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Original Research

Assessment of cyclic fatigue resistance of two rotary file systems- An in vitro study

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ABSTRACT:
Background: Nickel–titanium (NiTi) endodontic files have increased flexibility and strength compared with stainless steel instruments. The present study was conducted to determine cyclic fatigue resistance of two rotary file systems. **Materials & Methods:** This in vitro study was conducted in the department of Endodontics. It consisted of 2 file system ie. One Shape files (OS) (Group I) and One Curve endodontic files (Group II). All files were rotated until fracture; the time to failure was recorded and the number of cycles to fracture (NCF) calculated. The length of the fractured fragments was measured too. **Results:** The mean time to failure (TtF) in group I was 52.6 seconds and in group II was 126.8 seconds. The difference was significant (P< 0.05). The number of cycles to failure (NCF) in group I was 314.2 and in group II was 724.8. The mean fragment length in group I was 4.25 mm and in group II was 4.13 mm. The difference was significant (P< 0.05). **Conclusion:** Authors found that cyclic fatigue resistance of OC endodontic instruments was greater as compared to OS.
Key words: Nickel–titanium, One Curve, One Shape files.

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INTRODUCTION

Nickel–titanium (NiTi) endodontic files have increased flexibility and strength compared with stainless steel instruments, but they seem to be vulnerable to fracture in clinical situations. Fracture of endodontic instruments usually occurs under two circumstances: torsional and cyclic fatigue.[1] When an endodontic instrument, within its elastic limits, rotates inside a curved canal, a mechanical load occurs, represented by alternating tensile and compressive stresses. The cyclical repetition of these loads leads to instrument fracture through low-cycle fatigue. Cyclic failure is implicated in more than one-third of the instruments fractured clinically and is likely to happen in the region of maximum canal curvature without any previous sign of permanent deformation.[2]

Adequate cleaning and shaping of the root canal system is essential for successful endodontic therapy. Most instrumentation techniques in which stainless steel instruments are used in curved canals pose the risk of zipping, ledge formation, and apical transportation; therefore, new generations of endodontic instruments have been developed using nickel-titanium (NiTi) alloys, which potentially allow the shaping of narrow and curved root canals without any aberrations.[3]

Flexural cyclic fatigue has an unpredictable clinical incidence; it occurs suddenly after free rotation of a certain number of cycles in a curved root canal as the file is being compressed (compressive stress) on the

inner curved surface and elongated (tensile stress) on the outer curve.[4]

One Shape files (OS) were launched into the dental market in 2011 as the first rotary single-file endodontic system. One Curve endodontic files (OC) were launched in 2018 as the evolution of OS instruments.[5] This bending and unbending of the file may cause surface crack formation at these regions of tensile stress concentration, resulting in breakage. Several attempts have been made to enhance the fatigue resistance of NiTi instruments by improving the cross-sectional design, the manufacturing process, or the surface treatment, as well as by introducing new alloys.[6] The present study was conducted to determine cyclic fatigue resistance of two rotary file systems.

MATERIALS & METHODS

This invitro study was conducted in the department of Endodontics. It consisted of 2 file system ie. One Shape files (OS) (Group I) and One Curve endodontic files (Group II). Ethical clearance was obtained from institutional ethical committee.

Group I consisted of 30 file and group II also comprised of 30 files systems. An artificial canal with 60° angle and 5-mm radius of curvature was milled in a stainless-steel block reproducing the size and taper of the files used. The test device was electrically heated to maintain the environmental temperature at 37 °C. All files were rotated until fracture; the time to failure was recorded and the number of cycles to fracture (NCF) calculated. The length of the fractured fragments was measured too. Fractographic examination and cross-sectional area calculation were performed by scanning electron microscopy analysis. Results thus obtained were subjected to statistical analysis. P value less than 0.05 was considered significant (P< 0.05).

RESULTS

Table I Distribution of patients

Groups	Group I	Group II
File systems	One Shape files (OS)	One Curve file (OC)
Number	30	30

Table I shows that group I had One Shape files (OS) consisted of 30 file and group II comprised of One Curve file (OC) with 30 files systems.

Table II Comparison of the time to failure (TtF) in both groups

Groups	Mean time to failure (TtF) (sec)	P value
Group I	52.6	0.001
Group II	126.8	

Table II, graph I shows that mean time to failure (TtF) in group I was 52.6 seconds and in group II was 126.8 seconds. The difference was significant (P< 0.05).

