Evaluation of the fracture resistance of Ni-Ti files in continuous and reciprocating motion in curved mesial canals of human permanent mandibular molars: An in Vitro Study

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Abstract

Aim: NiTi rotary files have gained popularity over recent years due to their inherent advantages. Despite their increased use worldwide the unexpected fatigue after extended clinical life span is one of the major shortcomings with these file systems. So the aim of this study was to evaluate the fracture resistance of Ni-Ti file (One Shape) in continuous and reciprocating motion in curved mesial canals of human permanent mandibular molars.

Materials and Method: Forty human permanent mandibular molars with mature apices were selected with an inclusion and exclusion criteria. After the access was prepared and working length determined and gylde path was achieved the teeth were divided into two groups.

Group A (Continuous Motion): Complete cleaning and shaping was done with One Shape® (Micro Mega, France) file in continuous motion. The file was re used in another tooth, until the file fractured. This was repeated until all the 5 files were fractured in the group.

Group B (Reciprocating Motion): Complete cleaning and shaping was done with One Shape® (Micro Mega, France) file in reciprocating motion. The file was re used in another tooth, until the file got separated / distorted. This was repeated until all the 5 files were separated in the group. The time needed for the complete preparation was also noted for both the groups. The groups were then observed under SEM.

Results: The Independent-Samples T Test procedure compares means for two groups of cases. Based on the results of the study it is not advisable to use this file in multiple teeth with any motion (CW/CCW). However it showed that use of continuous motion was safer and faster than reciprocating motion.

Conclusion: One Shape® file can be safely used to the working length of curved canals at least 5 times under continuous motion without any help of other files. While One Shape® can be used safely in reciprocating motion in at least 3 canals.

Keywords: Continuous motion, One shape file system, Reciprocating motion.

Introduction

Nickel-Titanium (Ni-Ti) rotary files are used to achieve shaping goals during root canal preparation phase, with many advantages over stainless steel files such as high flexibility, better cutting efficiency, and less time for canal preparation[1].

Despite increasing use of Ni-Ti rotary systems worldwide their cost, possibility of cross-contamination, and unexpected separation by fatigue after extended clinical life span are notable disadvantages[3,4,5]. Fracture of instruments used in rotary motion occurs in two different ways: fracture caused by torsion and fracture caused by flexural fatigue[6,7,8]. Torsional fracture occurs when an instrument tip or another part of the instrument is locked in a canal while the shank continues to rotate.

When the elastic limit of the metal is exceeded by the torque exerted by the hand piece, fracture of the tip becomes inevitable[9]. Instruments fractured because of torsional loads often carry specific signs such as plastic deformation[6].

Fracture caused by fatigue through flexure occurs because of metal fatigue. The instrument does not bind in the canal, but it rotates freely in a curvature, generating tension/compression cycles at the point of maximum flexure until the fracture occurs[10,11]. As an instrument is held in a static position and continues to rotate, one half of the instrument shaft on the outside of the curve is in tension, whereas the half of the shaft on the inside of the curve is in compression. This repeated tension-compression cycle, caused by rotation within curved canals, increases cyclic fatigue of the instrument over time and may be an important factor in instrument fracture. Single use of rotary files has been recommended to reduce instrument fatigue and to avoid cross-contamination.

Recently, a new concept for root canal preparation was introduced where only one F2 Pro Taper (Dentsply Tulsa Dental, Tulsa, OK) instrument was used in reciprocating movement. In this movement, the instrument rotates in counterclockwise (CCW) and clockwise (CW) directions, with 120° of difference between both movements. For every 3 cycles, there is a whole rotation of instrument.

One Shape® (Micro Mega, France) file is #25, with a .06 taper instrument made of super elastic Ni-Ti Wire. The unique design of the One Shape® instrument incorporates a variation of cross-sections along the active length of the file, which offers an optimal cutting action in three zones of the canal. It has 3 different cross section zones. The first zone presents a variable 3 cutting

edge design. The second, prior to the transition, has a cross-section that progressively changes from 3 to 2 cutting edges. The last (coronal) is provided with 2 cutting edges. Each instrument is electropolished to enhance cutting efficiency. One Shape® (Micro Mega, France) flexibility and unique downward movement ensures an effective apical progression. So the aim of the study was to evaluate the fracture resistance of Ni-Ti file (One Shape) in continuous and reciprocating motion in curved mesial canals of human permanent mandibular molars.

Materials and Method

Forty human permanent mandibular molars with mature apices extracted for Periodontic reasons were selected for this study. They were stored at 4°C in 0.1% Thymol solution and used within 1 month after extraction.

