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Comparative Evaluation Of Dentinal Defects Caused By Different Rotary Ni-Ti Instruments - A In Vitro Study

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Abstract: ***Aim: This study was carried out to compare the dentinal defects induced by three different rotary file system 2 shape (Micro-Mega, Besancon, Cedex, France), Neolix (Neolix, châtres-la-Forêt, France) and Protaper universal (DentsplyMaillefer, Ballaigues, Switzerland).***

Materials and methods: Eighty single-rooted mandibular premolars were selected based on predetermined criteria. Twenty teeth were left unprepared and served as a negative control(Group I) .The remaining sixty teeth was divided into three groups: Group II (Pro taper universal), group III (neolix) and group IV(2 Shape). Biomechanical preparation was carried out as per the manufacturer's instructions. After root canal preparation, all of the roots were sectioned perpendicular to the long axis at 3, 6, and 9 mm from the apex. These sections were visualized under stereomicroscope to evaluate the dentinal defects using predetermined criteria. The absence/presence of cracks was recorded, and the data were analyzed with a chi-square test. The significance level was set at P = 0.05.

Results: Roots prepared with ProTaper Universal showed maximum defects, whereas no significant difference was found in dentinal defects in roots prepared with neolix and 2 shape files. There was statistically significant difference between the Protaper group and other two groups (p < 0.05).

Conclusion: All of the NiTi files tested in the present study were found to cause dentinal defect.Statistical analysis showed no significant difference in root dentinal crack formation between 2 shape and Neolix rotary systems.

I. INTRODUCTION

A successful endodontic therapy is based upon triad of proper diagnosis, thorough biomechanical preparation and three dimensional obturation of root canal system. The chemo-mechanical root canal preparation involves preservation of the original course of the canal and removal of bacteria from the entire root canal system.

With recent advances in dental technology, various nickel-titanium instruments with different designs have been introduced. A common complication of mechanical canal preparation is vertical root fracture (VRF). It has not yet been determined, whether even minor dentinal defects could lead to root fractures; therefore, steps should be taken to prevent occurrence of such defects

However, several factors like force of instrumentation and obturation; retreatment procedure and high concentration of hypochlorite may also be responsible for the formation of dentinal defects in different degrees. A weakened root, as a result of flaring and instrumentation, could suffer VRFs during obturation procedures.

The purpose of this study is to compare the damage observed in root dentin after endodontic preparations with different Ni-Ti rotary file systems.

II. MATERIAL AND METHODS

Eighty extracted mandibularpremolars were selected and cleaned with periodontal scaler and stored in purified filtered water. The coronal portions of all teeth were removed with diamond disk, leaving roots 16 mm in length. All root surfaces were observed with stereomicroscope under ×12 to exclude cracks.

Patency of the canal was established using#10 K-File (Mani, Japan) in the canal.

The cemental surface of the root was coated with light body impression material and embedded into the acrylic blocks to simulate the periodontal ligament and avoid the external reinforcement. The specimens were then divided into four groups; each group containing 20 specimens each.

Group I: Left unprepared and served as Group I.

Group II: Twenty specimens were prepared using Endo Motor (X Smart Dentsply) and Protaper universal rotary files (Dentsply) using crown down technique according to the manufacturer's instructions.

Group III: Thirty specimens were prepared with Endo Motor (X Smart Dentsply) andNeolix (Neolix, châtres-la-Forêt, France) using crown down technique according to the manufacturer's instructions

Group IV: Thirty specimens were prepared with Endo Motor (X SmartDentsply) and 2 Shape Single file rotary system (MicroMega) using crown down technique according to the manufacturer's instructions.

In all the groups, canals were irrigated with 2.5% sodium hypochlorite (NaOCl) solution between each instrument and Glyde EDTA Gel (17%) was used during the preparation procedure. All roots were kept moist throughout the experimental procedures to prevent dehydration.

III. SECTIONING AND MICROSCOPIC OBSERVATIONS

All roots were cut horizontally at 3, 6, and 9 mm from the apex. Sections were then viewed under stereomicroscope. The appearance of dentinal defects was registered by the pictures that were taken digitally.

Roots were classified as "defected" if at least one of the three sections showed either a craze line, partial crack or a fracture. Results were expressed as the number and percentage of defected roots in each group.

