International Journal of Medical Research Professionals
P-ISSN: 2454-6356; E-ISSN: 2454-6364
DOI: 10.21276/ijmrp

Original Research Article.

Comparative Evaluation of Mechanical Failure of Different Rotary Endodontic Files: An SEM Study

Parul Verma[1*], Deebah Choudhary[1]

[1]Senior Lecturer,
Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences, Sehora, Jammu, India.

ABSTRACT

Conventional endodontic instruments make the intracanal procedures versatile with more efficiency and minimum complication. The development of microfractures in the I-RaCe Nickel-Titanium rotary (NTR) file and ProFile NTR file was evaluated by using Scanning electron microscopy (SEM). Thirty six maxillary buccal roots and thirty six mandibular mesial roots with an average canal curvature of 37° were assigned to each group and prepared with 21mm, 0.04 taper NTR files as follows: (1) I-RaCe (2) ProFile. File sizes 0.06 to 0.04 were used in a crown-down technique to a master apical file (MAF) size of 0.04/25. The MAF instruments were evaluated by SEM before use, after completion of 7 canals, and after completion of 14 canals. All I-RaCe instruments developed microfrcatures by the seven canal evaluation. The ProFile instruments showed no microfrctures at the 7-or-14 canal evaluations. I-RaCe files separated at a higher rate than ProFile instruments. Under the conditions of this study, unique file design and electropolishing did not inhibit the development of microfractures in I-RaCe NTR.

Key words: Electropolishing, File Separation, Nickel-Titanium Rotary File.

***Correspondence to:**

Dr. Deebah Choudhary,
Senior Lecturer,
Department of Conservative Dentistry and Endodontics,
Institute of Dental Sciences, Sehora, Jammu, India.

Article History:

Received: 14-09-2019, **Revised:** 10-10-2019, **Accepted:** 28-10-2019

Access this article online	
Website: www.ijmrp.com	Quick Response code
DOI: 10.21276/ijmrp.2019.5.6.013	

INTRODUCTION

Today nickel titanium files are mostly used in a rotary motion following the crown down technique with speed ranges of 150-600 rpm. Inspite of their greater flexibility and more resistance to torsional separation, separation via torsional and cyclic fatigue is still possible and common, especially after extended use.[1-3] Cyclic, static torsional, and dynamic torsional fatigue are the most common causes of rotary nickel titanium instrument fracture.[4]

I-RaCe is a new NTR file developed by FKG Dentaire Company, la-Chaux-de-Fonds, Switzerland. I-RaCe have an innovative design reflected by their name i.e., Reamers with Alternating Cutting Edges.[5] The surface of these instruments is electrolpolished. The ProFile instrument family has the cross-sectional geometry. The shape is made by machining three equally spaced U-shaped grooves around the shaft of a taper NiTi wire. There is a central parallel core inside that may account for the enhanced flexibility compared with Quantec[6] and ProTaper[7], which possess a tapered central core. Electropolishing has been shown to produce a smooth, amorphous oxide layer that is free of most crystalline defects. Residual stresses on the material surface are also removed in the process.[8]

Our hypothesis is that the electropolishing procedure used in the manufacture of the I-RaCe NTR files will inhibit the development of microfractures in comparison to the untreated surface of the ProFile NTR file.

The purpose of this study was to evaluate the surface characteristics and the incidence of separation of two rotary files i.e., ProFile (non-electropolished) and i-RaCe (electropolished) which were used in a clinically simulated extracted molar tooth model by scanning electron microscopy (SEM).

MATERIALS AND METHODS

Specimen Collection

Eighty freshly extracted permanent maxillary and mandibular teeth were placed in 10 % buffered formalin mixture for 24 hours. Teeth were then soaked in 5.25% Sodium Hypochlorite (Naocl) for 5 minutes and placed in sterile water for storage. Only buccal canals of maxillary molars and mesial canals of mandibular molars were selected.

Sample Size: 144 canals were used out of a possible one hundred and sixty canals due to six canals that were non-negotiable, four with an open apex and eight were calcified. The teeth were then randomly divided into two groups of 36 teeth each. Each group consisted of 18 maxillary first molars and 18 mandibular first molars. The groups were labeled as follows:-

Group-I: I-RaCe

Group-II: ProFile.

