Restor Dent Endod. 2021 Nov;46(4):e49
https://doi.org/10.5395/rde.2021.46.e49
pISSN 2234-7658·eISSN 2234-7666

Restorative Dentistry & Endodontics RDE

Research Article

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Fracture incidence of Reciproc instruments during root canal retreatment performed by postgraduate students: a cross-sectional retrospective clinical study

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ABSTRACT

Objectives: To evaluate the fracture incidence of Reciproc R25 instruments (VDW) used during non-surgical root canal retreatments performed by students in a postgraduate endodontic program.

Materials and Methods: From the analysis of clinical record cards and periapical radiographs of root canal retreatments performed by postgraduate students using the Reciproc R25, a total of 1,016 teeth (2,544 root canals) were selected. The instruments were discarded after a single use. The general incidence of instrument fractures and its frequency was analyzed considering the group of teeth and the root thirds where the fractures occurred. Statistical analysis was performed using the χ^2 test ($p < 0.01$).

Results: Seven instruments were separated during the procedures. The percentage of fracture in relation to the number of instrumented canals was 0.27% and 0.68% in relation to the number of instrumented teeth. Four fractures occurred in maxillary molars, 1 in a mandibular molar, 1 in a mandibular premolar and 1 in a maxillary incisor. A greater number of fractures was observed in molars when compared with the number of fractures observed in the other dental groups ($p < 0.01$). Considering all of the instrument fractures, 71.43% were located in the apical third and 28.57% in the middle third ($p < 0.01$). One instrument fragment was removed, one bypassed, while in 5 cases, the instrument fragment remained inside the root canal.

Conclusions: The use of Reciproc R25 instruments in root canal retreatments carried out by postgraduate students was associated with a low incidence of fractures.

Keywords: Fracture; Nickel-titanium files; Reciprocating motion; Retreatment

OPEN ACCESS

Received: Jan 8, 2021
Revised: Feb 18, 2021
Accepted: Feb 21, 2021

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Conflict of Interest
No potential conflict of interest relevant to this article was reported.

Author Contributions
Conceptualization: Ruivo LM, Rios MA, Vilela AM, Bueno CES; Formal analysis: Martin AS; Investigation: Ruivo LM, Pelegrine RA, Kato AS; Methodology: Ruivo LM, Pelegrine RA, Rios MA, Vilela AM, Bueno CES; Project administration: Bueno CES; Supervision: Bueno CES; Writing - original draft: Barbosa AFA; Writing - review & editing: Silva EJNL.

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INTRODUCTION

Despite the improvement of the technology used in root canal treatment, failures can occur. Most failures are usually related to the survival of microorganisms within the root canal systems, and in such cases, root canal reintervention is indicated as an attempt to correct flaws of the initial treatment [1,2]. During retreatment procedures, it is important to properly remove the filling materials and gain access to the apical foramen to make cleaning, shaping and disinfection procedures of the root canal system easier [3,4].

Several instruments were developed in order to perform the retreatment procedures [5-7]; however, despite not being originally designed for retreatment, the reciprocating movement could potentially be beneficial for the effective and safe removal of root filling material as confirmed by previous studies [8-10]. In addition, the idea of a reduced number of nickel-titanium (NiTi) instruments to remove filling materials is indeed appealing due to its safety and technique simplification. From an educational point of view, these aspects may result in a shorter and straighter learning curve, favoring professionals with little experience and allowing good results to be achieved [11].

Reciprocating kinematics *per se* has been linked to an extended lifespan of instruments when compared to continuous rotary motion [12]. Reciprocating kinematics relives the stress of the instrument by alternating counterclockwise and clockwise movements, explaining the greater fatigue resistance of instruments activated under this motion. Furthermore, the reciprocating motion reduces taper lock and thus, the overall risk of torsion fracture, as the instrument does not perform continuous full-360º turns [13]. As a direct result, clinical studies show reduced rates of kinematic fracture when these instruments were used during root canal treatment and retreatment [14-17]. Reciprocating systems have been considered to be safe and present a low incidence of instrument fractures, even when the root canal treatment was performed by undergraduate students [18]. However, an assessment of fracture incidence during root canal retreatment cases conducted by less experienced professionals, such as postgraduate students is currently not available in literature. Therefore, the aim of the present study was to evaluate the fracture incidence of Reciproc R25 instruments (VDW, Munich, Germany) in root canal retreatments performed by students from a post graduate program in endodontics.

