ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 5, Issue – 4, July - 2022, Page No. : 92 - 96

Comparative evaluation of cyclic fatigue resistance of three different rotary files after immersion in sodium hypochlorite

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Citation of this Article: Dr. Malasiddappa Metri, Dr. Prahlad A. Saraf, "Comparative evaluation of cyclic fatigue resistance of three different rotary files after immersion in sodium hypochlorite", IJDSIR- July - 2022, Vol. – 5, Issue - 4, P. No. 92 – 96.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Aim: The aim of this study was to compare the cyclic fatigue resistance of three nickel-titanium instruments after immersion in sodium hypochlorite.

Materials and Methods: A total of ninety files were used, files from the K3 (Sybron Endo, Orange, USA), K3XF (Sybron Endo, Orange, USA) and Protaper Next (PTN) (Dentsply, Maillefer, Ballaigues, Switzerland), systems were tested and separated into three groups (n=30), Group 1-without immersion in NaOCl solution and Group 2 and Group 3 immersed in 5.25% NaOCl solution, for 1 min, and 5 min, respectively. All instruments were submitted to the cyclic fatigue test.

Statistical Analysis: The test performed for the analysis of two independent factors was a two-way analysis of variance.

Conclusion: K3XF instruments were the most resistant to cyclic fatigue.

Keywords: Corrosion, Cyclic fatigue, NiTi, Sodium hypochlorite

Introduction

The introduction of nickel titanium (NiTi) alloy in the manufacture of endodontic instruments represented a breakthrough in endodontics. Its favourable mechanical properties allowed the fabrication of instruments with new designs, greater taper, alternative systems, and the introduction of a continuous rotation movement for the cleaning and shaping the root canals [1,2].

Despite the greater flexibility and resistance, the fracture of the instruments is still a worrying factor [3]. NiTi files appear to have a risk of separation mainly because of flexural cyclic fatigue and torsional fracture [4]. A study demonstrated that 70% of fractures were because of cyclic fatigue, while 30% was torsional fatigue [5]. Researchers in another study evaluated 27 fractured Protaper files and found flexural fatigue to be the major reason for failure (92.5%) [6]. Cyclic fatigue failure happens as a result of tension-compression stress cycles in the area of maximum flexure, particularly during preparing curved canals. Torsional fracture occurs when part of the file is locked to the dentin, while the shank maintains to rotate [7].

Among the irrigating solutions currently used in endodontic treatment, sodium hypochlorite (NaOCl) satisfies most of the requirements [8] and, due to its effective antimicrobial action, and mainly due to its capacity for tissue dissolution, has become the most used by endodontic professionals.

Corrosion is an additional factor that might limit the resistance to fatigue fracture, and it occurs during root canal cleaning and shaping when files come in contact with sodium hypochlorite (NaOCl) solution. Pits and surface defects are created which act as propagating point for fatigue failure of the files [4]. Effect of NaOCl on the cyclic fatigue resistance of the NiTi files was investigated through several studies, and findings were controversial [9-11].

Materials and methods

A total of ninety new files of three different instruments, K3 (Sybron Endo, Orange, USA), K3XF (Sybron Endo, Orange, USA) and Protaper Next (PTN) (Dentsply, Maillefer, Ballaigues, Switzerland) were select for the test. The thirty files of each group were separated into three sub-groups (n = 10). Group 1- (K3-1, K3XF-1, PTN-1) which were not immersed in 5.25% NaOCl solution, Group 2- (K3-2, K3XF-2, PTN-2) immersed in 5.25% NaOCl solution for 1 min and Group 3- (K3-3, K3XF-3, PTN-3) immersed in 5.25% NaOCl solution for 5 min.

The endodontic instruments were fixed to the X-Smart electric motor (Dentsply Maillefer, Ballaigues, Switzerland) and operated at a constant speed according to the manufacturers' recommendations. The instruments were inserted 19 mm from its tip, into a recipient that was filled with the amount of 5.25% NaOCl. After immersion, the instruments were washed in distilled water to neutralize any effect of the solution.

All instruments were subjected to the cyclic fatigue test in a device with a simulated artificial stainless-steel canal and the ability to fix the handpiece of the X-Smart electric motor, allowing the test in a statistically. The instruments were positioned and operated at speed recommended by the manufacturer, and the time elapsed between the beginning of the experiment, and the time of the fracture was registered. During the test, lubricant was used to reduce friction between the instruments and the canal walls (Pana Spray Plus-NSK GmbH Germany).

