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# Immersion of Mtwo nickel-titanium rotary files in antiseptic solution and fatigue resistance: Effects and analysis

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***Abstract*---**Background and aims: Widely application of rotary files for endo treatment would force us to obtain an accurate understanding about the characteristics and drawbacks of these instruments. Therefore in this study, the effects of immersion of NiTi M2 rotary file in deconex and sodium hypochlorite solution on the cyclic fatigue resistance was investigated Material and methods: In this exprimental study, 45 NITI M2 rotary files were divided in three groups I) control (without any immersion), II) immestion in deconex for 5 min and III) immesrion in sodium hypochlorite for 5 min and their cyclic fatigue resistance was investigated by using testing device and NCFs were recorded. The obtained results were analysis by using Fisher's statistic and the mean comparisons were carried out by using Tukey Results: The results showed that immersion of NiTi M2 rotary files in streluating solutions provides negative and significant effects on the cycle fatigue resistance and the highest NCF was obtained in the control (890.046) and the lowest was obtained in the files immmersed in deconex (546,076). Therefore, it is suggested to used autocalve as substitution for immersion to strelize NiTi M2 rotary files. Conclusion: The findings of this study indicated that the immersion of Mtwo nickel-titanium (NiTi) rotary files in disinfectants has a significant negative effect on the cyclic fatigue resistance of rotary files, as the highest levels of cyclic fatigue resistance were observed in untreated

(control) Mtwo NiTi rotary files. In contrast, the lowest cyclic fatigue resistance was witnessed in samples immersed in Deconex solution.
***Keywords***---*NiTi rotary files, Mtwo rotary files, immersion, Deconex, sodium hypochlorite.*

## Introduction

The ever-increasing use of rotary systems in the preparation of root canals for endodontic therapy necessitates a clear understanding of the characteristics and limitations of the instruments embedded therein. Nickel-titanium (NiTi) rotary files have been introduced to the endodontic therapy routine to enhance the quality of root canal preparation. Due to their major advantages over conventional stainless steel endodontic files, NiTi alloys have increasingly been used in dental root canal treatments. The superelastic property of nickel-titanium allows it to return to its original shape after initial deformation, hence the superiority over stainless steel files, which undergo permanent deformation. These characteristics have made nickel-titanium endodontic files more elastic, improving their fatigue resistance.

Moreover, over time, they exhibit less wear and deformation than stainless steel files. NiTi files can recover from perceived 10% deformations, while conventional alloys can barely recover from 1% deformation. Also, these files have good histocompatibility and display excellent anti-corrosion properties (1). However, the results of some clinical studies have shown that these files may not perform properly following fractures caused by fatigue or shear stress. The curvature of the root canals is often considered a basic risk factor for the fractures of endodontic files, themselves often caused by flexural stresses; needless to say that not human errors cause all flexural stresses. Shear failures may also occur due to excessive stresses in the alloys used in tools, which lead to deformation, and, subsequently, failures (2).

Compared to the conventional stainless steel rotary files, NiTi files offer a plethora of advantages, such as lower elasticity coefficient, superior canal shaping capability, speed and flexibility, higher root canal treatment success, and less transport. Nevertheless, they are plagued with their drawbacks. There is the risk of breaking during the therapeutic procedures, usually swiftly and without showing any obvious prior sign of permanent deformation and cracks in the root. There is a wide range of parameters attributable to the failure of the file, including the radius and angle of the curve, the size and cross-sectional area of the device, the speed of rotation, design, torque, surface properties and metallurgy of the alloy, and, last but not least, the technique and experience of the operator (3). Endodontic instruments are subjected to compressive and tensile stresses during rotation in curved canals. Flexural fatigue is evidenced as the most destructive type of cyclic fatigue owing to the numerous flexes while using the instrument in the canals. This stress is concentrated at the flexing point. Applying extended periods of tensile and compressive forces to NiTi rotary files in the flexing areas of the root canals has proven to lead to great destructive forces generated as the result of files being subjected to compressive stress on their inner surface and tensile stress on their outer surface, leading to small cracks created on the

surface of the file. Therefore, when stress accumulates around these areas, a sudden failure in the file occurs due to fatigue. This failure process happens without any symptoms because these tiny cracks are elusive of even microscopic examinations. Cyclic fatigue is defined as the number of cycles the instrument can perform before breaking (4).

