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Original Research

Comparison of the cyclic fatigue resistance of the original reciproc files with equipollents

Cyclic fatigue resistance of reciproc thype files

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Abstract

Aim: In this study, cyclic fatigue resistance of Reciproc R25, Golden Star RC, NIC RC and RO files were compared. The present study aimed to compare the cyclic fatigue strength of the original RC files and their equivalent GS, NIC and RO files.

Material and Methods: In this study, 100 files, 25 in each group, were subjected to cyclic fatigue test on the artificial canal on stainless steel block with 60° curvature, 5 mm radius and 1.5 mm depth. The files in all groups were rotated until they were broken in the artificial canal using the Reciproc ALL program. The time to break was recorded with a 1/100 second precision stopwatch for each file and the total number of rounds was calculated. Number of rounds of files and the lengths of fractures were recorded then evaluated statistically (P<.05). The files were examined by scanning electron microscopy (SEM) images to evaluate the fracture type.

Results: As a result of the data obtained from the study, the RC file was statistically the most resistant to cyclic fatigue (p <.05). GS and NIC files were found to be more resistant than RO (p <.05).

Discussion: Based on the data derived from this study, it is evident that the RC file exhibited the highest cyclic fatigue resistance, as indicated by statistically significant results. In comparison, GS and NIC files displayed greater resistance to cyclic fatigue than RO files. The examination of SEM images further corroborated the presence of cyclic fatigue fractures in the tested files. Notably, GS, NIC, and RO files, despite sharing a similar shape with the RC, failed to match the original RC file's level of resistance against cyclic fatigue, underscoring the importance of considering file composition and heat treatment in enhancing resistance.

Keywords

Cyclic Fatigue, Golden Star, NIC, Reciproc, Recip-One

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Introduction

Today, nickel-titanium rotary instruments (NiTi) are often used for mechanical instrumentation of root canals. NiTi files have gained popularity due to their lower incidence of complications, such as zipping, stepping, and perforation, compared to traditional stainless steel files [1, 2]. Despite the advantages of NiTi files, the risk of fracture should be considered by clinicians, especially in curved root canals [3]. A broken NiTi instrument in the root canal system adversely affects the success of root canal treatment (RCT). The main reasons for breaking NiTi files are cyclic fatigue and torsional fatigue [4, 5]. In cyclic fatigue, a specific area of NiTi files is subjected to compression and tensile forces in each cycle and eventually breaks [6]. Recently, several methods have been developed to increase the cyclic fatigue resistance of NiTi rotary files, such as various heat treatments, different cross-sectional designs and application of surface electro polishing processes [7]. According to a previously presented study [8], it has been reported that root canals can be enlarged by a single file with reciprocal motion. The kinematics of the file in a reciprocal motion are clockwise and counterclockwise. It has been found that reciprocal motion causes the resistance of the files to increase [9, 10]. The Reciproc (VDW motion to shape root canals in the clinic. Many studies have reported the superior ability of this system to root canal treatment [11] and retreatment [12, 13]. The original Reciproc (RC; VDW, Munich, Germany) file has M-Wire technology and is reported to have a very high cyclic resistance with reciprocal motion [14-16]. The Reciproc file is reported to be in austenitic phase during clinical use [17]. The original Reciproc R25, which is planned to be used in the study, and its equipollent productions are Golden Star RC 25 (GS; Golden Star LTD, Shenzhen, China), NIC RC 25 (NIC; Superline Thecnology, Shenzhen, China), Recip-One (RO; Rogin Medical LTD, Shenzhen, China) root canal files. In the literature, there is no study that compares the RC file's cyclic fatigue resistance with its equipollents (GS, NIC and RO). The purpose of the study is to compare the cyclic fracture resistance between RC files and its equipollents GS, NIC and RO files. The null hypothesis of the study is that the cyclic fatigue resistance of the original RC file resides in the same cyclic resistance as equipollent GS, NIC and RO files.

Material and Methods

Stainless steel artificial root canal with a 5 mm radius, 1.5 mm depth, and a 60° curvature were used described in the present study as a previous study [6]. In accordance with the limitations of the study, each type of NiTi file was used as a group. In the study, a total of 4 groups of 100 files was examined with a stereo microscope (SMZ1500, Nikon Corp., Tokyo, Japan), and damaged and/or deformity files were replaced with new ones. NiTi file types were tested. RC R25 and its equipollent production were selected as GS 25, NIC 25 and RO 25 (n = 25). The root canal files were tested in the "Reciproc All" program with the 6:1 reductive VDW Silver Reciproc endodontic motor (VDW). In order to reduce friction during the experiments, lubricant oil (WD-40, Milton Keynes, England) was used in the artificial root canal. The rotational time of the file in the artificial root canal was measured by stopwatch until it was broken (Fig. 1). Then, the rotational times until break were calculated in seconds and multiplied by the number of turns per second, and the number of cyclic failure (NCF) was found. The number of rounds per minute was calculated by the manufacturer to claim 300 rpm for the "Reciproc All" program. As a result of cyclic fatigue, the fractures of the files were measured by means of calipers to determine whether the areas affected by the cyclic force were the closest to each other. After the cyclic fatigue test, 8 pieces of fractured files (2 pieces from each group) were observed using a scanning electron microscope (SEM) (Zeiss Supra 40VP, Carl Zeiss SMT Inc., Oberkochen, Germany) to determine the fracture types under 500X and 3000X magnification.

