Conservation of dentin thickness in the root canals orifice following two preparation techniques

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Abstract

Objective: The aim of this study was to evaluate the amount of dentine removed after canal preparation using ProTaper (PT) and Greater Taper (GT) rotary instruments.

Materials and methods: Twenty extracted human teeth with single roots were selected and sectioned at the level of CEJ. The roots were distributed in two groups (n= 20) using stratified randomization, and prepared under simulated clinical conditions with ProTaper (PT) and Greater Taper (GT) rotary NiTi system. The pre- and post-preparation photographs were traced and superimposed, dentin thickness was measured at the levels of canal periphery, canal area, tooth area, mesial dentin thickness, distal dentin thickness, buccal dentin thickness and lingual dentin thickness both before and after preparation.

Results: The thickness of removed dentin was significantly different between the two preparation techniques ($p<0.01$) at the level of both tooth and canal area with more conservation for GT system while ProTaper system more conservative at buccolingual width than mesiodistal width, and GT system was more conservative at mesiodistal dimension than buccolingual dimension.

Conclusion: GT rotary instrumentation prepares root canals has greater conservation of dentine structure on the overall dimensions of the root, while the ProTaper system is more conservative at buccolingual dimension.

Keywords: *Dentine wall thickness, GT and ProTaper, Nickel Titanium rotary systems, root canal dimensions.*
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Introduction:

Coronal and root fracture teeth were the third most common cause of tooth loss in world after caries and periodontal disease[1]. It is generally accepted that the amount of remaining dentine is directly related to the strength of the tooth and the thickness of the dentinal wall at the root circumference is critical, and there is a direct correlation between the root thickness and the ability of the tooth to resist lateral forces and avoid fracture[2], so the thinner the dentin, the more likely the tooth is to fracture[3].

Besides other factors, stresses and the forces generated during instrumentation have been linked to an increase risk of root fractures. It was reported that the root canal preparation alone significantly weakened roots and may have created apical root cracks and thus canal preparation techniques play a vital role in affecting the root fractures. Canal preparation involves dentin removal and may compromise the fracture strength of the roots that could at any stage induce fractures whether complete or incomplete[4].

Over preparation of the coronal third of canal is one of the aberrations that may occur during root canal preparation and it may weaken the tooth, and root perforation is a possible consequence of canal preparation that may result in treatment failure[5].

In the last decades, many new NiTi rotary instruments have been developed and introduced by various manufacturers. Most clinicians prefer these systems because of their advantages such as saving time and better cutting efficiency. Nevertheless, some functions of NiTi rotary systems such as cleaning ability, increased stress, and the inability to adequately prepare oval canals are still controversial. Additionally, a potential relationship between the design of NiTi instruments and the incidence of vertical root fractures have been found and file design affected apical stress and strain concentrations during root canal instrumentation[6].

The ProTaper system (Dentsply Maillefer, Ballaigues, Switzerland) consists of 8 rotating NiTi instruments with different tapers and a convex triangular cross-section. These files are classified as shaping files and finishing files with a different taper in the coronal and apical portion. The apical configuration closely resembles ISO files. The shaping files are Sx, S1, and S2, designed for coronal enlargement. The Sx shaping files are to be used in a brushing and milling action. The finishing files are F1, F2, F3, F4 and F5 have subsequently#20, #25, #30, #40 and #50 tip diameters[7].

Greater Taper™ nickel–titanium rotary files have been introduced (Dentsply/Tulsa Dental, Tulsa, OK,

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USA; Dentsply/Maillefer, Ballaigues, Switzerland). These files have maximum flute diameters of 1.0 mm and exhibit flute tapers that are three, four, five and six times the standardized ISO 0.02 taper[8], GT instruments are the only taper-centric shaping instruments available, meaning that they vary primarily by their tapers, rather than by their tip diameters, GT instruments are available in four basic categories of sizing, the 20 series, the 30 series, the 40 series, and the 0.12 accessory series. The 20, 30, and 40 series GT Files have the same range of tapers, 0.04, 0.06, 0.08, and 0.10 mm/mm in each file set but vary by their designated tip diameters[9].

The purpose of this study was to evaluate dentine thickness in the coronal portion of single rooted tooth both pre- and post-preparation using ProTaper and Greater Taper (GT) rotary canal instrumentation techniques.

Materials and Methods:

The samples consisted of 20 single straight roots with well-formed and mature apices without visible apical resorption were kept in 10% formalin solution. The teeth were cut at CEJ using diamond disc mounted on straight hand piece to a level of approximately 15 mm length. The roots were embedded in cold cure acrylic resin using disposable syringe as a mounted mold, the specimens were marked by a soft pen from 1 to 10 as shown in figure 1 (A&B).