The 36 teeth in each group were then further divided into 5 subgroups viz. A1, A2, A3, A4, A5 and B1, B2, B3, B4, B5. Each subgroup received 7 teeth each. The selected canals of these 7 teeth were then prepared with a set of the respective rotary Nickel-Titanium file. Access cavities were prepared by using a #4 round carbide bur (Brassler USA) and refined with an Endo-Z bur (Dentsply/Maillefer, Tulsa, OK) in a high-speed handpiece. Patency of the canals was determined with a size 0.08 K-type file (Maillefer). Length determination was accomplished by a manipulation of # 10 stainless steel (SS) hand file (dentsply/Tulsa Dental, Tulsa, OK) coated in RC-prep (premier products Co, plymouth Meeting, PA) through the apical foramen as determined by visualization of the file with an operating microscope (Monix) at 10 x magnification and then subtracting 0.5mm. All files were lubricated preinsertion with RC-prep.

Canals were passively enlarged by using a watch-winding technique and alternating #8,10, & 15 SS hand files. When a #15 SS reached working length, roots were numbered, and a intra-oral periapical radiograph was taken with #15 SS at working length. Initial radiographs were taken from the proximal and buccal directions, and exposure time and processing were standardized. The radiographs were used to detect canals that joined each other (Type III canal variation). In these cases, only one canal was included in the study. The angle of curvature was determined by using the method described by Schneider with the help of AutoCAD software. The average angle of curvature was 37° and ranged from 10° to 95°.

Coronal preflaring was accomplished by using low-speed Gates Glidden burs #4, 3, and 2 (Densply/Tulsa Dental) in a crown-down technique. Coronal preflaring was considered complete when a Gates Glidden #2 bur reached within 6 mm of the apex.

Before instrumentation, all canals were irrigated with 5.25% NaOcl. An X-Smart rotary endomotor with the torque control in the off position was used for rotary instrumentation. A light up and down motion was used to advance each file to two or three engagements of dentin. No files were left in the canal for longer than two to three seconds. The instrumentation was considered complete when a 25/0.04 file reached working length. If this goal was not achieved, the canals were irrigated, patency was established with a #10 SS, and the crown-down procedure was repeated till working length is achieved. Rotary files were evaluated after use for surface irregularities.

Scanning Electron Microscopy: A 25/0.04 NTR file from each group was observed under SEM before use, after 7 canals, and finally after 14 canals to visualize the presence of microfractures, pitting, or fretting. All files were placed in an ultrasonic bath for 25 minutes, autoclaved, wiped with gauze soaked in 70 % alcohol, and allowed to dry. Files were mounted on 23-mm SEM specimen mount stubs using double-sided carbon tape. In an attempt to evaluate the same area of a file on multiple examinations, a line was drawn in permanent ink on the handle of the first side of the file evaluated. All files were evaluated at known distances from the tip including 0, 1, 2, and 3 mm. files were imaged at two magnifications: 500 X, and 1000 X. These files were further used in the canals till they fractured. The total number of canals prepared by a set of files before the fracture, were calculated to evaluate their clinical performance.

RESULTS

A total of ten NTR files deformed or separated during instrumentation of 144 canals (Table 1). All files were used in canals till the time they fractured. The number of the canals prepared by each file until fracture was tabulated so that statistical analysis of the clinical performance of these set of files could be evaluated. The results obtained were statistically analyzed using one-way ANOVA and t-Test.

Boxplot showing 1st quartile and 3rd quartile with median. The expansions showing maximum and minimum values.

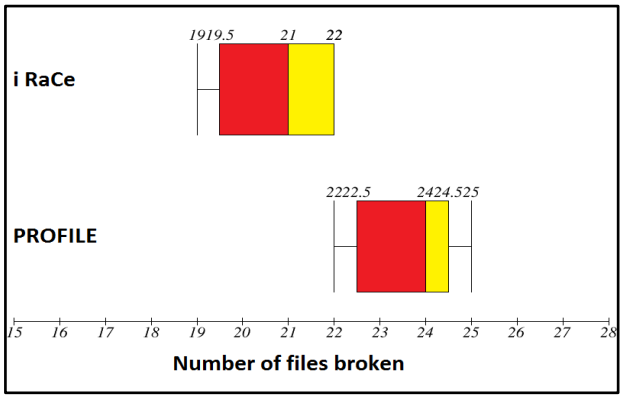
Graph showing the mean number of canals after which the files of two groups fractured. The mean graph showing that Profile file performed clinically better than I-RaCe file. I-RaCe fractured after preparing lesser number of canals than Profile.

