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A comparitive evaluation of life span of nickel titanium rotary file system in continuous motion with reciprocating file system in curved root canals : An in vitro study.

Dental Science

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ABSTRACT

Aim: To evaluate the fracture resistance of Ni-Ti files in continuous and reciprocating motion in curved mesial canals of human permanent mandibular molars.

Material and methods: 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. Endodontic access was obtained and a size 10 K-file was introduced to determine the working length of the root canal. After the completion of preparation, the teeth were randomly distributed 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 reused in another tooth, until the file fractured. This was repeated until all the 5 files were fractured in the group. Group B (Reciprocating Motion) – Same procedure for cleaning and shaping was done. The file was reused 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 noted for both the groups. Evaluation of fractured instrument was then subjected to Scanning Electron Microscope Evaluation.

Results: Average number of canals that can be prepared successfully without fracture by a single One Shape® file in continuous motion was found to be 5.4 canals. Similarly on an average 3.6 canals can be prepared successfully in reciprocating motion without fracture using One Shape® file. Average time required for preparation of one canal in continuous motion is 223 seconds and that in reciprocating motion is 344 using One Shape®.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 showed that significantly more number of canals can be prepared using One Shape® files in continuous motion.

Conclusion: 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 One Shape® file was much slower than root canal instrumentation in continuous motion.

KEYWORDS:

Fracture resistance, Continuous, reciprocating, Endodontics.

INTRODUCTION

Nickel-Titanium (Ni-Ti) rotary files are used to achieve shaping goals during canal preparation phase, with many advantages over stainless steel files such as high flexibility, better cutting efficiency, and less time for canal preparation1.

Despite increasing use of Ni-Ti rotary systems worldwide their cost, possibility of cross-contamination2, and unexpected separation by fatigue after extended clinical life span are notable disadvantages3. Fracture of instruments used in rotary motion occurs in two different ways: fracture caused by torsion and fracture caused by flexural fatigue4. 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 handpiece, fracture of the tip becomes inevitable9. Instruments fractured because of torsional loads often carry specific signs such as plastic deformation4.

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 occurs5. 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 fracture5. Single use of rotary files has been recommended to reduce instrument fatigue and to avoid cross-contamination1.

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. Minimal fatigue along the length of the file virtually eliminates the risk of separation

The One Shape® instrument has a safety tip and is 25 mm at the tip with a .06 taper. The aim of the present study is to evaluate the resistance to fracture of One Shape® Ni-Ti files, used in continuous and reciprocating motion, in curved mesial canals of human permanent mandibular molar teeth, with angulation of 30-45°.

MATERIALS AND METHODS

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. Teeth with a curved root (>20°- 45°);Teeth which had no visible root caries and teeth with no sign of external or internal root resorption were selected for the study. Pre-operative radiographs were taken which were screened and any teeth that did not meet the required criteria were excluded from the study.

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

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

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.

RESULTS :

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.

Table 1 and **2** shows the life span of the files when used in continuous and reciprocating motion respectively.

Table 3 shows the average time required to shape canals with each method.

Table 4 and **5** shows the results of T-Test for the difference between the two groups for the longetivity of the file and the time required to shape the canal respectively.

The data was analysed through INDEPENDENT SAMPLE T-Test:-
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.

TABLES

TABLE 1: Life span of One Shape file when used in Continuous motion

Sr. No	Specimen no. (Files)	Canals prepared until file separation
1	1	4
2	2	7
3	3	5
4	4	5
5	5	6
Total	5	27 (5.4 canals)

TABLE 2: Life span of One Shape file when used in reciprocating motion

Sr. No	Specimen no. (Files)	Canals prepared until file separation
1	1	2
2	2	3
3	3	4
4	4	4
5	5	5
Total	5	18 (3.6 canals)

TABLE 3: Average time required for preparation for one canal

Sr. No	Specimen no.	Continuous Motion	Reciprocating Motion
1	1	223 secs	323 secs
2	2	203 secs	325 secs
3	3	251 secs	350 secs
4	4	209 secs	354 secs
5	5	232 secs	371 secs

