# Comparative Evaluation of Surface Defects In Single File Rotary Systems Before and After Instrumentation In Curved Root Canals

## Keywords

*Scanning Electron Microscope*
*Rotary*
*Single File Systems*
*Endodontic Instrument*
*Continuous Rotation*

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## ABSTRACT

*This study aims to evaluate the surface defects and efficiency of two single file rotary systems with different surface treatments in curved root canal instrumentation. A total of 160 root canals were randomly divided into two groups and were subjected to root canal instrumentation with electropolished surface rotary file (Group 1) and with EDM surface treated rotary file (Group 2). All the files were then subjected to SEM analysis to evaluate the surface defects prior to the root canal instrumentation,after 5 uses and 8 uses inside the root canal. From the scanning electron microscopic images, the surface defects as observed were scored and were statistically analyzed. SEM analysis of both the single file systems revealed significantly varying surface defects. Rotary file with electropolishing appeared to be more resistant to deformation compared to the rotary file with EDM treatment after instrumentation of five canals. Hence it can be concluded that electropolished file can be safely instrumented for five times compared to EDM processed files in curved root canals.*

## INTRODUCTION

Root canal instruments play an important role in the canal preparation in endodontic treatment. Initially, instruments based on stainless steel were widely used. However, high rigidity of stainless steel instruments has been an impediment in efficient cleaning of root canal, especially the curved canals. Alternatively, nickel-titanium (NiTi) alloy based instruments were developed which exhibits superelasticity and shape memory.[1] The superelasticity of NiTi permits their use in continuous rotation in curved root canals as it exhibits high flexibility to produce a tapered root canal form with minimum canal transportation.[2–5]

Currently, NiTi files with different working motion to complete the root canal preparation with a single file has become popular. The single file rotary system presents multiple advantages such as substantial saving in chair-side time, no change in working length and reduced cross contamination between the patients.[6,7] However, the fracture of the instrument is the most common problem encountered during their clinical use.[8,9]



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In order to extend the clinical usage of the files without fracture, NiTi based rotary files were subjected to various surface treatments like ion implantation, thermal nitridation, cryogenic treatment, electropolishing and electric discharge machining (EDM). Electropolishing process is the most common method used to produce a smooth surface texture and homogeneous surface oxide layer with less defects and residual surface stresses, which improves the fracture resistance of the NiTi files.[10] One Shape single file system is an Electropolished austenite based 55-Niti alloy with a tip size of 25 and asymmetrical cross-section along the working length at a constant taper of 0.06. In addition, the number of cutting edges progressively decreases from three to two from the apical to coronal third of the instrument. This design provides longer pitch along the length of the blade and thereby minimizes threading and binding of the instrument in continuous rotation.[11] In a study by Sekar *et al*, One Shape files demonstrated significantly higher fracture resistance when compared with Revo-S SU files in both reciprocating and continuous motion.[12] Similarly, they were found to be efficient in maintaining the canal curvatures and showed less debris extrusion.[13-14]

Recently, a non-contact EDM method was introduced in which the NiTi files are immersed in a lubricating dielectric oil and subjected to pulsating electric sparks. This results in localized melting or evaporation of the alloy to create a well-controlled roughness on the instrument.[15] Manufacturers claim that EDM process improves the cutting efficiency and fracture resistance of the files. Though, the roughness on the surface of the files is assumed to negatively affect the mechanical properties of the files, some of the research investigations have reported the EDM treatment increases the fatigue resistance of the rotary files.[16,17]

Neoniti A1 is one such single file system with a tip size of 25, taper of .08 and its non-homothetic rectangular section along the blade that enables a progressive flexibility to negotiate the curvature of the root canals. The EDM process of these files permits superior cutting efficiency. Previous studies using this rotary file system have shown increased cyclic fatigue resistance when compared to RaCe, twisted file, protaper next and Mtwo.[18] It is more efficient and less time consuming as compared to the other retreatment file systems used.[19]

Most manufacturers of single file systems recommend that these instruments can be used for about 3 to 4 root canals. The existing literature suggests that the use of multifile NiTi root canal instrumentation reduces the instrument efficiency. However, there is scant literature on the effect of multiple use of single file rotary systems.[20-21] Similarly, the effect of different surface treatments such as electropolishing and EDM on the longevity of the service life of these single file rotary systems has not been reported widely. Hence,the aim of the present study was to evaluate the surface defects and efficiency of two single file rotary systems with different surface treatments in curved root canal instrumentation.