Statistical Analysis

All statistical analyses were performed using SPSS 24.0 (SPSS Inc., Chicago, IL, USA). Shapiro–Wilk tests were used for testing normality. Group comparisons were conducted through the utilization of analysis of variance (ANOVA) followed by post-hoc Tukey tests. P-value < .05 was considered statistically significant. This study was approved by the Ethics Committee of Pamukkale University (Date: 2023-08-17, No:E-60116787-020-406510).

Results

The cyclic fatigue resistance of the original RC file was found to be significantly higher than the equipollents GS, NIC and RO files (P<.05). While there was no statistically difference between NIC and GS files in terms of cyclic fatigue resistance, the resistance of RO file was statistically significantly lower than NIC and GS files (P<.05, Table 1). There was no significant difference in the mean length of the fractured parts (Table 1), so that the fragments exposed to compression and tensile forces were identical. SEM analysis of the fractured surfaces of the files have typical cyclic fatigue crack origins (Figure 2).

Discussion

In the present study, the cyclic fatigue resistance simulations of the RC file were compared with GS, NIC and RO files. Files were tested in a 5 mm diameter artificial canal with a 60° curve angle. In this study, when the lengths of the broken parts were examined, no statistically significant difference was found between the lengths of the parts. This finding shows that the files tested are in a standard position in the artificial canal and that the area from which the force comes corresponds to the same region [18]. It has been reported that the reciprocal motion increases the resistance of the files against cyclic fatigue considerably [9, 14]. In this study, the files using with reciprocal motion were compared with each other. According

Table 1. : Number of cyclic failure (NCF) and Fractured Lengths (FL) (mean ± standard deviation)

	NCF	FL
Reciproc	10610 ± 124.58[a]	4.3 ± 0.14[a]
Golden Star	6162.51 ± 73.24[b]	4.5 ± 0.22[a]
NIC	6317 ± 81.61[b]	4.4 ± 0.08[a]
Recip-One	2492.28 ± 62.35[c]	4.47 ± 0.1[a]

Different superscript letters indicate significant differences between groups (P<.05).

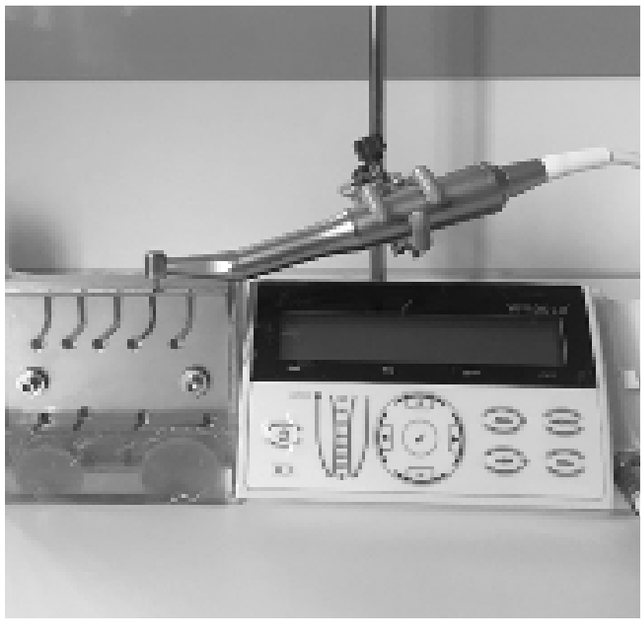

Figure 1. Test setup with stainless steel root canal used in the experimental study.