Graph I Time to failure (TtF) in both groups

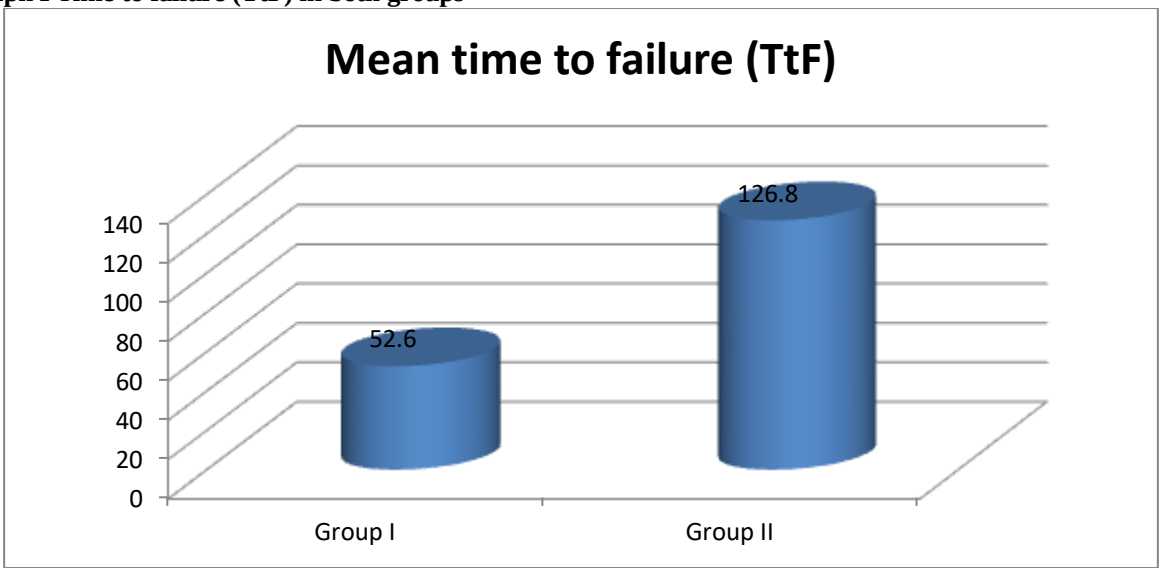

Table III Comparison of number of cycles to failure in both groups

Groups	Number of cycles to failure (NCF)	P value
Group I	314.2	0.001
Group II	724.8	

Table III shows that number of cycles to failure (NCF) in group I was 314.2 and in group II was 724.8. The difference was significant (P< 0.05).

Table III Comparison of fragment length (FL) in both groups

Groups	Fragment length (FL) (mm)	P value
Group I	4.25	0.72
Group II	4.13	

Table IV shows that mean fragment length in group I was 4.25 mm and in group II was 4.13 mm. The difference was significant (P< 0.05).

DISCUSSION

The fracture of endodontic instruments during root canal preparation is of major concern because it can make root canal treatment more difficult.[7] Many factors can affect the risk of instrument fracture inside the root canal, such as the abruptness of the canal curvature, including the angle, radius, and position of the maximum curvature center, as well as the instrument alloy, design, surface treatment, rotational speed, kinematics, and the operator's skill.[8] The catastrophic fracture of endodontic instruments has been attributed to torsional or cyclic stress. Cyclic failure occurs when the endodontic file rotates freely in a curvature whilst being subjected to repeated cycles of tension and compression, which disintegrate its structure and consequently lead to fracture.[9] The present study was conducted to determine cyclic fatigue resistance of two rotary file systems.

In this study, group I had One Shape files (OS) consisted of 30 file and group II comprised of One Curve file (OC) with 30 files systems. We found that mean time to failure (TtF) in group I was 126.8 seconds and in group II was 52.6 seconds. Serafin et al[10] evaluated the difference in cyclic fatigue resistance between OneCurve (OC) and OneShape (OS) endodontic single-file NiTi systems in a severely curved artificial canal. Statistical analysis showed that OC files exhibited significantly greater cyclic fatigue resistance than OS (p0.01). SEM fractographic analysis confirmed that all the scanned samples separated due to cyclic fatigue. Within the limitations of the present study, OC endodontic instruments resisted to cyclic fatigue better than OS. The improved mechanical resistance of OC could be related to new NiTi alloy used for their manufacturing.

We found that number of cycles to failure (NCF) in group I was 314.2 and in group II was 724.8. The mean fragment length in group I was 4.25 mm and in group II was 4.13 mm. El Feky et al[11] compared the flexural cyclic fatigue resistance and the length of the fractured segments (FLs) of recently introduced M-Pro rotary files with that of RaCe rotary files in curved canals and to evaluate the fracture surface by scanning electron microscopy (SEM). Thirty-six endodontic files with the same tip size and taper (size 25, 0.06 taper) were used. The samples were classified into 2 groups (n = 18): the M-Pro group (M-Pro IMD) and the RaCe group (FKG). A custom-made simulated canal model was fabricated to evaluate the total number of cycles to failure and the FL. SEM was used to examine the fracture surfaces of the fragmented segments. The M-Pro group showed significantly higher resistance to flexural cyclic fatigue than the RaCe group ($p < 0.05$), but there was no significant difference in the FLs between the 2 groups ($p \geq 0.05$).

OS instruments are made of austenite 55-NiTi while OC are made of a supposed control memory NiTi wire; control memory instruments are mainly in the martensitic phase and have been manufactured by a thermomechanical process that controls the memory of the material and makes the files extremely flexible and resistant to cyclic fatigue. We utilized Pruett et al[12] method of designing of the simulated canal. This method describes the root canal curvature based on the angle of curvature and the radius of curvature. The radius of curvature represents how abruptly or severely a specific angle of curvature occurs as the canal deviates from a straight line.

CONCLUSION

Authors found that cyclic fatigue resistance of OC endodontic instruments was greater as compared to OS.

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