## MATERIALS AND METHODS

A total of 160 root canals (in 80 human molars) with root canal curvature, ranging from 15° to 30° (extracted for periodontal reasons) was selected for the study after approval from the Institutional ethical committee (IEC 269/2015). Angle of the curvature of the root were determined using the technique of Schneider.[22] Only buccal canals of maxillary molars and mesial canals of mandibular molars were selected. Teeth were then cleaned and stored in 0.2% sodium azide at $4^0$C until the experiment.

Access cavity was prepared by using a #4 round carbide bur and refined with an Endo-Z bur using a high-speed handpiece. Consequently, root canal orifice was enlarged using Gates glidden drills up to size no 3. Working length was established by inserting no.10 K file into the root canal until it was visible at the apical foramen from which 1mm was subtracted. Later, glide path was verified using a size 15 K-file. The root canals were then randomly divided into two groups (n=80).

In Group 1, root canals were prepared using OneShape (tip size = 25, taper = 0.06) in clockwise rotation at 400 rpm generated by the X-Smart motor, and the torque was adjusted to 4 Ncm. The files were used in a push – pull (pecking) motion according to the manufacturer's instructions.

In Group 2, root canals were shaped using neoniti A1 file (tip size= 25, taper = 0.08) in continuous rotation at 300 -500 rpm and a torque limit of 1.5 N.cm. The instrument was carefully introduced into the root canal by alternating 2-3 wall brushing actions and 2-3 pecking movements (axially back and forth) until the working length was reached. Irrigation in both the groups was performed with 5 ml of 2.5% NaOCl and 5ml of 17% EDTA using a 28 gauge side vented needle which was placed 1mm short of working length. Entire instrumentation was performed by single operator who was specialized in rotary instruments.

A total of 10 files per rotary system was used to instrument the root canal. Each file was used to instrument 5 canals followed by 8 canals. All the files (i.e. before instrumentation [control group] and after 5 and 8 uses) were then subjected to JSM-6010 scanning electron microscopy to evaluate the surface defects at coronal, middle and apical third of the instrument. The scanning of the instrument was carried out at an accelerating voltage of 20kV. For each file several images with increasing magnification at apical, middle and coronal thirds was captured. The images obtained from scanning electron microscopy were then analyzed by two independent observers to minimize the bias. Prior to the observation of the microscopic images, the observers were familiarized with the scoring pattern, as mentioned below, to be followed for the classification of surface defects on the root canal instruments. The observers were given at least 5 random images initially to familiarize with the scoring. The presence of defects (plastic deformation, blunting of the cutting edges, microcracks, craters and fracture,) was scored according to the following criteria.

1. No defect (No plastic deformation or bending or other deformation of the cutting edge is visible)
2. Minor plastic deformation (The cutting edge or flute of the instrument is curved or deformed with the disruption of cutting edge)
3. Blunting of cutting edges/Microcracks (The flute or cutting edges of the instrument is blunt with or without microcracks)

4. Craters (Some part of the flute or cutting edge of the instrument is missing as indicated by a crater on the surface)
5. Fracture

The scoring of surface defects as observed from scanning electron micrographs was analyzed using Chi-square test and the significant difference were compared using Mann-Whitney test and Wilcoxon signed rank test at a confidence interval of 95%.

