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Comparing the cyclic fatigue fracture resistance of single file systems with that of multiple rotary file system: An in-vitro study

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ABSTRACT

Aim: The aim of this study is to comparatively evaluate the cyclic fatigue fracture resistance of single file system with that multiple rotary file system.

Materials and method: Three nickel titanium rotary systems Neoendo Flex; Oricam, F360; Komet and One Curve; Micromega size #25 were used in this study. Ten files were used in each file system, which are 25 mm long and tested with cyclic fatigue. Each experimental file was coated with EDTA gel and was placed in endodomotor handpiece with rubber stopper. File was then rotated according to respective rpm and torque in two simulated artificial curved canals with different angles of curvature (45º and 60°) and 5-mm radius of curvature and simultaneously digital stop watch was started. The number of cycles to fracture (NCF) and time taken (in seconds) until the file fractured were recorded in seconds using cyclic fatigue testing device. The data were analyzed statistically using one-way ANOVA followed by Post hoc Tukey test with significance set at ($p < 0.05$).

Results: Group 3; One Curve has highest mean and standard deviation of (2.892 ± 0.667), followed by Group 1; Neoendo Flex (2.321 ± 0.126) and Group 2; F360 (2.054 ± 0.048). Intergroup comparison showed statistically significant results.

Conclusion: Within the limitations of this study, it can be concluded that One Curve showed high resistance to cyclic fatigue when used in curved canals.

Keywords: Cyclic fatigue, NiTi rotary files, single file instruments.

INTRODUCTION

In common with many other dental and medical fields, endodontics has altered and evolved over time. It mainly consists of access cavity preparation followed by cleaning and shaping of root canal, and a three-dimensional seal of the prepared pulp space. A key factor in achieving success is the endodontic instruments. Stainless steel instruments have taken the position of carbon steel alloy equipment used in root canal procedures, which had the drawback of rusting and corrosion. In clinical use, stainless steel instruments also demonstrated drawbacks in the form of procedural errors such as ledges, zips, or perforations that changed the normal structure of the canal[1].To overcome this drawbacks, Frederick Wang and Sir William Buehler of the Naval Ordinance Laboratory in Maryland invented nickel-titanium alloy root canal instrument in the 1960s[2].The superelasticity of NiTi rotary files allows to produce the desirable tapered root canal form with a reduced tendency to canal transportation. NiTi instruments seem to have a high risk of separation despite these benefits, mostly due to

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fatigue and torsional shear pressures. When the instrument's tip binds in the root canal while the file is still spinning, torsional fatigue happens[3].It has been noted that cyclic fatigue failure happens suddenly and without any prior indication of irreversible deformation. This occurs when the instrument rotates within a curved root canal and experiences an excessive number of cycles of tension-compression strain in the maximum curvature zone of the root canal. Many factors that may affect the fatigue resistance of NiTi rotary files have been studied, including rotational speed, metal surface treatments, repeated autoclaving, and metallurgical characterization of the NiTi alloys[4].

Thus, even with advancements in NiTi alloy, unexpected breakage of rotary devices continues to be a significant worry for clinics. The incidence of clinical fracture in NiTi instruments varies from 0.26% to 21%[5]. NiTi alloy production technique and technological advancements have produced a new generation of files with improved physical-mechanical qualities, flexibility, and resistance to cyclic fatigue. Various designs, alloys, manufacturing processes, and strategies have been suggested to lower the number of fractures[6,7].The idea of "Less is More," or the idea that the biomechanical preparation of a canal can be completed with just one or two files, has dominated recent advancements in endodontic canal preparation. Because of this, a single file method has been created to shape most canals, irrespective of their curvature, length, or diameter.

However root canal shaping with only one file submit the instrument to the great deal of torsional and flexural stresses. Today as there are large number of single file systems available, a comparative evaluation of these systems need to be done[8].

Thus the aim of the current in-vitro study is to compare the cyclic fatigue fracture resistance of single file systems with that of multiple rotary system.

MATERIALS AND METHOD

1. Custom made Cyclic fatigue tester
2. Single Step Rotary files: F360 (Komet) and One curve (Micromega)
3. Multiple File System: Neoendo (Orikam) 25#
4. Stop watch

METHODOLOGY

Three NiTi rotary systems Neoendo Flex(Oricam),F360(Komet),One Curve(Micromega) were used in this study. Ten rotary instruments of each type with the total of 30 instruments of 25 mm in length and tested with cyclic fatigue fracture resistance tests were divided into 3 groups. Every instrument was inspected for defects or deformities before the experiment.

Group 1- (n=10) Neoendo Flex(Oricam) multiple file system

Group 2- (n=10) F360(Komet) single file system

Group 3- (n=10) One Curve(Micromega) single file system

The endomotor hand piece was mounted on a mobile device that allowed for the simple placement of each instrument inside the artificial canal. To prevent the instruments from slipping out and to allow for observation of the instruments, the artificial canals were covered with glass.

