

# Reciproc Endodontic File Surface Defects After Single Use: An SEM Analysis

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Received : 21-11-20  
Revised : 30-11-20  
Accepted : 22-12-20  
Published : 30-01-21

ABSTRACT

**Objective:** The aim of this investigation was to detect defects that may occur to Reciproc endodontic files after a single use. **Materials and Methods:** A sample of convenience of Reciproc files (VDW GmbH, Munich, Germany) that were used to prepare root canals of anterior or posterior teeth were collected. The files were divided equally into two groups: Group 1 (R25) files were used to prepare mesial root canals of 50 human permanent mandibular molars, and Group 2 (R40) included 50 files that were used to prepare permanent maxillary incisor teeth. Files were analyzed after single use by using a scanning electron microscope at X120 to detect changes in surface morphology. The data were statistically analyzed by using the  $\chi^2$  test, and statistical significance was set at  $P < 0.05$ . **Results:** A total of 96 Reciproc NiTi files were collected; of those, 67 (70%) were unaffected and 29 (30%) showed overall surface deformations. The types of deformation were blade disruption (22%), surface pitting (12%), and unwinding and tip deformation (1%). No microcracks were detected, and none of the studied files showed fracture. R40 was three times more likely to be deformed and showed blade disruption compared with R25 ( $P < 0.05$ ). **Conclusions:** Reciproc rotary NiTi files show high resistance to deformation after a single use. Blade disruption was the most frequent defect occurring in both the small and large files.

**KEYWORDS:** Flexibility, niti alloy, reciproc files, resistance, scanning electron microscopy, SEM

## INTRODUCTION

In recent years, several developments have taken place in the endodontics armamentarium, such as the introduction of multiple new NiTi rotary instruments.<sup>[1]</sup> This is due to the fact that NiTi rotary instruments save time and prevent procedural errors owing to their high flexibility; hence, they are considered the gold standard for shaping root canals.<sup>[1,2]</sup>

However, the use of these instruments in root canal preparation is associated with an increased incidence of their fracture inside the root canal, which may hinder proper cleaning and shaping of the root canal system.<sup>[3,4]</sup> The removal of fractured file segment is a difficult procedure that may result in a significant

decrease in residual dentin, which might negatively affect the prognosis of endodontic treatment.<sup>[5,6]</sup>

The most common cause of endodontic instrument fracture is cyclic fatigue.<sup>[7]</sup> This fatigue can be visualized as structural changes on the surface of the instrument after each use. This is possible while using files made of stainless steel; however, cyclic fatigue in NiTi files cannot be assessed clinically and structural changes in NiTi files can only be visualized by using more advanced techniques such as the stereomicroscope or scanning electron microscope.<sup>[8]</sup> Therefore, the single

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**How to cite this article:** Howait M. Reciproc endodontic file surface defects after single use: An SEM analysis. J Int Soc Prevent Communit Dent 2021;11:98-103.

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**Website:** www.jispcd.org

**DOI:** 10.4103/jispcd.JISPCD\_412\_20

use of NiTi files was recommended to prevent cyclic fatigue failure and instrument separation.<sup>[8-10]</sup>

NiTi files were first introduced in a sequence of files in different sizes to achieve the proper shaping of the root canal system. More recently, improved knowledge and manufacturing led to the reduction of the numbers of files used during the procedure and the introduction of NiTi files, as a single file system, to complete the shaping of the root canal system.<sup>[11-13]</sup>

Reciproc files (VDW GmbH, Munich, Germany) are made of the M-wire, which is an NiTi alloy created by using thermal processing and has been reported to be responsible for increasing flexibility and resistance to cyclic fatigue.<sup>[7,14,15]</sup> These files possess a reciprocating rotation motion that has been used with stainless steel instruments for many years.<sup>[16]</sup> The reciprocation involves alternating movement as the file rotates at a certain angle in the cutting direction and shortly after in the opposite direction over a much smaller angle.<sup>[7]</sup> Several studies have reported that NiTi rotary instruments exhibit higher cyclic fatigue when used in reciprocating movement compared with continuous rotation association.<sup>[14,16,17]</sup>

Thus far, there are limited data regarding the effect of single-use Reciproc files on its surface morphology. Therefore, the current study aimed at evaluating the changes in surface morphology of Reciproc endodontic files after a single use in anterior and posterior teeth by using scanning electron microscopy (SEM).

