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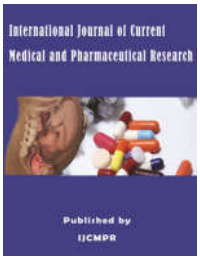

Research Article

THE EFFECT OF GOLD -WIRE RECIPROCATING INSTRUMENT VERSUS NITI ROTARY INSTRUMENTS ON THE INCIDENCE OF ROOT DEFECTS DURING ROOT CANAL PREPARATION

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ABSTRACT

Aim: To compare and analyze the incidence of root dentinal defects when root canals were prepared with instrumentation in rotary, reciprocation and hand motions.

Materials and methods: 60 freshly extracted mandibular first molars for periodontal reason with fully formed apices were collected. Mesial roots with the standardized root length of 13mm was obtained. Custom made acrylic blocks were made. All the root samples were randomly divided into four following groups (n=15) based upon the file system used to prepare the root canal. Group I: No preparation (control), Group II: Wave one Gold, Group III: MTwo, Group IV: Protaper Universal – Manual.

Working length was standardized as 12.5mm. Final apical diameter was standardized as size 25. All roots were sectioned horizontally at 9mm, 6mm and 3mm from apex. All 45 root sections in each group were examined under stereo-microscope to examine dentinal cracks or craze lines. Results were statistically analyzed.

Results: All three motions of instruments produced dentinal defects at all levels. All three experimental groups produced lesser dentinal defects in apical 1/3 level and more dentinal defects on coronal 1/3 level. MTwo file system produced more number of dentinal defects compared to Wave One Gold and Protaper universal manual files.

Conclusion: Protaper manual files produced lesser dentinal defects compared to Wave one Gold reciprocating and M Two rotary files. M two rotary instruments produced the most complete fractures compared to WaveOne Gold and Protaper universal manual files.

INTRODUCTION

Canal preparation involves radiuclar dentin removal and might compromise the strength of the roots (Sathorn *et al*., 2005). The fracture resistance of root canal treated teeth is directly related to the amount of remaining tooth structure (Wilcox *et al*., 1997). Instrumented root canals are significantly weaker compared to uninstrumented intact root canals (Zandbiglari *et al*., 2006). The dentinal radicular micro-crack is a difficult clinical problem to diagnose and treat (Clark *et al*.,2003, Kahler 2008, Snyder, 1976) and it is one of the third most common reasons for tooth extraction after caries and periodontal disease (Braly and Maxwell, 198, Hiatt, 1973). These micro-cracks start in the radicular dentin, and may spread into external surface of root under repeated loads and results in catastrophic complete root fracture. According to Andreasen, root fractures are defined as "fractures involving the dentine, cementum and pulp".[1]Resistance to fracture is an important paradigm in endodontics. Two types of toughening mechanism existing in dentine. Those are (i) intrinsic toughening mechanisms operate ahead of the crack tip and act to enhance the dentine's inherent resistance to micro-structural damage and cracking; and (ii) extrinsic toughening mechanisms that operate behind the crack tip by promoting crack-tip shielding, which reduces the local stress intensity experienced at the crack tip (Kruzic *et al*. 2003). Root fracture is a common cause of failure in many endodontically treated teeth. The root structure is weakened by excessive removal of dentin during root canal preparation or post space preparation resulting in increased susceptibility to root fracture. The high prevalence of root fracture in endodontically treated teeth is originally due to dehydrated and less elastic dentin after endodontic treatment. [2] The pulpless tooth has less than 9% water content than its healthy counterpart which attributes to the predominant factor for triggering the root fracture.[3] Water loss strongly affects the mechanical behavior of dentin. Dehydration may induce cracks in dentin regardless of canal instrumentation.[4] Dentinal cracks or root fractures occur when the tensile stress in the root canal wall exceeds the tensile strength of dentin.[5] Various hypothesis proposed for the

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causes of root fracture were the intrinsic morphological characteristics of teeth (Wilcox *et al*.,1997), root size (Wilcox *et al*.,1997, Sathorn *et al*., 2005),use of high concentrations of sodium hypochlorite, spreader design (Holcomb *et al*.,1987 , Pitts *et al*.,1983), excessive force during filling procedures by lateral condensation (Meister *et al*., 1980) and retreatment procedure, post placement and corrosion(Obermayr *et al*., 1991, Petersen 1971).

