International Journal of Medical and Health Research
ISSN: 2454-9142
Received: 10-08-2020; Accepted: 25-08-2020; Published: 11-09-2020
www.medicalsciencejournal.com
Volume 6; Issue 9; 2020; Page No. 51-53

A cross-sectional retrospective study of fracture incidence of instruments from a reciprocating single file system by students in an endodontic graduate programme

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Abstract
Aim: To assess the fracture incidence of instruments from single -file reciprocating systems when used by students in an endodontic graduate programme.
Methodology: Dental records and periapical radiographs of patients treated by students on an endodontic graduate programme using reciprocating systems were assessed. Information on tooth type, number of treated root canals, number of fractured instruments, fragment size, and angle, radius, arc length and position of root canal curvature where fractures occurred were tabulated for analysis. The risk of fracture was calculated for each group of teeth, root canal and root thirds, while the incidence of fractures reported for the reciprocating systems was compared using the chi -square test at 5% significance level.
Results: Overall, 2,056 root canals (826 teeth) from 810 patients were included. The incidence of fractured files from single -file reciprocating systems in relation to number of instrumented canals was 0.92%. Fracture rates of 0.84% and 0.93% were found in 830 and 1,226 root canals instrumented with Wave One and Reciproc systems, respectively. No significant differences were observed between the systems. The highest fracture rate was 52.6% in the mesiobuccal root of mandibular molars. The central angle, radius and arc length of the curvature of root canals where the instruments fractured ranged from 58° to 84°, from 1.7 to 7.2 mm and from 2.4 to 7.6 mm, respectively
Conclusion: The use of Wave One and Reciproc single -file reciprocating systems in an endodontics graduate programme were associated with a low incidence of instrument fractures.

Keywords: fracture incidence, graduate endodontic programme, reuse

Introduction
Although automated endodontic instruments have great flexibility, they may fracture during root canal preparation [1, 2], which in turn may influence the outcome of root canal treatment [3]. The fracture of files involves many factors such as experience of the operator, design and manufacturing process of the instrument, instrumentation technique and root canal configuration [2, 4, 6]. Several clinical studies have reported a low incidence of fracture in single -file reciprocating systems when instrumentation is performed by experienced endodontists [7, 10]. A comparison between experienced endodontists and students of a graduate endodontic programme was conducted by Shen *et al*. [11], who reported a low risk of fracture in both groups when Wave One files were used. Considering that there are no studies evaluating the fracture incidence of reused single -file reciprocating systems by students, the purpose of this study was to assess the fracture incidence of single file reciprocating instruments during clinical root canal treatment performed by students in an endodontic graduate programme.

Materials and Methods
The study was approved by the local research ethics committee and follows the recommendations of the STROBE statement for observational epidemiology studies [12]. This cross -sectional retrospective study used dental records and radiographs of patients treated by 24 students of an endodontic graduate programme within a 24 -month period. All the patients approved the use of their dental records for study, but only those treated with reciprocating systems were selected. All the students included in the study had an initial experience with single -file reciprocating systems, since they received pre -clinical training that consisted of instrumentation of four extracted teeth of each tooth type using WaveOne (Dentsply Sirona, Ballaigues, Switzerland) and Reciproc (VDW GmbH, Munich, Germany) systems. All students were trained to access root canals following a straight line to the orifices, and perform an initial glide path using a size 15 K -file. Next, the coronal third of the root canal was prepared using a reciprocating file with three pecking motions and subsequent irrigation with 2.5% sodium hypochlorite.
The middle third was prepared in the same manner and the working length was established 1 mm short of the apical foramen before preparation of the apical third according to the previous steps. After each use, the students checked the instrument at 8X magnification, and in the case of any plastic deformation, the file was discarded. In the absence of alterations, the files were washed with detergent and then submitted to ultrasound before being sterilised in an autoclave for re -use in a maximum of six root canals. Before re -use of the file, the heat -expanded ring was carefully removed using a sterile scalpel blade. If the handle was affected during ring removal, the instrument was discarded.
Data on type of tooth, number of treated root canals, type of reciprocating single file used and number of fractured files

were tabulated for incidence analysis. Periapical radiographs of the root canals with fractured instrument were evaluated for size and localisation of the fragment and for determination of the angle and radius of curvature of the root canal according to the method proposed by Pruett *et al*. [13]. Additionally, the arc length and the position of root canal curvature where the instrument fractured were recorded.

The risk of fracture was calculated according to tooth type, root canal and root thirds, while the incidence of fracture in the WaveOne and Reciproc systems was compared using chi -square test at a 5% significance level.