## MATERIALS AND METHODS

The design of the study was approved by the Research Ethics Committee of King Abdul Aziz University. Reciproc files (VDW GmbH, Munich, Germany) that were used to prepare root canals for anterior or posterior teeth were collected. The files were used according to the manufacturer's instructions and by one endodontist. Files were collected by a nonrandom convenience sample. The collected files were divided into two groups: Group 1 (R25) and Group 2 (R40). All files were used once.

### SAMPLE SIZE AND SELECTION

A priori power analysis was conducted by using G\*Power3 with a medium effect size ( $d = 0.30$ ), and an alpha of 0.10. to achieve a power of 0.90. The required sample to test the difference between the two groups using the chi-square test was 96.<sup>[18]</sup>

To standardize the sample, Group 1 consisted of R25 files that were used on the mesial roots of mandibular molars that were 18–20 mm in length. Group 2 consisted of R40 files that were used on maxillary anterior teeth

that were 20–24 mm in length. All selected teeth showed less than 30 degrees curvature measured by using the Schnieder technique<sup>[19]</sup> on the preoperative digital radiograph using a CCD sensor (CDR Elite, Schick Technologies, Long Island City, NY, USA) that were captured at 60kV, 7mA, and 0.06s using the parallel technique; they were analyzed by using the Schick digital radiograph software.

Reciproc files that were used to prepare roots longer than the specified lengths and/or roots with calcific changes and narrowing of the pulp chamber were excluded.

### ROOT CANAL INSTRUMENTATION

The access cavity was performed by using an endodontic access bur (size 1) diamond friction grip bur (Dentsply/Maillefer, Ballaigues, Switzerland), and straight-line access for the mesial wall was performed by using the Endo-Z stainless steel bur (Dentsply/Maillefer, Ballaigues, Switzerland). Working length was determined by using a size 10 K-type file (Dentsply/Maillefer, Ballaigues, Switzerland) and Electronic Apex locator (Root ZX II-J. Morita, Tokyo, Japan).

The anatomic diameter of the canals was standardized with size 15 and 20 K-type files (Dentsply/Maillefer, Ballaigues, Switzerland) for Groups 1 and 2, respectively. The root canal was prepared until the tip passively reached the full working length.

All the instruments were used in reciprocating motion according to the manufactural instructions by using a VDW silver motor (VDW GmbH, Munich, Germany) with contra-angle 6:1 reduction (Sirona, Germany).

During the preparation cycles, the instruments were used in passive pecking motion with a range of 2–3 mm. The instruments were wiped with an alcohol swab and clean gauze, and the root canals were irrigated with 5.25% NaOCl by using a 27-gauge side-vented needle until the working length was reached.

After instrumentation, the instruments were cleaned from debris by using an ultrasonic bath, autoclaved, and finally stored in polypropylene tubes in a dust-free environment before SEM analysis.

### SEM ANALYSIS

The Reciproc files were held by the shank by using utility wax in the SEM sample holder. Samples were scanned by using Quanta FEG 400 (FEI, USA). The images of the 4 mm distal end, which is the active part (area of interest), were processed by using the standard 120, 250, and 1000× magnifications. All SEM images were analyzed by two calibrated examiners who reviewed the images on a computer screen and recorded the

presence and type of deformations that occurred to the Reciproc endodontic files. The deformations included fracture, tip deformation, microcrack, unwinding, blade disruption, and surface pitting.

One trained investigator performed all the recordings. Cronbach's  $\alpha$  was used to test intraexaminer reliability. Data from 20 randomly selected files were analyzed twice with 1-week intervals by the same examiner. The results of the Cronbach's  $\alpha$  were  $>0.91$ , indicating excellent reliability.

#### STATISTICAL ANALYSIS

The data were analyzed by using frequency tables and  $\chi^2$  tests. The Statistical Package for Social Sciences (IBM SPSS Statistics for Macintosh, Version 26.0. Armonk, NY, USA) was used. The level of significance was set at a  $P$ -value of 0.05.