A good instrument is assumed to resist breaking for more than 1000 cycles. It has been suggested that cyclic fatigue accounts for 82-92% of mechanical failures. The cross-section and the design of the file (through affecting the stress distribution during load application) are major predictors of instrument resistance during the application of flexing forces. Researchers suggest that instruments with a larger diameter succumb to flexural fatigue sooner than those with a smaller diameter, as they are attributed to higher levels of internal stress accumulation. On the other hand, an increase in the diameter and cross-sectional area of the instrument can also be attributed to an increase in resistance to torsional fracture. Studies investigating the effect of NiTi rotary instrument design using geometrical simulation concluded that instruments with a U-shaped flute design and smaller cross-sectional area are more flexible than the triple triangular helix design but are more prone to torsional shear stresses. Infection control has always been of paramount interest to scientific and academic circles, given its close affiliation with the dentistry-related procedure. The dispersion of blood and saliva often accompanies direct dental procedures. They are deemed one of the major causes of the spread of pathogenic agents, hence the necessity of seeking to fully comply with the principles of disinfection, sterilization and personal protection. One of the highly-established requirements in infection control in dental settings is the disinfection of non-critical and semi-critical surfaces and tools between patients, as bacteria suspended from the mouth and respiratory system can continue to live on a surface for a remarkable period. Among the compounds used in disinfection dental tools and equipment are tetravalent ammonium compounds, including solutions such as Microtone and Deconex plus 53, which have been on the market since the 90s and are extensively used by dentists in Iran as well (6, 7).

Disinfectant solutions such as sodium hypochlorite and EDTA are endodontic applications' most commonly used solutions. The purposes of using these solutions include disinfection, lubrication and cleaning of mineral debris. It has been reported in many studies that the use of disinfectant solutions causes corrosion and deterioration of the metal surface of endodontics tools and may have a negative effect on the resistance of files to breakage. On the contrary, several studies have not reported the negative effect of disinfectant solutions on the fatigue resistance of NiTi rotary files (8-10). NiTi rotary file breakage is one of the biggest concerns of dentists when using this tool. Evaluation of the risk factors involved in file breakage can help dentists to make better clinical judgments about the limitations of NiTi rotary files. Considering the importance of the problem of infection control and choosing a suitable substance for disinfecting dental office tools and equipment, as well as considering the use of NiTi rotary files more than once in dental services due to the high costs of using them, this study Investigating the effect of immersion in Deconex solution on the resistance of Mtwo nickel-titanium rotary file in endodontics applications.

**Materials and Methods**

The current research was performed as an interventional study using a quasi-experimental design. After reviewing the corresponding literature (11-16), 45 NiTi M two (VDW, Germany) rotary files were classified and hence examined in 15 groups were tested. For the research, the files were divided into two groups of control and experiment, files from the latter of which were group immersed in Deconex and sodium hypochlorite solution. The files from the intervention group remained in the Deconex and sodium hypochlorite solution for a minute before determining their cyclic fatigue resistance. Then the files were placed in the testing device to determine the level of fatigue. This device is made of a 30x30 wooden base connected to the ground by four connecting rubbers to prevent vibration during testing. The metal block is made of stainless steel and contains an indentation with a 45-degree curve, which is, in fact, a molding reverse of size ISO 15 Gutta Percha-Points 4%, connected to the base of the device by a screw. The handpiece was connected to the base with a low-speed casting by a rotary motor and a plastic connector clip, such that after installing the file-containing handpiece, the cutting part of the file is completely placed in the indentation of the metal block and is ready for the test. During the test, the handpiece rotated with a speed of 350 rpm and a torque of 1 Nm for the Mtwo rotary file.

The fixing clamp of the handpiece could change position in the horizontal and vertical direction such that the file installed at the tip of the handpiece could be placed properly in the indentation of the metal block without being subjected to any pressure or stress. The files then started to rotate with the predetermined speed and torque exclusive to each file. During the rotation of the files, the artificial root canal was covered with tempered glass to prevent the instrument from slipping while providing the grounds for the operator to observe and input controls to the procedure. 5.2% sodium hypochlorite was used as a lubricant to reduce the friction of the file with the walls of the artificial canal. All the instruments were rotated until failure. Employing tempered glasses made the detection of failure highly easy to observe and record. The failure time for each file was recorded using a timer. Then the Number of cycles required for failure was calculated as the Number of cycles to failure (NCF) for each device through the following formula:

NCF = Number of revolutions per minute x Failure time per 60 seconds

First, the mean and standard deviation samples from both groups were calculated. In case the data were deemed normal distribution, ANOVA is used to compare the groups. If the variables have homoscedasticity, the Walch test is used. The appropriate post hoc test should be used for pairwise comparison. If the data are not normal, Kruskal–Wallis H test should be used for comparison. Tukey's honest significance test was used to compare the means pairwise. Since rotary files were tested *in vitro*, there was no need for ethical approval.

