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NUMBER OF FILE USAGE ON DENTINAL DEFECT INCIDENCE OF WAVEONE GOLD AND RECIPROC NITI INSTRUMENTS

WaveOne GOLD ve Reciproc NiTi Kanal Aletlerinin Kullanım Sayısının Dentin Defekti Oluşturma İnsidansı Üzerine Etkisinin İncelenmesi

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ABSTRACT

Objectives: To compare the incidences of dentinal defects caused by Reciproc and WaveOne GOLD NiTi files during root canal preparation and to exam the effect of number of file usage on the incidence of dentinal defect.

Materials and Methods: Two hundred seventy mandibular incisor teeth were randomly divided into 3 different groups as follows: negative control (no preparation performed) (n: 30), Reciproc (n: 120) and WaveOne GOLD (n: 120) groups. The specimens were sliced at 3, 6 and 9 mm from the apex. Microscopic pictures of the specimens were taken with the aid of light emitting diode and the dentinal defects were examined.

Results: There was no statistically difference among the WaveOne GOLD, Reciproc and control groups in terms of dentinal defect formation. The number of dentinal defects occurred in apical region in Reciproc group following 4th use was found to be statistically higher than 1st, 2nd, and 3rd use in WaveOne GOLD group ($p < .05$).

Conclusion: All the NiTi files tested in present study were found to cause defect in root canal dentin but there were not significant difference among the WaveOne GOLD, Reciproc and control groups in term of total dentinal defect formation

Keywords: Reciproc; WaveOne GOLD; Usage; Crack; Dentinal Defect

ÖZ

Amaç: Kök kanal preperasyonu sırasında Reciproc ve WaveOne GOLD NiTi kanal aletlerinin neden olduğu dentinal defekt vakalarını karşılaştırmak ve eğe kullanım sayısının dentinal defekt insidansı üzerindeki etkisini incelemek.

Materyal ve Metot: İki yüz yetmiş adet mandibular kesici diş çalışmaya dahi edildi ve rastgele 3 gruba ayrıldı. Negatif kontrol grubu (n = 30) herhangi bir işlem yapılmadı, 120'şer diş de reciproc ve waveone gold gruplarına yerleştirildi. Örneklerden apeksten 3, 6 ve 9 mm uzakta olucak şekilde yatay kesitler alındı ve light emitting diode lazer yardımı ile çekilen fotoğraflarda dentinal defekt varlığı araştırıldı.

Bulgular: WaveOne GOLD, Reciproc ve control grupları arasında dentinal defect oluşumu açısından istatistiksel olarak anlamlı bir fark yoktur. Resiproc eğesinin 4. Kullanımı sonrası apical bölgede oluşturduğu dentinal defect sayısı WaveOne GOLD grubunun 1., 2. ve 3. Kullanımları sonrası oluşan sayudan istatistiksel olarak anlamlı derecede fazladır ($p < ,05$).

Sonuç: Çalışmamızda test ettiğimiz tüm NiTi eğeler kök kanal dentininde defect oluşumuna neden oldu ancak WaveOne GOLD, Reciproc ve kontrol groupları arasında toplam dentin defekti oluşumu açısından istatistiksel olarak anlamlı bir fark bulunmadı.

Anahtar Kelimeler: Reciproc; WaveOne Gold; Kullanım; Çatlak; Dentin defekti

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INTRODUCTION

Root canal preparation is one of the most important phases of a successful root canal treatment.[1] As a result of the contact between the file and the canal walls during root canal preparation, momentary stress accumulations may occur and these stresses may cause defects in dentin.[2] Occurring dentinal defects may result in vertical fractures due to recurrent endodontic treatments, restorative procedures, and occlusal loads.[3]

Under favor of their clockwise rotation, the reciprocal single-file systems, which drew attention and became popular since they were introduced to the market, decrease the level of stress that the files are exposed within the canal and increase their cyclic fatigue resistance in proportion to continuous rotation file systems.[4] Reciproc (RPC; VDW, Munich, Germany) and WaveOne (WO; Dentsply Maillefer, Baillagues, Switzerland) are the most popular single-file systems that complete 360° with different degrees of rotation in clockwise and counterclockwise directions.[5]