The roots were divided into two groups according to the instrumentation technique:

Group (A): 10 roots were instrumented using Greater Taper (GT) rotary system.

Group (B): 10 roots were instrumented using Protaper Taper rotary system.

A photograph of each specimen was taken, under stereomicroscope at 100x using Sony digital camera (14 MP) at 2X of magnification before and after instrumentation.

For group (A) all root-canal preparations were performed in a crown-down fashion using GT Greater Taper NiTi rotary system until size 40 (ISO 0.06) taper while group (B) all roots prepared using ProTaper NiTi rotary system until size (F4) resemble to size 40 (ISO 0.06 taper). All samples were frequently irrigated with 2.5% sodium hypochlorite. Canals were dried with paper points.

All preparation photographs were analyzed by using AutoCAD 2013 software program as shown in figures 2 & 3, measuring the following variables were taken:

1. Canal Periphery (mm).
2. Canal Area (mm^2).
3. Tooth Area (mm^2).
4. Mesial dentin thickness.
5. Distal dentin thickness.
6. Buccal dentin thickness.
7. Lingual dentin thickness. [1]

To compare the root thicknesses before and after preparation in each of the groups and in each measurement (reading, variable), paired t-test was used. t-test (Student's t-test) was used to compare the amount of dentinal substance removed from each dimensions by the two techniques. The data were analyzed with SPSS software version 16.0 (SPSS Inc., Chicago, IL). The significance level was set at 5%.

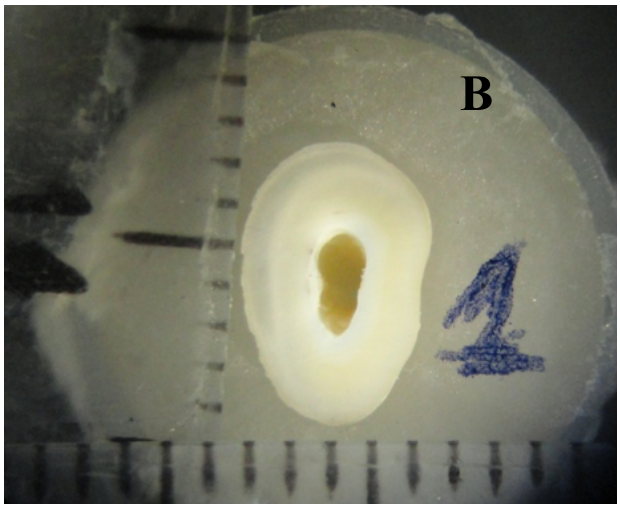

Figure 1: A: Sample distribution, B: Specimen mounted on acrylic resin block

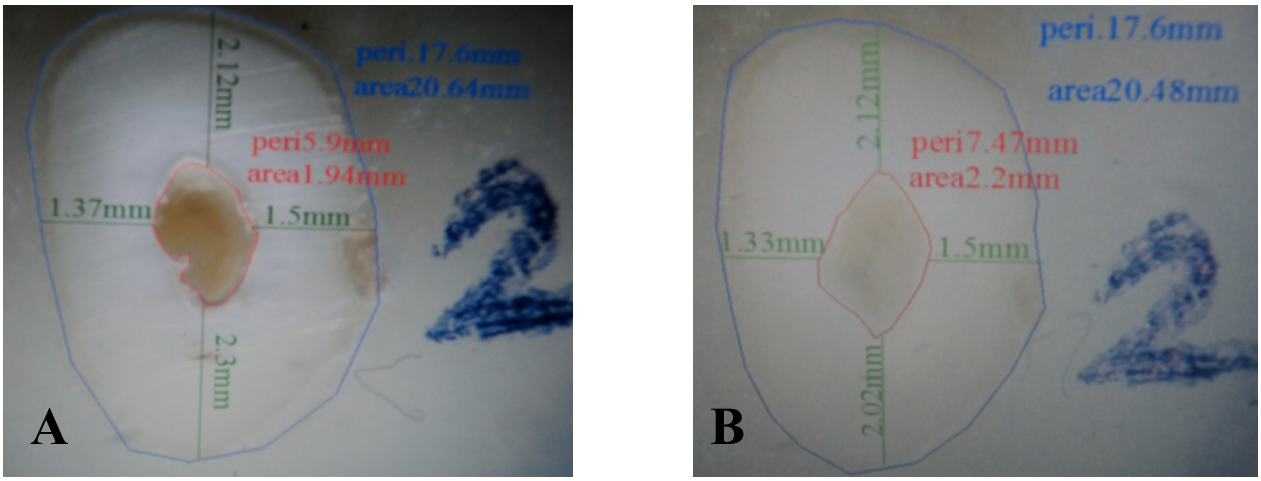

Figure 2: A: Photomicrograph of root canal prepared with GT rotary NiTi system; pre-preparation. B: Same image post-preparation