Results

A total of 966 root canal treatments involving 920 patients were performed during a 24 -month period, with 140 teeth being excluded because other conventional rotary systems had been used for their treatment. Therefore, a total of 2,056 root canals in 826 teeth (153 anterior teeth, 183 premolars, 490 molars) were instrumented using single -file reciprocating systems. In the study period, no instrument was discarded with plastic deformation or alteration of the handle, but 11 and 8 files fractured in the first and the subsequent 12 -month period, respectively. No significant differences were observed between both periods of study (x 2 =0.95, p=0.3297).

As for the localisation of the fragment inside the root canal, 74% of the fractures occurred in the apical third and 26% in the middle third. The length of the fractured segments ranged from 2 to 6 mm, with a greatest incidence of 5 -mm fragments (47%). The central angle, radius and arc length of the curvature of root canals where the instruments fractured ranged from 58° to 84°, from 1.7 to 7.2 mm and from 2.4 to 7.6 mm, respectively (Table 1).

Table 1: Fracture instrument data.

System	File	Tooth number	Root canal	Fracture location third	Root canal curvature Fractured segments length ⏐ Angle ⏐ Radius ⏐ Arc length ⏐ Arc location ⏐				
Wave One	Small	36	ML	Middle	5mm	83^0	3.8mm	5.5mm	Middle
		14	B	Apical	3mm	68^0	2.2mm	2.6mm	Apical
	Primary	27	MB	Apical	2mm	64^0	1.7mm	1.9mm	Apical
		46	ML	Apical	5mm	62^0	6.7mm	7.2mm	Middle
		38	ML	Apical	5mm	68^0	4.4mm	5.2mm	Middle
		46	MB	Apical	3mm	70^0	2.2mm	2.7mm	Apical
		46	MB	Apical	3mm	66^0	2.4mm	2.8mm	Apical
Reciproc	R25	16	MB	Apical	5mm	84^0	2.4mm	3.5mm	Apical
		27	DB	Apical	5mm	68^0	3.2mm	3.8mm	Apical
		46	MB	Apical	5mm	64^0	5.4mm	6mm	Middle
		47	MB	Middle	5mm	72^0	4.7mm	5.9mm	Middle
		47	MB	Apical	2mm	60^0	2.3mm	2.4mm	Apical
		47	MB	Apical	3mm	80^0	3.6mm	5mm	Apical
	R40	46	DB	Apical	3mm	77^0	2mm	2.7mm	Apical
		46	DL	Apical	5mm	66^0	4.3mm	5mm	Apical

Discussion

The alloy for endodontic instruments, as well as their design and instrumentation technique, has been modified in order to make them more resistant to fracture [11, 14, 16]. However, fracture of automated Ni -Ti instruments might occur during root canal preparation unexpectedly [5, 7, 10, 17]. The results of the present cross -sectional retrospective study have shown a low number of fractured instruments in two single -file reciprocating systems when they were used by students of endodontic graduate programme in up to six root canals.

Root canal preparation using a single Ni -Ti instrument simplifies the endodontic treatment [15]. Initially, the students had no experience with reciprocating systems, and for this reason they understood pre -clinical training using this technique for 128 hours on extracted teeth. Nevertheless, no significant differences were observed in fracture incidence of files in treatments performed by the first cohort and the second cohort.

The fracture incidences of files for root canals and teeth treated were 0.92% and 2.3%, respectively. The number of root canals varies according to type of teeth, for this reason the fracture incidence should consider the number of root canals as it is more accurate than considering the number of teeth treated [18].

The fracture incidence of single -file reciprocating systems when used by endodontists ranges from 0.13% to 0.21% [7, 8] when used only once, and up to 0.26% when re -used [10]. A greatest fracture incidence in the present study may be explained by the clinician's skill level and it has been some findings demonstrated that clinical experience is a factor that can influence the incidence of fractured instruments [4, 5].

In the present study, all root canal treatments were performed by re -using sterilised files for a maximum of six root canals, thus demonstrating the possibility of multiple use of reciprocating single files with a low fracture rate. This approach is comparable to studies investigating the single use of these endodontic systems by undergraduate students [9] and their re -use by experienced endodontists [10].

Because of the limited information available for cross -sectional retrospective studies using a database, it suggests that prospective clinical randomised studies should be conducted to further investigate the findings of this study. To conclude the use of WaveOne and Reciproc systems in an endodontic graduate programme were associated with low incidence of fracture for both systems.

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