MATERIALS AND METHODS

Sample calculation

This study was approved by the local ethics committee (approval No. 1.563.723). A sample size calculation was performed using the χ^2 test. Based on degrees of freedom 1, $\alpha = 0.01$ and 95% power, a total of 726 samples were indicated as the ideal size required for observing significant differences. Therefore, a total of 1,016 teeth matching the inclusion criteria were obtained from medical records. The number of teeth and the number of root canals used in this study are shown in **Table 1**.

Table 1. Number of total teeth and root canals used in this study

Variables	Incisors		Canines		Premolars		Molars	
	No. of teeth	No. of root canals	No. of teeth	No. of root canals	No. of teeth	No. of root canals	No. of teeth	No. of root canals
Maxillary	140	140	26	26	171	342	194	747
Mandibular	76	76	15	15	115	138	279	1,060

Retreatment procedure

The root canal retreatment was performed in incisors, canines, premolars and molars. The reintervention with the instrument Reciproc R25 (VDW) was performed with "RECIPROC ALL" movement on a VDW Silver motor (VDW) according to the instructions provided by the manufacturer. Each instrument was used for a single tooth.

All root canal retreatments were performed by 24 postgraduate students from July 2014 until March 2017. The teeth were selected from patients with ages between 18 to 60 years old, with completely formed apices and curvatures under 45° [19].

The same protocol was adopted for every procedure, and it is as follows [17]: First off infiltrative anesthesia would be administered, followed by removal of the previous restoration with the aid of a high-speed spherical diamond bur, with sizes compatible with the volume of each pulp chamber; once the form of convenience was established, the isolation was performed and the access was finished. Afterwards, the top coronal part of the root filling material was removed by Gates Glidden or ultrasonic tips, followed by the Reciproc R25 instrument, used with three "in-and-out" movements with slight apical pressure. The instrument was, then, removed and cleaned with a sterile gauze; the root canal was irrigated with 2.5% sodium hypochlorite (NaOCl). These steps were repeated until apical patency was achieved with a size 10 K-file (Dentsply-Sirona, Baillagues, Switzerland). The working length (WL) was established at 1 mm short of the apical foramen using a Romiapex A15 electronic foraminal locator (Romidan, Kiryat Ono, Israel). The apical third of the root canal was prepared, repeating the same movement until the R25 instrument reached the WL. After 3 movements, the instrument was removed from the canal, cleaned with a sterile gauze and reintroduced. A total of 20 ml of 2.5% NaOCl were used for each tooth. A size 10 K-file was used to verify and maintain patency every time an instrument was removed from the root canal. In the retreatment cases in which the WL could not be reached, Reciproc R25 instruments were used up until where the hand file would reach. Instruments were used until no gutta-percha residues were observed neither on the instrument nor within the root canal by means of an operating microscope with a 16× magnification (Alliance Microscopia, São Paulo, Brazil). In all cases, a lateral brushing cutting action was performed to relocate the orifices and to prepare around the entire canal circumference. When necessary, R40 and/or R50 instruments were used to complement the removal of gutta-percha.

After root canal preparation, irrigation using ultrasonic activation with 2.5% NaOCl and 17% ethylenediaminetetraacetic acid was performed and the root canals were dried and filled, either in the same or in a subsequent visit. A database of all cases was maintained including data on instrument fracture, such as tooth, canal involved and resolution of the case, that is, instrument removed, bypassed or remained inside the root canal.

Statistical analysis

The risk of fracture was calculated according to tooth types and root canal thirds and compared using χ^2 test at a 5% significance level.

RESULTS

A total of 1,016 retreatments involving 2,544 root canals were performed. The details of the samples used are shown in **Table 1**.

A total of 7 Reciproc R25 instruments were fractured during root canal retreatments, which represents 0.68% of the number of teeth and 0.27% of the number of root canals treated. Four fractures occurred in maxillary molars, 1 in a mandibular molar, 1 in a mandibular premolar and 1 in a maxillary incisor (**Figure 1**). A greater number of fractures was observed in molars when compared with the number of fractures observed in the other dental groups ($p < 0.01$). Considering all of the instrument fractures, 71.43% were located in the apical third and 28.57% in the middle third ($p < 0.01$). One instrument fragment was removed and one bypassed, while in 5 cases the instrument fragment remained inside the root canal. These results are available in **Table 2**. Thirteen R40 instruments and 7 R50 instruments were used to complement the removal of gutta-percha. No fracture was registered for the Reciproc R40 and R50 instruments.