WO files were recently modified to WaveOne GOLD (WOG; Dentsply Maillefer) files. While maintaining the reciprocation movement of file, its cross-section, dimensions and geometry were changed. The cross-section of file was altered to parallelogram having 2 cutting edges. Moreover, the off-center design that ProTaper Next (Dentsply Maillefer) files have was used also in WaveOne GOLD files. The most significant change in files is the production employing GOLD heat treatment. GOLD heat treatment is performed by reversing the M-Wire technology utilizing pre-production heat treatment, and by manually heating the file after production and then slowly cooling it. The manufacturer company claims that new GOLD heat treatment increases the flexibility of files.[6]

In many studies, it has been reported that the cyclic fatigue resistance of NiTi files significantly decreased following the clinic use for long time.[7, 8] But, in literature, there is no consensus on after how many uses the NiTi files should be discarded. In their *in vivo* study on examining the cyclic fatigue resistance of ProFile (Dentsply Maillefer) files after the use, Yared *et al.*[9] have reported that there was no statistically significant difference between the files that have been used in molar teeth and the non-used files. Researchers have emphasized that ProFile files could be securely used in 4 molar teeth having averagely 3 canals. But, on the other hand, Wolcott *et al.*[10] have reported in their *in vivo* study that the ProTaper Universal (Dentsply Maillefer) NiTi files, which they have used in shaping totally 4652 canals, can be securely used in up to 4 canals.

In comprehensive literature review, no study examining the effect of number of use of NiTi files on the incidence of dentinal defects was found. For this reason, the aim of present *in vitro* study was determined to be the comparison of incidences of dentinal defects caused by Reciproc and WaveOne GOLD NiTi files during shaping the mandibular incisor teeth's root canals and the examination of effect of number of file usage on the incidence of dentinal defect. The first null hypothesis of present study was that there would be no difference between the dentinal defect incidences of Reciproc and WaveOne GOLD files. Second null hypothesis was that the number of use of files would have no effect on the incidence of dentinal defect formation.

MATERIALS AND METHODS

Specimen Selection

Two hundred seventy mandibular incisor teeth having straight canals, which have been extracted due to periodontal reasons, were selected. The soft and hard tissues around the teeth were mechanically removed using a periodontal curette. The crowns of teeth were removed from the enamel-cement junction under water-cooling in the way allowing 14 mm of root length. The radiographic images of teeth were taken in mesio-distal and bucco-lingual directions. The teeth have calcification, having

history of previous root canal treatment, involving internal and/or external resorption, or fractured and/or having immature roots were excluded. The selected teeth were kept in distilled water at 4°C for the experimental procedures.

The roots of teeth were wrapped with aluminum foil and then embedded into acrylic resin (Imicryl, Konya, Turkey).[11] After the acrylic resin set, the teeth were taken out from the resin, and the foils were removed. To simulate the periodontal ligament, the resin blocks were filled with viscous silicon impression material (Express XT Light Body Quick; 3M ESPE, Neuss, Germany) and the specimens were then placed into the resin blocks again.

Root Canal Preparation

The canals of teeth were penetrated using #10 K-file (Dentsply Maillefer) until the tip of file is seen from the apex. The working length was set to 1 mm shorter than this length. For all of the specimens, the glide path was created ensuring the apical diameter of #15. For each of specimens, 20 ml 1% sodium hypochlorite (NaOCl) was used during the preparation. The entire procedure was executed by the same endodontist having 5 years of experience. Thirty non-treated specimens were assigned as negative control group.

Root Canal Preparation

Group 1: Reciproc

A hundred twenty specimens in this group were then divided into 4 sub-groups (1A, 2A, 3A and 4A), 30 specimens in each. The specimens in Group 1A were prepared using 30 non-used Reciproc R25 (25/.08) files and VDW Gold Reciproc (VDW) endodontic motor utilizing "Reciproc ALL" program of endodontic motor. And then, these files were used in preparation of specimens in Groups 2A, 3A and 4A, respectively. Thus, the dentinal defects on specimens in Group 1A were examined after 1st use, those of specimens in Group 2A after 2nd use, those of specimens in 3A following 3rd use, and those of specimens in Group 4A after 4th use.