# RESULTS

Surface defects observed in Group 1 and Group 2 at all the thirds of the instrument in control, 5th use and 8th use are demonstrated in Figure1; Figure 2; Figure 3 and Figure 4. Comparison of means of defect scores of all the parts of Group 1 and Group 2 using chi-square test indicated significant differences in the surface defects between 5th use and 8th use compared to control group (before instrumentation) only at the apical third of the instrument ($p = 0.04$ and 0.026 for 5th and 8th use groups respectively).

Comparison of defect scores of Group 1 was not statistically significant at the apical third of the instrument irrespective of the number of times the instrument was used inside the root canal ($p = 0.116$). However, the apical third of Group 2 showed significant changes in surface finish after 5th use ($p = 0.004$) as well as 8th use ($p = 0.004$) compared to control group. A significant increase in surface defects was also observed between 5th use and 8th use at the apical third of the Group 2 ($p = 0.002$).

The middle third of both Group 1 and Group 2 did not show statistical difference in the surface defects compared to control groups after 5th and 8th use ($p = 0.051$ and 0.223 respectively). Similarly, no significant differences in surface defects was observed at coronal third after 5th and 8th use of Group 1 and 2 ($p = 0.368$ and 0.135 respectively) compared to control groups of the respective instruments.

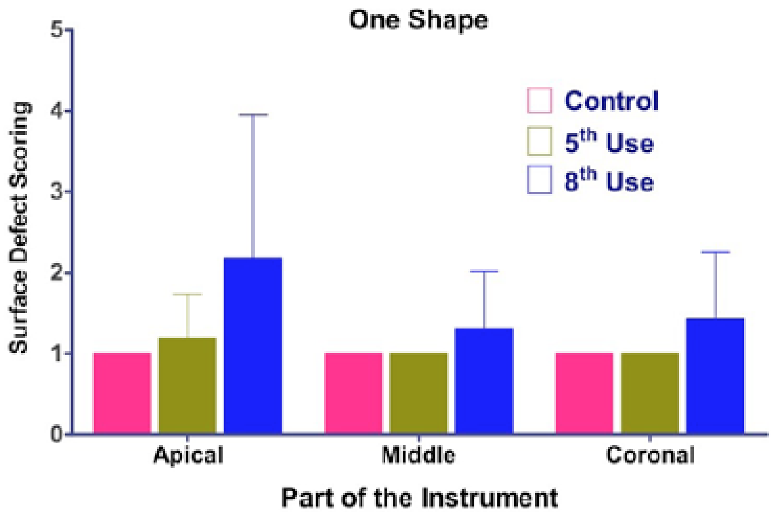


**Figure 1:** Surface defects of One shape at apical, middle and coronal thirds of the instrument for control, 5th use and after 8th use