#### RESULTS

A total of 96 Reciproc NiTi files were collected: 50 for R25 and 46 for R40. Of the 96 files collected, 67 (70%) were unaffected [Figure 1] and 29 (30%) showed surface deformations. Of the 29 deformed files, 21 (22%) had blade disruption [Figure 2A and B], 11 (12%) had surface pitting [Figure 2C], and 1 (1%) had unwinding and tip deformation [Figure 2D]. No microcracks were detected, and none of the 96 files were fractured. Table 1 illustrates the frequencies of surface changes after clinical use.

A total of 10 R25 files out of 50 (20%) were deformed: six of them had blade disruption (12%), two had surface pitting (4%), one unwinding (2%), and one tip deformation (2%). A total of 19 R40 files were deformed out of 46 (41%): 14 of them had blade disruption (30%), and 4 of them had surface pitting (8%).

We tested the effect of size on the type of deformation by using the chi-square test, and we found that R40 was three times more likely to be deformed compared with the smaller file R25 ( $P < 0.05$ ). Also, R40 had three times the odds of blade disruption compared with R25 ( $P < 0.05$ ) [Table 2].

#### DISCUSSION

The current study aimed at detecting the defects that occur to Reciproc endodontic files after their single use. NiTi rotary instruments have been considered the gold standard in shaping root canals for many reasons, They save time and tend to make fewer procedural errors due to high flexibility.

The main findings are that about one-third of the files collected after single use had surface defects; these defects consisted mainly of blade disruption and pit deformation. There was a difference in affected files among R25 and R40 files (20% and 40%, respectively).

Similarly, Hanan *et al.* evaluated two groups of the reciprocating instruments and showed that WaveOne instruments had significantly more surface defects and deformation compared with Reciproc both before and after its use.<sup>[20]</sup> Their results are in line with our findings where the most common defect was blade disruption and grooves among the file structure.

Our results are also in agreement with studies that showed Reciproc files to have better physical properties than WaveOne.<sup>[3,14]</sup>

Shen *et al.* presented possible explanations for the instrument fatigue failure that include manufacturing defects, inadequate access, and design of the instrument.<sup>[10]</sup> Also, operator experience was found to be a determining factor in NiTi instrument fracture and/or deformation.<sup>[4,21,22]</sup>

