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Effect of Different Torque Setting of ProTaper Gold on Crack Formation in Root Dentin

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Abstract **Original Research Article**

Introduction: The aim of the present study was to observe the incidence of cracks in root canal dentin using the ProTaper Gold system (Dentsply Maillefer) at low- and high-torque settings. ***Methods:*** Sixty mandibular premolar teeth that had been extracted for different reasons were selected. The teeth were divided into 3 groups: an unprepared control group, a low-torque settings group (SX = 3, S1 = 3, S2 = 1, F1 = 1, F2 = 2, F3 = 2, F4 = 2 Ncm), and a high-torque settings group (SX = 5, S1 = 5, S2 = 1.5, F1 = 1.5, F2 = 3.10, F3 = 3.10, F4 = 3.10 Ncm). After a root canal procedure, all the teeth were horizontally sectioned at 3, 6, and 9 mm from the apex. Then, under a stereomicroscope, all the slices were examined to determine the presence of cracks. A chi-square test was used for data analysis. The significance level was set at P = .05. ***Results:*** Vertical root fractures were not observed in any of the groups. There were no cracks in the unprepared control group. There were significantly fewer cracks (15.6% of the sections) in the low-torque group than in the high-torque group (27.3% of the sections) (P < .05). ***Conclusions:*** In this in vitro study, the instrumentation of root canals with the ProTaper Gold instrument caused more crack formation in root canal dentin at high-torque than at low-torque settings.

Keywords: Protaper Dentsply Maillefer cracks in root.

INTRODUCTION

Root canal instrumentation has the potential to induce dentinal damage [1] and to generate cracks on the apical surface [2], which could ultimately lead to the development of vertical root fractures [3]. Root canal instrumentation includes both enlargement and shaping of the root canal system to allow effective disinfection by irrigants and medicaments [4].

Craze lines and complete and incomplete cracks in root canal dentin may develop into vertical root fracture [5, 3, 6, 7].

For many years, root canal preparation was performed using stainless steel hand endodontic files [2]. Today, clinicians have access to many newly developed nickel-titanium (NiTi) rotary instruments. These systems are preferred because of their various advantages, such as saving time and better cutting efficiency [8, 9]. However, instrumentation with rotary NiTi instruments can potentially cause cracks in the root dentin [10, 1, 11, 12]. Dentinal cracks or root fractures occur when the tensile stress in the root canal wall exceeds the tensile stress of dentin [13]. Rotary NiTi files with large tapers can produce increased friction and stresses on the canal wall and cause dentinal cracks in root dentin [1].

According to various studies fractures with NiTi instruments occur via 2 failure modes: torsional stress and flexural fatigue [14–16]. One of the failure modes is torsional stress; clinicians can reduce the intensity of torsional stress by using different torque settings. Increasing the torque can cause the instrument to lock, resulting in instrument fractures [17]. According to some authors there is a strong positive correlation between the maximum torque an instrument can withstand and its diameter [18–20]. Gambarini [21] suggested that the risk of intracanal fracture increases when the instrument specific torque limit is exceeded. The author suggested that a specific torque limit (close to the limit of elasticity) be set for each instrument size and type. Thus, the manufacturers recommend different torque settings for different file sizes.

Numerous studies have compared dentinal crack formation with different rotary NiTi systems [1, 12, 13, 22]. ProTaper Gold is a newly introduced file

system with convex triangular cross-section and progressive taper which enhance cutting action while decreasing rotational friction between the blade of the file and dentin [23].

The non-cutting tip design allows each instrument to safely follow the secured portion of the canal while the small flat area on the tip enhances its ability to find its way through soft tissue and debris [24].

There are no current data on the effect of different torque settings of ProTaper Gold on crack formation in the literature. Hence, the aim of the present study was to observe the incidence of cracks in root dentin using the ProTaper Gold system at low- or high-torque settings.

MATERIALS AND METHODS

Sixty extracted human mandibular premolars with single root canals were selected. Teeth with fracture lines, open apices, dental caries or resorption defects were excluded. Radiographs were taken to verify the presence of a single canal. The external root surfaces were inspected at 10X magnification under a stereomicroscope (Olympus, Japan) to exclude the possibility of any external defects or cracks. The teeth were sectioned under water cooling with a diamond disc (Horico, Germany) 15 mm from the apex. The roots were covered with a single layer of aluminum foil and inserted in acrylic resin (DPI, India) set in an acrylic tube. The root was then removed from the acrylic tube, and the aluminum foil suspended from the root surface. A light body silicon-based material (Fxeceed, GC, Japan)) was used to fill the space created by the foil and to simulate the periodontal ligament, and the root into the acrylic tube. Teeth were assigned to three root canal shaping groups.