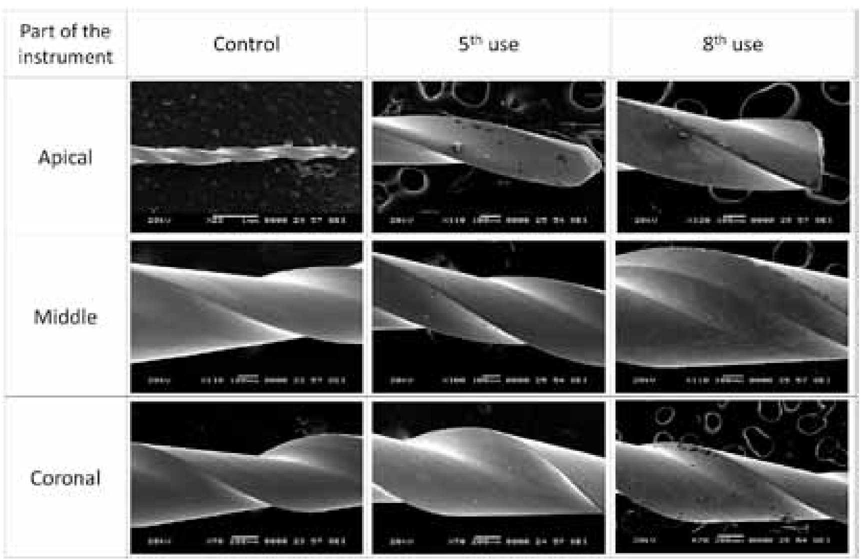


**Figure 2:** Scanning electron microscopic images showing surface defects on various parts of One shape

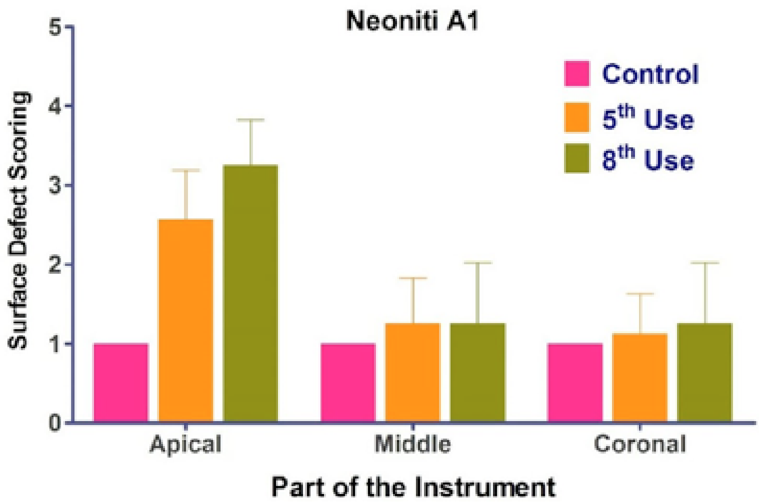


**Figure 3:** Surface defects of neoniti A1 at apical, middle and coronal thirds of the instrument for control, 5th use and after 8th use

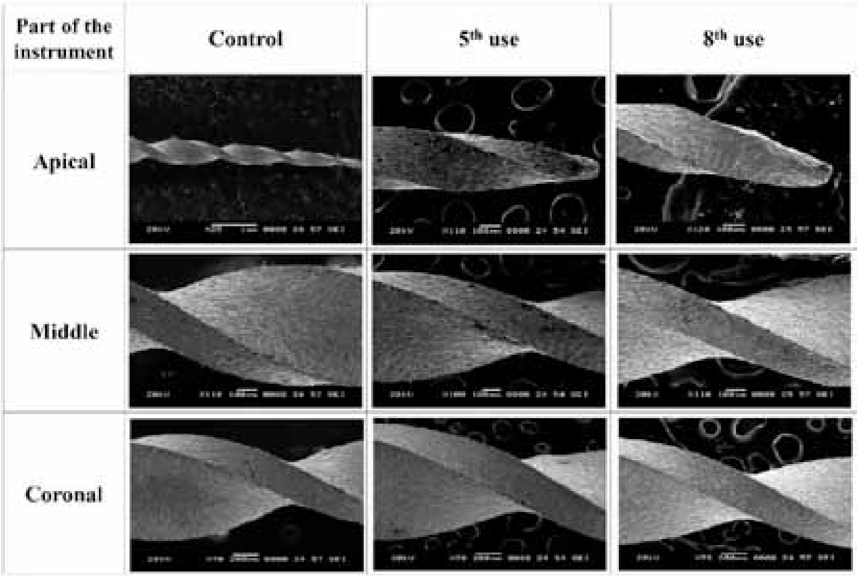


**Figure 4:** Scanning electron microscopic images showing surface defects on various parts of neoniti A1

# DISCUSSION

Various studies have evaluated for apical extrusion of debris, canal transportation, incidence of root microcracks and shaping ability of single file NiTi rotary systems.[23-26] However, studies evaluating the deterioration and number of uses of single file NiTi in curved canals are lacking. Hence, the present study was aimed at evaluating the surface defects of two commercially available single file rotary systems subjected to root canal instrumentation in curved canals for five times and eight times and compared with surface features of a new file.