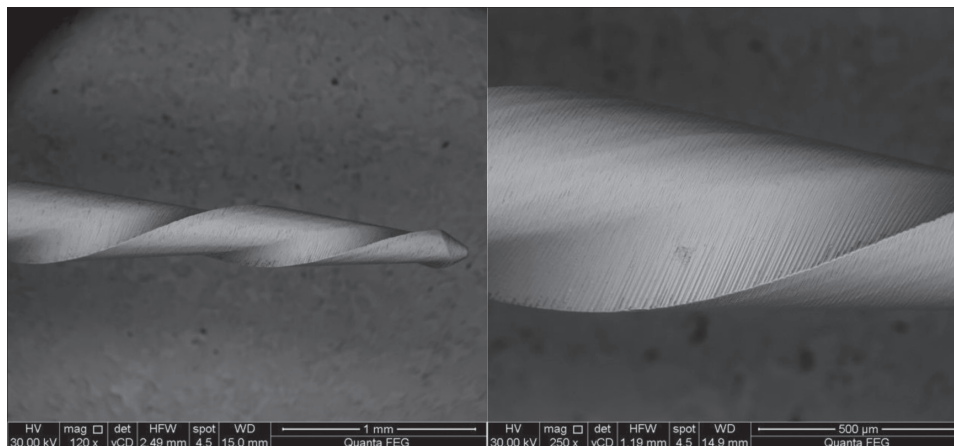
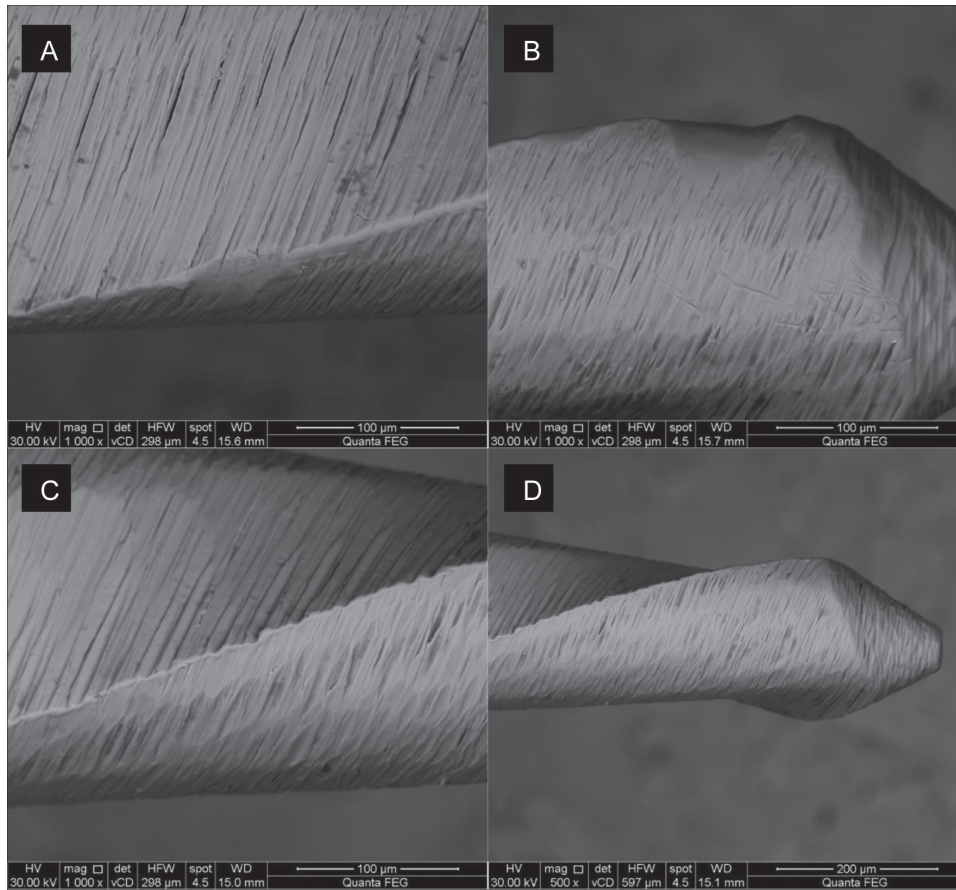


Figure 1: Representative SEM micrograph of unaffected Reciproc R25 (magnification 120–250 $\times$ )



**Figure 2:** Representative SEM micrograph of Reciproc R25 showing the following (A,B) Blade disruption (magnification 1000×), (C) surface pitting (magnification 1000×), (D) tip deformation (magnification 500×)

**Table 1: Types of deformations and frequency of surface changes after clinical use**

Variables		Frequency	Percent
Deformation	Yes	29	30.2
Fracture	No	96	100.0
Unwinding	Yes	1	1.0
Microcracks	No	96	100.0
Tip deformity	Yes	1	1.0
Blade disruption	Yes	21	21.9
Surface pitting	Yes	11	11.5

A clinical study evaluated the fracture incidence of Reciproc R25 after being used clinically.<sup>[4]</sup> The results found a decrease in the incidence of fracture with Reciproc R25 files in premolars and molars during instrumentation of root canals. Previous studies have also shown less torsional fatigue on the instrument, because reciprocating motion is likely to be associated with the more favorable mechanical behavior of NiTi instruments, as compared with continuous rotation.<sup>[7,14,16,23,24]</sup>

This feature of the Reciproc files suggests that these files are capable of operating for a longer period before they

fail.<sup>[25]</sup> According to Varela-Patino *et al.*, the capability of reciproc files to operate for longer periods appears to be a safe alternative as compared with the continuous rotary movement.<sup>[26]</sup>

