



Original Article

Evaluation of Dentin Cracks by Stereomicroscope after Preparation of Mesio Buccal Canal of Maxillary First Molars Using Edge Taper Platinum and ProTaper Gold Rotary Files: A Laboratory Study

Narjes Hoshiyari¹, Seyedali Seyedmajidi², Anahita Lotfizadeh³, Eghlima Malakan³, Abolfazl Hosseinnataj⁴, Azam Haddadi Kohsar^{1*}

¹Department of Endodontics, Dental Research Center, Mazandaran University of Medical Sciences, Sari, Iran

²Dental Materials Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, Iran

³Dentist, Mazandaran, Iran

⁴Department of Biostatistics, Faculty of Health, Mazandaran University of Medical Sciences, Sari, Iran

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*Corresponding author:

Azam Haddadi Kohsar,
Email: haddadi_azam@yahoo.com

Abstract

Background: Successful root canal treatment depends on correct cleaning, widening, and shaping of the root canal system. Root canal preparation using rotary files can cause dentin cracks. This study aimed to evaluate the number of dentin cracks created after the preparation of the mesio buccal root canal of the first maxillary molars by ProTaper Gold and Edge taper platinum rotary files using a stereomicroscope.

Methods: In this laboratory study, 72 maxillary first molars were collected and randomly divided into three groups (n=24): control group, ProTaper Gold group, and Edge taper platinum group. Mesio buccal canal preparation was performed in Edge taper platinum and ProTaper Gold groups up to file size F2. All roots were cut horizontally at distances of 3, 6, and 9 mm from the apex with a disc. The sections were examined under a stereomicroscope at 40x magnification. Fisher's exact test and Chi-square test were used in SPSS version 22.0 for analyzing data. A significant level of 5% was considered.

Results: In the control group, no cracks were observed in any of the sections. At 3 and 9 mm from the apex, the ProTaper Gold group had the highest frequency of cracks and at 6 mm from the apex, the Edge taper platinum group had the highest frequency of cracks. There was no significant difference in the frequency of dentin cracks between ProTaper Gold and Edge taper platinum groups in any of the sections.

Conclusion: Both ProTaper Gold and Edge taper platinum systems caused the formation of dentin cracks. Preparation of root canals by Edge taper platinum and ProTaper Gold rotary files causes the formation of dentin cracks to the same extent.

Keywords: Dentin cracks, First maxillary molar, Mesio buccal root canal, Stereomicroscope, Rotary files



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Background

Successful root canal treatment depends on correct cleaning, widening, and shaping of the root canal (1). Mechanical instrumentation includes cleaning and shaping and by this method, the effectiveness of detergents and antibacterial agents in eradicating bacteria and eliminating bacterial by-products is achieved. Therefore, enough space for three-dimensional obturation is prepared (2,3). The anatomy and morphology of the root canal system pose other challenges to disinfection. Isthmuses, inter-canal and intra-canal connections, and round and oval canals make root canal disinfection challenging (4-8).

Inaccurate root canal instrumentation may have

inevitable consequences. During the biomechanical preparation of root canals, the contact between the instrument and the canal walls puts pressure on the dentin and may produce craze lines (9-11). Cracks may spread over a long period and cause vertical root fracture (VRF) (12). Root fracture in 10.9%-31% of cases causes tooth extraction (13). Root fracture may occur after the extension of microcracks or craze lines due to occlusal stress (14).

Rotary nickel-titanium (Ni-Ti) files were developed in the 1980s. Compared to manual instruments, they have shorter instrumentation time and better performance (2). Conversely, Ni-Ti rotary files can cause more friction



and stress than manual files (6). In addition, canals with more curvature may increase the pressure on the rotary files, resulting in perforation, canal transportation, lodging, or instrument fracture (15-17). Instruments and instrumentation techniques should be selected based on their ability to form (especially in canals with curvature) and the possibility of achieving faster and non-deflection preparations (6,17).

Various Ni-Ti file systems are commercially available, based on their cross-sectional shape, groove angle, taper, depth of flutes, and number of spirals or flutes per unit length. They all have different characteristics, which may affect file performance (17-19).