The data was analyzed using one-way ANOVA and t-Test for independent samples and comparison was done between two file systems. In both the tests, p value came out to be <0.05 which means that the difference between both the groups was statistically significant.

Table 1: No. of Canals Prepared Before File Fracture

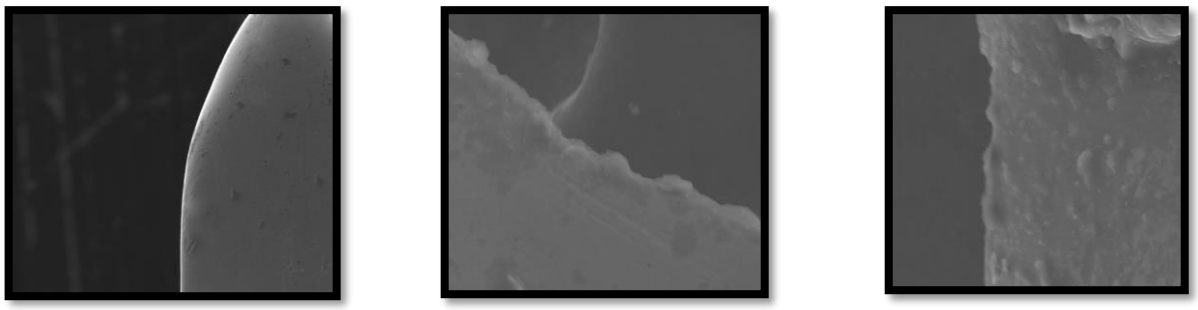
File Number	*i RaCe*	PROFILE
1	21	25
2	20	24
3	22	22
4	22	24
5	19	23

Graph 1: Number of files broken



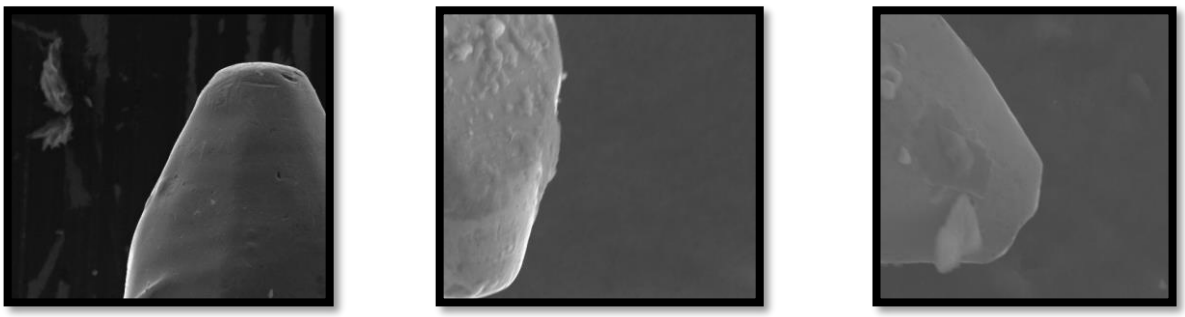
Scanning Electron Microscopy Evaluation

Pre instrumentation scanning electron microscope examination of I-RaCe files (electropolished) revealed that the surface was smooth with no visible microfractures. (Fig. 1 A). SEM examination of new ProFile files (non-electroppolished) revealed machining grooves, some pitting, and slight metal fold over at edges with no visible microfrcatures (Fig. 2 A). After instrumenting seven canals each I-RaCe file exhibited nicks and notches. In ProFile excessive wear was seen in the tip but the flute surface was showing slight irregularities due to mild abrasion. After usage in fourteen canals I-RaCe showed definite microfractures which entered onto the body of the file thus leaving the thin fins of metal at the surface of the flute. The ProFile showed wears in the forms of craters which left no fins of metal at the periphery but transmitted microcracks towards the body of the file. On the contrary the tip of the file showed excessive wear. The tip was almost seen blunt.