Fig. 1

Selection Criteria

Inclusion Criteria:

- Teeth with a curved root (>20°- 45°),
- Teeth which had no visible root caries
- Teeth with no sign of external or internal root resorption

Exclusion Criteria:

- Teeth with fractured roots
- Teeth with incomplete apex
- Teeth with root caries

Pre-operative radiographs were taken which were screened and any teeth that did not meet the required criteria were excluded from the study.

Schneider Method for Calculating Curvature of the Root

The Schneider method involves first drawing a line parallel to the long axis of the canal, in the coronal third; a second line is then drawn from the apical foramen to intersect the point where the first line left the long axis of the canal. The Schneider angle is the intersection of these lines. Following extraction, teeth were cleaned by removing the remaining soft tissue and then stored in 0.1% thymol solution at room temperature. Before utilization, teeth were taken out and washed under tap water to remove the traces of thymol solution.

Instrumentation Methodology

Endodontic access was obtained with a #330 round bur and a size 10 K- file was introduced into the root canal until the tip was just visible at the apical foramen. From that point, 1 mm was subtracted, and that length was defined as the working length of the root canal. After the working length was determined, a glide path was produced using #15 K-file.

Grouping

After the completion of preparation, the teeth were randomly distributed into two groups:

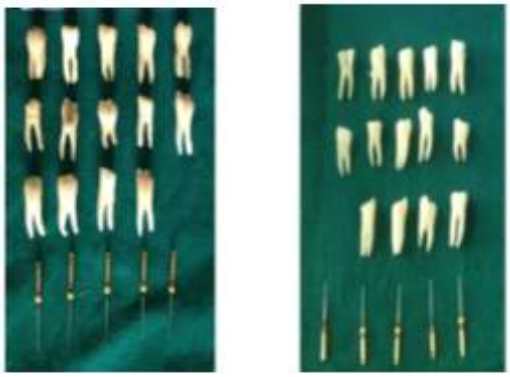

Fig. 2: Group A **Group B**

Group A (Continuous Motion): Complete cleaning and shaping was done with One Shape® (Micro Mega, France) file in continuous motion. The file was re used in another tooth, until the file fractured. This was repeated until all the 5 files were fractured in the group.
Group B (Reciprocating Motion): Complete cleaning and shaping was done with One Shape® (Micro Mega, France) file in reciprocating motion. The file was re used in another tooth, until the file got separated/ distorted. This was repeated until all the 5 files were separated in the group. The time needed for the complete preparation was also noted for both the groups.

Fig. 3

Fig. 4

Scanning Electron Microscope Evaluation

The SEM (Model: LEO s- 440i with OXFORD Energy Dispersive X-Ray Analyzer (EDX) (MODEL: 7060) analysis was done at the Institute for plasma research, Gandhinagar. Was done at magnifications of 500x, 2,000x, and 5,000x for disclosing the fracture mechanism. And also back scattered images were used to rule out the debris accumulation when in doubt with ductile fracture.

The entire study group was divided randomly into two groups equally (n=20). Only the mesial canals were chosen to be included into the study. Each group was allotted 5 One Shape® files each. The number of canals until 1 One Shape® file was fractured, and the time required to shape each canal were observed. Also the fractured instrument were evaluated by Scanning Electron Microscopy at 500x, 2000x and 5000x to understand the mechanism of fracture, the type and the factors affecting the fracture.

The data was analysed through INDEPENDENT SAMPLE T-Test.

Results

The Independent-Samples T Test procedure compares means for two groups of cases. Ideally, for this test, the subjects should be randomly assigned to two groups, so that any difference in response is due to the treatment (or lack of treatment) and not to other factors. This analysis was confirmed by comparison of two groups by T test. The p value calculated for the number of canals prepared was 0.037, was statistically significant (<0.05) and shows that significantly more number of canals can be prepared using One Shape® files in continuous motion.

The p value for average time required for a single canal preparation was <0.0001, which shows that when using One Shape® file in continuous motion, significantly less time was required to prepare one canal compared to the time required to prepare the canal in reciprocating motion.

The mean value also suggest that in continuous motion the file can be used in 5.4 canals and in reciprocating motion the file can be used in 3.6 canals, when the canals were curved. So it shows that the single file can be safely used up to apex without more chances of separation. There is no need of additional filing. But it also shows that the files should not be re-used in the patients, as suggested by the company.

The scanning electron microscopy pictures also show signs of both torsional and fatigue failure in all the files, irrespective to the group, suggesting that the file is showing consistent failures beyond certain number of canals, and hence not advisable to use in multiple teeth. In the present study, SEM images showed micro voids, crater-like and spherical dimples, which are representative of a ductile fracture resulting from the catastrophic failure of the material once the fatigue crack has attained a certain critical depth. The surface of the One Shape® was electroplated and claims to resist the crack propagation.