The defects observed were scored and classified under following predetermined criteria

- ✓ "No defect" was observed as root dentine devoid of any lines or cracks where both the external surface of the root and the internal root canal wall had no defects.
- ✓ "Fracture" was observed as a line extending from the root canal space to the outer surface of the root.
- ✓ "Craze line" line extending from the outer surface into the dentine that did not reach the canal lumen
- ✓ "Partial crack" line extending from the canal wall into the dentine without reaching the outer surface of the root.

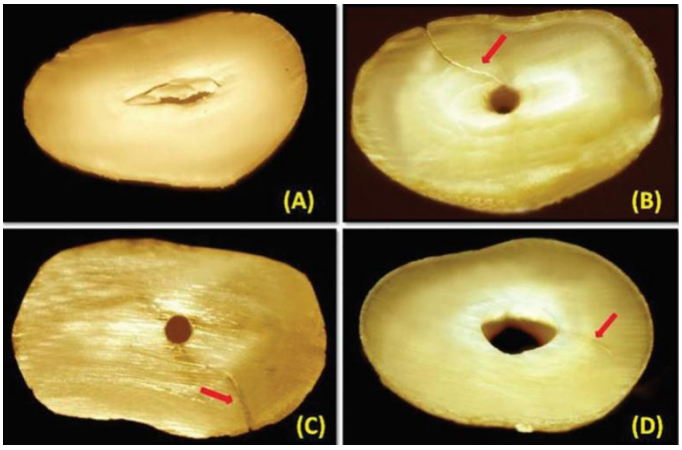

Figure 1: various dentinal defects

STATISTICAL ANALYSIS

The data were analyzed using statistical software program. A Chi-square test was performed to determine statistically significant difference in the appearance of defected roots between the experimental groups. Chi-square test was also performed to determine the defects at different horizontal sections in each group. The level of significance was set at $P < 0.05$.

IV. RESULTS

Figure 2 is a bar chart representing the number of root defects in each group.

The teeth in the control group showed no defects. The maximum percentage of defect was seen in the teeth instrumented using Protaper universal file system (8/20)(40%). The percentage of defects seen in the other two groups are neolix (2/20)(10%), and 2 SHAPE (1/20)(5%). Statistical significant difference was seen between protaper universal and the other two rotary groups. No significant difference was found between the neolix and 2 shape group (P > 0.05). All experimental groups demonstrated significantly more defects at the 3 mm level when compared with the unprepared group.

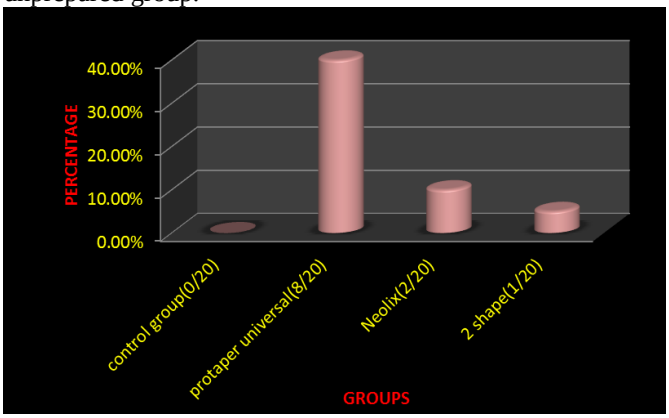

Figure 2: Bar Chart Representing Percentage Of Root Defects

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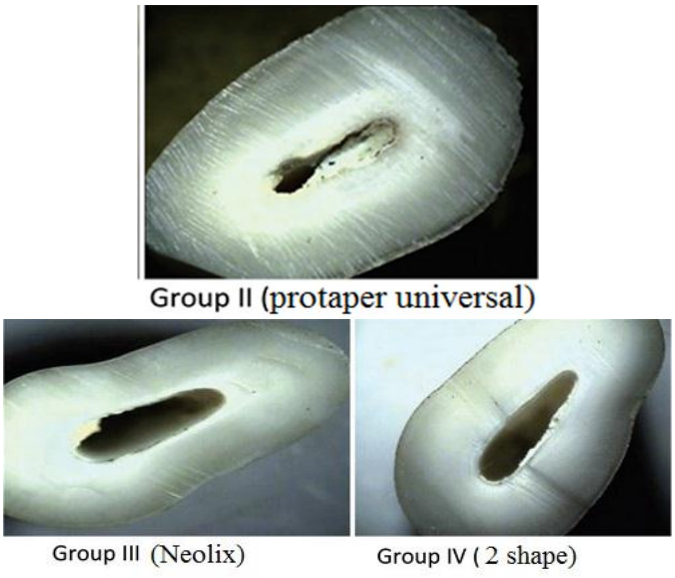

Figure 3: Stereomicroscopic Images Showing Dentinal Defects

V. DISCUSSION

Many new NiTi rotary instruments have been developed and introduced by various manufacturers. Majority of practitioners prefer these systems because of their advantages such as saving time and better cutting efficiency. Root canal preparation with larger tapered rotary NiTi instruments involves more dentin removal, which compromises the fracture strength of the roots leading to vertical root fracture.

