

RESEARCH ARTICLE

# Root Dentine Strain Generation during Root Canal Instrumentation with Rotation and Reciprocation Motions

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## ABSTRACT

The aim of the study is to measure and compare strain generated on root dentine surface by two different instrumentation motions. Thirty extracted single canal premolars were used in this study which randomly was divided into two groups, one group was prepared with ProTaper NEXT X2 file in rotation motion, and the second group was prepared by WaveOne GOLD primary file in reciprocation motion, the canals were irrigated during canal preparation by 2 ml of sodium hypochlorite and 17% EDTA gel was used. Strain measurement was performed by strain gauges and a digital strain output reader, data were recorded every 5 s for 50 s. The results of this study have shown that WaveOne GOLD had higher mean  $0.7308 \pm 0.41106$  than ProTaper next  $0.5385 \pm 0.39904$  which means WaveOne GOLD generates greater strain than ProTaper NEXT. However, according to Student's *t*-test between two groups there is no statistical difference between them. Based on the results of this study, there was no difference between the two motions; both motions generated strain on root dentine surface.

**Keywords:** Endodontics; Instrumentation; Reciprocation motion; Root canal; Root dentine strain; Rotation motion

## INTRODUCTION

The primary goal of endodontic treatment is to conserve the remaining tooth after dental caries or trauma to assure the retained tooth structure and the following restoration are both functional and esthetic. Success of root canal shaping is the key point for success of endodontic therapy and the following restorations, (Liu and Wu, 2016).

During the previous decades a very rapid and broad development has been made in dentistry (Modh et al., 2018). The first steps toward the development of endodontic are the introduction of nickel-titanium (NiTi) alloy and the subsequent automation of mechanical preparation, (Gavini et al., 2018). Advantage of nickel titanium is its reduced procedural errors such as zipping, stripping ledge formation, and perforations. They are more flexible than stainless steel files which were inflexible with larger file sizes and lead to procedural errors and decreasing the success rate of endodontic treatments. Further advancements in endodontics are single file rotary files which make it able to prepare the root canal system by only one file which has working time less than sequenced rotary systems. In addition to rotary movement, reciprocating movement was introduced into dentistry which is claimed to relieve stress on instrument

by its counter clockwise and clockwise motion which disengages the instrument from dentinal wall, (Machado et al., 2010, Khawaja et al., 2016).

During root canal instrumentation, dentinal microcracks may occur apically and extend to the coronal parts of the tooth which may end up in vertical fracture and lead to extraction of the tooth since there is no predictable treatment for vertical root fracture. This problem might occur during canal shaping since during shaping of canals, dentinal walls thickness may decrease and produce stress and strain on root especially in the apical third region in which crack might be easily formed. In addition, strain is also generated on the root dentin surface at the same time with heat production since temperature elevation produces an initial dentinal contraction, followed by its expansion, (Amade et al., 2013; Jamleh et al., 2016). Furthermore, one of the causes that generate microcracks in root dentin was revealed to be the force applied to the root canal walls during mechanical instrumentation of root canal using nickel titanium rotary or reciprocation systems. In addition, tip design, cross-sectional geometry, type of taper, shape of flute, and pitch might also be linked to dentinal crack formation, (Dixit et al., 2016; Carlesi et al., 2018).

Since there is lack of studies in literature examining strain generation comparing rotation and reciprocation motion. The aim of this study is to evaluate the strain generation by the two motions on external root dentine surface. The null hypothesis tested was that there is no difference among the strain generation for rotation and reciprocation motion.

## MATERIALS AND METHODS

Thirty extracted single canal human premolar teeth whose roots were similar in size and shape were used in this study. Root surfaces of these samples were washed with water to remove blood, soft-tissue remnants and ultrasonic scalers were used to remove calculus form the root surfaces.

To provide a straight line access and to provide a reference point (Jamleh et al., 2015), each sample root was measured to 12 mm by a digital caliper (TRUPER) and was cut by a diamond disc bur by a slow speed handpiece Figure 1, and was stored in distilled water at room temperature.