Rotary nickel–titanium based preparation became the mainstream approach to mechanically enlarge the root canal space to overcome the drawbacks of conventional rigid stainless steel manual preparation, such as canal transportation and perforation.[6] Rotary NiTi files with large tapers can produce increased friction and stresses on the canal wall and cause dentinal cracks in root dentin.[7,8] Rotary files system differ in their preparation protocols, number of files, metallurgy, kinematics(speed and torque) and design features such as taper, NiTi core diameter, cross-sectional geometry, rake angle, helical angle and pitch which may influence the generation of dentinal cracks.[9] The incidence of dentinal cracks vary from 12% to 60%.[10,11] Various surface treatments of NiTi instruments like cryogenic treatment, electropolishing, thermal nitridation, plasma immersion ion implantation minimize or eliminate their inherent defects, increase the surface hardness, flexibility, resistance to cyclic fatigue, cutting efficiency of endodontic instruments resulting in reduced stresses on dentinal wall and dentinal defects.[12]

Single file endodontics was introduced to reduce the number of files used for preparing the canals and to reduce the stresses produced on dentinal walls.[13] Reciprocating motion of files rather than continuous rotation was found to be more centered in the canal and allows continuous release of files when engaged in the inner wall of root dentin and relieves the stress on the instrument by counter-clockwise (cutting action) and clockwise (release of the instrument) movements.[14,15,16] The metallurgy and manufacturing process of alloy material of the rotary files also plays a vital role in generation of dentinal cracks. Recently Gold wire technology has been introduced to increase the flexibility which in turn reduce the stresses on dentinal wall and generation of dentinal micro-cracks.[17]

Wave One Gold file system is a single file, reciprocating file system manufactured by Gold Wire technology introduced by Cliff Ruddle, Sergio Kuttler, Wilhelm Petrot and Julian Webber. Wave One Gold files have a parallelogram cross section with 85º active cutting edge with alternate one and two point contact. It rotates at reciprocation motion of 150 º counter-clockwise and 30 º clockwise.

MTwo file system (VDW Munich,Germany) was introduced as “Single length method”. MTwo has a S- shaped cross-section, two efficient cutting edges with safe tip design, variable helical angle and negative rake angle.

Protaper Universal file system (Dentsply, Maillefer, Bellaigues, Switzerland) is the pioneer engine-driven instrument that employs full 360º rotation with convex triangular cross-section, safe tip design, variable helical angle, negative rake angle and multiple tapers within shaft. The Protaper Universal file system comprises of shaping files (S_x, S1, S_2) and finishing files (F_1,F_2,F_3,F_4,F_5).

Few reports have been reported so far on analyzing the dentinal micro-cracks formation by Wave one Gold files. The aim of this study was to analyze the effect of Gold wire reciprocating instruments and NiTi rotary instruments on the on the incidence of root defects during root canal preparation. Wave one Gold files and MTwo files have been taken in this study for Gold wire reciprocation motion and NiTi continuous rotation motion respectively. The null hypothesis was proposed that there would be no significant difference in dentinal micro-cracks production between the Gold wire reciprocating instruments and NiTi rotary instruments groups.

MATERIALS AND METHODS

Sixty mandibular first molars with fully formed apices freshly extracted for periodontal reason were collected (Fig.1). Mesial roots with 25-30º curvature (Pruett *et al*., 1997) were excluded for the study. The procedures of the collection, storage, sterilization and handling of extracted teeth were done as per the Occupational Safety and Health Administration (OSHA) recommendation and guidelines (Tate and White 1991). The crown of each tooth was decoronated at CEJ level and distal roots were separated from mesial roots using a diamond disc with water as a coolant to obtain the standardized root length of 13mm (Fig.2). All the mesial roots were examined under stereo-microscope to determine the existence of any previous craze lines or cracks. Roots with such defects were excluded in this study.

Roots were covered with aluminum foil to simulate the periodontal ligament space and embedded in the custom-made acrylic blocks. Then the aluminum foil was discarded and polyvinyl siloxane impression material (Aquasil, Dentsply Maillefer) was injected into custom-made acrylic block and roots with foil were re-inserted (Fig.3). The impression material was used to simulate resilient nature of the periodontal ligament and allowed to set. All the root samples were randomly divided into four following groups (Fig.4.1, 4.2, 4.3, 4.4).