Group 2: WaveOne GOLD

A hundred twenty specimens in this group were then divided into 4 sub-groups (1B, 2B, 3B and 4B), 30 specimens in each. The specimens in Group 1B were prepared using 30 non-used WaveOne GOLD Primary (25/.07) files and VDW Gold Reciproc (VDW) endodontic motor utilizing "WaveOne ALL" program of endodontic motor. And then, these files were used in preparation of specimens in Groups 2B, 3B and 4B, respectively. Thus, the dentinal defects on specimens in Group 1A were examined after 1st use, those of specimens in Group 2A after 2nd use, those of specimens in 3A following 3rd use, and those of specimens in Group 4A after 4th use.

Assessment of Dentinal Defects

Under water-cooling (Isomet; Buehler Ltd, Lake Bluff, IL, USA), the roots of 270 specimens were cut perpendicular to tooth axis at 3, 6, and 9 mm distant from the apex, and 3 slices were obtained from each specimen. Trans-illumination was applied to the slices from 1 mm distance in mesial, distal, buccal, and lingual directions using light emitting diode (LED; LED Light; Denshine Technology, China) device. The digital images (4 images from each slice) were taken under x25 magnification using a digital camera connected to stereomicroscope (Olympus BX43, Olympus Co., Tokyo, Japan). Totally 3240 digital images, 360 from each sub-group, were examined in terms of the presence of any crack. The images obtained were randomly assigned to 2 experienced endodontists, who were not involved in the preparation of the specimens, in order to determine the presence or absence of dentinal defects. To define crack formation, 2 different categories were made ("no crack" and "crack") in order to avoid the confusing description of root cracks. "No crack" was defined as the 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.[12]

Statistical Analyses

In examining the intergroup incidence of dentinal defects, Chi-Square test was utilized. The level of statistical significance was set to 5%. The statistical analyses were performed using SPSS 21 (IBM-SPSS Inc., Chicago, IL, USA) software.

RESULTS

In present study, totally 3240 images from 810 tooth slices were examined. The distribution of the numbers dentinal defects caused following 1st, 2nd, 3rd, and 4th use in RPC and WOG groups by the apical, middle, and coronal regions are presented in Table 1.

Table 1. The Number and Percentage of Slices with Defect after Different Number of Usage at Each Level (n =30)

		Reciproc Group				WaveOne GOLD Group			
		3 mm *n* (%)	6 mm *n* (%)	9 mm *n* (%)	Total of specimens of presenting defects n (%)	3 mm *n* (%)	6 mm *n* (%)	9 mm *n* (%)	Total of specimens of presenting defects n (%)
Control Group		8 (26.7%) ^{a}	12 (40%) ^{a}	10 (33.3%) ^{a}	14 (46.7%) ^{a}	8 (26.7%) ^{a}	12 (40%) ^{a}	10 (33.3%) ^{a}	14 (46.7%) ^{a}
Number of Usage	1st	10 (33.3%) ^{a}	15 (50%) ^{a}	10 (33.3%) ^{a}	15 (30%) ^{a}	9 (30%) ^{a}	14 (46.7%) ^{a}	8 (26.7%) ^{a}	15 (30%) ^{a}
	2nd	10 (33.3%) ^{a}	16 (53.3%) ^{a}	11 (36.7%) ^{a}	18 (60%) ^{a}	9 (30%) ^{a}	15 (50%) ^{a}	10 (33.3%) ^{a}	18 (60%) ^{a}
	3rd	16 (53.3%) ^{a}	18 (60%) ^{a}	14 (46.7%) ^{a}	22 (73.3%) ^{a}	14 (46.7%) ^{a}	17 (56.7%) ^{a}	12 (40%) ^{a}	20 (66.7%) ^{a}
	4th	22 (73.3%) ^{b}	18 (60%) ^{a}	15 (50%) ^{a}	26 (86.7%) ^{a}	20 (66.7%) ^{a}	18 (60%) ^{a}	13 (43.3%) ^{a}	25 (83.3%) ^{a}
P-value		< .05	> .05	> .05	> .05	> .05	> .05	> .05	> .05

*****Different superscripts indicate statistically different at p = .05.

It was determined that the total number of defects in RPC and WOG groups increased following 1st, 2nd, 3rd, and 4th use in proportion to control group but the difference was not statistically significant (p> .05) (Figure 1).