The ProTaper instruments include Ni-Ti files with a conical design. ProTaper Next has an eccentric rectangular cross-section that gives the file a snake-like motion as it progresses through the root canal. ProTaper Gold has a triangular cross-section made by proprietary metallurgy that increases flexibility and resistance to cyclic fatigue (15,20-23).

Heat-treated Ni-Ti rotary files are available with the same shape, structure, and function as the ProTaper Gold file, including edge taper platinum, flex gold, and Pro-T. These files are recently known as replica-like systems. Among them, the edge taper platinum file has more flexibility and lower rotational resistance than the ProTaper Gold file. Although replica-like systems are sold and used daily around the world, not enough studies have been done in this field (24).

Commonly used methods for assessing dentin defects are radiography, dental sections, and plastic blocks (25). The stereomicroscope has been used as a tool to study the roots in the evaluation of apical anatomy and to evaluate the sealing capability using different filling materials and techniques. It can also be used as a valuable tool for students in the field of endodontics to evaluate debridement and obturation techniques (26).

In this study, the number of dentin cracks created after the preparation of the mesiobuccal canal of the first maxillary molars by ProTaper Gold and edge taper platinum rotary files was investigated using a stereomicroscope.

Materials and Methods

This Ex-vivo study was carried out after receiving ethical approval (IR.MAZUMS.REC.1400.396). The samples were chosen from the extracted first upper molars which were collected from dental clinics in Sari (Mazandaran, Iran). Based on the results of previous similar studies and taking into account the value of $C=7.85$ (a test power of 80% and a significance level of 5%), the total sample size was calculated to be 72 teeth, which were divided into three groups (24 teeth in each group) (27).

Collected teeth were cleaned by a periodontal scaler and kept in distilled water to prevent dehydration during the study. Additionally, the teeth were disinfected with sodium hypochlorite 2.5% and investigated for initial evaluation of microcracks by stereomicroscope at a magnification of

25x (Dewinter, Milano, Italy).

The inclusion criteria of the study were maxillary first molars with mature roots having apex with moderate canal curves (20° - 40°) (measured according to Schneider's method (28), roots without caries and external resorption, and the maximum width of the end of the canal which matches the file size number 15.

Teeth having reduced pulp space, pulp stones, calcified canals, hypercementosis, root caries, internal or external root resorption, previous root canal therapy, open apex, and fully curved canals were excluded from the study (27).

For the preparation of the samples, the access cavity was prepared with a fissure diamond bur, and the orifice of the mesiobuccal canal was identified by an endodontic catheter.

Canals with a K file size 10 or maximum 15 (Dentsply Maillefer, Ballaigues, Switzerland) which had a snag in apical constriction were selected. The second mesiobuccal canals were not considered. Then, the crowns were cut with a fissure bur (Brasseler USA, Savannah, GA, USA). The working length of all samples was 13 mm. The working length was determined visually using file number 10. The rate of penetration into the canal and the working length, 1 mm shorter than the anatomic apex, were recorded using ISO #10 K-file and #15 K-file, respectively. Afterward, the degree of root curvatures was assessed.

First, periapical radiographs were conducted. Then, root curvatures were measured by Schneider's method.

For tooth preparation, collected teeth were randomly divided into three groups of 24.

- Group 1: control group, in which teeth remained without preparation.
- Group 2: canals were prepared by ProTaper Gold file (Dentsply Maillefer, Ballaigues, Switzerland) and electromotor at 300 rpm and 3N torque. According to the manufacturer's instructions, an apical canal preparation was done up to file size F2 (25#0.08)
- Group 3: canals were prepared by Edge taper platinum file (EdgeEndo, Albuquerque, NM, USA) and electromotor at 300 rpm and 4N torque according to the manufacturer's instruction, and apical canal preparation was done up to file size F2 (25#0.06). Each canal was prepared with 1 file package and the rotation time of each canal was 5-10 seconds.

After preparation, the samples were mounted in resin. Then, all the roots were cut at distances of 3, 6, and 9 mm from the apex with a diamond disc (a thickness of 0.3 mm under water cooling conditions) and a three-axis cutting machine (NemoFanavaran Pars, Mashhad, Iran).