Group I : No preparation (control) (n=15)
Group II : Wave one Gold (n=15)
Group III : MTwo (n=15)
Group IV : Protaper Universal - Manual (n=15)

Group I : No preparation-control(n=15)

Fifteen roots were left unprepared and served as control.
The remaining 45 teeth were subjected into the following protocol for canal preparation.

Working length determination

ISO size 10 k file (Mani, Inc., Tochigi, Japan) was introduced into the canal to check the patency and working length was established by subtracting 0.5 mm from root length of 13mm and standardized as 12.5mm. Glide path was made using 2% size 15 K-file. Sodium hypochlorite 3 % (Prime Dental Products, India) and EDTA 17% (Prime Dental Products, India) was used as irrigation regimen. Final apical diameter was standardized as size 25. Canal preparation was carried out corresponding to the groups as follows,

Group II : Wave one Gold (n=15)

Wave one Gold reciprocating primary file (7% taper, size 25) were used to prepare the mesial canal with 6:1 reduction hand piece and X-Smart Plus motor at 300 rpm with predetermined torque settings. The angle of reciprocation was set as 150 º counter-clockwise and 30 º clockwise.

Group III : MTwo (n=15)

MTwo rotary files were used to enlarge mesial canals by following basic sequence of files (4% size 10, 5% size 15, 6% size 20, 6% size 25). Preparation was done at 280 rpm with preprogrammed torque limit in VDW silver Reciproc motor.

Group IV: Protaper Universal Manual (n=15)

Protaper hand files (Dentsply Maillefer) were used to enlarge mesial canals till 6% taper, size 25 by following sequence Sx, S_1,S_2, F_1,F_2.

Sectioning and stereo-microcscopic examination

All roots were removed from acrylic blocks and sectioned horizontally at 9mm, 6mm and 3mm from apex using hard tissue microtome using water as coolant. The cut root sections were washed to remove debris and stored in normal saline. All 45 root sections in each group were examined under stereo-microscope (Olympus BX 43) under 25X magnification to examine dentinal cracks or craze lines. Digital images were captured and stored using a digital camera attached with stereo-microscope.

To define crack formation, three different categories were made according to Shemesh *et al*., in 2009**.,**(Fig.5.1, 5.2, 5.3)

1. ***No defect–*** absence of any craze lines or cracks.
2. ***Incomplete defect–*** craze lines do not extend completely from canal lumen to external root surface or vice-versa.
3. ***Complete fracture*** – craze line extends completely from canal lumen to external root surface.

Statistical Analysis

To compare proportions between groups Chi-Square test was applied, if any expected cell frequency was less than five then Fisher's exact test is used. To analyze the data SPSS (IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY: IBM Corp. Released 2013) was used. Significance level was fixed as 5% **(α = 0.05)**.

Fig.1 Teeth samples

Fig.2 Mesial root section

Fig.3 Acrylic block with root section

Fig 4.1 Group 1- control

Fig 4.2 Group 2- Wave one Gold

Fig 4.3 Group 3- MTwo

Fig 4.4 Group 4 Protaper universal manual

Classification of root defects (Shemesh et al., 2009):

Fig 5.1 No defect

Fig5.2 Incomplete defect

Fig 5.3 Complete fracture

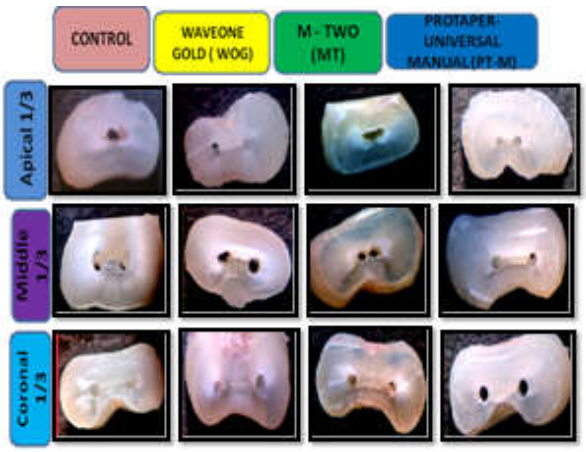


Fig.6

RESULTS

No of slices with dentinal defects have been tabulated and analyzed statistically.(Table 1 and 2).