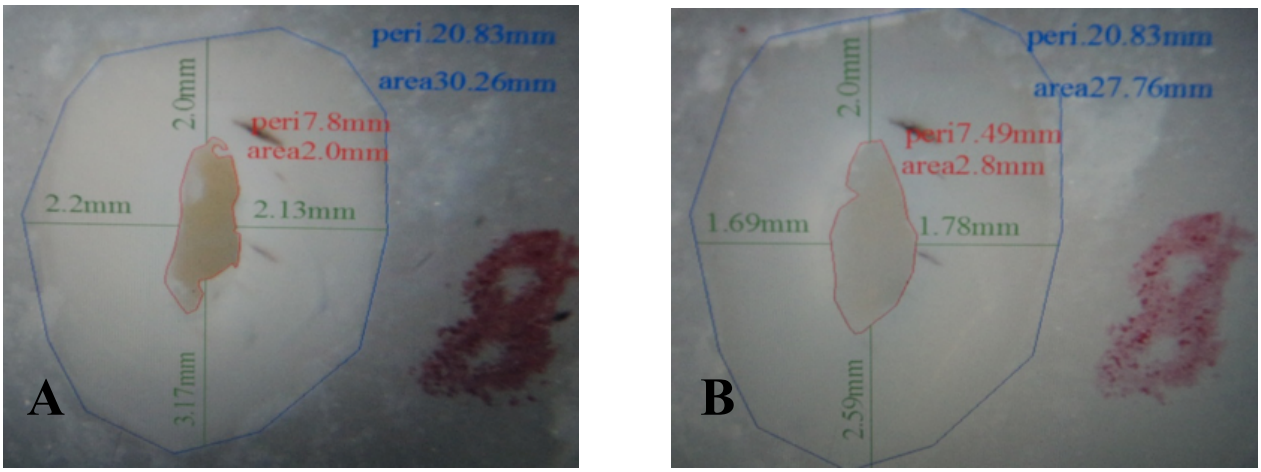

Figure 3: A: Photomicrograph of root canal prepared with Protaper rotary NiTi system; pre-preparation. B: Same image post-preparation

The relative percentage of dentin removal in each dimension was calculated by dividing the amount of dentin removed to the initial dimension multiplied by 100[10].

Results:

The mean and standard deviation before and after instrumentation techniques for each group are presented in Table 1.

The remaining root dentin thicknesses were evaluated and significant differences were found for all dimensions and measurements before and after instrumentation ($p<0.05$). In the mesial and distal dimensions the ProTaper system reduced the length more than the GT system, while the GT system removed slightly more dentine from the buccal and lingual dimensions. The canal periphery was increased by about 10% by both systems.

In Table 2 which shows the mean and statics of removed dentine after instrumentation for both groups at all variables, both rotary instrumentation techniques had effect on coronal dentin thickness while there was significant removing of dentin thickness for ProTaper system at canal area and highly significant dentin reduction at the level of tooth area compared with GT rotary system.

Discussion:

The aim of all dental treatment should be to prevent and treat disease without inflicting iatrogenic damage to tooth structure. Non-surgical root canal therapy involves instrumentation that results in removal of dentin. Post-endodontic rehabilitation of teeth frequently requires post placement to reinforce a coronal restoration. Both root canal treatment and post placement remove dentinal tissue and have been implicated as a cause of vertical root fractures (VRFs) [11].