For each instrument, the number of cycles up to the fracture was calculated by multiplying the time in seconds until the fracture time by the number of revolutions per second. The results were analyzed using the Statistical Package for the Social Sciences, version-20 (IBM SPSS).

Results

The number of cycles until fracture of the instruments, measured in the different groups, is shown in Table 1.

Table 1: Mean of cycles (numbers ± standard deviation) until fracture in the different groups, submitted to different treatments.

	K3	K3XF	Protaper Next
Control	251.2±102.4	2375.2±132.5	531.3±67.2
NaOCl - 1 minute	225.9±125.5	1361.3±172.4	475.1±168.4

NaOCl - 5 minute	206.8±197.8	1068.6±159.2	424.5±76.1

The analysis of two independent factors (two-way ANOVA) revealed that the K3XF instruments presented a greater number of cycles until the fracture when compared to the others, regardless of the treatment to which they were submitted (P <0.001). The control group showed a greater number of cycles until the fracture occurs than the same instruments submitted to NaOCl (P <0.001); these, in turn, were also statistically different from each other (P <0.001).

PTN instruments showed the lowest values of cycles until a fracture occurs (P <0.001). There was no significant difference between treatments (P = 0.998). The same was observed in the group formed by the K3 instruments.

The sizes of the instrument's fragments measured in the different groups are shown in Table 2.

Table 2: Mean of the size of the fragments (millimetres ± standard deviation) after the fracture in the different groups, submitted to different treatments.

	K3	K3XF	Protaper Next
Control	8.68±0.62	7.21±0.53	5.62±0.54
NaOCl - 1 minute	6.69±0.283	6.18±0.67	4.86±0.26
NaOCl - 5 minute	6.97±0.15	7.41±0.82	4.36±0.57

Two-way ANOVA for two independent factors, type of instrument and treatment, revealed that in the control group, and the fragments of the instruments presented different sizes among each other (P <0.001). In NaOCl treated groups, K3XF and K3 instruments presented similar fragment sizes (P >0.05), whereas PTN instruments had significantly smaller fragment sizes (P <0.001).

Discussion

The cyclic fatigue device and the statistical approach used in this study were previously discussed in a recent report [12]. There are no standardized specifications to test the CF of rotary NiTi instruments only to test the torsional load of .02 NiTi files used for hand instrumentation [13].

The present study compared the cyclic fatigue resistance of three NiTi files, K3, K3XF and Protaper Next, after immersion in 5.25% NaOCl for one and five minutes, compared to no immersion. Up to this moment, no study has evaluated the cyclic fatigue resistance of these three instruments after immersion in NaOCl.

Nickel-titanium rotary files have become a standard tool to shape root canals, but they tend to unexpectedly break because of cyclic fatigue, which is induced by the alternating tension-compression cycles to which they are subjected when flexed in the maximum curvature region of the canal and rotated [14].

The results of this study showed that the cyclic fatigue resistance of the 3 tested files was significantly greater when the files were used in a reciprocating motion, rather than in continuous rotation, as in previous studies [15]. These differences had not been analyzed for K3 and K3XF files.

Both PTN and K3XF showed a significant longer mean life than K3 under reciprocating motion. Earlier studies have reported that thermal treatment of NiTi alloys resulted in greater cyclic fatigue resistance when used in continuous rotation [16].

The results of the present study showed that K3XF under continuous rotation showed a significantly longer mean life than TF and K3, whereas TF was better than K3. This finding suggests that the latest developments in files (trough improvements in constituent alloys, in their design, and/or in their manufacturing processes) have produced more resistant instruments.

NaOCl at different concentrations and temperatures influenced the cyclic fatigue resistance of the Protaper Gold system [17], agreeing with the results of PTN and K3 presented in this study. NaOCl did not have any effect on the cyclic fatigue resistance of the K3XF found in this study.

Regarding immersion in NaOCl solution, the studies present controversial results, in which some concluded that the NaOCl reduces the resistance to cyclic fatigue of the tested instruments [18], and others indicated that the solution did not change the resistance of the systems tested [19]. This discrepancy in the results observed in the literature can be explained by the different methodologies and immersion protocols used, making further studies necessary to standardize the methods and devices used.

Conclusion

Within the limitations of the present study concludes that, K3XF instruments were the most resistant to cyclic fatigue after immersion in 5.25% NaOCl. The PTN instruments had the intermediate values and the K3 instruments had the lowest values of resistance to cyclic fatigue.

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