The sections were then examined under a stereomicroscope (Dewinter Technologies, Milano, Italy) at 40x magnification. Digital images were recorded with a digital camera attached to a stereomicroscope at 25x and 40x magnifications and examined by two endodontists for dentin cracks. The obtained data were divided into two groups (presence and absence of cracks). The data were presented using descriptive statistics (frequency and

percentage). To compare the frequency of dentin cracks between groups, Fisher's exact test and chi-square test were used in SPSS version 22.0 at the significance level of 5%.

Results

The frequency of teeth with dentin cracks in each of the studied groups was evaluated at different cross-sections. At 3 mm from the apex (apical), dentin cracks were observed only in the ProTaper Gold group (3 cases). The number of cracks in this section was not significantly different between the three groups (Table 1).

At 6 mm from the apex (middle), 8 cases of dentin cracks were observed in the ProTaper Gold group, and 10 cases of dentin cracks were observed in the Edge taper platinum group. Additionally, no cases were observed in the control group. The number of cracks was significantly different between the 3 groups (Table 2).

At 9 mm from the apex (coronal), 15 cases of dentin cracks were observed in the ProTaper Gold group, and 10 cases of dentin cracks were observed in the Edge taper platinum group. Besides, no cases were observed in the control group. In this section, the number of dentin cracks was significantly different between the 3 groups (Table 3).

No cracks were observed in the control group in any of the sections. At 3 and 9 mm from the apex, the ProTaper Gold group had the highest frequency and at 6 mm from the apex, the Edge taper platinum group had the highest frequency of the cracked teeth.

Comparing the frequency of cracked teeth between ProTaper Gold and Edge taper platinum groups in different sections, no significant difference was observed between all three sections (Table 4).

The images related to the examination of cracks by stereomicroscope in the ProTaper Gold, Edge taper Platinum, and control groups are shown in Figures 1 to 3.

Discussion

There are many different Ni-Ti file systems on the market, and dentists are trying to find studies that compare these systems clinically. Considering that the maxillary first molar teeth are very prone to fracture due to their narrow mesiodistal dimensions, they were used in the

present study (29). The stereomicroscope has been used as a tool to study the roots in the examination of the apex anatomy and evaluate sealing capability using different filling materials and techniques (30). It can also be used as a useful teaching tool. Therefore, we examined the number of dentinal cracks created by the preparation of the mesiobuccal canal of the first maxillary molars with ProTaper Gold and Edge taper platinum rotary files. The examination was done utilizing a stereomicroscope.

By comparing the number of cracked teeth at different root levels between the ProTaper Gold and Edge taper platinum groups, no significant difference was observed between the studied systems at 3, 6, or 9 mm from the apex. This finding was consistent with the findings of studies by Fráter et al (30) and Karataş et al (31). In these studies, there was no significant difference between 3, 6, or 9 mm sections. In a study conducted by Fráter et al, there was no difference between ProTaper Gold files and other studied file systems in producing dentinal cracks.

In the present study, there was no significant difference in the number of microcracks at 3 mm (apical one-third) between the 3 groups (ProTaper, Edge taper, and control), and only in the ProTaper group, cracks were observed at 3 mm (3 cases). However, at 6 mm (middle third) and 9 mm (cervical third), the number of cracks was significantly different between the 3 groups. In the control group, no cracks were observed in any of the sections.

In an in vitro study, Chole et al compared the formation of dentin cracks after root canal preparation with ProTaper Universal, ProTaper Next, and ProTaper Gold rotary files. At 3 and 9 mm, ProTaper Universal, ProTaper Next, and ProTaper Gold had the highest number of dentin cracks, respectively. At 6 mm from the apex, the number of dentin cracks created by ProTaper Next and ProTaper Gold was equal. In their study, it was reported that generally, ProTaper Next and ProTaper Gold rotary files produced significantly fewer dentin cracks than ProTaper Universal (32).