Twenty teeth were left unprepared as a negative control group, and the remaining 40 teeth were assigned to 2 experimental groups. A size 10 K-type file was used to determine the working length of the canals. A glide path was performed with a size 15 K-type file. The root canal instrumentation was performed with the ProTaper Gold system in a sequence of SX (two thirds of the working length), S1–2, and F1–4. Two different torque settings (minimum and maximum) recommended by the manufacturer were used for the root canal instrumentations (Table 1).

All the instruments were used at 250 rpm using an endodontic motor (Endomate DT, NSK, Japan). The root canals were irrigated with 2ml of 3% sodium hypochlorite solution after each instrument change. After preparation, the specimens were rinsed with 5 mL distilled water.

Sectioning and Microscopic Examination

All of the roots were sectioned perpendicular to the long axis at 3, 6 and 9mm from the apex using a diamond disc (Horico, Germany) under water cooling. Coronal aspect of each slice was evaluated at 25X magnification under stereomicroscope (Olympus, Japan).

To define crack formation, 2 different categories were made ie, ‘‘no crack’’ and ‘‘crack’’. ‘‘No crack’’ was defined as root dentin without cracks or craze lines either at the internal surface of the root canal wall or the external surface of the root. ‘‘Crack’’ was defined as all lines observed on the slice that either extended from the root canal lumen to the dentin or from the outer root surface into the dentin [11].

RESULT

The results were expressed as percentage of cracked roots in each group. A chi-square test was used for data analysis. $P < .05$ was regarded as statistically significant.

There were no cracks in the unprepared control group. Vertical root fractures were not observed in any of the groups. There were significantly fewer cracks in the low-torque group (15.6% of the sections) than in the high-torque group (27.3% of the sections) ($P < .05$).

Table-1: Maximum and Minimum Torque Settings Recommended by the Manufacturer for Each of the ProTaper Gold System Files

	Low torque group (n=20)	High torque group (n=20)
SX	3	5
S1	3	5
S2	1	1.5
F1	1	1.5
F2	2	3.10
F3	2	3.10
F4	2	3.10

DISCUSSION

The causes of endodontic file separation are torsional and cyclic fatigue (16). Torsional stress occurs when the tip or any other part of the file is locked or bound within a canal while the shaft continues to rotate. Manufacturers recommend different torque settings for each instrument to prevent instrument separation.

Dentinal crack formation is related not only to the design of the instrument but also to its instrument's kinematics [25]. Manufacturers recommend different speeds and torque settings for different diameters of files. Generally, a higher torque setting is suggested for larger files. The concept of high-torque strength comes from the greater mass of metal found in the larger NiTi tapers [26, 27]. It is suggested that if the instrument-specific torque limit (fracture limit) is exceeded, it increases the risk of intracanal fracture of file. A specific torque limit (close to the limit of elasticity) might be set for each instrument size and type [21]. Although a high-torque setting (3–5Ncm) is recommended for the S1 instrument, this is the smallest of all the ProTaper Gold files. The recommended setting may be because the S1 is the first file to penetrate to the working length. Penetration to the working length with the first file may require excessive force [22, 28, 29]. According to the results of this study, high-torque settings caused more dentinal cracks than low-torque settings of ProTaper Gold system. The higher crack formation in the group of high-torque settings may be related to greater stress on the dentinal surface. Theoretically, at higher torque settings, instruments tend to reach the apical terminus with less auto reverse action. In addition to torque settings, the root canal shaping procedure may affect the stress on the file and dentinal surface. For this reason, newly marketed instruments should be evaluated at different torque settings to determine their effects on dentinal crack formation. Similarly, the impact of the different speed settings of these instruments should be examined to ascertain their impact on dentinal crack formation [25].

There are several methods to evaluate dentinal crack formation after different endodontic instrumentations [30–34]. The most recent being micro–computed tomographic imaging, which is a highly accurate and nondestructive method. A limitation of the present study was that we used a sectioning method with a low-speed saw and stereomicroscopic evaluation for crack determination.

CONCLUSIONS

Within the limitations of this in vitro study, the instrumentation of root canals with the ProTaper Gold instrument used at high-torque settings caused more crack formation in root canal dentin than when used at low-torque settings.

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