Table 1 No of root slices of control group, Waveone gold, MTwo and Protaper Universal manual files with dentinal defects

Level	Wave one Gold (n=15)	M Two (n=15)	Protaper Universal Manual (n=15)	p-value
Coronal 1/3	3	4	4	0.999 (NS)
Middle 1/3	4	7	4	0.407 (NS)
Apical 1/3	7	9	5	0.401 (NS)
Total	14	20	13	0.277 (NS)
p-value	0.365 (NS)	0.220 (NS)	0.999(NS)	

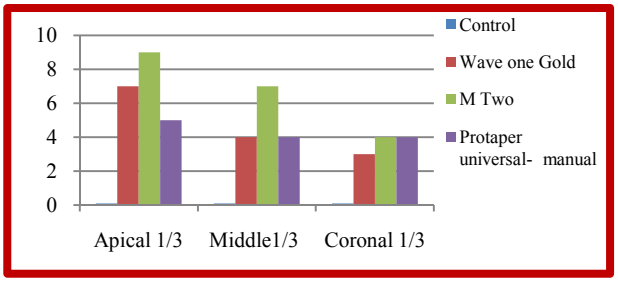
NS- not significant

Table 2 No of root slices of control group, Waveone gold, MTwo and Protaper Universal manual files with complete fractures.

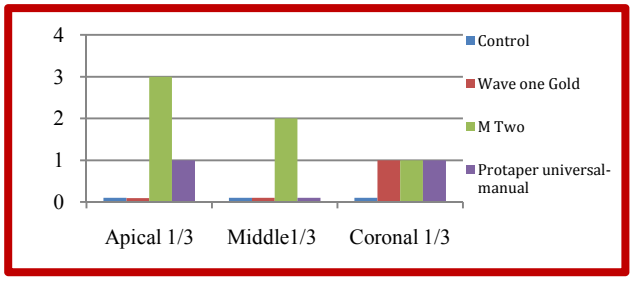
Level	Wave one Gold (n=15)	M Two (n=15)	Protaper Universal Manual (n=15)	p-value
Coronal 1/3	1	1	1	1.000 (NS)
Middle 1/3	0	2	0	0.318 (NS)
Apical 1/3	0	3	1	0.302 (NS)
Total	1	6	2	0.146 (NS)
p-value	0.999 (NS)	0.858 (NS)	0.999 (NS)	

NS - not significant

Graphs



Graph 1 No. of root slices of control group, Waveone gold, MTwo and Protaper Universal manual files with dentinal defects.



Graph 2 No. of root slices of control group, Waveone gold, MTwo and Protaper Universal manual files with complete fractures.

DISCUSSION

Root fracture is one of the most important frustrating complication which has to be avoided for the successful root canal therapy. Various methods have been used to analyze the dentinal defects produced by instrumentation during the shaping procedures in endodontic therapy. Those are Endoscopy, Infrared thermography, Micro-CT, Optical Coherence Tomography, Scanning Electron Microscope, Stereomicroscope, Synchrotron Radiation-based Micro-Computed Tomography, Translumination, Transmission Electron Microscopy. [18]

As the storage condition before, during and after the canal preparation affect the incidence of dentinal defect (Burklein 2013, Liu *et al*., 2013), extracted teeth were stored in normal saline throughout the study to avoid dehydration of root dentin.[19,20]

Though micro CT is the non – invasive, more accurate and reliable method to detect the dentinal defect and microcracks, scanning and reconstruction procedures take considerable time, the technique is not suitable for clinical use, the equipment is quite expensive, and the complexity of the technical procedures requires strict standardization protocol a high learning curve and in-depth knowledge of dedicated software.[18] Any dentin damage from pre- to postoperative conditions may occur and not be observable because it is below the spatial resolution threshold of the micro-CT system (Gustavo De Deus *et al*., 2014). Though scanning electron microscope gives high definition three dimensional images with much greater magnification and resolution, its gold sputtering procedure has the potential to cause cracks. Hence in this study conventional stereomicroscope has been used to evaluate the dentinal defects.