Table 1: Mean values and SD of each of the measured groups pre- and post-preparation

Variable (mm)	Prep. Tech	Pre -preparation		Post-preparation		% Variation	T-test	Sig.
		Mean	SD	Mean	SD			
Canal Periphery (mm)	**GT**	5.84	1.34	6.39	1.29	9.48%	3.891	H.S*
	PT	6.12	1.12	6.70	1.40	9.43%	6.503	H.S*
Canal Area (mm^2)	**GT**	1.80	0.72	2.25	0.75	25.17%	5.065	H.S*
	PT	2.12	0.85	2.97	1.24	40.20%	2.867	H.S*
Tooth Area (mm^2)	**GT**	26.40	9.44	26.07	9.38	-1.25%	3.836	H.S*
	PT	32.28	10.37	29.56	9.40	-8.41%	2.35	H.S*
Mesial Width (mm)	**GT**	1.97	0.47	1.83	0.46	-7.21%	4.707	S**
	PT	2.08	0.20	1.92	0.25	-7.47%	3.823	S**
Distal Width (mm)	**GT**	1.96	0.50	1.83	0.45	-6.78%	5.611	H.S*
	PT	2.08	0.42	1.81	0.40	-12.67%	7.558	H.S*
Buccal Width (mm)	**GT**	2.27	0.40	2.19	0.40	-3.49%	3.1	S**
	PT	2.41	0.46	2.34	0.47	-3.15%	5.061	S**
Lingual Width (mm)	**GT**	2.42	0.60	2.23	0.55	-8.05%	2.72	H.S*
	PT	2.72	0.41	2.58	0.37	-4.97%	2.548	H.S*

*H.S: Highly significant (P<0.001), **S: Significant (P<0.05)

This study analyzed the dentin thickness remaining in the coronal portion of single rooted tooth after instrumentation with two types of root canal rotary instruments.

It should be noted that the findings of this study are restricted by variables such as age and properties of dentin. Moreover, it may be more appropriate to conduct such measurements using more accurate techniques such as the micro-computed tomography (μCT) and with a greater number of cross-sections.

Lateral forces result in high stress concentrations in radicular dentine at the coronal one third of the root, the rotational axis of the tooth is located at the crest of the alveolar bone, and most of the applied force is concentrated around the circumference of the tooth where the crown diameter is the smallest, corresponding to the cervical region of the tooth at the cemento-enamel junction (CEJ), whereas the concentration of the forces is the lowest within the root canal. The center of the root canal, representing the central axis of the tooth, is a neutral area with regard to force concentration. This force distribution may explain the susceptibility of teeth to fracture at the CEJ area when lateral forces are exerted on the coronal portion of the tooth during occlusal loading. From the point of view of stress concentration, the thickness of the dentinal wall between the root canal and its external circumference assumes great significance. There is a direct correlation between the root thickness and the ability of the tooth to resist lateral forces and avoid fracture[2,12].

The design of this study was such that an analysis of areas and dentine thickness before and after the root canal preparation would furnish data concerning the quantity of dentine being removed at the cervical level of the tooth.

In the present study the significant and more important results are shown by the difference effect of both systems on the canal and tooth area. Although both systems had a significant effect on the size of the

Table 2: statistical differences between the effects of both systems on each variable

Variables	Group	Minimum	Maximum	Mean	SD	T-test	df	Sig.
Canal Periphery (mm)	**GT**	0.06	1.57	0.5530	0.44947	0.116	18	N.S*
	PT	0.09	1.59	0.5770	0.47726			
Canal Area (mm^2)	**GT**	0.17	0.92	0.4520	0.21979	2.391	18	S**
	PT	0.44	2.07	0.8510	0.47964			
Tooth Area (mm^2)	**GT**	0.10	0.81	0.3291	0.20549	6.535	18	H.S***
	PT	1.85	5.84	2.7130	1.13512			
Mesial Width (mm)	**GT**	0	0.50	0.1420	0.15662	0.185	18	N.S
	PT	0	0.50	0.1550	0.15813			
Distal Width (mm)	**GT**	0	0.38	0.1330	0.10965	2.081	18	N.S
	PT	0.03	0.55	0.2630	0.16432			
Buccal Width (mm)	**GT**	0	0.34	0.0790	0.10630	0.069	18	N.S
	PT	0	0.29	0.0760	0.08834			
Lingual Width (mm)	**GT**	0	0.45	0.1950	0.13100	0.892	18	N.S
	PT	0	0.58	0.1350	0.16755			

*N.S: Not significant' **S: Significant (P<0.05), ***H.S: Highly significant (P<0.001)

canal area and tooth area. The canal area was increased by both systems highly significantly (p<0.01) about 40% for ProTaper and 25% for GT system as shown in table 1 and the findings of the present study is in agreement with study reported by Dong Choi et al (2004)[5] which reported that ProTaper cut more dentin than ProFile, GT Rotary file and Quantec file tested in mesiobuccal and mesiolingual canals of 40 mesial roots of extracted human lower molars were instrumented using the crown-down technique using muffle system, and this may explained by that the taper of the ProTaper files is bigger than the other files at the same level of the root canal, which may result in greatest reduction in the thickness of root canal dentin.

