

Original Article

The Effect of Autoclave Sterilization on Resistance to Cyclic Fatigue of Hero Endodontic File #642 (6%) at Two Artificial Curvature

Masoud Khabiri¹, Maziar Ebrahimi¹, Mohammad Reza Saei¹

¹ Dept. of Endodontic, Dental School, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran.

KEY WORDS

Cyclic Fatigue;
Hero Rotary Instrument;
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ABSTRACT

Statement of the Problem: File fracture can interfere with cleaning and shaping of the canal and compromise periradicular healing. Autoclave sterilization may prone the files to fracture.

Purpose: The purpose of the present study was to determine the effect of autoclave sterilization on the cyclic fatigue resistance of Hero642 rotary instrument in two curvatures of 45 and 60 degrees.

Materials and Method: For this experimental *in-vitro* study, 90 Nickel-Titanium HERO 642 rotary files #30 with 0.06 taper were selected. They were divided into two groups (curvature of 45 and 60 degree) of 45 files. Each group was then subdivided into 3 subgroups; group I: no sterilization, group II: 5 cycles of sterilization and group III: 10 cycles of sterilization. Files were used in artificial canals until fracture. The cyclic fatigue was measured as the number of cycles before fracture. The data was statically analyzed by Student's t-test and two-way analysis of variance.

Results: There was a significant difference in cyclic fatigue of two curvature of 45 and 60 degrees ($p= 0.001$). However, sterilization process has no significant effect on cyclic fatigue of HERO files ($p= 0.557$).

Conclusion: Sterilization had no effect on the cyclic fatigue of HERO 642 files when used in curvature of 45 or 60 degrees.

Corresponding Author: Ebrahimi M., Dept. of Endodontic, Dental School, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran. Email: ebrahimimd@gmail.com
Tel: +98-3135354053

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Introduction

Currently, the use of nickel- titanium (NiTi) files is an inseparable part of root canal therapy. The super- elasticity property of these files allows them to give proper form to canals even with sever curvature. [1-2] However, compared to hand files; rotary files are more likely to fracture during canal preparation. This failure can be due to either cyclic fatigue or tensional fatigue. [3-4] In torsional fatigue, the rotational forces are applied on the file, which is in friction with the walls of the canal. Cyclic fatigue occurs because of frequent bending of the file in a canal curvature.

The impact of torsional fatigue, metal fatigue and

combination of these two phenomena is still controversial. [5] Metal fatigue, which is usually caused by continuous rotation periods, is a major reason for fracture of rotary endodontic files. [6] Meanwhile, torsional fatigue is considered the reason of about 90% of NiTi rotary files fracture. [5, 7] In fact, stress cause initiation of tiny cracks the areas of stress concentration and then cracks rapidly propagate due to cyclic fatigue and finally leads to file fracture. [8]

Temperature changes affect crystalline phases in NiTi alloy. These changes result in enhanced physical properties of the alloy such as higher cutting efficacy and resistance to fracture. [9-10] In the same manner,

cyclic fatigue of brand new NiTi files is significantly different from those sterilized for several times. [11] However, sterilization is not necessarily effective on the cyclic fatigue of all files. [12-14] For instance, A study reported decreased degrees of rotation to failure of GTX files sterilized for 3 times and 7 times; however, sterilization of twisted file for 3 and 7 times did not reduce their degrees of rotation to failure. [14] Another study showed that in contrast to K3xf files, sterilization had no negative effect on cyclic fatigue K3, Mtwo and Vortex files. [15]

File fracture is one of the biggest concerns of clinicians when using NiTi rotary instrument [15] evaluation of risk factors of file fracture can help clinicians to have a better judgment about limitation of NiTi rotary files. The aim of the present study was evaluation of autoclave sterilization on the resistance to cyclic fatigue of HERO 642 endodontic file at two artificial curvatures.

Materials and Method

In this experimental-laboratory study, 90 new Hero 642 files with size #30 and 6% taper were divided into two equal groups of 45 and 60-degree curvatures. Each group was subdivided into three subgroups, subgroup 1: not sterilization, subgroup 2: 5 cycles of sterilization subgroup 3: 10 cycles of sterilization.

