ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2020; 6(3): 571-574

www.oraljournal.com
Received: 10-05-2020
Accepted: 05-07-2020

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Comparative evaluation of cyclic fatigue fracture resistance of newer Ni Ti rotary files: An *in vitro* study

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DOI: https://doi.org/10.22271/oral.2020.v6.i3i.1009

Abstract
The single-file technique has been developed for shaping the vast majority of canals, regardless of their length, diameter, or curvature.
Aim: This study compared the cyclic fatigue fracture resistance in canal after instrumentation with single file system and multiple file system i.e- One Curve, F360 (single file systems) and Neoendo (multiple rotary file).
Method: Ten rotary instruments of each type and totalling 30 instruments of 25 mm in length were divided into 3 groups. Group 1: Neoendo, Group 2:F360, Group 3: One Curve. The dental 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 time was then converted into number of cycles to failure. NCF = Number of rotations per minute x Time to fracture.
Result: The mean values of time in seconds to fracture in F360 were lowest followed by Neoendo and highest was found in One Curve group.

Keywords: Elastic modulus, flexural strength, provisional restorative materials

Introduction
Over the past 2 decades, nickel-titanium (NiTi) instruments have become an important part of the armamentarium for root canal treatment. They are increasingly used by generalists and specialists to facilitate the cleaning and shaping of root canals. Despite their undeniably favorable qualities, there is a potential risk of ‘‘unexpected’’ fracture with NiTi instruments. [1-3].

The mechanical behavior of NiTi alloy is determined by the relative proportions and characteristics of the microstructural phases. Heat treatment (thermal processing) is one of the most fundamental approaches toward adjusting the transition temperatures of NiTi alloys and affecting the fatigue resistance of NiTi endodontic files. [4-6]

Over the decade, an outstanding display of files has emerged for negotiating and shaping canals. Every new age group of files has more developed canal preparation techniques through novelty in design, movement and material. Endodontists have visualized preparing canals utilizing a single-file technique. Therefore, practically all canals can now be optimally prepared using a single-file technique. Newly the focus is on the idea “less is more” for endodontic canal preparation, which means the whole cleaning and shaping of root canal space can be done with only one file. [7-9]

Thus, a single-file technique has been developed for shaping the vast majority of canals, regardless of their length, diameter, or curvature.

Why Single File Rotary System
1. Make root canal therapy easier for a dentist.
2. Reduces working time.
3. Lowers cross contamination.
4. Decrease in armamentarium

5. No need for organizing the files
6. Reduction in the instrument fatigue.

However root canal shaping with only one file submits 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.
Neoendo flex files (Orikam Healthcare India Private limited) are recently introduced files designed with a triangular cross section and a proprietary heat treatment rendering them highy flexible. The manufacturers also claim that the flutes do not open when the stress level is reached, which helps in increasing the cyclic fatigue resistance.

One Curve, the Endo DNA
Manufactured from heat-treated Nickel-Titanium alloy, One Curve is a single-use, rotary file that enables shaping of the full length of the canal with a single instrument, directly to the apex.
C. Wire is a One Curve exclusive Nickel-Titanium treatment designed, developed and applied by Micro Mega which offers: Dramatically increased flexibility and shape memory 2.4 times more resistant to fracture caused by cyclic fatigue comparef to the previous generation of files.
Combined with the patented design, C Wire defines One Curve's personality traits as its own DNA: One Curve is a smart, efficient and conservative instrument: Only one instrument to reduce the mechanical shaping time, single use to cancel the risks of cross contamination for serenity during the treatment and health safety for the patients

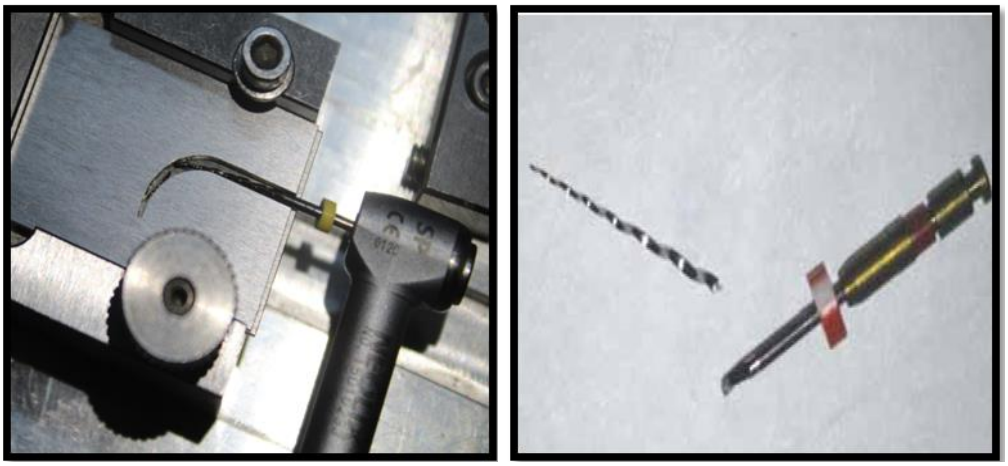
An efficient instrument
- Increased blade flexibility and more fracture resistance for higher overall security
- Exclusive proprietary C.Wire heat treatment: controlled memory of NiTi and ability to pre-bend the file for easier access to the root canal and elimination of constraints
- Perfect taper and diameter for a final shaping that meets standards of an

