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ORIGINAL ARTICLE

Incidence of ProTaper Universal System Instrument Fractures - A Retrospective Clinical Study

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ABSTRACT

Objective: The aim of this retrospective clinical study was to evaluate the incidence of ProTaper Universal System instrument fractures, associated with observation of the arch, group of teeth, and root thirds in which these fractures occurred.

Methods: From analysis of charts, clinical record cards and radiographs of endodontic treatments performed by postgraduate students using the ProTaper Universal System at a reference center, a total of 1031 teeth and 2355 canals were analyzed. The general incidence of instrument fractures and their frequency, considering the group of teeth, arch and root thirds, were cataloged and the data obtained were statistically analyzed (Exact Fischer test, with level of significance of 1%).

Results: The general percentage of fractures, considering the number of teeth and number of root canals evaluated was 4.4% and 1.9%, respectively. Instrument fractures occurred more frequently in the mandibular first (8.8%) and second (9.6%) molars, however, without statistically significant difference between them (p=0.81). In the first and second maxillary molars, the incidence of fracture was 4.7% and 5.1%, respectively, also without significant difference (p=0.81). Considering the dental arches (maxillary and mandibular), the fractures occurred with significantly higher frequency in the mandibular arch (66.7%), in comparison with the maxillary arch (33.3%) (p<0.01). A significantly higher percentage of fractures occurred in the apical third (84.4%) compared with the middle third (15.6%) (p<0.01).

Conclusion: The general percentage of fractures, considering the number of teeth and number of root canals evaluated was 4.4% and 1.9%, respectively. However, the arch (mandibular) and root third (apical) had a significant effect on the incidence of instrument fractures.

Keywords: Fracture, endodontic files, nickel-titanium instruments, ProTaper universal

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HIGHLIGHTS

- The aim of this retrospective clinical study was to evaluate the incidence of ProTaper Universal System instrument fractures, associated with observation of the arch, group of teeth, and root thirds in which these fractures occurred.
- Instrument fractures occurred more frequently in the mandibular first (8.8%) and second (9.6%) molars, however, without statistically significant difference between them (p=0.81). In the first and second maxillary molars, the incidence of fracture was 4.7% and 5.1%, respectively, also without significant difference (p=0.81).
- The fractures occurred with significantly higher frequency in the mandibular arch (66.7%), in comparison with the maxillary arch (33.3%) (p<0.01).
- A significantly higher percentage of fractures occurred in the apical third (84.4%) compared with the middle third (15.6%) (p<0.01).
- The general percentage of fractures, considering the number of teeth and number of root canals evaluated was 4.4% and 1.9%, respectively. However, the arch (mandibular) and root third (apical) had a significant effect on the incidence of these fractures.

INTRODUCTION

The advent of nickel titanium (NiTi) instruments has significantly improved mechanical preparation of root canal systems, minimizing procedural errors such as step formation and apical transportation (1, 2). Nevertheless, fracture continues to be one of the main concerns associated with the use of this type of instrument (3, 4).

NiTi instruments used in continuous rotation are subjected to two types of antagonistic forces. The portion of the instrument that acts on the external part of the curvature undergoes stress, while the portion that acts on the internal part of the curvature undergoes compression. At each rotation a complete cycle of tension and compression occurs, leading to fracture of the instrument due to cyclic fatigue. For fracture by torsion to occur, the tip of the in-

strument must be immobilized and a rotational force must continue to be applied to the instrument. When the plastic limit of the instrument is broken by virtue of the application of force, fracture occurs (3).

Some factors, such as the instrument design, may seriously influence the mechanism of fracture by torsion, since the cutting blades act as stress concentrators that promote structural defects (3). On the other hand, instruments that have radial surfaces tend to have greater mechanical strength (5).

The ProTaper Universal System (Dentsply/Maillefer, Ballaigues, Switzerland) is still one of the automated systems most used for root canal preparations (6, 7). Due to its triangular cross-section and progressive taper, the rotational friction between the blades of the instrument and dentine is reduced, thus minimizing fatigue, without compromising its cutting capacity (8, 9). However, there are few studies that have clinically evaluated the incidence of fracture of the instruments of this system (10, 11).

Therefore, the aim of this retrospective clinical study was to evaluate the incidence of ProTaper Universal System instrument fractures, associated with observation of the arch, group of teeth, and root thirds in which these fractures occurred. The null hypothesis tested was that these factors would not interfere in increasing the incidence of fracture of the instruments of this system.

MATERIALS AND METHODS

Clinical and Data Collection Procedures

After approval from the Clinical Research Ethics Committee of the Paranaense University (CAAE: 58036016.4.0000.0109), this retrospective clinical study was conducted by means of analyzing charts, clinical record cards and radiographs of patients submitted to endodontic treatments performed by postgraduate students of the second year of the Specialization Course in Endodontics of FUNORTE/SOEBRÁS (Florianópolis Nucleus), Florianópolis, Santa Catarina, Brazil, between March 2009 and March 2014. All students received exactly the same laboratory training prior to performing treatments on patients. Therefore, all the patients who participated in this study, or their legal guardians, signed the Term of Free and Informed Consent, in which they authorized the treatment to be performed.