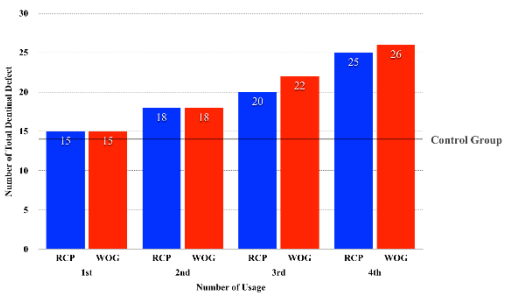

Figure 1. The number of total dentinal defects in the WaveOne GOLD and the Reciproc group after 1, 2, 3 and 4 usage. There was no significant difference among the groups (P > .05).

On the other hand, the number of dentinal defects occurred in apical region in RPC group following 4th use was found to be statistically higher than the control group and 1st, 2nd, and 3rd use in WOG group (p<.05). Furthermore, no statistically significant difference was observed between WOG and RPC groups in terms of total dentinal defect formation (p>.05).

DISCUSSION

In present study, it was aimed to compare the incidences of dentinal defect caused by Reciproc and WaveOne GOLD NiTi files during shaping the root canals of mandibular incisor teeth and to examine the effects of number of use of files on the defect formation incidence. According to the obtained results, it was determined that dentinal defects formed by all of the tested NiTi files but there was no statistically significant difference between the defect incidences among the RPC, WOG and control groups. For this reason, first null hypothesis of the present study was accepted. Moreover, it was determined that the number of the usage of files didn't affected the total dentinal defect formation incidence during the root canal shaping procedures, second null hypothesis was also accepted.

The manufacturers of WOG and RPC NiTi files recommend using the files on single tooth. Based on the preparation of 4-canal maxillary first molar tooth, the files were assumed to be used for 4 times in the present study.[13] It has been reported that use of larger files in shaping the root canals increased the incidence of dentinal defect formation.[14] For this reason, in present study, the apical diameter of files was determined to be 0.25 mm, and no larger file was used. Moreover, in order to protect the microstructure of dentin, 1% NaOCl was used as irrigation solution. Thus, it was aimed to ensure most of the dentinal defects to be related with the mechanic preparation.

It has been reported that the forces applied while extracting the teeth and the stress during storing the teeth and obtaining the slices might

cause dentinal defect.[15] This may explain the formation of dentinal defects in negative control group, where no intervention was made in present study. The studies employing classical method of sectioning have failed in determining these defects in negative control groups (16). When illumination was applied on the obtained dentin slices, the light moves along the dentin, but it stops at the point of any crack on dentin and thus the presence of crack and/or fracture can be determined.[16] In study of Coelho *et al.*[17], the dentinal defects could be determined in many specimens in negative control groups by employing LED. For this reason, LED trans-illumination was employed in present study.

The use of reciprocation movement with single-file NiTi systems in preparation of straight and curved root canals rather as an alternative to continuous rotation movement became very popular.[18] Under favor of higher degree of reciprocation movement of file in counterclockwise (cutting) direction than the movement in clockwise (relax of file) direction, and the file moves towards the apical. It has been reported in many studies that the reciprocation movement increases the fatigue of file by declining the tension and compaction forces that the file is exposed to within the canal.[19] According to the manufacturer, the single-use NiTi files can be use in up to 3-4 canals in the same molar teeth or for the same patient (6). But, however, the root canal preparation procedure may lead defects on the file's surface[20] and this might decrease the cutting efficiency of the file.[21] Pirani *et al.*[22] have reported that, in their study on examining the surficial properties of RPC and WO NiTi files after 1st and 3rd use, the number of use didn't significantly affect the amplitudes of defects seen on the files. Researchers have argued that the use of files up to 3 times would be safe. Similarly, Gambarini *et al.*[23] have examined the cutting efficiencies of Twisted File (Axis/SybronEndo, Orange, CA, USA) files after 1st and 10th use, and have reported that the number of use of files didn't significantly influence the cutting efficiency. On the other hand, Seago *et al.*[24] have investigated and compared the cutting efficiencies and flexibilities of HyFlex CM (Coltene-Whaledent, Allstetten, Switzerland) files after 1st and 10th use and after sterilization and reported that the cutting efficiencies significantly declined after 2nd and 3rd use and 7th, 8th and 9th use. Moreover, the micro-cracks and defects on the surfaces of NiTi files used in SEM studies and the deteriorations on the cutting edges have been reported.[25] Although the differences were statistically non-significant, the deformation may be shown as a reason for the increase in the dentinal defect incidence seen in specimens alongside the increase in the number of use.