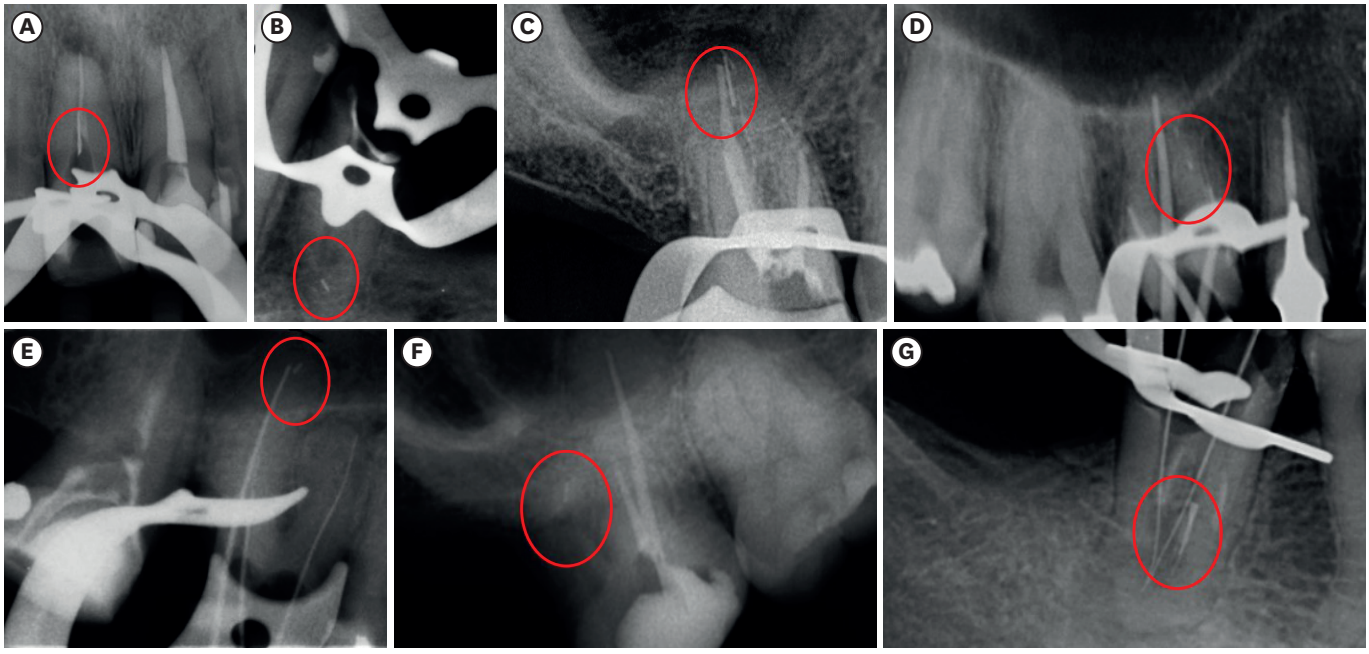

Figure 1. Radiograph images of the 7 Reciproc R25 instruments fractured during root canal retreatments in each tooth and respective root canal. A maxillary central incisor with a fragment of fractured instrument in its middle third (A); a mandibular second premolar with a fragment of fractured instrument in the apical third of its vestibular root canal (B); a maxillary second molar with a fragment of fractured instrument in the apical third of its palatal root canal (C); a maxillary first molar with a fragment of fractured instrument in the apical third of its mesiobuccal root canal (D); a maxillary first molar with a fragment of fractured instrument in the apical third of its palatal root canal (E); a maxillary second molar with a fragment of fractured instrument in the apical third of its distobuccal root canal (F); a mandibular first molar with a fragment of fractured instrument in the middle third of its mesiobuccal root canal (G).