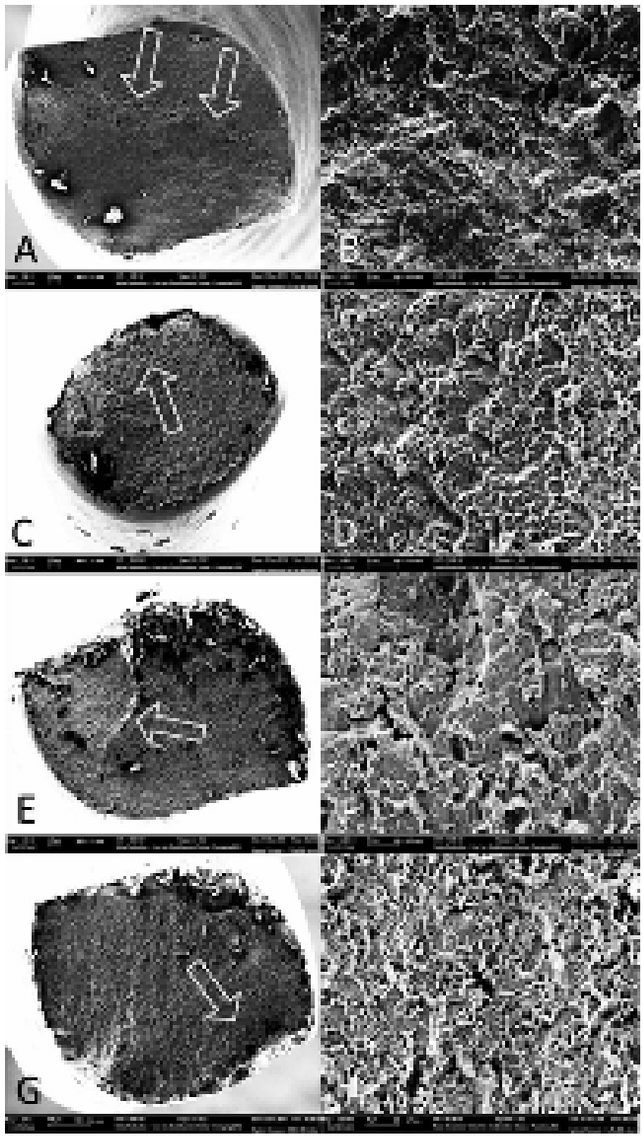

Figure 2. Fractured areas of Reciproc (A, B), Golden Star (C, D), NIC (E, F) and Recip-One (G, H) file scanning electron microscope images.

to statistical data, the cyclic resistance of the original RC file was found to be significantly better than its equipollents GS, NIC and RO files. As a result of the presented study, the null hypothesis was rejected. The use of NiTi files with endodontic motors in the shaping of the root canals shortened the treatment process and also reduced the complications during the treatment (perforations, change working length, apical transportation) [19].

During RCT, root canal files broken during instrumentation of the root canals adversely affect the success of the treatment. The main causes broken of root canal files are torsional and cyclic fatigue [19]. The cyclic fatigue resistance of the files , which have been used in the present study, was compared. Root canal files generally work with 2 kinds of motion. The first is a continuous rotation motion, which has a continuous clockwise rotation movement while the second is the reciprocating motion, which is clockwise and counterclockwise at various angles. In previous studies [9, 14], it has been observed that the resistance of the files at curved canals with reciprocal motion increases significantly. It is also reported that RC files have higher resistance than classic files such as Mtwo and ProTaper although they have similar cross section [20]. In the literature, there is no study that compares RC files resistance with its own equipollents. While GS and NIC files in the semi-martensitic phase with heat treatment, the RO file is made of super-elastic NiTi alloy which has not been heat treated. Heat treated files such as GS and NIC, which are close to the gold color, have been very popular lately, and many studies have been done about these type files [21]. Almost all of these studies, which are also called gold alloy, have been reported to increase the resistance of the files to the fracture as a result of the heat treatment they are subjected to after shaping the files [22-24]. In the present study, it was found that the heat treated GS and NIC files, which are called gold alloys, were found to have statistically less cyclic fatigue resistance compared to the RC file which was not heat treated and only called M-Wire ($P<.05$). This result is not compatible with previous studies [22-24] for heat-treated files. This is because GS and NIC files are produced as equipollents of RC files, and they do not belong to a recognized company and that the quality of production is lower. However, when the equipollent production files are compared among themselves, the cyclic fatigue resistance of the RO file, which is only super elastic, is statistically lower than the heat treated GS and NIC files [22-24]. The results of the tests showed that the lengths of the broken file parts were very close to each other, indicating that the regions where the cyclic fatigue intensity was the same, so that the metal volumes affected were close to each other.

Conclusion

In the present study, the RC file have statistically the highest cyclic fatigue resistance, and the RO file has the lowest. However, performances of GS and NIC files cannot be considered bad. Notably, while GS, NIC, and RO files share a similar shape with the RC file, they fall short of replicating its original level of resistance against cyclic fatigue. This emphasizes the significance of considering file composition and heat treatment in enhancing cyclic fatigue resistance.

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Scientific Responsibility Statement
The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and Human Rights Statement
All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or compareable ethical standards.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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