(A) **(B)** **(C)**

Fig 1: I-RaCe



(A) **(B)** **(C)**

Fig 2: ProFile

DISCUSSION

The primary objective of this study was to analyze the files for surface imperfections if any before use and after use under Scanning Electron Microscopy. The number of canals prepared by each file before separation gave the quantitative insight of their clinical performance. This study assessed the effect of electropolishing on rotary files. An unexpected statistically significant finding was that the polished files failed sooner in canal curvatures. This did not correlate to previous studies that showed increased resistance to cyclic fatigue.[3,8] We hypothesize that electropolishing is very technique sensitive and may have a varying affect on the mechanical properties among different batches of file.

ProFile NTR files were chosen as the control instrument because these files are not electropolished, and previous studies have suggested that machining defects and surface treatment may affect the durability of these instruments.[3,4,9-13]

In the current study it was seen that under scanning electron microscope, the unused instruments of ProFile (non-electropolished) did not reveal any microcracks but metal roll overs and mechanizing grooves were seen. On the contrary I-RaCe showed a smooth electropolished surface with fewer remnants of transverse running grooves and occasional pits.[14,15]

After use in 7 canals, there were fewer or no microcracks visible in ProFile. Scanning electron microscopy of ProFile showed surface irregularity and maximum wear was observed at the tip of the file. Unexpectedly I-RaCe files showed lot of fretting, microcracks, nicking and notching and extensive crater formation. The extent and frequency of defects increased from 7 to 14 canals as discussed in a study by Herold et al.[14]

After use in 14 canals, crater formation on ProFile transmitting crack was observed under SEM and there was total loss of tip of the file. Under scanning electron microscope, I-RaCe rotary file showed craters facilitating microcracks through nicks and notches, with thin fins of metal at the periphery of the file after use in 14 canals as concluded in a study by Herold et al.[14]

The fractured surface of both the ProFile and I-RaCe showed quite similar surface features thus suggesting same mechanism of fracture. In ProFile there was frequent fracture defects in which crack met the triangular border.[15] Thus it is possible that the multitude of the mechanizing marks at multiple locations in which the resolved shear stress is greater than that required for crystallographic slip to occur. The observation in this study is in agreement with the prevailing idea of propagation of cracks from the already established machining grooves in non elctropolished files[16-20], thus establishing that electropolishing is one of the factors for reducing crack propagation to the center of the file.

Quantifying the clinical performance of all these files, the number of canals prepared before file separation happened, ProFile performed better than I-RaCe. This might be attributed to helical angle, pitch number and arrangement of spirals in the flute part.[15] ProFile performed better than I-RaCe which is against the findings of[15], but he compared their cyclic fatigue not their incidence of separation while shaping extracted teeth.

The current study is in accordance with the study of Herold[14] that electropolishing did not prevent microcrack formation. This study contradicts several studies that show electropolishing might improve the instruments working properties.[15] The better performance of ProFile than I-RaCe suggests that instrument design is highly significant than surface characteristics.[21]

Keeping all these factors in mind it is hereby concluded that usage period of the file is a complex issue depending on a number of factors. Although the factors evaluated in this study clearly suggest that the file design and the manufacturing technique are more significant than a smooth surface attained by electropolishing.

CONCLUSION

All files were assessed before use under Scanning Electron Microscope for surface characteristics and later after use in 7 and 14 canals subsequently. The number of canals prepared by each file of each group before separations was also recorded.

Observations of the Present Study are

1. Electropolished files i.e., I-RaCe show better Pre instrumentation finished surface but wear off at a faster and greater rate than other files after use.
2. ProFile initially shows grooves and metal rollovers but wears at a lesser rate than I-RaCe in spite of being non-electropolished.
3. For incidence of file separation, ProFile performed best by shaping maximum number of canals prior to fracture than I-RaCe.

Clinical Significance

This study showed the worth of alterations and changes in the conventional manufacturing of file for the betterment of endodontic instrumentation.

REFERENCES

1. Walia H, Brantley WA, Gerstein H. 1988. An initial investigation of the bending and torsional properties of Nitinol root canal files. Journal of Endodontics, 14:346-51.

2. Wolcott S, Wolcott J, Ishley D, Kennedy W, Jhonson S, Minnich S, Meyers J. 2006. Seperation incidence of protaper rotary instruments: a large cohort clinical evaluation. Journal of Endodontics, 32:1139-41.

3. Parashos P, Messer HH. 2006. Rotary NiTi instrument fracture and its consequences. Journal of Endodontics, 32:1031-43.

