



## Effects of ProTaper Universal, Mtwo, and HyFlex Instruments on Crack Formation in Dentin

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### KEYWORDS

Dentinal cracks, ProTaper Universal, HyFlex, Mtwo, root canal instrumentation.

### Abstract:

**Objective:** The purpose of the present study was to evaluate the incidence of cracks in root dentin after root canal shaping procedures performed with the newly introduced HyFlex instruments compared with the ProTaper Universal and Mtwo instruments

**Methods:** One hundred extracted single-rooted mandibular premolars with mature apices and straight root canals ( $<5^\circ$ ) were selected and kept in distilled water. External root surfaces were meticulously inspected for defects using an LED.D, and radiovisiographs were taken to exclude teeth with multiple canals. The teeth were sectioned under water cooling, covered in wax, and set in an acrylic block. Light body silicon-based material was used to simulate the periodontal ligament. The samples were randomly divided into four groups: Group 1 (negative control, uninstrumented), Group 2 (ProTaper Universal), Group 3 (HyFlex), and Group 4 (Mtwo). The results were expressed as the number and percentage of cracked roots, and statistical analysis was performed using a chi-square test at a 95% confidence level ( $P = .05$ ).

**Results:** No cracks were observed in the negative control group. Vertical root fractures were absent in all groups. The incidence of dentinal cracks varied significantly among the instrumented groups: Mtwo and HyFlex instruments induced fewer cracks (12% and 8%, respectively), whereas ProTaper Universal instruments showed a higher incidence of cracks (48%) ( $p < .05$ ).

**Conclusion:** This study concluded that Instrumentation of root canals with Hyflex CM, Mtwo, and ProTaper could cause damage to root canal dentin. Hyflex CM has a tendency to cause less dentinal cracks as compared with other files.

### Introduction:

Endodontic instrumentation has undergone significant advancements with the advent of nickel-titanium (NiTi) rotary instruments, providing clinicians with enhanced efficiency and precision in root canal procedures. ProTaper Universal, MTwo, and HyFlex are among the widely utilized NiTi

rotary systems, each boasting unique design features and cutting geometries. However, concerns persist regarding the potential impact of these instruments on dentin, specifically the propensity to induce crack formation. Root canal instrumentation aims to effectively shape and clean the intricate root canal system while preserving the structural



integrity of dentin. The continuous evolution of endodontic instruments has seen the rise of NiTi rotary systems, offering advantages such as increased flexibility, improved resistance to cyclic fatigue, and enhanced cutting efficiency. ProTaper Universal, MTwo, and HyFlex are at the forefront of these innovations, each designed to address specific challenges encountered during root canal procedures<sup>1-5</sup>. Despite the widespread adoption of NiTi rotary instruments, concerns linger regarding their potential to induce cracks in dentin. Dentinal microcracks, whether visible or not, have been associated with compromised structural integrity and may serve as potential pathways for microbial infiltration, jeopardizing the long-term success of endodontic treatments. Hence, a nuanced understanding of the impact of these instruments on dentin is imperative for clinicians to make informed decisions in their daily practice<sup>6-8</sup>. The purpose of the present study was to evaluate the incidence of cracks in root dentin after root canal shaping procedures performed with the newly introduced HyFlex instruments compared with the ProTaper Universal and Mtwo instruments.

### Materials and methods

100 extracted single rooted mandibular premolars with mature apices and straight root canals ( $<5^\circ$ ) were selected and kept in distilled water till use.

The external root surfaces of all the teeth were inspected under a LED.D (Woodpecker, China) to exclude the possibility of any external defects or cracks. Radiovisiographs were taken in mesiodistal and buccolingual direction to eliminate any tooth with multiple canals, and were replaced with new teeth whenever necessary.

To ensure standardization of length, the teeth were sectioned under water cooling with a low-speed saw, 16 mm from the apex.

These teeth were then covered in a single thin layer of wax and set in an acrylic block, after which the tooth was removed and the wax was removed. A light body silicon-based material (Oranwash; Zhermack SpA, Rovigo, Italy) was used to fill the space created by the wax and to simulate the periodontal ligament, and the root was placed into the impression material.