TATABLE 5: Average time for preparation of canals (T-Test)

	GROUP	N	Mean	Standard Deviation	Standard Error Mean	Mean Difference	p value
Canals prepared until file separation	Continuous motion	5	5.40	1.140	0.510	1.80	0.037
	Reciprocating motion	5	3.60	1.140	0.510		

TABLE 5: Average time for preparation of canals (T-Test)

	GROUP	N	Mean	Standard Deviation	Standard Error Mean	Mean Difference	p value
Mean time required for the preparation	Continuous motion	5	223.6	19.100	8.542	-121.00	<0.0001
	Reciprocating motion	5	344.6	20.403	9.125		

On the basis of the observations made in this study following results were obtained:

As noted in Table 1, average number of canals that can be prepared successfully without fracture by a single One Shape® file in continuous motion are 5.4 canals. Similarly the Table 2 shows that on an average 3.6 canals can be prepared successfully in reciprocating motion without fracture using One Shape® file.

As shown in Table 3, average time required for preparation of one canal in continuous motion is 223 seconds and that in reciprocating motion is 344 using One Shape®.

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(FIG 1).

DISCUSSION

During root canal preparation, two or more Ni-Ti rotary files have been used sequentially or in combination according to their shaping characteristics. When using a series of Ni-Ti files, certain files bear more stress than others. For this reason, it is not possible to measure the lifespan of a certain file that reaches the full working length with completion of the root canal preparation. So far, apart from the recommendations to discard the Ni-Ti file when it undergoes deformation or when the operator becomes instinctively insecure about the state of the file, there have been no reports on the fracture incidence of certain types of Ni-Ti files. Therefore, this is one of first studies determining the lifespan of one master apical size Ni-Ti file that goes to the working length6.

Several devices and methods have been used to investigate in vitro the cyclic fatigue fracture resistance of Ni-Ti rotary endodontic instruments7. All of these studies attempt to simulate the rotation of the instrument within a curvature to determine how long it would last before fatigue fracture occurs. The rotating instrument is either confined in a glass or metal tube, in a grooved block-and-rod assembly, or in a sloped metal block or three-point bending pins. A three-point bending device is a rather new method to the endodontic literature although the principle has long been used in an engineering context8. It has been used to impose the curvature on the rotating instrument,9 the strain amplitude on the surface of the instrument may be estimated for each and every specimen with this method. However none of them can accurately simulate the anatomy of human teeth, and its canal variations. Therefore human permanent mandibular molars with curved canals were used in this study.

In previous study by Patino10 he showed that reciprocating motion was showing better resistance to separation than the continuous motion. They used ProTaper files S1, S2, F1, F2 & F3 in sequence in both continuous and reciprocating motion which showed that reciprocating motion had better longevity compared to continuous motion. The result could be due to use of files that can cut in both the directions - CW and CCW directions.

In this study, the minimum extent of One Shape® file usage before fracture was after 3 canal preparations, and this result shows that the average number of canals prepared with a single file upto apex can be used in less number of canals when compared to using sequential files such as ProTaper. Peters et al suggested that ProTaper files should be thrown away after being used in four to five constricted canals. According to another recent study, the lifespan of the ProTaper files was found to be 10 canals when they were used in sequence under continuous rotation, whereas these ProTaper files could be used in up to 13 canals without fracture when used in reciprocating motion. Among the files used in their experiment, F2 files were shown to be reused in up to 10 canals without fracture under reciprocating motion, and this result was contradicting to our study in which the mean lifespan of the One Shape® was 3.6 canals in reciprocating motion. Because no coronal flaring with any instrument was done, it would be unwise to compare these results directly. However, considering that the same lifespan was obtained without any help of other sequential files, the results of this study would appear to be less favourable in reciprocating motion.