4. Iqbal MK, Kohli MR, Kim JS. 2006. A retrospective clinical study of incidence of root canal instrument separation in an endodontics graduate program: a Penn Endo database study. Journal of Endodontics, 32:1048-52.

5. Sarah J.Merett, Susan T.Bryant and Paul M.H.Dummer. 2006. Comparison of the shaping ability of RaCe and Flex Master Rotary Ni-Ti systems in simulated canals. Journal of Endodontics, 32, No 10.

6. Peters OA, Schonenberger K, Laib A. 2001. Effects of four NiTi preparation techniques on root canal geometry assessed by micro computed tomography. Int Endod J, 34:221-30.

7. Berutti E, Chiandussi G, Gaviglio I, et al. 2003. Comparative analysis of torsional and bending stresses in two mathematical models of nickel-titanium rotary instruments: ProTaper versus ProFile. J Endod, 29:15-9.

8. Anderson Margot E, Price John W.H, Parashos Peter. 2007. Fracture resistance of electropolished rotary nickel-titanium endodontic instruments. J Endod, 33:1212-6.

9. Wei X, Ling J, Jiang J, Huang X, Liu.L. 2007. Modes of failure of ProTaper nickel titanium rotary instruments after clinical use. Journal of Endodontics, 33: 276-9.

10. Gambarini G. 2001. Cyclic fatigue of nickel-titanium rotary instruments after clinical use with low-and-high-torque endodontic motors. Journal of Endodontics, 27:772-4.

11. James H. Yao, Scott A. Schwartz, Thomas J. Beeson. 2006. Cyclic Fatigue of three types of Rotary Nickel-Titanium Files in a Dynamic Model. Journal of Endodontics, 32:55-7.

12. Yared GM, Bou Dagher FE, Machtou P. 2000. Cyclic fatigue of ProFile rotary instruments after clinical use. Int Endod J, 33:204-7.

13. Tygesen Yancy A., Steinman H. Robert, Ciavarro Cesare. 2001. Comparison of distortion and separation utilizing ProFile and Pow-R-Nickel-Titanium rotary files. J Endod, 27:762-4.

14. Herold Keven S, Johnson Bradford R, Wenckus Christopher S. 2007. A scanning electron microscopy evaluation of microfractures, deformation and separation in EndoSequence and ProFile nickel-titanium rotary files using an extracted molar tooth model. J Endod, 33:712-4.

15. Hyeon-Cheol Kim. 2010. Cyclic fatigue and fracture characteristics of ground and twisted nickel-titanium rotary files. J Endod, 36:147-52.

16. Tripi Roberta t, Bonaccorso Antonio, Condorelli Guido G. 2006. Cyclic fatigue of different nickel-titanium endodontic rotary instruments. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endod, 102:106-14.

17. Cheung Gary S.P, Shen Ya, Darvell Brian W. 2007. Does electropolishing improve the low-cycle fatigue behaviour of a nickel-titanium rotary instrument in hypochlorite? J Endod, 33:1217-21.

18. Gambarini G, Grande NM, Plotino G, et al. 2008. Fatigue resistance of engine-driven rotary nickel-titanium instruments produced by new manufacturing methods. J Endod, 34:1003-5.

19. Park Su-Young, Cheung Gary S.P, Yum Jiwan, Hur Bock, Park Jeong-Kil, Kim Hyeon-Cheol. 2010. Dynamic torsional resistance of nickel-titanium rotary instruments.JEndod,36:1200-4.

20. Miao W, Mi X, Zhu M, Guo J,Kou Y. 2002. Effect of surface preparation on mechanical properties of a NiTi alloy. Mater Sci Forum, 394-395:173-6.

21. So-Ram Oh, Chang Seok-Woo, Lee Yoon, Gu YU, Son Won-Jun, Lee Woocheol, Baek Seung Ho, Bae Kwang-Shik, Choi Gi-Woon, Lim Sang-Min, Kum kee Yeon. 2010. A comparison of nickel-titanium rotary instruments manufactured using different methods and cross sectional areas: ability to resist cyclic fatigue. Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 109:622-8.

Source of Support: Nil. **Conflict of Interest:** None Declared.

Cite this article as: Parul Verma, Deebah Choudhary. Comparative Evaluation of Mechanical Failure of Different Rotary Endodontic Files: An SEM Study. Int J Med Res Prof. 2019 Nov; 5(6):52-55. DOI:10.21276/ijmrp.2019.5.6.013