The artificial metal canals were made according to the study of Plotino *et al.* [15] as one of the acceptable methods for testing the cyclic fatigue. The artificial canals were 19mm long, 1.5mm width, 2mm depth, with a constant curvature radius of 5mm and curvature angle of 45 and 60 degrees. Canals prepared on blocks using a diamond fissure bur #008 by high-speed handpiece; then a fine diamond round bur was used to slightly polish the internal area of tracks. Finally, the surface of canals was electroplated. The metal block was mounted in plaster and prepared for cyclic fatigue testing. Subgroups 2 and 3 of files were sterilized for 5 and 10 cycles, respectively, at 134°C, 30 psi for 36 minutes (20 minutes for sterilization cycle and 16 minutes for drying cycle) using an autoclave (B class, Dental X, Italy).

Then the surface of artificial canals were coated by a thin layer of glycerin as a lubricant Each file was rotated using Endomate DT (NSK, Shinagawa-ku, Tokyo, Japan) at a constant speed of 300 rpm with a torque

of 1 Ncm. To prevent any displacement, the Endomate handpiece was firmly attached to plaster block. Then, files of each group were used in 45 degree or 60-degree curvature until fractured (Figure 1). The time from beginning of file rotation until fracture was measured and recorded. Number of cycle to fracture (NCF) calculated by multiplying rpm to fracture time (in minutes).

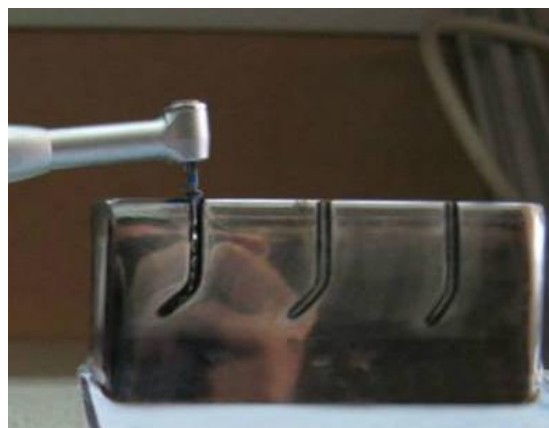


Figure 1: Cyclic fatigue testing

Two-way ANOVA (two-sided) was used to compare the resistance of files in different sterilization scenarios (generally without regard to the type of curvature) and a t-test was conducted to compare the resistance of files in each sterilization scenarios at two curvature angles of 45 and 60 degrees. The SPSS 22 software (IBM, Chicago, IL) was used to analyze the data and the significance level was considered equal to $\alpha = 0.05$.

Results

The ANOVA results showed that there was no significant difference in cyclic fatigue of files for different sterilization cycles ($p = 0.557$) but there were significant differences in cyclic fatigue of the files between two curvatures of 45 and 60 degrees (regardless of the sterilization cycles) ($p = 0.001$). In addition, the interaction of curvature and sterilization was not significant ($p = 0.963$). This means that difference between NCF at 45 and 60 degrees was similar in 0, 5 and 10 cycles of sterilization and sterilization had no up or down regulating effect on the NCF of the files.

Pair wise comparison of groups using Student's t-test showed that in any sterilization situation, there is a significant statistical difference between the 45 and 60 degree curvatures ($p = 0.001$) (Table 1).

Table 1: Comparison of cyclic fatigue resistance in experimental groups

Sterile	Curvatures	No	Mean±SD(NCF)	p Value
0	45	15	895 ± 52	0.001
	60	15	768 ± 39.76	
5	45	15	886 ± 40.31	0.001
	60	15	764 ± 46.68	
10	45	15	883 ± 43.74	0.001
	60	15	755 ± 30.79	

Discussion

In this study, we evaluated the effect two curvatures and sterilization process on the cyclic fatigue of HERO NiTi files. Our results showed, as the curvature angle increased cyclic fatigue resistance of NiTi files decreased; however, autoclave sterilization cycles have no effect on the resistance to cyclic fatigue in either curvature.

