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SHORT REPORT

Comparison of fracture and deformation in the rotary endodontic instruments: Protaper versus K-3 system

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Abstract

This experimental study was done on extracted human teeth to compare the fracture and deformation of the two rotary endodontic files system namely K-3 and Protapers. It was conducted at the dental clinics of the Aga Khan University Hospital, Karachi, A log of file deformation or fracture during root canal preparation was kept. The location of fracture was noted along with the identity of the canal in which fracture took place. The fracture in the two rotary systems was compared. SPSS 20 was used for data analysis. Of the 172(80.4%) teeth possessing more than 15 degrees of curvature, fracture occurred in 7(4.1%) cases and deformation in 10(5.8%). Of the 42(19.6%) teeth possessing less than 15 degrees of curvature, fracture occurred in none of them while deformation was seen in 1(2.4%). There was no difference in K-3 and Protaper files with respect to file deformation and fracture. Most of the fractures occurred in mesiobuccal canals of maxillary molars, n=3(21.4%). The likelihood of file fracture increased 5.65-fold when the same file was used more than 3 times. Irrespective of the rotary system, apical third of the root canal space was the most common site for file fracture.

Keywords: Endodontics, Root canal therapy, Root canal preparation, Instrumentation.

Introduction

In contemporary dental practice, Nickel titanium (NiTi) rotary files are instrument of choice for mechanical preparation of the root canal space. By virtue of the intrinsic high elasticity and shape memory, these files maintain the shape of curved root canals without unnecessary tooth substance loss. Popular versions of NiTi instruments include Protaper and K-3 systems. Fracture of rotary files during root canal procedure is an uncommon but a serious event. Such an accident results in an inadequate cleaning and shaping apically beyond the area of instrument fracture and makes the tooth vulnerable to develop an infection again. The affected tooth demonstrates a guarded prognosis and would

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eventually lead to extraction as retrieval or bypass of the fractured instruments in the apical third is mostly impractical, if not impossible.

Bortnick¹ showed that there was no difference in the file distortion or fracture when hand- and engine-driven instruments were compared. Parachos² assessed the presence of post-instrumentation defects and concluded that the deformation in rotary instruments was mostly operator related. Hence, a careful technique along with reducing the number of times an instrument is used and discarding the deformed instrument upon first evidence of deformation is of paramount importance to limit the incidence of an instrument fracture.

An increase in the root canal curvature also contributes towards an increased likelihood of fracture.³ A study by Khongkhunthian⁴ on fracture of profile instruments during root canal preparation showed an incidence of 26.9% fracture when a pure rotary technique was employed, whereas with a hybrid technique (ProFile and hand files), no instrument fracture was noted. A retrospective study conducted by Tzanetakis⁵ reported that the overall prevalence of instrument fracture during root canal preparation by postgraduate students was 1.83%. With a global rise in the usage of rotary endodontic systems, there is an increased likelihood of experiencing fracture of rotary instruments, but there is a paucity of local data on this topic.

The current study was planned to compare fracture and deformation in Protaper versus K-3 rotary file systems at various distances from the apex in the human extracted teeth.

Methods and Results

This in-vitro experimental study was conducted from January 2016 to April 2016 at the dental clinics of the Aga Khan University Hospital (AKUH), Karachi. World Health Organisation (WHO) sample size calculator⁶ was used while keeping the findings of Scahfer & Florek⁷ in perspective, according to which we calculated the sample size at 90% power and 5% level of significance. After approval from the institutional review committee, non-probability consecutive sampling technique was

Table: Canal type and fracture/ deformation of instrument.

Curvature	Canal identity	Fracture/ deformation of instrument			Total	P-value
		None	Fracture	Deformation		
More than 15 degrees	Single rooted	35	0	2	37	0.016
	Mesiobuccal	11	1	2	14	
	Mesiolingual	5	1	0	6	
	Distal	19	2	2	23	
	Distobuccal	3	0	0	3	
	Distolingual	1	0	0	1	
	Molar palatal	14	0	1	15	
	Premolar buccal	32	2	1	35	
	Premolar palatal	35	1	2	38	
Total		155	7	10	172	
Less than 15 degrees	Single rooted	5	0	0	5	
	Mesiobuccal	5	0	0	5	
	Mesiolingual	4	0	0	4	
	Distal	9	0	0	9	
	Distobuccal	0	0	1	1	
	Distolingual	3	0	0	3	
	Molar palatal	3	0	0	3	
	Premolar buccal	7	0	0	7	
	Premolar palatal	5	0	0	5	
Total		41	0	1	42	

