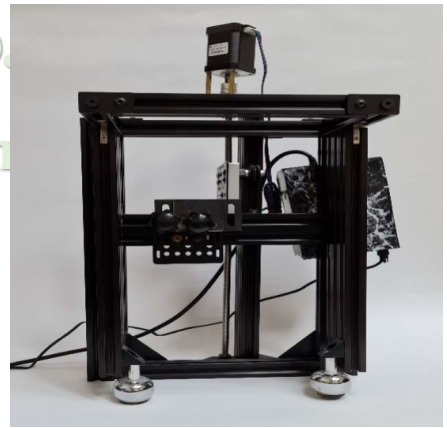

Figure (1) photograph showing the dynamic cyclic fatigue testing device

Results

The recorded data was tested for normal distribution using Shapiro –wilk test

for normality. The data was normally distributed, consequently unpaired t test was used.

In 3mm radius artificial canal, the Pepsi Gold files showed significantly higher NCF with mean value (924.3 ± 74.5) than M3 Pro Gold files with mean value (688.6 ± 36.7). P< 0.01.

In 5mm radius artificial canal, the Pepsi Gold files showed significantly higher NCF with mean value (1721.1 ± 56.5) than M3 Pro Gold files with mean value (1372.5 ± 71.5). P< 0.01.

Table (1): Mean and standard deviation (SD) NCF in 3 and 5mm radius at body temperature of Pepsi Gold files and M3 Pro gold files.

	M3Pro Gold files Mean ± SD	Pepsi Gold files Mean ± SD	P value
Radius 3	688.6 ±36.7	924.3 ±74.5	.00001*
Radius 5	1372.5 ±71.5	1721.1 ±56.5	.00001*

***significant (P ≤ 0.05)**

Discussion

Although the new Ni-Ti instruments had great flexibility but file separation is still main issue for the endodontists. It occurs by 2 ways: the first is torsional fatigue, that happens when the tip of the instrument is locked in the canal while the other part of the instrument continues rotating above the materials elastic limit.[23] The 2nd is CF, that occurs from rotating of the file around a curvature with frequent compression and tension of the metal and at the end fracture.[24] There are 2 types of CFR tests static and dynamic test. In the static test the file was constrained in the canal[25-28], however the dynamic test was closer to the clinical situation[24,28-30]. So, we used the dynamic model in this study.

The 2 files tested were made from Ni-Ti alloy. Both files were made from the martensite that had higher CFR.[31]CFR has usually been tested at RT but the new alloys represent transformation temperatures much more than the traditional austenitie material that has transformation temperature near the BT. New studies have presented different CFR of rotary Ni-Ti files while examined at different temperature. CFR of recent rotary instruments decreased when tested around BT compared with RT. Therefore, we performed this study in BT.

The CFR is dependent on several factors such as file design, alloy type and file kinematics, thread number, cross section, helical angles, small tip size, taper and heat treatment that have an impact on the cyclic fatigue resistance and flexibility of the files.[32-34] The 2 files that were tested had the same features and were made from the CM wire to exclude any variable that could affect the CFR results.

The null hypothesis was rejected as there was statistically significant difference between the two instruments. Within the limitations of this study the results showed that M3 Pro Gold files had lower CFR than Pepsi Gold files in both canal radii which is in agreement with other research by Abd ElHamid H. and Dawood A.[35,36]

Our results are probably due to the presence of the austenite phase in the M3 Pro Gold at temperature lower than Pepsi Gold. The martensite phase has the ability to deform more than the austenite phase because of the twinning property of this phase, which is an internal movement of lattices without the break of the atomic bonds through absorbing stresses.[37]

Our results are inconsistent with other research by Pedullà et al., Yehia., Miccoli et al. and Nasr et al.[14,38-40] which compared the CM wire with other wires (t wire and conventional wire). The other wires had lower resistance to cyclic fatigue and lower flexibility. Others compared different heat treatments and found that the gold heat treatment had the best results.

There is significant effect of the canal radius on the CFR which agree with the

previous studies.[26,41,42] The smaller the curvature radius, the larger the stresses on the file and the lower the CFR of the file.[43,20]

We have some limitations in this study that the cyclic fatigue was evaluated in a stainless-steel canals but the clinical performance of the files is affected by another factors such as the initial size of the canal, the MD and BL curvature of the canal, the different radii of the canals and the dentin hardness.

Conclusions

Within the limitation of this study, it was concluded that:

1.Pepsi Gold instruments have higher fatigue resistance than M3 Pro Gold instruments.

2.The greater the radius, the higher the cyclic fatigue resistance

Recommendation:

More studies can be conducted to:

- Evaluate the M3 pro gold files and the Pepsi gold files in more severe curvature angles and double curvatures.

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