The samples were randomly divided into two groups 15 teeth in each based on the endodontic file and the instrumentation motion during root canal. The groups were as following;

- Group 1: ProTaper NEXT file no.: X2(025/06) (PTN; Dentsply Maillefer, Ballaigues, Switzerland)
- Group 2: WaveOne GOLD file no.: Primary (25/07) (WOG; Dentsply Maillefer, Ballaigues, Switzerland).

### Tooth Mounting

Apical third of the teeth were imbedded into 8 mm length and 10 mm width self-cure acrylic resin, it was taken into consideration that each tooth sample was placed in the center with long axis of the tooth being perpendicular. During mounting imbedding the teeth, it was made sure to leave middle third of each sample was free for strain gauge attachment.

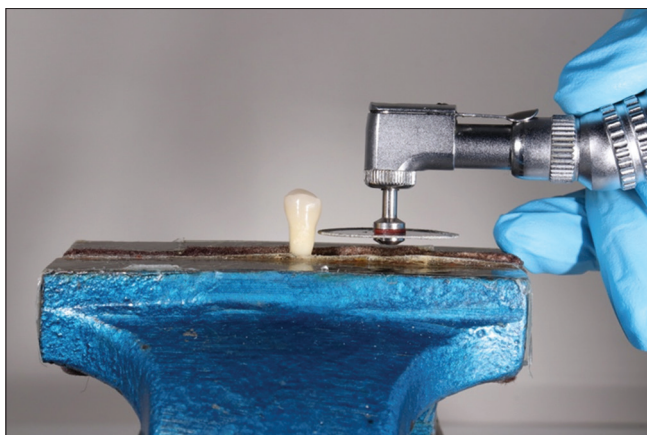


Figure 1: Decoronation process

### Strain Measurement

After cleaning and mounting of the teeth, each sample was acid etched with 37% phosphoric acid (TehnoDent, Russia) for 15 s and was washed vigorously with water and was dried with air spray to increase the bonding retention of the strain gauge, (Amade et al., 2013). Epoxy based bonding material (Alteco 3-tone epoxy adhesive, Japan) was mixed in one to one ratio according to manufacturer's instructions; the gauge (BF350-3AA, China) was held by a tweezer at its terminals and a layer of the epoxy-based adhesive was applied to the bottom layer of the strain gauge by its applicator and a layer was also placed on the tooth surface. The samples were left undisturbed for complete setting for 24 h. A thin layer of silicon impression material (Variotime, Kulzer) was placed in the surface of the strain gauge to protect it from the solvents used for irrigation during instrumentation procedure Figure 2, (Amade et al., 2013).

Strain gauges were connected to strain gauge amplifier load cell (SMOWO, China) through two electric clamps and the load cell amplifier was connected to digital strain output reader (OMEGA DP25B, USA), Figure 3 During root canal instrumentation strain was recorded by this system at 5 s intervals for 50 s which was a mean time for canal preparation.

### Root Canal Preparation and Irrigation

Working length and canal patency were previously established for each sample by introducing size 10 K-file into the canal until the tip of the file was just visible at the end of the canal before mounting the sample to acrylic base the and the working lengths were set by 1 mm shorter from the apex. Canal patency was established by a size 10 K-file in watch winding motion, along with irrigation with 5.25% sodium hypochlorite.

After confirmation of the glide path, the samples were mounted on vise and the canal instrumentation procedure