Cyclic fatigue is the one of the most important factors in NiTi file fractures. [7] However, frictional force during rotational movement can also result in file fracture. [4] Since the main objective of this study was to evaluate the cyclic fatigue of files, we tried to reduce the friction as much as possible. Therefore, the inner diameter of the artificial canals was considered 1.5mm, which was wider than 1.25mm, the largest diameter of Hero No. 30 with 6% taper. Additionally, we used polished artificial canals a covered by slippery liquid (glycerin) during testing, to minimize the friction. These considerations reduced the effect of friction as a confounding factor.

In the present study, no significant difference was observed in resistance of Hero Files No. 30 with 6% taper 30 before and after sterilization in 5 and 10 autoclave cycles when used in 45 or 60 degrees curvatures. This is in agreement with the results of some other studies that showed no significant differences in cyclic fatigue for the K3, Mtwo and Vortex, and GTX files before and after autoclave sterilization process. [14-15, 21] In one study, sterilization process lead to increased cyclic fatigue resistance of k3xf files. [15] Hilfer *et al.* [13] also showed that the sterilization caused no significant change on cyclic fatigue in GTX 20 (4%) and GTX 20 (6%) and Twisted 25 (4%) files. However, the resistance to cyclic fatigue of twisted 25 (6%) files declined after sterilization. On the other hand, King *et al.* [14] showed autoclave sterilization could reduce the torque at failure without changing degrees of rotation to failure of GT series X files after seven sterilization cycles.

Hilfer *et al.* stated that 170° centigrade is the minimum temperature that can change crystalline structure of NiTi files and therefore autoclave sterilization temperatures are not sufficient to change the crystalline structure of NiTi Files. The crystalline change and increased fatigue resistance can be expected only after reaching to temperatures near to 430 of centigrade. [13]

In contrary, Plotino *et al.*, [15] showed NiTi is a very sensitive alloy and any thermal and mechanical changes can affect its physical properties. They believe autoclave sterilization can increase the cyclic fatigue resistance of different NiTi files. However, variety in manufacturing process of different files, especially some procedures such as heat treatment, can affect the behavior of files to the sterilization process. As a first generation endodontic rotary file, Hero 642 is a file without any heating process during the manufacturing; therefore, lack of change in mechanical properties of this file after the sterilization process is expected. [16-17]

The other point, which we focused in our study, was the effect of curvature of the canal on the cyclic fatigue of the file. Previous studies showed the radius and angle of canal curvature, to some extent, can affect the cyclic fatigue resistance of NiTi files. [18-20] We measured the cyclic fatigue at two different curvature angles of 45 and 60 degrees, with a radius of curvature of 5mm for both artificial canals to avoid their confounding effect. These selections were made based on the previous studies. [21-22]

In our study, the rotation cycles of Hero file with tip size of 30 and 6% tapper at a 60 and 45 degrees curvature were 762 and 888 cycles, respectively. Our results showed significant lower cyclic fatigue resistance of files in curvature of 60 degree compared to 45 degrees. Plotino *et al.* [15] study is most similar to the present study in terms of design. In their study, the number of cycles for fracture of Hero is similar to that of k3xf files but higher than NCF for K3, Mtwo, Vortex.

The results of Azimi *et al.* [23] study are consistent with the results of the present study. In their study, increasing curvature from 30 to 60 degrees, RaCe files (25) (6%) showed less resistance to cyclic fatigue.

The Noteworthy point in this study is that all aspects of cyclic fatigue cannot be considered in a single study, since each study covers a limited number of rotary files or small or large curvatures are used to study cyclic fatigue (30°, 45°, 60° and 90°) and all systems of rotary files have not been covered in all curvatures. This shows the necessity of conducting several research studies on all files.

Conclusion

Increased angle of channel curvature has had a positive impact on reducing cyclic fatigue resistance of NiTi files, while autoclave sterilization has had no significant effect on cyclic fatigue resistance of Hero files.

Conflict of Interest

There is no conflict of interest.

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