**Findings**

Kolmogorov-Smirnov and Shapiro–Wilk tests were used to determine the normality of variables, the results from which indicated that the main research

variables had a normal distribution. As such, the ANOVA test can be used to check and compare the cyclic fatigue resistance of the NiTi Mtwo rotary file. Furthermore, the effect of disinfectants on the cyclic fatigue resistance of the NiTi Mtwo rotary file was examined using Fisher's exact test. The significance values of the probability of the difference in the cyclic fatigue resistance of the rotary file among disinfectants (0.000) were determined to be much smaller than 0.05, confirming the statistical significance of the difference. That is, the disinfectant type significantly affects the cyclic fatigue resistance of the rotary file ($p < 0.05$).

Table 1 shows the descriptive statistics of the cyclic fatigue resistance of the rotary file based on disinfectants. These statistics represent the frequency, mean, standard deviation, 95% confidence interval, and minimum and maximum value. As shown in the table, the mean cyclic fatigue resistance of the rotary file is the highest for the control samples and lower in the files immersed in the Deconex solution compared to other solutions. Moreover, the findings indicate that the use of disinfectants has a negative effect on the cyclic fatigue resistance of the Mtwo NiTi rotary file.

*Table 1: Descriptive statistics on the cyclic fatigue resistance of rotary file sorted by disinfectants*

| Disinfectant | Mean | SD | Error | Lower bound | Upper bound | Min | Max |
|---|---|---|---|---|---|---|---|
| Control | 991.10 | 757.90 | 933.562 | 846.531 | 20.289 | 78.785 | 890.046 |
| Deconex | 600.49 | 373.12 | 578.029 | 514.123 | 14.898 | 57.700 | 546.076 |
| sodium hypochlorite | 769.56 | 553.85 | 680.989 | 603.164 | 18.142 | 70.267 | 642.077 |

To further examine the mean comparison, the groups were compared pairwise using Tukey's test, presented in Table 2. The findings indicate that the difference between all the examined groups is significant ($P<0.05$). This significant difference further confirms the significance level values of Table 1. That is, it can be concluded that the highest cyclic fatigue resistance of the Mtwo NiTi rotary file was witnessed in the control samples, while the lowest resistance pertained to the files immersed in Deconex solution. Also, the difference in the fatigue resistance of files immersed in Deconex with those immersed in sodium hypochlorite and control samples was statistically significant ($P < 0.05$).

*Table 2: Pairwise comparison of cyclic fatigue resistance of rotary files in various disinfectants*

| Disinfectant | Against | Difference of means | Error | Sig. level | Lower bound | Upper bound |
|---|---|---|---|---|---|---|
| Control | Deconex | 405.520 | 282.419 | 0.000 | 25.334 | 343.970 |
| | sodium hypochlorite | 309.519 | 186.419 | 0.000 | 25.334 | 247.969 |
| Deconex | Control | -282.419 | -405.520 | 0.000 | 25.334 | -343.970 |
| | sodium hypochlorite | -34.450 | -157.550 | 0.001 | 25.334 | -96.000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| sodium hypochlorite | Control | -186.419 | -309.519 | 0.000 | 25.334 | -247.969 |
| | Deconex | 157.550 | 34.450 | 0.001 | 25.334 | 96.000 |

The findings indicate that the immersion of M two nickel-titanium rotary file in sodium hypochlorite and Deconex disinfectants have a negative and significant effect on the cyclic fatigue resistance of rotary files, as the cyclic fatigue resistance of Mtwo NiTi rotary file is reduced until it breaks by immersion in the studied disinfectant solutions. The minimum for the Number of cycles to failure (NCF) was witnessed in Mtwo rotary files treated with Deconex (546.076), the maximum of which pertained to the control samples (890.046).

**Discussion**

The current study aimed to examine the effect of immersion of Mtwo nickel-titanium rotary files in Deconex solution and sodium hypochlorite on their cyclic fatigue resistance. The present research results showed that the immersion of rotary files in disinfectants negatively and significantly affects the cyclic fatigue resistance of the files above. The highest cyclic fatigue resistance was obtained in rotary files not treated with disinfectants (control), while the lowest cyclic fatigue resistance pertained to the samples immersed in Deconex solution. The results of this research were inconsistent with those of Pedulla et al. (17), Cai et al. (18), Bulem et al. (19), Pedulla et al. (4), Pedulla et al. (20), and Pedulli et al. (21). The results of Peters and Sonntag showed that files immersed in 3% sodium hypochlorite showed a high level of corrosion. Nevertheless, no statistically significant difference was observed in corrosion resistance of different rotary files (22). Pedulla et al. examined the cyclic fatigue resistance of rotary files immersed in sodium hypochlorite solution; the findings to which indicated that the application of sodium hypochlorite solution does not necessarily undermine the cyclic fatigue resistance of rotary files, yet the type of rotary file has a significant effect on the cyclic fatigue resistance (23). Moreover, their studies showed that immersion in sodium hypochlorite solution does not decrease the cyclic fatigue resistance of rotary files, but immersion in EDTA for 3 minutes significantly decreases the resistance (21).