Table 1. The Frequency of Dentin Cracks at 3 mm From the Apex in the Study Groups

Group	Frequency	Percent	Chi-square Test	P Value
ProTaper Gold	3	12.5		
Edge taper platinum	0	0.0	4.27	0.102
Control	0	0.0		

Table 2. The Frequency of Dentin Cracks at 6 mm From the Apex in the Study Groups

Groups	Frequency	Percent	Chi-square Test	P Value
ProTaper Gold	8	33.3		
Edge taper platinum	10	41.7	12.44	0.002
Control	0	0.0		

Table 3. The Frequency of Dentin Cracks at 9 mm From the Apex in the Study Groups

Groups	Frequency	Percent	Chi-square Test	P value
ProTaper Gold	15	62.5		
Edge taper platinum	10	41.7	21.45	<0.001
Control	0	0.0		

Table 4. Frequency of Dentin Cracks in ProTaper and Edge Taper Groups in Different Sections

Section	Groups	Frequency of Cracks	Chi-square Test	P value
3 mm	ProTaper Gold	3		
	Edge taper platinum	0	3.20	0.234
6 mm	ProTaper Gold	8		
	Edge taper platinum	10	0.36	0.551
9 mm	ProTaper Gold	15		
	Edge taper platinum	10	2.09	0.149

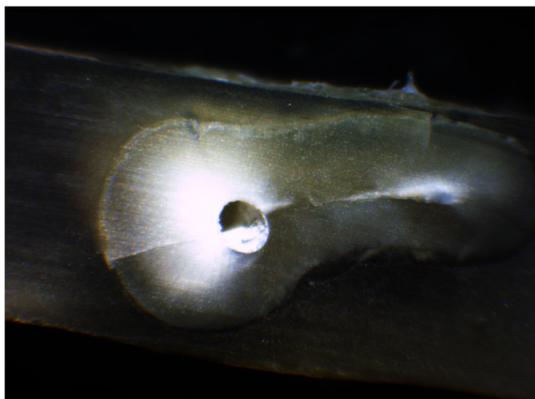


Figure 1. Dentin Cracks Created by ProTaper Gold Files

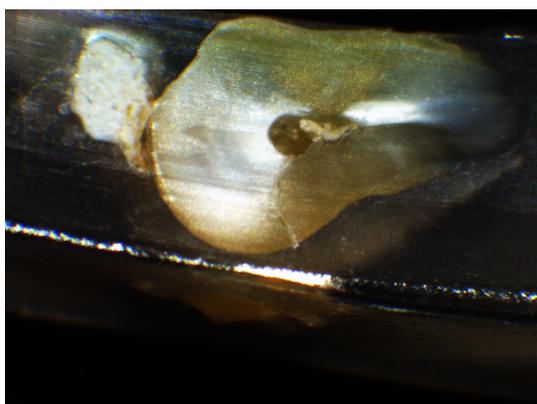


Figure 2. Dentin cracks Created by Edge Taper Platinum Files

In the present study, at 3 and 9 mm from the apex, the ProTaper Gold group had the highest number of cracks and at 6 mm from the apex, the Edge taper platinum produced the highest number of cracks. In general, we did not find a significant difference between the two groups of files. The differences could generally indicate that the number of dentin cracks formed by the Edge taper platinum file, especially in apical and cervical sections, may be lower than that of the cracks formed by ProTaper Next and ProTaper Gold files.

The results of two studies conducted by Chole et al (32) and Nishad et al (33), who examined apical dentin cracks due to root canal preparation with ProTaper Universal, ProTaper Next, and ProTaper Gold rotary files, are contradictory.

In the study done by Chole et al, the roots were only cut at 3 mm from the apex for examination with a stereomicroscope. The control group remained intact and the other groups were prepared with files. The results of this study showed that the number of dentin defects was significantly lower in ProTaper Gold and ProTaper Universal groups (32). In the study conducted by Nishad et al, no significant difference was observed between ProTaper Universal and ProTaper Next and between ProTaper Gold and ProTaper Next (33). However, this study also introduced ProTaper Gold as one of the groups which had the least number of dentin cracks. Overall, in line with both previous studies, the superiority of this file

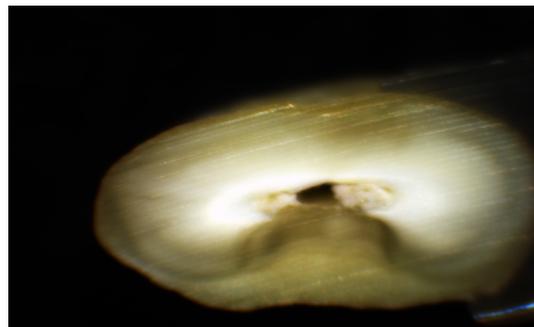


Figure 3. Control Group (Without Dentin Cracks)

over the other two groups can be noticed.