Moreover, it has been reported that there are increased chances of unexpected fractures when instruments are used by less-experienced operators, despite the technological advancement in rotary and reciprocating techniques and instruments.<sup>[22]</sup> Still, instruments with reciprocating motion tend to lower the chance of root canal aberration and showed similar fracture resistance in the hands of less-experienced operators compared with continuous rotary motion.<sup>[27,28]</sup>

The current study showed insignificant deformation after a single use in both sizes. This agrees with a previous clinical study that showed a small percentage of fractures (0.91%) for Reciproc R25 and WaveOne reciprocating instruments compared with other rotary instruments.<sup>[4]</sup> Furthermore, Arens *et al.* showed that single-use instruments are advantageous, as they develop defects even when the new files are handed over to experienced endodontics.<sup>[29]</sup> Also, Shen *et al.* reported that single use of endodontic instruments is capable of

**Table 2: Effect of size changes on the frequency of surface defects**

Variables		File #		Odds	P value
		25	40		
Deformation	Yes	10(34.5%)	19(65.5%)	0.355	0.023
	No	40(59.7%)	27(40.3%)		
Fracture	No	50(52.1%)	46(47.9%)	0.335	0.335
Unwinding	No	49(51.6%)	46(48.4%)		
Microcracks	Yes	1(100.0%)	0(0.0%)	3.548	0.015
	No	50(52.1%)	46(47.9%)		
Tip deformation	No	49(51.6%)	46(48.4%)	0.080	0.080
	Yes	1(100.0%)	0(0.0%)		
Blade disruption	No	44(58.7%)	31(41.3%)	0.080	0.080
	Yes	6(28.6%)	15(71.4%)		
Surface pitting	No	47(55.3%)	38(44.7%)	0.080	0.080
	Yes	3(27.3%)	8(72.7%)		

reducing instrument fatigue and it also decreases the possibility of cross-contamination.<sup>[30]</sup>

Files are exposed to an increased level of stress during root canal shaping, which leads to the occurrence of cyclic and torsional fatigue.<sup>[31]</sup> Hence, cyclic fatigue studies using standard artificial canals may minimize the impact of other factors, including material types and anatomical characteristics, such as curvature angles and radii, of the natural root canal, which could present disadvantages of laboratory studies when comparing cyclic/torsional fatigue resistance.<sup>[7,15]</sup> These characteristics are likely to render the complexity of endodontic treatment that increases the importance of conducting clinical studies on the behavior of NiTi instruments. In our study, this variable was considered. Furthermore, our results showed a difference in the number of defects between different sizes of the Reciproc instruments R25 and R40. This disagrees with Shen *et al.*, who showed that wave one reciprocating files had more surface defects in the smaller files compared with the large ones.<sup>[10]</sup> This could be explained due to the fact that they used the larger files in sequence after the smaller ones and the difference in cross-section design of the Reciproc files compared with WaveOne files.

Further, Hanan *et al.* evaluated the changes that occur at 2 and 4 mm after instrumentation.<sup>[20]</sup> They did not find any significant difference. This was in agreement with our results.

One limitation to the current study is that we did not obtain SEM images of the files before instrumentation. Hanan *et al.* evaluated files before and after their use on extracted mandibular molars and found that there was a significant number of defects in both Reciproc and WaveOne files before their use; however, these defects had no significant effects on the mechanical

performance of the studied files.<sup>[19]</sup> In the current study, Reciproc was used on patients, and scanning and re-sterilizing them will damage their physical properties.

In conclusion, Reciproc rotary NiTi files show high resistance to deformation after a single use. The risk of Reciproc file fractures is low when these files are used once. Blade disruption was the most frequent defect occurring in both the small and large files. Further clinical studies are needed to correlate the types of surface defects with the different anatomical factors.

#### ACKNOWLEDGMENT

Not applicable.

#### FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

#### CONFLICTS OF INTEREST

There are no conflicts of interest.

#### AUTHORS' CONTRIBUTIONS

Concepts, Design, Definition of intellectual content, Literature search, Experimental studies, Data acquisition, Data analysis, Statistical analysis, Article preparation, and Article editing and review.

#### ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

Not applicable.

#### PATIENT DECLARATION OF CONSENT

Not applicable.

#### DATA AVAILABILITY STATEMENT

Not applicable.

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