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Comparative Evaluation of Cyclic Fatigue Resistance of Two Commercially Available Rotary File Systems in Simulated Root Canals

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Background: Despite significant technological advancements in the characteristics and shape of nickel-titanium (NiTi) files, fracture can still happen while they are being used. This study aimed to compare the resistance to cyclic fatigue of two different endodontic rotary file systems.

Material and Method: In present in-vitro study 40 rotating NiTi files in total, separated into two groups: group I (Protaper Next, Dentsply) and group II (NeoEndo Flex, Orikam Healthcare India Private Limited). The institutional ethical review board gave the study its approval. The length, 6% taper, and ISO size of rotary files were maintained as standards. All of these files underwent testing in a model made equipment with a radius of curvature of 5 mm and an angle of curvature of 60°. Every file was inserted into the Dentsply X smart and rotated at 400 rpm and 2.5 N/cm torque. Time until the file fractured was noted. Number of cycles performed by a file until fracture was calculated as no. of cycles performed by experimental file until fracture = 400/60 x Time taken till fracture was recorded.

Result: The NCF values were highest for protaper next file (905 ± 84.31) and least cyclic resistance was observed with Neo Endo Flex files (645 ± 41.51).

Conclusion: Cyclic flexural fatigue resistance was observed highest for protaper next group and lowest for Neoendo group.

Keywords: Cyclic fatigue, Rotary NiTi files, Neoendo, Protaper next

Introduction: Like many other dental and medical specialties, endodontics has developed over time and undergone changes. It essentially consists of root canal therapy, which involves preparing the access cavity, cleaning and reshaping the root canal, and then sealing the prepared pulp space in three dimensions. A significant factor in success is the use of endodontic equipment. Stainless steel instruments were used to perform root canals in the past since carbon steel alloy instruments had the drawback of becoming corroded and rusted. In clinical settings,

stainless steel devices also demonstrated drawbacks in the form of procedural mistakes including holes, zips, or ledges that changed natural canal structure. These mistakes may have reduced the effectiveness of the root canal procedure.[1,2]

Nickel-titanium (Ni-Ti) files are increasingly used in endodontic procedures due to their outstanding mechanical qualities. Despite their great degree of flexibility, endodontic treatment failure poses a serious issue. These files can break when they are at their most flexible without any obvious signs of earlier, irreversible distortion. Torsional overload and flexural fatigue are the two factors that lead to the breaking of rotary Ni-Ti instruments.[3-5] Torsional stress and cyclic fatigue have an impact on endodontic rotary instruments in the clinical settings. When the file is fixed inside the canal but the other half of the instrument is still switched, a fracture from torsional load occurs. When the handpiece's applied torque exceeds the metal's maximum elasticity, the tip will predictably shatter.[6] Alloy fatigue causes the instruments to break as a result of cyclic fatigue. At the point of excessive flexure, the rotation of files causes a succession of stresses and compressions that continue until the instrument breaks. When the instruments reach the point of cycle fatigue, there is no evidence of plastic deformation, but when files break as a result of torsional overload, a variety of deformation, including unwinding, straightening, reverse winding, and twisting, can be seen. A fracture of files is caused by an incorrect clinical procedure and many other factors.[7-10] This study aimed to compare the resistance to cyclic fatigue of several endodontic rotary systems

Material and Method: A total of 40 NiTi instruments of 2 different rotary systems of length 21mm were included in the present study. Before testing, all files were autoclaved and examined to detect any deformation. The files were divided into 2 experimental groups (n = 20) as follows: Group I: Protaper next, Group II: Neoendo Flex files instruments of size 25, 0.06 taper. These files were tested in a simulated constructed apparatus with angle of curvature 60° and radius of curvature 5 mm. Each file was coated with EDTA Gel and was placed in Dentsply Xsmart endomotor handpiece with the file stoppers at support steel cylinder and file tip between two shaping steel cylinders on the simulated constructed apparatus. Each file was then allowed to rotate at 400 rpm and 2.5 N/cm torque preset in endomotor and simultaneously a digital stopwatch was started. Time taken (in seconds) until file fractured was recorded. The formula to calculate number of cycles to failure (NCF) is NCF = revolutions per minute × time to failure

(seconds)/60. The values obtained were analysed using SPSS 23.0. The data was subjected to statistical analysis.

Result: **Table 1** shows that time taken until fracture in group I was 42.21 ± 3.41 seconds and in group II was 27.23 ± 2.78 seconds which was found to be statistically significant (p< 0.05). **Table II** shows that number of cycles performed in group I files until fractured was 905± 84.31 and in group II was 645± 41.51 which was found to be statistically significant (P< 0.05).

Table I Mean (standard deviation) of time to fracture			
Group	***N***	**Mean ± Std Deviation**	**P Value**
Group I Protaper Next	20	42.21 ± 3.41	< 0.05
Group II Neoendo Flex	20	27.23 ± 2.78	

Table II Mean (standard deviation) of number of cycles to fracture			
Group	***N***	**Mean ± Std Deviation**	**P Value**
Group I Protaper Next	20	905± 84.31	< 0.05
Group II Neoendo Flex	20	645± 41.51	

Discussion: 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. For this reason, important changes have been combined to make NiTi instruments safer: improved alloys, different movements (reciprocating motion), and new concepts of use (single-use).[11]

According to Cheung GS et al.[12], cyclic fatigue has been identified as the cause of up to 93% of instrument fractures. A retained tool will make it more difficult to properly prepare, clean, and fill a root canal. Therefore, at least for teeth connected to periapical pathoses, the success rate of root canal therapy may decline.[13]

It would seem fair for any preventive plan to consider the mechanical and physical characteristics of the tools being used and to be founded on solid and trustworthy findings from research carried out in settings that closely resemble clinical situations. Studies have employed a

variety of techniques to examine the in-vitro cyclic fatigue fracture resistance of NiTi rotary endodontic instruments in an effort to more accurately imitate the conditions in the clinic.[14,15]

The present study aimed to evaluate cyclic fatigue resistance of two different rotary file system i.e. protaper next and neoendo flex file.

From the observation of our study it was found that the protaper next showed better cyclic fatigue resistance then neoendo flex file. In a cyclic fatigue investigation of Protaper Next, 2 Shape, Hyflex CM, and TF Adaptive, Koçak et al.[16] found that Protaper Next had a much higher NCF value than 2 Shape (29146 NCF). Olcay et al.[17] published a study in 2019 looking at the cyclic wear of the 2 Shape, Protaper Next, and Wave One Gold in a 60-degree simulated canal. They found that, similar to Koçak et al,[16] Protaper Next (807.033.43 NCF) significantly outperformed 2 Shape (388.613.08 NCF) which is in accordance to our study.

In this work, the cyclic fatigue test—which is defined by the tension/compression cycles at the site of maximal flexure—is used to assess the in vitro resistance to fracture brought on by the accumulation of metal fatigue. Because this circumstance varies from intracanal instrumentation, when the fracture occurs as a result of multiple simultaneous variables, including torsional stress, it is challenging to evaluate the therapeutic value of the results of such testing. This is an entirely mechanical test to determine the instruments' ability to bend, which is the sole attribute that can be extrapolated. Due to the widespread usage of NiTi rotary instruments, it is necessary to standardize testing of their properties, including cyclic fatigue, in order to assure consistency of approach and similar results for a safer, more effective clinical application.

Conclusion: Cyclic flexural fatigue resistance was observed highest for protaper next group and lowest for Neoendo flex file.

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