In an in vitro study, Hussien et al compared the rate of dentin crack formation between the RECIPROC blue, ProTaper Gold, ProTaper Next, and RECIPROC nickel-titanium rotary file systems. The results showed that dentin defects were seen in all groups (except for the control group), as in the present study, the ProTaper Gold file created dentin cracks in all 3, 6, and 9 mm sections. However, in the present study, the Edge Taper Platinum file was also examined and it was indicated that it did not cause any dentin cracks in the apical sections, which could show the superiority of this file over the ProTaper Gold file in apical sections. In the study of Hussien et al, no significant difference was observed in any of the intra-group and inter-group comparisons (34). In the present study, a two-by-two comparison of ProTaper Gold and Edge taper platinum files did not demonstrate any significant difference. In their study, the root samples were sectioned horizontally at 2, 4.5, and 7 mm from the apex. Based on the results, nickel-titanium rotary systems were not significantly different from others.

Although the number of cracks in different sections was not significantly different, the number of cracks in both Edge taper platinum and ProTaper Gold rotary files at 9 mm from the apex was higher compared to other sections. This finding was consistent with the results of the study by Harandi et al who stated that microcracks occurred mainly in the coronal part (9 mm) and no microcracks occurred in the control group (27). The systems used in the study conducted by Harandi et al included ProTaper Universal (rotary, multi-file system), Neolix (rotary, single-file system), and SafeSider (reciprocation movement, multi-file system). Besides, a stereomicroscope was used to assess cracks. In summary, it can be assumed that crack formation cannot be attributed to a single factor. Instead, crack formation is the result of several factors, possibly incremental and/or synergistic, such as tip design, cross-section design, taper, Ni-Ti alloy production process, and so on (11). Given the limitations of this study, it should be considered that the in vitro approach can produce a false positive effect due to the extraction forces to which the teeth are exposed during extraction, the storage conditions, and the sectioning method (35,36).

The sectioning method is not reliable because if it is not accompanied by a CT scan, cracks in the dentin cannot be

ruled out. The sectioning method itself may also help to form dentin cracks; however, it is unlikely to significantly affect the results. Untreated (but sectioned) control specimens showed no cracks at all. Several other studies also concluded the same (31,37-39).

Problems with the use of extracted teeth have been highlighted by De-Deus et al (40); however, the present findings seem to contradict the possible role of tooth extraction in the formation of dentinal cracks within the root canal (41). Overall, while it is theoretically impossible to rule out the influence of these factors, the complete absence of cracks in the control samples is a strong argument against the role of the factors mentioned above in this study.

As there is still no clear agreement on the interpretation of the collected results from microscopic evaluations after sectioning and CT evaluation, future research should be performed with both evaluation methods in similar samples. The need for future research in this field has been clearly emphasized by Zaslansky et al (42).

Conclusion

Both ProTaper Gold and Edge taper platinum systems caused the formation of dentin cracks. Preparation of root canals by Edge taper platinum and ProTaper Gold rotary files causes the formation of dentin cracks to the same extent.

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Authors' Contribution

Conceptualization: Narjes Hoshiyari, Azam Haddadi Kohsar.

Data curation: Eghlima Malakan, Seyedali Seyedmajidi.

Formal analysis: Seyedali Seyedmajidi.

Funding acquisition: Azam Haddadi.

Investigation: Anahita Lotfizadeh, Eghlima Malakan.

Methodology: Azam Haddadi, Seyedali Seyedmajidi.

Project administration: Narjes Hoshiyari.

Resources: Abolfazl Hosseinnataj.

Software: Abolfazl Hosseinnataj.

Supervision: Azam Haddadi.

Validation: Narjes Hoshiyari.

Visualization: Seyedali Seyedmajidi.

Writing—original draft: Eghlima Malakan, Anahita Lotfizadeh.

Writing—review & editing: Anahita Lotfizadeh, Azam Haddadi.

Competing Interests

The authors have no conflict of interests to declare.

Ethical Approval

This study was approved by ethical committee of Mazandaran University of Medical Sciences (ethical approval No. IR.MAZUMS.REC.1400.396).

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