The present findings reveal that there is no significant difference between the ProTaper and GT group for the amount of the dentine removed at buccal, lingual, mesial and distal width, the ProTaper system removed more dentine mesially and distally while the GT system removed more dentine buccally and lingually and these result coincide with studies that were reported by El Hilaly Eid & Amin (2011)[13] showing that ProTaper did not seem to touch the canal wall buccolingually , whereas it removed dentin as much as manual H-files ; this could be attributed to both the circumferential motion used with ProTaper in a trial to access the buccolingual recesses, and study done by Grande et al (2007)[7] explained that the metallurgic properties of the alloy and the small tip of the instrument may have contributed to an ineffective action on the buccolingual dentinal walls.

According to the present study ProTaper system mostly remove dentin in mesiodistal dimension and more conservative in buccolingual direction while GT system which was less conservative in buccolingual dimension and this support the evidence that clinically its better to prepare the canal by ProTaper rotary system because clinical and experimental studies have shown that root fractures occur predominantly in a buccolingual direction, root cross-sections are usually ovoid in shape, especially in roots that are more prone to fracture such as mandibular incisors and mesiobuccal roots of molars and dentin thickness in the buccolingual direction, particularly in mandibular incisors, is often double that of proximal dentin, yet fracture usually runs through this thick region[3,5].

Conclussions:

Under the conditions of this in vitro study the following conclusions can be obtained:

1. The use of GT rotary file system and ProTaper system to prepare canals resulted in decreasing root dentin thickness at overall parameters and variables.

2. GT system was more conservative at tooth canal and canal area compared with ProTaper system which had taken significantly more dentin at these two levels.

3. ProTaper system had taken less dentin at the level of buccolingual dimension and much dentin removed at mesiodistal dimension while GT system are more conservative at mesio-distal than buccolingual dimension.

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References:

1. *Lammertyn PA and Sierra LG. Dentine thickness in buccal roots of maxillary first premolars following preparation with three techniques. International magazine of endodontology. 2012; 8 (3): 30-5.*
2. *Plotino G, Grande NM, Falanga A, Di Giuseppe IL, Lamorgese V and Somma F. Dentine removal in the coronal portion of root canals following two preparation techniques. Int Endod J. 2007; 40: 852-8.*
3. *Sathorn C, Palamara JEA, Palamara D and Messer. Effect of root canal size and external root surface morphology on fracture susceptibility and pattern: A Finite Element Analysis. JOE. 2005; 31: 288-92.*
4. *Vats A, Punja A, Hegde P, Hegde MN, Bains R and Loomba K. Evaluation of effect of root canal preparation techniques on inducing root fractures: An in vitro study. Asian J Oral Health Allied Sci. 2011; 1: 17-21.*
5. *Dong Choi S, Uk Jin M, Ok Kim K and Kyo Kim S. Shaping ability of four rotary nickel-titanium instruments to prepare root canal at danger zone. J Kor Acad Cons Dent. 2004; 29:446-53.*
6. *Yoldas O, Yilmaz S, Atakan G, Kuden Cand Kasan Z. Dentinal microcrack formation during root canal preparations by different NiTi rotary instruments and the self-adjusting file. J Endod. 2012; 38 (2): 232-35.*
7. *Grande NM, Plotino G, Butti A, Messina F, Pameijer CH and Somma F. Cross-sectional analysis of root canals prepared with NiTi rotary instruments and stainless steel reciprocating files. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007; 103:120-6.*
8. *Gluskin AH, Brown DC and Buchanan LS. A reconstructed computerized tomographic comparison of Ni–Ti rotary GT™ files versus traditional instruments in canals shaped by novice operators. Int Endod J. 2001; 34: 476–484.*
9. *Buchanan LS. ProSystem GT: design, technique and advantages. Endod Topics. 2005; 10: 168–75.*
10. *Akhlaghi NM, Kahali R, Abtahi A, Tabatabaee S, Mehrvarzfar P and Parirokh M. Comparison of dentine removal using V-taper and K-Flexofile instruments. Int Endod J. 2010; 43:1029-36.*
11. *Saeed MH, Bardestani Z, El Sadek DA and Ismail AI. Influnces of hands stainless steel and NiTi rotary file on the resistance to fracture of endodontic treated roots. IJRSR. 2014; 5: 660 -4.*
12. *El Hilaly Eid and Amin SA. Changes in diameter, cross-sectional area, and extent of canal-wall touching on using 3 instrumentation techniques in long-oval canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011; 112:688-95.*