To standardize the sample, the teeth selected were those that had been submitted to identical biomechanical preparation protocols, using the ProTaper Universal System (Dentsply/Maillefer) after anesthesia and placement of the rubber dam: 1) coronal access; 2) localization and initial preparation of the root canal entrances with instrument SX; 3) preparation of the cervical and middle third(s) with Gates Glidden Drills (Dentsply/Maillefer); 4) determination of the working length(s) with the use of an electronic foraminal locator; 5) manual glide path creation with the Flexo-file #15 (Dentsply/Maillefer) instrument up to the working length; 6) use of instruments S1 and S2; and 7) conclusion of the preparation by means of using instruments F1, F2, F3, F4 or F5, depending on the anatomical diameter of the canal. Canals with anatomical diameters of 8 and 10, 15 and 20, 25 and 30, and above to 30 were instrumented until F2, F3, F4 and F5 files, respectively. At each change of instrument, 2.5 mL of sodium hypochlorite solution (Fórmula & Ação, São Paulo, SP, Brazil) was used in the concentrations of 2.5% for cases of biopulpectomy, and 5.25% for the cases of pulp necrosis. As the final irrigation protocol, 3 mL of 17% EDTA (Biodinâmica, Ibiporã, PR, Brazil) was applied for 3 minutes within the root canals to remove the residual smear layer. Afterwards, the canals were filled by the single cone technique, with AH Plus Cement (Dentsply-DeTrey, Konstanz, Germany).

Engine-driven files were used adapted to an electric motor (X-Smart, Dentsply-Maillefer) with a 16:1 reduction handpiece using recommended torques (1.5 Ncm for S2; 2.0 Ncm for F1; 3.0 Ncm for SX, S1, F2, and F3; respectively) and rotation speed (250 rpm). Instruments were discarded and replaced when they were worn, fractured, or with any other discernible defects observed by using a loupe at 4x magnification (EyeMag Pro S; Carl Zeiss do Brasil Ltda., São Paulo, SP, Brazil). Each instrument was used for a maximum of 4 times (10). Instruments that had been used in very complex or severely curved canals were discarded at once (11).

In case of instrument fractures, the occurrence was noted on the patient's clinical record chart, followed by radiographic exam for proof and localization of the fractured instrument (canal and root third). Based on the data collected, 1031 teeth were selected, totaling 2355 root canals.

Statistical Analysis

The general incidence of instrument fractures and their frequency, considering the group of teeth, arch and root thirds, were cataloged and the data obtained were statistically analyzed (Exact Fischer test, with level of significance of 1%) by using the Minitab 17.0 Software (Minitab Inc., State College Philadelphia, PA, USA).

RESULTS

The total number of teeth and root canals evaluated and the incidence of fractures are summarized in Table 1.

The general percentage of fractures, considering the number of teeth and number of root canals may be visualized in Table 2. Instrument fractures occurred more frequently in the first (8.8%) and second (9.6%) mandibular molars, however, without statistically significant difference between them (p=0.81).

In the first and second maxillary molars, the incidence of fracture was 4.7% and 5.1%, respectively, also without significant difference (p=0.81) (Table 3). Considering the dental arches (maxillary and mandibular), the fractures occurred with significantly higher frequency in the mandibular arch (66.7%), in comparison with the maxillary arch (33.3%) (p<0.01).

A significantly higher percentage of fractures occurred in the apical third (84.4%) compared with the middle third (15.6%) (p<0.01). Comparison of the values may be seen in Table 4.

TABLE 1. Total number of teeth and root canals evaluated, and incidence of fractures

Teeth	Quantity of canals	Maxillary arch			Mandibular arch		
		No. of teeth	No. of canals	No. of fractures	No. of teeth	No. of canals	No. of fractures
Central incisors	1	51	51	0	15	15	0
Lateral incisors	1	49	49	0	12	12	0
	2	0	0	0	1	2	0
Canines	1	36	36	0	13	13	0
	2	0	0	0	2	4	0
First premolars	1	4	4	0	34	34	0
	2	71	142	1	2	4	0
Second premolars	1	45	45	1	56	56	0
	2	52	104	1	2	4	0
First molars	1	2	2	0	1	1	0
	2	3	6	0	7	14	1
	3	167	501	7	152	456	13
	4	18	72	2	45	180	4
Second molars	1	3	3	0	1	1	0
	2	6	12	0	16	32	0
	3	46	138	2	92	276	11
	4	4	16	1	6	24	0
Third molars	1	0	0	0	0	0	0
	2	0	0	0	5	10	0
	3	3	9	0	9	27	1
	4	0	0	0	0	0	0
Total	-	560	1190	15	471	1165	30

TABLE 2. Number of fractures/evaluated teeth (%), fractures/evaluated canals (%) per arch, and general mean relative to incidence of fractures

	Maxillary arch	Mandibular arch	Total	Percentage of fractures
Number of fractures/evaluated teeth	15/560 (2.6%)	30/471 (6.3%)	45/1031	4.4%
Number of fractures/evaluated canals	15/1190 (1.2%)	30/1165 (2.5%)	45/2355	1.9%