The motor and timer were then simultaneously activated. All of the instruments were rotated at the speed and torque recommended by the manufacturer.

Group 1- Neoendo Flex, 350 rpm/1.5 Ncm

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Group 2- F360, 250 rpm /1.8 Ncm
Group 3- One Curve, 350 rpm /2 Ncm
During each test, the instrument was monitored and visualized through the glass until fracture occurred and the time to fracture was registered in seconds. The time was then converted into number of cycles to failure.
No of cycles to fracture (NCF) = Number of rotations per minute x Time to fracture.

RESULTS

Group 3; One Curve has highest mean and standard deviation of (2.892 ± 0.667), followed by Group 1; Neoendo Flex (2.321 ± 0.126) and Group 2; F360 (2.054 ± 0.048). Intergroup comparison showed statistically significant results.
Table 1: Mean Time to Fracture of Different Types of File Systems

Groups	N	Mean	Std.Dev	Minimum	Maximum	P value
Group 1	10	2.321	0.126	2.17	2.44	0.005(S)
Group 2	10	2.054	0.048	2.00	2.16	0.005(S)
Group 3	10	2.892	0.667	1.00	3.17	0.005(S)
Group 4	10	2.422	0.519	1.00	3.17	0.005(S)

P≤0.05,significant using one way ANOVA

Table 2: Post Hoc Tukey Analysis Of Comparison Of Time To Fracture Of Different Types Of File Systems (Intergroup Comparison)

File systems	Neoendo flex	F360	One curve
Neoendo flex	-	Mean diff-58.97	Mean diff-30.45
F360	Mean diff-53.21	-	Mean diff-18.22
One curve	Mean diff-29.26	Mean diff-17.48	-

P≤0.05,significant using one way ANOVA

DISCUSSION

Cyclic fatigue has been reported to be one of the major factors resulting in file separation in curved canals, thus justifying the need for studies comparing the cyclic fatigue resistance (CFR) of NiTi rotary files at different canal angulations. The use of natural teeth was avoided because it is difficult to standardize root canal length, degree and radius of curvature as well as dentin hardness[9].Although the simulated canal created in a non-tooth device is unable to replicate clinical conditions, it minimizes the impact of other variables that may influence file fracture, thus facilitating standardization[10,11].
In this study, cyclic fatigue resistance of rotary Neoendo Flex; Oricam, F360; Komet and One Curve; Micromega file systems was tested and compared under simulated condition. All the instruments were rotated or reciprocated until fracture occurred. To obviate errors, all files were tested by single operator, while the other operator was simultaneously operating the stopwatch. The time to fracture in seconds was multiplied by the number of rotation cycles per second (rpm/60) to obtain the NCF for each instrument (Kiefner 2014). According to the results of the present study, the cyclic fatigue resistance of Group 3 One Curve is higher

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compared with the other file systems used i.e. Group 1 and Group 2 [Table 1]. The difference was found to be statistically significant at $p < 0.005$.

The One Curve is a single file novel instrument designed and marketed to shape root canals using a single-file technique in continuous rotation. C-wire (defines file traits its own DNA) is a proprietary process exclusively developed and implemented by Micro Mega for One Curve having 2.4X resistance to cyclic fatique[12]. Results of the current study showed that One Curve exhibits high cyclic fracture resistance than Neoendo and F360. This could be due to the microstructure irregular and a "crater-like" superficial surface, C-wire heat treatment and controlled memory. This superficial aspect represents an innovation in comparison with conventional NiTi files and mechanical behavior of NiTi materials because NiTi instruments were deformed until the complete transformation to martensite phase; after that failure occurred at the ultimate tensile strength of this phase. The Single file systems, are the new asset in endodontic which has fundamentally changed the concept of reducing armamentarium. The general period of treatment is shortened, and it's easy for patients to accept the treatment due to less followups. Bartolas A et al 2016 studied multiple-file vs single file endodontics in dental practice: a study in routine care which showed improvement of endodontic pain between single file and multiple file system, there were no statistical significant differences between the two systems and single file system prepared root canals significantly faster than Multiple File systems[13]. Saleh AM et al (J Endod 2015) explained that F360 and One Curve files maintained the original canal curvatures with lesser tendency to straighten the S-shaped canals[14]. Bruklein and his colleagues concluded that the single-file F360 preserved the original anatomy of severely curved canal. Ujjwal K et al 2018 concluded that single file system Neolix showed highest resistance to cyclic fatigue when used in artificial canals[15].Comparing the other systems, Neoendo Flex showed greater cyclic fatigue resistance than F360 file. However, more studies are required to determine the cyclic fatigue resistance of file systems.

CONCLUSION

Among all the groups, the group with One Curve showed highest resistance to cyclic fatigue when used in artificial simulated curved canals. However further long-term studies with longer follow-ups are required to access the best file in this group.

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