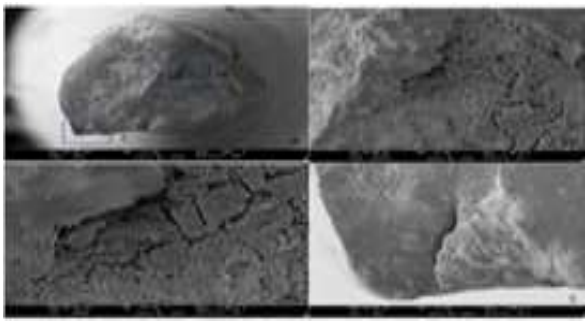

Fig. 5

A: One shape file after separation at 500x.
B1: The boxed area (center of the file) in image A at 2000x.
B2: The boxed area (center of the file) in image A at 5000x.
C: Boxed area (the edge of the file at 5000x.

The image 5 (C), 6(C) shows the deformation occurring at the edge of the file, multiple crack propagation can be seen. Also there are multiple cracks seen on fig. 5(B), 6(B). There are also multiple dimples can be seen in the region suggestive of a combined ductile and brittle fracture. To rule out the debris from the rough surface of the files, the back-scattered images were taken at 5000x magnification as seen in 5(D). Although any of these (cross section/surface condition) couldn't make a file safe enough to be used repeatedly in separate teeth, based on the results of the study it is not advisable to use this file in multiple teeth with any motion (CW/CCW). However, it showed that use of continuous motion was safer and faster than reciprocating motion.

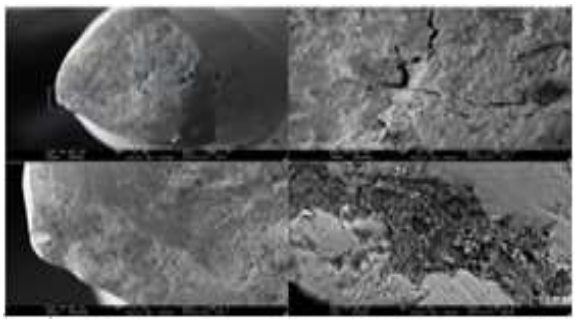

Fig. 6

A: One shape file after separation at 500x.
B: the boxed area (center of the file) in image A at 2000x.
C: Boxed area (the edge of the file) at 2000x.
C2: Back scattered image, to rule out the debris, of the boxed area (the edge of the file) in image C at 5000x.

Discussion

Most of the previous studies on this topic were focused on non-standardized files (Wave one, Pro Taper F2, ProTaper sequential) however this study is one of the first study to be done on ISO standardized files. One such study used Reciproc file which showed increased resistance to fracture in reciprocating motion. That may be explained by the continuous cross section of the file throughout the length, which might be making it more favorable to be used in reciprocating motion. While upon testing it was clear that triple cross section is clearly favoring the continuous motion and not reciprocating motion. It was also more time consuming when the continuous motion method was used.

The findings of this study suggest that the newly introduced, single use, single file system, One Shape® is safer to be used in tooth with curved roots. Continuous motion is better for the particular file when compared to reciprocating motion, which was more effective in prolonging the lifespan of the file, it also was less time consuming. However further studies are needed to expand the characteristics of One Shape® file. Results obtained were tabulated and evaluated by using SPSS-13 software.

The mean values were compared by T-Test. The level of significance was set at $p = 0.05$.

The results of the study shows average number of canals successfully cleaned and shaped with continuous motion were significantly higher that the reciprocating motion. Also the time needed for the preparation was significantly less in continuous motion than reciprocating motion. And the Scanning Electron Microscopic image showed both the signs of ductile fracture and brittle fracture, showing that the fracture of the file was combined fatigue and torsional fracture.

For One Shape® files it is recommended to use the file in reciprocating motion in a single tooth.

Conclusion

In conclusion, within the limitation of this study, single One Shape® file can be safely used to the working length of curved canals at least 5 times under continuous motion without any help of other files. While One Shape® can be used safely in reciprocating motion in at least 3 canals. Preparation in reciprocating motion with only One Shape® file was much slower than root canal instrumentation in continuous motion.

It is unadvisable to use these files in multiple patients as they are unable to withstand continuous motion in more than 5 canals.

However being marketed as a single us file it has certain advantages like:

- Less files needed
- No chance of cross contamination
- No need to sterilize (pre sterilized single use files)

The files were better to be used in continuous motion than in reciprocating motion.

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