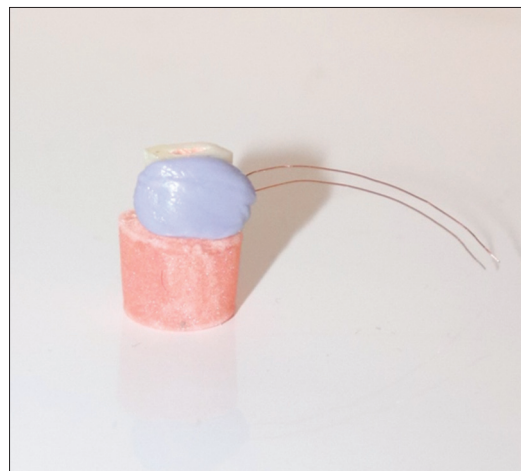


Figure 2: Strain gauge is covered by silicone impression material

for the first group was started with ProTaper NEXT X2(25/06), the canals were instrumented in brushing motion with concomitant irrigation with 2 ml 5.25% sodium hypochlorite irrigation solution according to the pilot study done previously with determined number of strokes and duration for full instrumentation, later, the files were cleaned with a cotton roll to remove dentinal debris during the root canal preparation process. This procedure was followed by 1 ml of 17% EDTA gel for 1 min and then flushed by 10 ml of 5.25% sodium hypochlorite and finally followed by a flush of 10 ml of saline and the irrigation needle was placed inside the canal to the 3 mm shorter from the full working length, (Amade et al., 2013). To standardize the technique, the canals were prepared with a total of 12 strokes to the full working length which was enough for complete canal preparation according to the previously done pilot study. The second group was prepared in reciprocation motion with WaveOne GOLD (Dentsply Maillefer, Ballaigues, Switzerland) and the X smart plus endodontic motor was set up on WaveOne GOLD pre-programmed option that is present in the device. The canals were instrumented, in the same manner was previously mentioned.

In both groups, each sample was prepared 1 for 50 s which was the average time for preparation of the canal. In addition, each file was used for only two samples and was discarded.



**Figure 3: Connection of electric clamp, amplifier, and digital output reader**

The recorded data were then statistically analyzed by descriptive statistics and *t*-test for difference between two groups of motions (rotation and reciprocation).

## RESULTS

The mean of strain elevation and standard deviations for the experimental groups are shown in Table 1. Descriptive statistic between two groups, ProTaper NEXT for rotary motion, and WaveOne GOLD for reciprocation motion, have shown that WaveOne GOLD had higher mean  $0.7308 \pm 0.41106$  than ProTaper next  $0.5385 \pm 0.39904$  which means WaveOne GOLD generates greater strain than ProTaper NEXT Tables 1 and 2.

Student's *t*-test have shown that there is no significant difference ( $P > 0.05$ ,  $P = 0.352$ ) between the WaveOne Gold (reciprocation) and ProTaper Next(rotation) in strain generation on root dentine Table 3.

## DISCUSSION

In this *in vitro* study, the strain generation on root dentine surface during root canal preparation with two different instrumentation motions was investigated. The results of this study supported the null hypothesis that there is no difference between the strain measurements of rotation and reciprocation motion. There was no statistical difference between the ProTaper NEXT and WaveOne GOLD files in strain generation during root canal preparation.

Canal shaping is a critical stage for successful treatment of the root canal as it provides sufficient room for effective disinfection and root canal filling. However, this procedure may weaken root dentine structure, since during root canal preparation dentinal thickness decreases which leads to strain accumulation, (Hulsmann et al., 2005; Jamleh et al., 2016). In addition, intra canal rotation of the file inside the root canal can increase the strain leading to root deformation such as micro cracks, (Miguéns-Vila et al., 2017). Cassimiro et al., 2017, have stated that root canal morphology, in addition to cross section of the instrument would affect the amount of contact with the root dentine which, in turn, may increase tension in addition they also

**Table 1: Mean maximum strain (in  $\mu S$  and  $\pm$ Standrad deviation) defined by descriptive statistics ( $n=15$ ) as strain generation during root canal instrumentation showing that WaveOne GOLD had higher strain generation than ProTaper NEXT**