Several techniques such as magnifying loupes, surgical operating microscope, stereomicroscope and atomic force microscopy have been used for evaluating the surface defects on the instrument.[9,27-29] However, SEM was used in the present study because it has been the accepted method for the accurate evaluation of deformation of instruments.[30]

SEM images of the unused instrument of group 1(One Shape) did not reveal any defect. However, in group 2 (neoniti A1) instruments showed some irregularity on the surface of the instrument. Group 1 instruments are subjected to electropolishing process during the manufacturing which results in a smoother surface. Further, lack of surface defects enhances longevity of the file during clinical use. Alapati *et al.* reported that, the presence of imperfections in new instruments may contribute to the deterioration of the instrument or can lead to larger defects.[31]

The results of the present study demonstrated that after instrumentation of 5 canals, group 2 instruments exhibited defects in the form of minor plastic deformation, blunting of cutting edge and these defects were seen more at apical third of the instrument The incidence of deformation or other forms of defects at the middle and coronal thirds of the instruments was less. This finding may be attributed to the high torsional loads when the tip of the instrument is forced into a narrow canal lumen.[32]

It was also shown that the number of surface defects increased with the number of uses inside the canal. This is in agreement with the studies that have observed increased number of defects on NiTi rotary instruments after prolonged use.[30,33] The increase in the defects on the surface of the instrument seem to be more with group 2 compared to group 1. This could be due to the rough surface pattern of group 2. EDM processing of the Group 2 file system results in a rough surface which leads to concentration of stresses during the canal instrumentation. However, no fracture of the instrument was observed during the study. This could be due to the increased fatigue resistance of the instruments subjected to EDM process as reported in the earlier investigations.[16,17]

In Group 1, it was observed that, the defects at the apical third increased after 5th and 8th use. However, the defect scoring at the apical third of Group 1 after 5th use was significantly less compared to Group 2. This suggests that Group 1 is more resistant to deformation compared to Group 2. Group 1 instrument has a variable cross-section design along with a long pitch, which may reduce the effect of file being screwed into the canal walls.[34] After 8th use, both groups showed significant increase in the defect scoring especially at the apical third of the instrument. The resistance to formation of defects on the instruments with usage depends on a variety of factors such as diameter, taper, amount of force applied and the number of uses. It is important to notice that one of the instrument fractured during use. The reason for the fracture of the instrument could be due to the continuous mode of rotation increasing the probability of binding the instrument tip into dentinal walls, exceeding the elastic limit of the metal thereby increasing the risk of fracture.[35]

These results indicate that the method used for the manufacturing of the file and the resultant surface texture significantly influences the efficiency and service life of the rotary file systems. Among the two systems evaluated in the present study, electro discharge machining method presented a rotary file system with significantly rough surface texture and the number of surface defects increased with the number of uses in the canal. However, the increase in the number of defects with electropolished system was less.

# CONCLUSION

Within the limitations of the present *in vitro* study, it can be concluded that electropolished file can be safely instrumented for five times compared to EDM processed files in curved root canals.

## MANUFACTURERS' DETAILS

- One Shape, Micro Mega, Besancon, France
- neoniti A1,Neolix,Chatres-la-Foret, France
- 0.2% sodium azide ,Millipore Sigma, St. Louis, MO, USA
- #4 round carbide bur, Brassler USA
- Endo-Z bur, Dentsply/Maillefer, Tulsa, OK
- Gates Glidden drills, Dentsply Tulsa dental specialties, Switzerland
- 10 K file ,Mani Inc., Tochigi Ken, Japan
- X-Smart motor, Dentsply Maillefer, Baillagues, Switzerland
- 28 gauge side vented needle,Vista Dental Inc,USA
- 2.5% NaOCl ,KMC Pharmacy, Manipal, India
- 17% EDTA ,Merck, Darmstadt, Germany
- JSM-6010 scanning electron microscopy,JEOL, Tokyo, Japan

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