During the biomechanical preparation, rotational forces applied on the walls of the root canal result in formation of microcracks or craze lines[6]. While using rotary files formation of these defects can be caused by many factors. Tip design, cross section geometry, constant or variable taper, and pitch and flute form. In the present study, dentinal defects occurred in around 10% of total number of samples tested and in 40 % of the sample in the protaper group, and these may develop into fractures following any additional procedure such as preparation, obturation, and retreatment or by repeated stress of occlusal forces. Bier *et al*. reported that craze lines occurred in 4 to 16% samples. Onnink*et al*. were the first to report dentinal defects as a consequence of canal preparation but only found small defects entirely within dentin that did not communicate with the canal wall.

Sectioning method using diamond disk used in the presentstudy could also result in dentinal defects. However, because both the control group did not show any defect, we may conclude that the defects seen were not due to sectioning procedure used.

Mandibular premolars were selected for the study because of the high prevalence of VRF as reported by Tamseet al. It was also reported that occlusal load on mandibular premolars during chewing is three times as high as the other teeth.

The amount of material removed from the root canal depends on the shape of the rotary instrument and the penetration depth in the canal. Furthermore, the higher number of rotations in the canal necessary to complete a preparation with rotary Ni-Ti files with large taper, may contribute to the formation of dentinal defects.

File design, however, is also likely to affect the shaping forces on the root dentin. Forces generated during instrumentation have been linked to an increased risk of root fracture. During preparation, a canal is shaped by the contact between instrument and dentin walls. These contacts create many momentary stress concentrations in dentin. Such stress concentrations may leave dentinal defects in which VRF can initiate. Higher stresses in the root during instrumentation can be expected to increase dentinal defects and thus increase VRF risk.

ProTaper had 40% of dentinal defects as compared to other rotary systems which was significantly different. ProTaper rotary files are with progressive taper design which increases stiffness and facilitates active cutting motion and removes relatively more dentin coronally compared with other systems. ProTaper file F2 has a large taper of 0.08 which could explain the higher incidence of damage than other tapered rotary files. Bier et al. observed cracks in the horizontal sections of 16% of the roots instrumented with the ProTaper system and reported that ProTaperrotary files created more dentin damage than other rotary instruments.

Neolix (Neolix, châtres-la-Forêt, France) and 2 shape both groups showed presence of dentinal defects in form of partial or complete cracks. Neolix has a non-homothetic rectangular section along the blade enabling a progressive flexibility to better negotiate the curves and respect the canal anatomy. It is a single file system which has an inbuilt abrasive property of the flutes and edges associate a grater and cutting action, avoiding smear layer risk. Its ability to conform to the root anatomy and greater flexibility may be the reason for less number of dentinal defects seen in his group.

2 shape file system produced the least number of defects. It has a triple helix cross –section with two main cutting edges and one secondary cutting edge for debris removal. The asymmetrical cross section allows for increased efficacy of the circumferential brushing movements for efficient selective cleaning thus reducing the incidence of dentinal defects created during cleaning and shaping of root canal.

In the present study, a uniformed tapered preparation (0.06-0.08) was attempted in all groups. The observation that all groups prepared showed various degrees of damage supports the idea that greater tapered files may generate an increased stress on the dentin wall. Fewer microcrack formations occurred in apical thirds than middle and coronal thirds. In 2013, Liu et al. reported that during the instrumentation procedure, the stresses generated at 1 mm short of the Apical Foramen were merely one-third of the stress at more coronal levels.

VI. CONCLUSION

Within the limitation of the study it can be concluded that all the rotary instruments, induce dentinal defects, with protaper universal producing a higher number of defects as compared to the other two groups. Reasons may be the greater taper, more rotations and aggressive cutting which can

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generate increased stresses on the dentin wall and subsequent formation of dentinal defects.

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