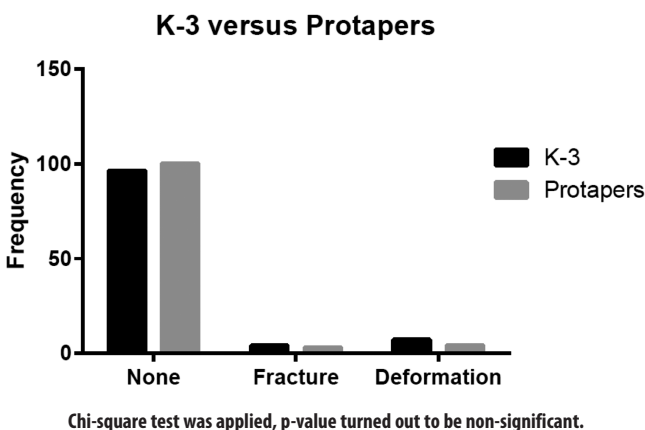


Figure: Fracture and deformation of instruments (Protapers vs. K-3).

employed to obtain 214 extracted human maxillary, mandibular, molars and premolars with no history of root canal treatment. Teeth were collected and equally divided into K-3 or Protapers groups of 107(50%) each. Carious and/or severely calcified teeth, teeth showing root resorption, root fractures/defects or teeth exhibiting open apices were excluded from the study. Each rotary file was used to prepare 5(2.3%) teeth after which the instrument was discarded and replaced by new instruments. Type of instrument fractured (K-3 or Protapers), number of canals prepared before fracture and location of the fractured instrument were noted.

SPSS 20 was used for data analysis. Frequency distribution of the deformed and fractured files was computed. Chi-square and odds ratio (OR) was applied to determine association between the fracture and the rotary system. Chi-square test was also applied to determine difference in file fracture in the two systems with respect to the frequency of file use. P<0.05 was considered significant.

The most likely canal to get the file deformation or separation was mesiobuccal canal of the maxillary molars n=3(21.4%), followed by mandibular molar distal n=4 (17.4%) and buccal canal of the maxillary premolars n=3(8.5%). Of the 172(80.4%) teeth possessing more than 15 degrees of curvature, fracture occurred in 7(4.1%) cases and deformation in 10(5.8%). Of the 42(19.6%) teeth possessing less than 15 degrees of curvature, fracture occurred in none of them while deformation was observed in 1(2.4%) canal as shown in Table.

The frequency of fracture and deformation of the two rotary instruments was noted. A total of seven files fractured, out of which 4(57.1%) files in K-3 group with number 0.25 being the most common to fracture, and 3(42.9%) in Protaper group with S1 being the most commonly fractured instrument. A total of 11 files deformed during preparation. Out of these, 7(63.6%) were K-3 and 4(36.4%) belonged to Protaper group (Figure).

It was noticed that if rotary files (K-3 and Protaper) was used thrice or more, the fracture or deformation increased

to over five times (OR: 5.65).

Conclusion

The fracture mode of a rotary file is reported to be either a torsional type or a flexural type or a combination of both.^{8,9} When used in the early stages of a root canal preparation, NiTi rotary instruments are more prone to torsional fracture as they are likely to be exposed to a greater torsional stress owing to a greater contact with the canal walls.

Yun HH¹⁰ showed that Protaper files experienced more instrument deformation compared to Profile, GT Rotary and Quantec. In the present study, the two groups experienced fracture and deformation mainly in the apical third. The incidence of deformation was more common in the K-3 group compared to the Protaper. These results are in agreement with the previous work,^{3-5,7,8} which showed that an increase in the canal curvature in the apical third exposes the different parts of the rotary instrument to the flexure and the cyclic fatigue that might result in instrument fracture. Jintao et al.⁷ reported that the instruments which experience fracture were mainly found to be in the apical or the middle third of the canal. They reported 94% of the fractured instruments located in the apical third of the canals.

Kosti⁷ studied the effects of root canal curvature on the Profile instruments fracture and concluded that the incidence of file fracture increases with an increase in root canal curvature. In the present study, it was observed that the incidence of fracture/deformation increases several times (OR: 5.65) if the same instrument (K-3 or Protaper) was used more than thrice for the preparation of the root canal space.

Shaping files were more prone to fracture in the Protaper group, whereas in the K-3 group, more file fractures were noted during final stages of root canal treatment. Seven files were deformed in the K-3 group and four files among the Protaper group experienced deformation (unwinding of the flutes) indicating excessive torsional stresses.⁹ Our results are in agreement with Sattapan et al.,¹¹ who observed that files that separated due to excessive torsion

and also exhibited signs of deterioration above the point of fracture.

The strength of the present study was that we used extracted teeth instead of resin blocks to mimic the clinical scenario and obtained readings that simulate the actual clinical situation. However, not using the hand files at all in any of the comparison group was our main limitation.

There was no statistically significant difference in K-3 and Protaper files with respect to file deformation and fracture. However, it was noticed that mesiobuccal roots of maxillary molars and buccal canals of premolars are more prone to file separation.

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