El Nasr and El Kader[26] have reported that the mechanical properties of the alloy, of which the files were made, affected the dentinal defects occurred while preparation of the root canals. Plotino *et al.*[27], in their study on comparing the cutting efficiencies of RPC and WO NiTi files, have reported that RPC files had statistically significantly better cutting efficiency than WO files. The authors have attributed this result to the cross-section of RPC file and its positive cutting angle. Moreover, the authors have argued that, regardless of the movement type of the files, the cross-section played significant role in their cutting efficiencies. Similar to the study of Plotino *et al.*[28], the studies have reported that NiTi rotary file systems having S-shaped cross-section and 2 cutting edges had advanced cutting properties[29] Besides the cross-section of files, also their efficiency in removal of debris play significant role, because unremoved debris within the canals would occlude the cutting blades of files.[30] It is thought that, under favor of the S-shaped cross-section of RPC file used in present study and the off-center design of WOG file, they have high level of dentin removal efficiencies and thus high level of cutting efficiencies, and that this caused

dentinal defect at the statistically same level with control group.

Similar to the results of present study, Coelho *et al.*[18] have investigated the dentinal defects caused by ProFile (Dentsply Maillefer), TRUShape (Dentsply Maillefer) and WaveOne GOLD systems during shaping the mesial canals of mandibular molar teeth by using light-emitting diode and reported that there was no statistically difference between the experimental groups and the negative control groups. Moreover, Karataş *et al.*[31] have also examined the dentinal cracks on mandibular incisor teeth caused by ProTaper Universal, ProFile Vortex (Dentsply Maillefer), ProTaper GOLD, Reciproc (VDW, Munich, Germany), and F360 (Komet Brasseler, Lemgo, Germany), and reported that there was statistically non-significant difference between ProTaper Universal, ProFile Vortex, ProTaper GOLD and Reciproc groups in terms of dentinal defect formation. These results corroborate the findings of present study.

Kim *et al.*[32] have reported that the stress in apical region during root canal shaping was higher than the medial and coronal regions. Despite the results of that study, Versluis *et al.*[33] have reported that the level of stress occurring in coronal and middle third during root canal shaping was 3 times higher than the stress in apical third. Similar to the results of Versluis *et al.*'s study, even though the difference was statistically non-significant except for the 4th use groups, more dentinal defects were found in medial third in present study. The deformation at the tip of files is believed to be the reason for more dentinal defect in apical region after 4th use.

Even though it was paid importance to imitate the clinic conditions in laboratory environment in present study, especially in the studies on examining the mechanical properties of teeth, many external factors such as storing the teeth after extraction and until the sectioning procedure affect the results of study.[34] For this reason, as stated in study of Coelho *et al.*[35], the use of teeth extracted using periodontal reasons, which require very low level of force during extraction, and the careful storage of these teeth until the sectioning procedures would allow more successful outcomes.

One of the limitations of present study is the difficulty of standardization of apical pressure applied by the operator during root canal shaping procedure.

CONCLUSION

All of the NiTi files tested in present study were found to cause defect in root canal dentin. However, it has not been revealed yet if the dentinal defects occurring root canal shaping have any effect or importance on the success of endodontic treatment from clinical aspect. For this reason, *in vivo* studies examining the role of dentinal defects, which occur during root canal shaping procedures, on the endodontic failure are needed.

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