In another research by the same authors, the effect of immersing Reciproc R and WaveOne rotary files in sodium hypochlorite solution was examined, and the results showed that the cyclic fatigue resistance of the Reciproc R 25 rotary file was higher than that of the WaveOne rotary file, and immersion in sodium hypochlorite had no significant effect on the cyclic fatigue resistance of the rotary files (17). The results from Bulem et al. revealed that the cyclic fatigue resistance of the Mtwo rotary file was higher than that of other files, yet the resistance of rotary files was not affected by immersion in sodium hypochlorite and disinfection with an autoclave (19). Dagna et al. studied the cyclic fatigue resistance of three nickel-titanium rotary files (namely, Wave One and Reciproc R25, Shape One) immersed in a 10% EDTA solution. The results showed that the cyclic fatigue resistance of the Reciproc R25 rotary file was higher than that of other rotary files, and, again, immersing the rotary files in the EDTA solution did not undermine the resistance of the rotary files (11). Cai et al. reported that although

the surface hardness of rotary files immersed in disinfectants increases, the application of disinfectants does not reduce the cyclic fatigue resistance of rotary files (18). In another study by Pedulla and et al., the effects of immersing and sterilizing Twisted Files and Hyflex CM rotary files in 5% sodium hypochlorite were examined, the findings to which showed that the cyclic fatigue resistance of rotary files is not affected nor positively nor negatively, by immersion in sodium hypochlorite (20).

de Castro Martins et al. (2006) studied the effect of sodium hypocrite on cyclic fatigue resistance and surface properties of ProFile rotary file, the results from which indicated that the application of 5.25% sodium hypochlorite has a positive effect on the cyclic fatigue resistance of ProFile rotary files (24). Findings from the majority of studies show that the cyclic fatigue resistance of NiTi rotary files is not affected by immersion in disinfectants. However, the results of the current study suggest a negative and significant effect for the immersion of rotary files in disinfectants. This contrast can be attributed to the difference in the examined rotary files, the rotation speed of the files, the investigated disinfectants, the concentration of the materials used, the temperature of the materials used, the duration of immersion and potential pretreatments. The chemical stability of disinfectants is perceived to be affected by various factors, including Ph, temperature, concentration, presence of organic substances, and exposure to light and air (25, 26). That is, the methods by which the disinfectants are applied during the disinfection process are of paramount importance, as the literature has revealed that the surface resistance and corrosion of nickel-titanium rotary files are influenced by a plethora of factors, including the alloy composition of the file, the concentration of consumables and the duration of immersion.

The findings of the current study were proven to be in line with those of Peters et al. (2011) and Ametrano et al. (2011). Peters et al. (2011) studied the cyclic fatigue resistance of RaCE and ProFile rotary files immersed in sodium hypochlorite solution in America. For their study, 160 rotary files were immersed in 5.25% sodium hypochlorite solution at 21 and 60 degrees Celsius for 1 and 2 hours, respectively, after which the cyclic fatigue resistance of the files was evaluated. The results indicated decreased cyclic fatigue resistance of ProFile and RaCE rotary files immersed in sodium hypochlorite solution (27). Ametrano et al. (2011) examined the effect of sodium hypochlorite and EDTA on the surface properties of the ProTaper rotary file. The results showed that the short-term contact of ProTaper rotary files with sodium hypochlorite and EDTA disinfectant solutions significantly alters the surface properties of rotary files. As such, the instant contact of ProTaper rotary files with sodium hypochlorite and EDTA disinfectant solutions reduces the surface hardness of rotary files (28).

**Conclusion**

The findings of this indicated that the immersion of Mtwo NiTi rotary file in disinfecting solutions has a significant negative effect on the cyclic fatigue resistance of rotary files, as the highest levels of cyclic fatigue resistance was observed in untreated (control) Mtwo NiTi rotary files, while the lowest cyclic fatigue resistance was witnessed in samples immersed in Deconex solution.

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