There are various factors that cause the dentinal defects during canal preparation. They are NiTi core diameter, rake angle, flute depth, taper of file (Bier *et al*.,2009), tip design, cross sectional geometry of file (Yoldas *et al*.,2012), flexibility of file (Burklein *et al*.,2012) and kinematics (Blum *et al*., 1997). In this study we analyzed the effect of Gold -wire reciprocating instrument and NiTi rotary instruments on the incidence of root defects during root canal preparation.

The thorough instrumentation of apical region is considered as critical zone for instrumentation. In this study, all the groups were standardized only in terms of the final apical diameter (ISO 25) and not in terms of the final canal taper (WaveOne Gold 7%, M Two 6%, and Protaper manual files 8%), and this might have influenced the outcome.

The specimens of the control group in this study had no defects, which would imply that an interplay between three sources of stresses on the root dentin namely., sectioning process, chemical attack with sodium hypochlorite and mechanical preparation did not induce any dentinal damage. This is in accordance with the results obtained in the studies done by Gustavo De Deus (2014), Burklein *et al*. (2013), Capar *et al*. (2014, 2015), Kansal *et al*. (2014), Nasr & Kader (2014), Topcuoglu *et al*. (2014).

The test results showed that all the three experimental groups produced the dentinal defects in all the three levels in root. All the three groups produced more number of dentinal defects in apical 1/3 level and lesser dentinal defects in coronal 1/3 level. M Two group produced more number of defects in all three

levels than Wave One Gold and ProTaper manual files which was not statistically significant ($p > 0.05$). In our study, Protaper Universal manual instruments produced lesser dentinal defects in comparison with engine driven instruments. This is in accordance with the studies done by Burklein *et al*. 2013, Liu *et al*. 2013a,b, Ashwinkumar *et al*. 2014 in which the test results showed engine-driven instruments caused more dentinal defects compared to manual file. More rotations are required to complete a preparation with rotary NiTi instruments as compared to manual files (Pasqualini *et al*., 2008). Continuous rotation with constant torque produces more stresses on dentinal walls and cracks formation (Bier *et al*., 2009, Kim *et al*. 2010).

By using reciprocating files, the remaining stress on the file is released and its reciprocating motion reduces the risk of cyclic fatigue caused by compression and tension cycle (Liu *et al*., 2013 and Aswinkumar *et al*., 2014). Our study is in agreement with these studies as more amount of dentinal defects were present with M Two rotary instruments. Having an S-shaped cross section with two sharp cutting edges and minimal radial land along the entire working part of M Two file design also attributed to the formation of more stresses in dentinal wall resulting in more dentinal defects.

The raw metal in Wave One Gold is nickel titanium which is repeatedly heated and cooled, giving it not only its gold colour, but also considerably improving its strength, flexibility and resistance to cyclic fatigue which will aid in reducing the dentinal cracks and fracture (Cliff Ruddle, Sergio Kuttler, Wilhelm Pertot and Julian Webber). Primary Wave One Gold file is at least 80% more flexible, 50% more resistant to cyclic fatigue and 23% more efficient, compared to the original Primary Wave One M-wire file. This novel gold wire technology attributed to the lesser number of defects produced by Wave One Gold files in this study.

While analyzing the complete fractures in all groups , M Two group presented with more number of specimens with complete fracture which was not statistically significant($p = 0.0146$). The aggressive cutting cross sectional design of M Two might be attributed to the more amount of complete fracture. High flexibility obtained by Gold wire technology contributes to much less number of fracture specimen in this study. Despite the efforts made under laboratory conditions to make the situation similar to clinical conditions, Clinically, the reported failure due to vertical root fracture is low (Friedman *et al*. 2003). Also, it is not clear whether all the micro-cracks would lead to vertical root fracture, and this needs to be studied further.

CONCLUSION

Within the limitations of the present study, it can be concluded that,

1. All three motions of instruments produced dentinal defects at all levels.
2. All three experimental groups produced lesser dentinal defects in apical 1/3 level and more dentinal defects on coronal 1/3 level.
3. MTwo file system produced more number of dentinal defects compared to WaveOne Gold and Protaper universal manual files.
4. M two rotary instruments produced the most complete fractures compared to WaveOne Gold and Protaper universal manual files.
5. Protaper manual files produced lesser dentinal defects compared to Wave one Gold reciprocating and M Two rotary files.

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