One Curve is a single-use, heat-treated NiTi rotary file that enables shaping of the full length of the canal with a single instrument, directly to the apex. C. wire defines One Curve's personality traits as its own DNA: One Curve is a smart, efficient, and conservative instrument manufactured by Micro-Mega Company. The advantages of One Curve, single-file technology are listed below:
Now-a-days simplifying endodontic procedures with complete safety and effectiveness is our primary concern. Micro-Mega now offers One Shape, the one and only NiTi instrument in continuous rotation for quality root canal preparations. One Shape allows for curved canal negotiation with an instrumental and easy dynamic. Its non-working (safety) tip ensures an effective apical progression avoiding obstructions which are often preceded by instrument separation. Quality root canal shaping can be achieved with one single instrument with remarkable design. A root canal treatment is approximately 4 times faster than a conventional treatment with One Shape file. Overall duration of treatment is shortened. Simplification of the endodontic instrument sequence is possible. NeoEndo files are 3rd Generation files that have been predisposed to gold thermal treatment which increases their cutting efficiency along with cyclic fatigue resistance. The F360 (Komet, Brasseler GmbH & Co., Lemgo, Germany) is a new single-use and multi-file Ni-Ti system: basic sequence is based on two files with tip diameter of 25 and 35 and taper 0.04; accessory files for apical shaping are available with the same taper and tip diameter of 45 or 55. The files are made of a conventional austenite 55-45 Ni-Ti alloy. A modified S-shaped cross sectional design is used for the entire working part of the file.

Materials
Custom made Cyclic fatigue tester, Single Step Rotary files: F360 (Komet), One curve (Micromega), Multiple File System -Neoendo (Orikam) 25, Stop watch. Ten rotary instruments of each type and totalling 30 instruments of 25 mm in length, were divided into 3 groups. Artificial grooves simulating canals measuring 1.5 mm in width, 20 mm in length, and 2.5 in depth with a U-shaped cross-section were machined into 316L stainless steel blocks by computer-assisted milling and hardened with polished chrome plating. A 4-mm-thick glass was screwed in front of the simulated canals to prevent the instrument from slipping out. The hand-piece of an endodontic electromotor (X-Smart; Dentsply Maillefer, Ballaigues, Switzerland) with a reduction ratio of 1:20 was fixed above the block so cyclic fatigue could be assessed in a static mode. After putting a glass slab on the block and fixing the hand-piece to the block with the file in it, the instruments (n=10 from each subgroup) freely rotated in a "static" mode (i.e., without any pecking movement). The rotational speed and torque suggested for all evaluated rotary instruments by their manufacturers were similar except for that of Twisted file. To standardize the study, 300 rpm speed and 2 N.Cm torque was applied.
Liquid paraffin (Kimiagar Toos, Mashhad, Iran) was used as lubricant during the file rotation and it was applied on the canal walls by a micro-brush. The instruments were used until fracture occurred and the time to fracture was recorded in seconds by two methods: (A) Direct visualization with a ×2.5 loupe (Heine HR binocular loupes, Heine Optotechnik, Herrsching, Germany) and listening (B) playing captured videos by Corel Video Studio ProX2 software (Corel Corp., Ottawa, Canada). The NCF was calculated using the following formula: NCF = Time (seconds) to failure × rotational speed/60.

Custom made artificial groove simulating the root canal with curvature of 45 degree

The time was then converted into number of cycles to failure. NCF = Number of rotations per minute x Time to fracture.