TABLE 3. Ratio, number and percentage of teeth where fractures occurred

Teeth	Endodontically treated teeth		Incidence of fractures	Percentage of fractures considering total number of teeth evaluated	Percentage of fractures in relation to the group of teeth itself	Percentage in relation to general number of fractures
First premolars	Maxillary	75	1	0.1%	1.3%	2.2%
	Mandibular	36	0	0%	0%	0%
Second premolars	Maxillary	97	2	0.2%	2.1%	4.5%
	Mandibular	58	0	0%	0%	0%
First molars	Maxillary	190	9	0.9%	4.7%	20%
	Mandibular	205	18	1.7%	8.8%	40%
Second molars	Maxillary	59	3	0.3%	5.1%	6.7%
	Mandibular	115	11	1.1%	9.6%	24.4%
Third molars	Maxillary	3	0	0%	0%	0%
	Mandibular	14	1	0.1%	7.1%	2.2%
	Total		45	4.4%	-	100%

DISCUSSION

Cleaning and shaping of the root canal system has become safer with the advent of instruments made of NiTi, by significantly reducing the incidence of apical transportation, root perforations and zip formation, in comparison with treatments performed with stainless steel instruments (12). The aim of this retrospective clinical study was to evaluate the incidence of ProTaper Universal System instrument fractures, associated with observation of the arch, group of teeth, and root thirds in which these fractures occurred. The null hypothesis was rejected because the group of teeth and root third had significant influence on the occurrence of fractures.

TABLE 4. Distribution and percentage of fractures, considering the position in the arch and root third

Arch	Root third		Total
	Middle	Apical	
Maxillary	3	12**	15
	6.7%	26.7%	33.3%
Mandibular	4	26**	30
	8.9%	57.8%	66.7%
Total	7*	38*	45
	15.6%	84.4%	100.0%

*Exact Fisher Test (p=0.000)
**Exact Fisher Test (p=0.001)

Considering the number of teeth (1031) and root canals (2355) evaluated, the general incidence of fracture was 4.4% and 1.9%, respectively. These rates can be considered low, mainly when considering the number of root canals evaluated. These results were in agreement with those obtained in previous studies that also obtained low incidence of NiTi instrument fracture (10, 13-16).

Analyzing the incidence of fracture of ProTaper Universal System instruments, Wolcott, et al. (10) and Di Fiore, et al. (13) found a 2.4% and 0.41% rates of fracture in 4652 and 828 root canals evaluated, respectively. One of the main reasons associated with the higher instrument fracture rates observed in the present study compared with both studies previously cited was the experience of the operators. In the study by Wolcott et al. (10), operators were endodontists with 15 years of experience, on an average. In the study by Di Fiore et al. (13), the operators were students from the Endodontics Residency Program at New York University. In the present study, the operators were also postgraduate students, however, in Brazil, postgraduate courses usually take place once a month. On the other hand, endodontics residency programs of american universities happen in full time. Therefore, students are subjected to a longer training load, which gives them a significantly greater clinical experience. In previous studies, the experience of the operators has been indicated as an important variable for the reduction of fracture incidence when using different NiTi systems (17, 18). Pirani et al. (19) also found a relatively high rate of fracture (5.3%) of ProTaper Universal System instruments when used by postgraduate students of the University of Bologna. However, in this study it is necessary to consider the greater complexity of the interventions because they were endodontic retreatments.

In the present study, 93.3% of the fractures occurred in molars, results that were corroborated by several studies (10, 12, 13). This finding was due to the anatomic characteristics found in these teeth, which imposed greater difficulties during instrumentation, predisposing to a higher incidence of instrument fractures (20-23). Moreover, it is worth pointing out that 66.7% of the fractures occurred in mandibular molars, and of these, 80% occurred in the mesial root. The mesial root of mandibular molars, in addition to the curvature toward the distal direction frequently observed, may also present curvatures in the bucco-lingual direction, which are not visualized radiographically (24, 25). This may have significantly contributed to the high rates of fracture observed specifically in this group of teeth, because this anatomic complexity results in greater rotary flexure of the instrument, thereby concentrating the forces of stress that may cause premature failure of the NiTi alloy (26).

Similarly, when the root third was considered in the analysis, 84.4% of the fractures occurred in the apical third. When NiTi instruments act in the apical third, they are subject to fracture by both torsion and rotary flexure by virtue of the smaller dimensions of the root canal, in addition to the eventual presence of curvatures (11, 26, 27).

In spite of the greater flexibility and elasticity, in comparison with manual instruments made of stainless steel, automated NiTi instruments tend to present a higher rate of fracture during root canal preparations (12). Nevertheless, as observed in the present study, this incidence was low considering the number of teeth and root canals evaluated, demonstrating that they were safe to use.

CONCLUSION

Based on results obtained from this study, it can be concluded that the incidence of rotary ProTaper universal files fracture is low amongst postgraduate students. The arch (mandibular) and root third (apical) have a significant effect on the incidence of these fractures.

Disclosures

Conflict of interest: The authors deny any conflict of interest.

Ethics Committee Approval: CAAE: 58036016.4.0000.0109

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