The samples were then randomly divided into 4 groups of 25 samples each.

Group 1: this was the negative control group. The samples were left uninstrumented.

In the other 75 samples, the working length was determined with a 10 number hand K file (Mani Co, Tokyo, Japan). Glide path was prepared using 15 number K file. Hand filing was done till 20 no K file in all 75 samples.

Following this, an Endomotor (Xsmart, Denstply) was used for rotary instrumentation. The root canals were irrigated with 2.5ml of 1% sodium hypochlorite solution after each instrument change. After preparation, the specimens from the prepared groups were rinsed with 5 mL distilled water. The root canal shaping procedures were performed according to the manufacturer's instructions for each instrument system as follows:

Group 2: For each ProTaper Universal file (Dentsply-Maillefer, Ballaigues, Switzerland), the individual rotational speed and the torque limit mentioned by the manufacturer was used. The sequence was as follows: SX, S1, S2, F1, F2, F3. The first 3 shaping files were used with a brushing motion away from the root concavities before light resistance was encountered, and the last 3 finishing files were used until the working length was reached.

Group 3: The HyFlex files were used with a rotational speed and torque according to the manufacturer's instructions. The HyFlex files were used in the sequence of 25/0.08 (two thirds of the working length), 20/0.04, 25/0.04, 20/0.06, 25/0.06, 30/0.06 for the full working length).

Group 4: MTwo (VDW, Munich, Germany) were used with a rotational speed and torque as mentioned by the manufacturer. The files were used in the sequence of 10/0.04, 15/0.05, 20/0.06, 25/0.06, 30/0.05, till the working length.

After this, all of the roots were sectioned perpendicular to the long axis at 2, 4, 6, and 8 mm from the apex using a low-speed saw under water cooling. In each group, a total of 100 slices were blindly examined for cracks using stereomicroscope under the magnification of 2.5x. Digital images of the same were captured.

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.

The results were expressed as the number and percentage of cracked roots in each group. The data were analyzed with a chi square test. The testing

was performed at the 95% confidence level ( $P = .05$ ).

#### Results:

The results show that no cracks were observed in the negative control group (unprepared). Vertical root fractures were not observed in any group. The Mtwo and HyFlex instruments caused fewer cracks (12% and 8%) than the Pro- Taper Universal instrument (48%) ( $p < .05$ ). (Table1) (Figure 1,2).

Table 1:

Group	Cracks presents	%	No Cracks	%	Total
Group I	0	0.00	25	100.00	25
Group II	12	48.00	13	52.00	25
Group III	2	8.00	23	92.00	25
Group IV	3	12.00	22	88.00	25
Total	17	17.00	83	83.00	100

Figure 1:

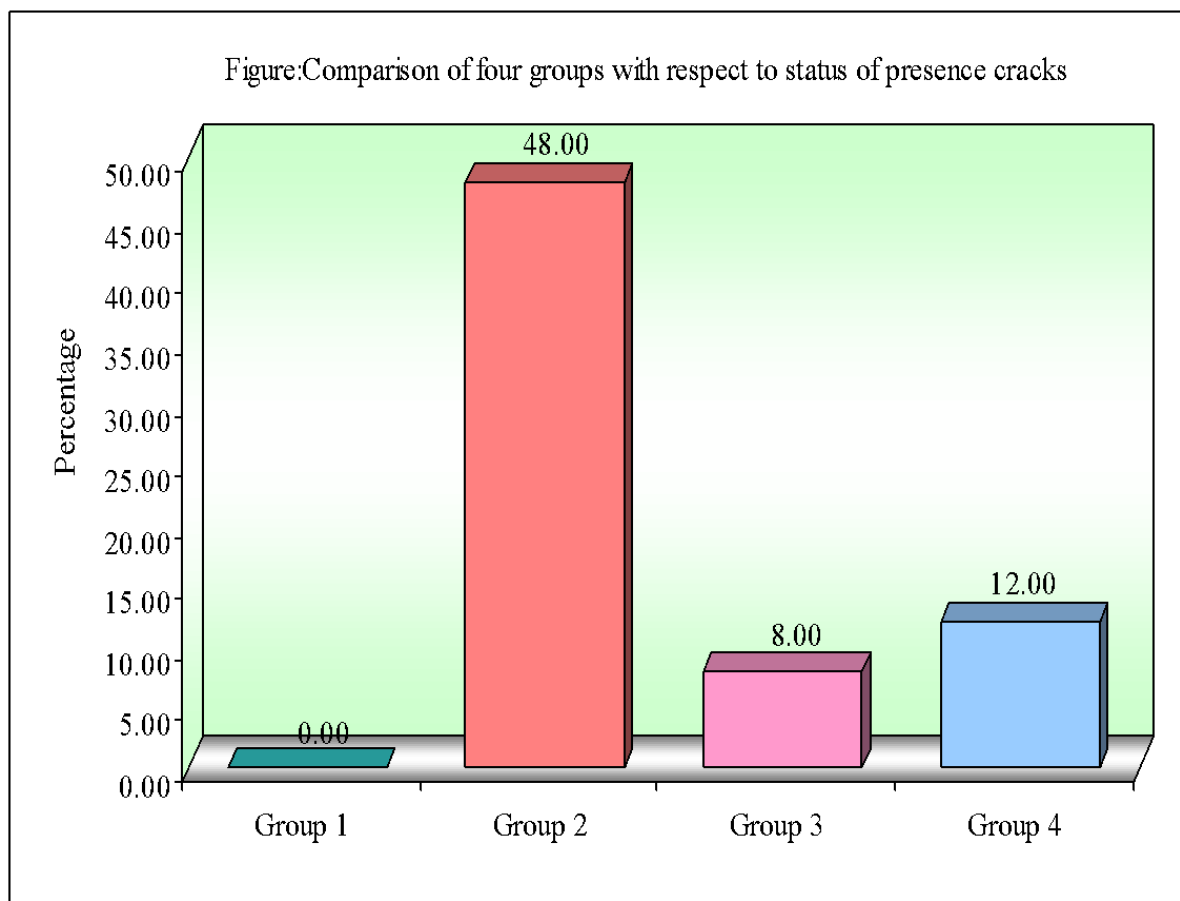
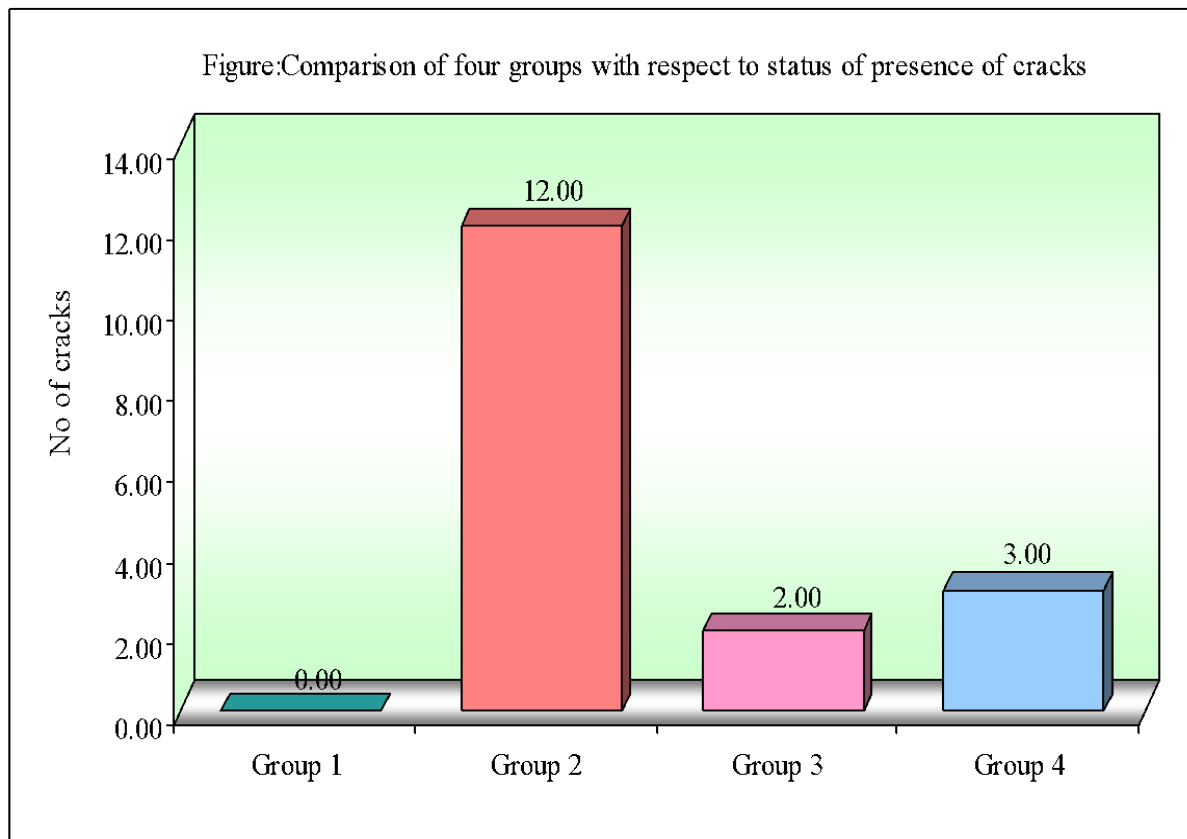