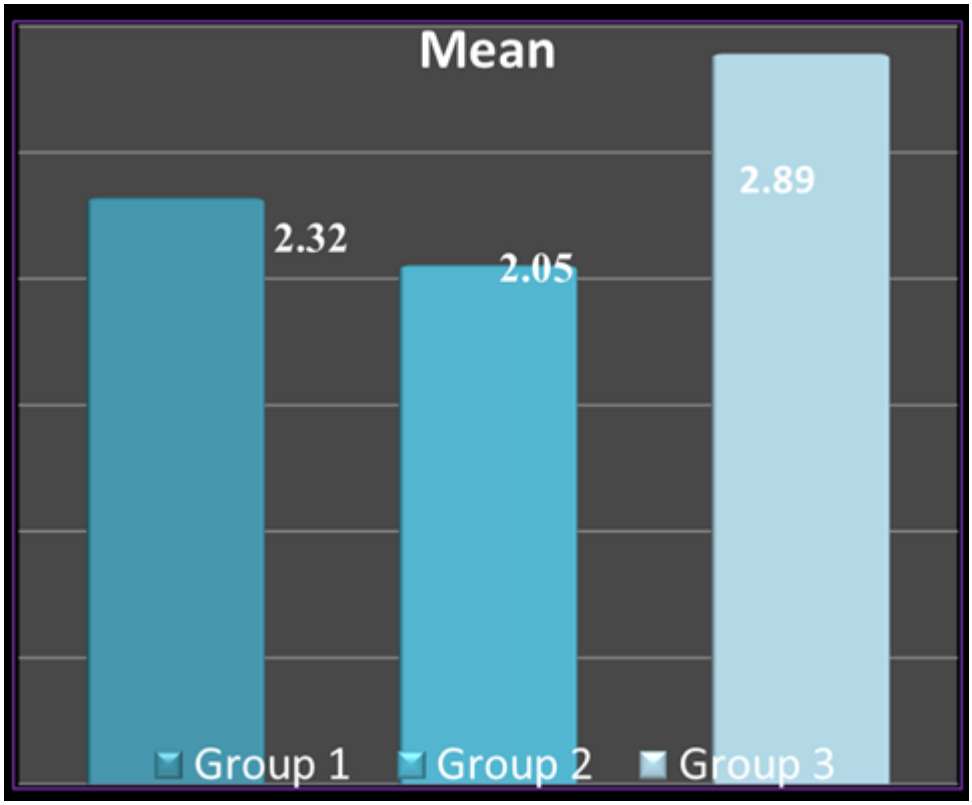


Fractured file segment

Results

The mean values of time in seconds was recorded and Anova Test was done. The result found was significant. The mean values of time in seconds to fracture in F360 was lowest followed by Neoendo, and highest was found in One Curve group.

	N	Mean	Std. Dev	Minimum	Maximum	P value
Group 1	10	2.321	0.126	2.17	2.44	
Group 2	10	2.054	0.048	2.00	2.16	0.001 (S)
Group 3	10	2.892	0.667	1.00	3.17	
Total	30	2.422	0.519	1.00	3.17	



Graph 1: Distribuition of mean values of time in seconds to fracture in F360, Neoendo, One Curve groups under study.

Discussion

Different types of rotary files exhibit differences in resistance to fatigue failure due to differences in various determinants such as their manufacturing process, structural characteristics and geometric designs, surface texture, the type of curve they are introduced into and the method used for fatigue failure calculation. Two methods for calculating the time of fracture were evaluated in this study. Most previous studies only used direct visualization. According to the results of this study, no significant difference was seen between the fracture time estimated by direct visualization and watching a captured video clip. When reviewing the captured video clips, the time of fracture can be determined more precisely and easily due to lack of eye strain. Single file systems, are the new asset in endodontic which has fundamentally changed the concepts by reducing armamentarium.

Three ways for improving the longevity of endodontic files have been suggested which include the following: (I) Thermal treatments before machining; (II) Choosing machining conditions adapted to the NiTi alloy and (III) electro-polishing.

This study compared the cyclic fatigue resistance of different types of NiTi rotary files with different manufacturing techniques and different improvement strategies.

Controversy remains regarding the effect of electro-polishing on the fatigue failure of rotary files. Some studies have shown that electro-polishing improves the instrument's working properties such as resistance to failure by producing a smooth and homogeneous protective surface oxide layer with less defects and residual surface stress whereas, Herold *et al*. inferred that electro-polishing did not prevent the development of microfractures and Barbosa *et al*. concluded that electrochemical polishing had no influence on the resistance to fracture of the rotary instruments tested. According to the findings of our study RaCe had the lowest NCF values in comparison to all other experimental rotary files in all canal types evaluated. Mtwo files are expected to show lower fatigue resistance than files undergone electro-polishing, such as RaCe, due to the crack-like surface features created subsequent to their machining manufacturing process

The general period of treatment is shortened, and it's easy for patients to accept the treatment due to less follow-ups.

According to Bartolas A *et al* 2016 Multiple-file vs. single-file endodontics in dental practice: a study in routine care. Regarding 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.

Saleh AM *et al* (J Endod 2015) F360 and One Curve files maintained the original canal curvatures with lesser tendency to straighten the S-shaped canals. Bruklein and and his colleagues concluded that the single-file F360 preserved the original anatomy of severely curved canal. Ujjwal K *et al* 2018 single file system Neolix showed highest resistance to cyclic fatigue when used in artificial canals.

Among all the groups, the group with One Curve showed highest resistance to cyclic fatigue when used in artificial simulated curve canals.

Conclusion

The fatigue resistance of the evaluated rotary files was lower in One-Curve followed by NeoEndo and then F360. One Curve exhibited the highest and F360 exhibited the lowest fatigue resistance compared to other evaluated files.

However further long-term studies with longer follow-ups are required to access the best file in this group**.**

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