In the current study, on an average 5.4 canals were prepared in continuous motion, and 3.6 canals were prepared in reciprocating motion. The results obtained were inverse to the results of similar studies on ProTaper files. When comparing the number of files needed in canal preparation, Varela-Patino et al36 showed that a total of 23 ProTaper file series were needed to prepare 60 canals in reciprocating motion, and a total of 30 ProTaper file series were needed to prepare 60 canals in continuous rotation motion. Less number of files were needed when using reciprocating motion in this study. Furthermore, this is in contrast to one's expectations that when using only one size master apical rotary file for the preparation of the entire root canal system, the stress exerted on this Ni-TI file should easily fracture it11. These results can be explained by two reasons. First, the torsional stress was reduced by using reciprocating motion. Reciprocating motion prevents the taper lock phenomenon by unsymmetrical repeating of the CW and CCW rotations12. As a result, it reduces torsional fracture, allowing us to understand how reciprocating motion shows better results compared with continuous rotation. In this study, 10 One Shape® files were used up to the apex. In contrast to the previous studies, 18 canals were cleaned up to apex with 5 One Shape® file in reciprocating motion, and 27 canals were cleaned with 5 One Shape® files in continuous motion. The reason is that the file used in this study was, One Shape® file, which are claimed to resist torsional fracture by uniformly distributing the stress exerted on it13.

Considering the efficiency of reciprocating motion, the total time taken for canal preparation in the RM group was more than that of that in the CM group. We noted a drastic reduction in the time needed for the preparation of curved canals to the working length with only one master apical size file under the continuous motion. This suggests that the continuous motion is superior not only in its mean lifespan but also in its cutting efficiency, which is ultimately expected to reduce the operator's fatigue. Our study is in contrast to the similar studies done on ProTaper files, which when used in continuous motion were slower and prepared fewer canals when compared to reciprocating motion. This property may be attributed to the cross section of the file, which shows positive rack angle and no radial lands. Also the triple cross section might lead to unfavourable distribution of forces in reciprocating motion.

According to a report by Sattapan et al4, fracture of Ni-Ti files occurs in one of two ways: flexural fracture and torsional fracture. Flexural fracture occurs because of repeated compression and tension in curved canal. Torsional fracture occurs when binding occurs at a part of the file other than the tip. In the clinical situation, both torsional stress and cyclic fatigue are exerted on files within the root canal, and these two forces influence each other. In fact, Ni-Ti files exposed to torsional stress are prone to fracture at a lower cyclic fatigue14, and torsional resistance decreases in used files15. Therefore, these two aspects of file fracture can be simultaneously observed when the cross-sectional area of the fractured file was examined under the SEM16.

According to previous studies that showed fractured Ni-Ti surfaces by using SEM analysis17, 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.

The FIG 1 shows the deformation occurring at the edge of the file, multiple crack propagation can be seen. Also there are multiple cracks seen on figures 1(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 1(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.

Most of the previous studies on this topic were focused on non standerdized files (Wave one, Pro Taper F2, ProTaper sequential) however this study is one of the first study to be done on ISO standerdized 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 favouring 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.

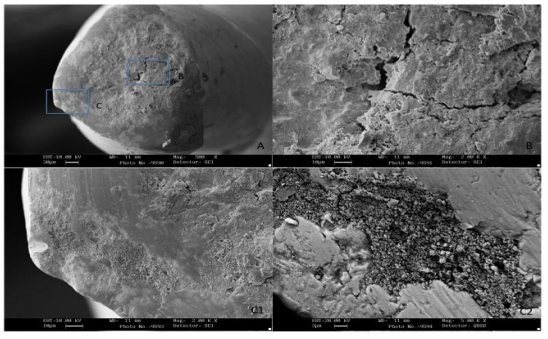

FIG 1: SEM images of separated file used in continuous motion.
A: One shape file after separation at 500x,
B: the boxed area (Center of the file) in image A at 2000x.
C: Boxed area (the edge of the file) at 2000x.
C2: Back scattered image, to rule out the debris, of the boxed area (the edge of the file) in image C at 5000x.

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 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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