Figure 2:

**Discussion:**

The observed incidence of dentinal cracks in this study following the use of ProTaper Universal, HyFlex CM, and Mtwo instruments aligns with and is supported by findings from previous studies, contributing to the growing body of evidence on the impact of different NiTi rotary systems on dentin integrity.

The results revealed that ProTaper Universal exhibited the highest incidence of dentinal cracks at 48%, corroborating with the findings of Capar et al., who reported a 56% incidence of crack formation due to ProTaper Universal<sup>9</sup>. This consistency in outcomes across studies emphasizes the potential predisposition of ProTaper Universal to induce cracks in root dentin. The literature consistently suggests that the design and mechanical properties of rotary instruments play a crucial role in the generation of dentinal cracks, and ProTaper Universal, with its specific file sequence and taper, seems to be associated with a higher risk.

HyFlex CM, on the other hand, demonstrated a significantly lower incidence of cracks at 8%, aligning with the study conducted by Capar et al., which also reported less crack formation with HyFlex CM. The unique design features of HyFlex CM, including controlled memory and increased flexibility, may contribute to its ability to navigate root canal complexities without exerting excessive stress on the dentin, thereby reducing the likelihood of crack formation<sup>9</sup>.

Several studies, including those by Kim et al. and Bier et al., have emphasized the role of taper in contributing to crack formation during root canal instrumentation. The greater taper of certain instruments, such as ProTaper Universal, may lead to increased stress concentration, potentially initiating cracks in the root dentin. This aligns with Banu Uysal et al.'s assertion that the ProTaper Universal F2 file, with its specific taper, may have a significant effect on the initiation of apical cracks<sup>10-13</sup>.



Furthermore, Wilcox et al. concluded that the extent of root dentin removal is directly correlated with the likelihood of root fracture. The findings of the current study and the referenced literature collectively underscore the importance of preserving as much root dentin as possible during endodontic procedures to minimize the risk of iatrogenic damage<sup>14,15</sup>.

Similarly, Mtwo instruments exhibited a relatively low incidence of dentinal cracks at 12%, confirming their favorable performance in terms of dentin preservation. This finding resonates with the study conducted by Liu et al., where Mtwo instruments were associated with a lower incidence of cracks compared to ProTaper. The metallurgical properties, flute design, and taper of Mtwo instruments might contribute to their reduced impact on root dentin<sup>14</sup>.

#### Conclusion:

This study concluded that Instrumentation of root canals with Hyflex CM, Mtwo, and ProTaper could cause damage to root canal dentin. Hyflex CM has a tendency to cause less dentinal cracks as compared with other files.

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