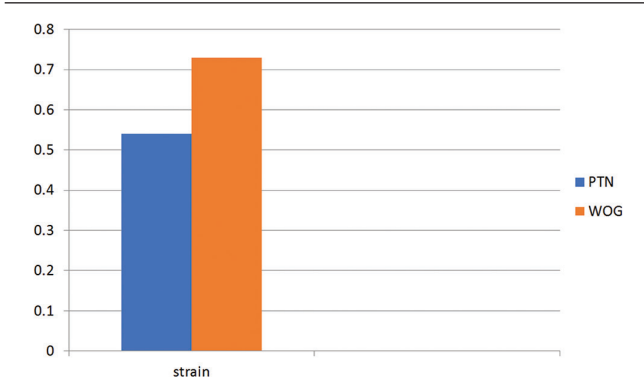
Descriptive Statistics Between PTN and WOG	Descriptive statistics						
	<i>n</i> Statistic	Minimum Statistic	Maximum7 Statistic	Mean Statistic	SE	SD Statistic	Variance Statistic
PTN	15	0.10	1.30	0.5385	0.11067	0.39904	0.159
WOG	15	0.20	1.50	0.7308	0.11401	0.41106	0.169

SD: Standard deviation, SE: Standard error, PTN: Pro taper NEXT, WOG: Wave one GOLD

**Table 2: P value of mean strain between reciprocation and rotary motions showing that there is no significant difference between the experimental groups**

t-Test Between PTN and WOG	t-test						t	df	Significant. (two-tailed)
	Paired differences				Lower	Upper			
	Mean	SD	SEM	95% CI of the difference					
PTN - WOG	-0.19231	0.71585	0.19854	-0.62489	0.24027	-0.969	28	0.352	

SD: Standard deviation, SEM: Standard error of mean, CI: Confidence interval, PTN: Pro taper NEXT, WOG: Wave one GOLD

**Table 3: Bar chart showing strain difference between the two motions**

mentioned in their study, tip design of rotary instrument, the taper type could also be related with dentinal microcrack formation, (Cassimiro et al., 2017).

ProTaper NEXT's a fifth-generation file that has an offset of mass of rotation with two cutting edges, which produce a mechanical wave motion that moves along the file length which, in turn, minimizes the engagement between the file and dentin in addition, this offset design provides a better cross-sectional space that improves cutting, loading, and debris removal out of canal when compared with a centered mass of rotation file, (Ruddle et al., 2013). On the other hand, WaveOne GOLD file has an alternating offset parallelogram cross-section design which limits the contact with the dentin to one or two points thus reducing taper lock and the screw effect, (Ruddle, 2016). These characteristics of the file designs can be the reason why there were no significant differences in the obtained results of this study.

Furthermore, in this study ProTaper next X2(25,06) file and WaveOne GOLD (primary 25,07) files were used in canal preparation, although same size of file was used but their taper is different, this different might be the reason of the higher mean of the WaveOne Gold file in strain generation. Cassimiro et al. in their study compared the effects of different instruments which included ProTaper NEXT and WaveOne GOLD instruments on root canal wall, in their result they found that there was no statistical difference between the groups; all the groups have shown degree of microcracks. Furthermore, Burklein et al., when

comparing rotation motion and reciprocation motion, found that dentinal microcracks were present in all the prepared canals and there was no statistical difference between the reciprocation and the rotation groups, (Cassimiro et al., 2017, Burklein et al., 2013) which supports the results of our study.

In this study, strain gauges have been used to evaluate the amount of strain generated by the two different reciprocation motions. Strain gauges is the most commonly used method of strain measurement due to its accessibility and ease of use and application on tooth surface however a special attention should be given to protect the gauges from irrigants since Amade et al. have reported that irrigants effect the readings of the gauges.

To different anatomical variations, single rooted premolars were used in this study. Extra oral environment, tooth storage media, and post-extraction dentinal changes might all effect the results as they are completely different from intraoral environment, a completely different data can be obtained in an intraoral environment. Thus, further studies should be done for reciprocation motion and rotation motion assessment.

## CONCLUSION

Within the limitation of this study, both rotation and reciprocation motion generated strain on root dentine surface and there was no significant difference in strain generation between the two motions. However, the strain generated by rotation motion was found to be less than reciprocation motion.

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