Table 2. Number of fractures in each group of teeth according to the respective tooth and root canal, fracture position, fragment size, and fragment management

Group of teeth	No. of fractures	Tooth	Root canal	Fracture position	Fragment size	Fragment management
Incisor	1	11	-	Middle third	6 mm	Removed
Premolar	1	35	Vestibular	Apical third	2 mm	NRNB
Maxillary molar	4	16	Palatal	Apical third	5 mm	NRNB
		16	Mesiobuccal	Apical third	1 mm	NRNB
		16	Palatal	Apical third	2 mm	NRNB
		17	Distobuccal	Apical third	2 mm	NRNB
Mandibular molar	1	46	Mesiobuccal	Middle third	4 mm	Bypassed

DB, distobuccal; MB, mesiobuccal; P, palatal. NRNB, neither removed nor bypassed.

https://doi.org/10.5395/rde.2021.46.e49

DISCUSSION

The success of root canal retreatment is directly related to the maximum removal of root filling materials, since these remnants may contain necrotic tissues and microorganisms responsible for the failure of the original endodontic treatment [1,2]. The use of instruments with reciprocating movement during the retreatment procedures is well established in literature, as these instruments require less time to complete the removal of filling material while being just as efficient as the other systems but with smaller fracture rates [8,9,20,21]. The majority of the studies performed were *in vitro* and, to this day, only one clinical study was performed to assess the fracture incidence of Reciproc instruments during root canal retreatment [17]. However, the mentioned study evaluated 757 retreatment cases, while in this study 1,016 cases were evaluated.

All the dental groups retreated with the Reciproc R25 instrument were included in this study, in order to have a wider and more varied pool of samples. In addition, while some studies regarding endodontic treatment, assessed the total number of teeth in which the instrument fractured occurred, this study, as others, also evaluated the total number of instrumented root canals [14,16,17,22,23].

The fracture incidence of reciprocating instruments in relation to the number of root canals, and the number of teeth was 0.27% and 0.68%, respectively. These results might be related to the physical and mechanical properties of the instruments manufactured with the M-Wire alloy. The considerable resistance to cyclic fatigue of these instruments has been reported by several studies [15,22,24-26]. Similar results were found by Cunha *et al.* [14] and Shen *et al.* [16] during root canal treatment, and Plotino *et al.* [17] during root canal treatment and retreatment. However, the studies of Cunha *et al.* [14] and Plotino *et al.* [17] were performed by specialists in endodontics, whereas in Shen *et al.* [16], the teeth were treated by graduate and postgraduate students. In this study, the teeth were retreated only by postgraduate students previously trained in preclinical laboratories.

Previous clinical studies have assessed the influence of operator training on the incidence of instrument fractures in cases of endodontic treatment when using manual and motor-driven instruments [14-17,22,23,25,27-29]. The present retrospective clinical study showed a reduced percentage of fractures in relation to the number of root canals (0.27%) using Reciproc R25 instruments in retreatment cases, regardless of the fact that it was performed by postgraduate students. This might indicate that reciprocating kinematics also amounts to a shorter learning curve in endodontics retreatment, as reported by Muñoz *et al.* [30]. That may be proven to be even more so if one considers previous studies in which continuous rotation instruments were used and the experience of the operator was a determining factor in the quality of the instrumentation of the teeth and in the fracture or deformation of NITI instruments [24,25].

A greater number of instrument fractures was observed in molars when compared with the number of fractures observed in the other groups of teeth, a fact corroborated by previous studies [27,29,31]. This finding is related to the anatomic characteristics of these teeth, which imposed greater difficulties during instrumentation, predisposing a higher incidence of instrument fractures. Besides that, it must be considered that anterior and posterior teeth have a different number of root canals, with the former usually presenting a single root canal, whereas the latter presents multiple. That means that a single instrument is used

in multiple root canals for each posterior tooth, while each instrument is used in a single root canal for anterior teeth. The fractures occurred during the preparation of middle and apical root thirds. These results are corroborated by the study of Cheung [32], according to which the curvature between the middle and the apical thirds of the root canals of molars are the sections most prone to fractures. In this study, the fractures occurred mostly in the apical third, as a result of their anatomy, smaller dimensions and the eventual presence of curvatures [14,33,34].

The results obtained in the present study, the studies of Muñoz *et al.* [30] and Shen *et al.* [16] showed a reduced rate of reciprocating instruments fracture when used by postgraduate students. The fact that students with limited experience are being able to safely use reciprocating instruments suggests that the resort to these kinds of instruments can shorten the learning process and improve the results of inexperienced professionals.

CONCLUSIONS

Based on the results of this retrospective clinical study, Reciproc R25 showed a low fracture incidence during root canal retreatment, despite it being performed by students in a postgraduate program of endodontics.

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