In Vitro The Effect of Canals Instrumented With Three Rotary Ni-Ti Systems on The Dislocation Resistanceo Guttafusion® Versus Single Cone Obturation Technique

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ABSTRACT

Background: Complete seal of the root canal system following its chemo-mechanical debridement plays a pivotal role for achieving successful endodontic treatment. This can be established by reducing the gaps between the core filling material and root canal wall.

Aim: To assess and compare the dislocation resistance of root canals obturated with GuttaFusion® and TotalFill BC sealer versus single cone obturation technique and TotalFill BC sealer after instrumentation of the canals with WaveOne, ProTaper Next and ProTaper Universal system.

Material and Method: Sixty extracted human permanent mandibular premolars were conducted in the current study. The teeth were decorated and left the root with 15mm length; the roots were divided randomly into three main groups, twenty roots in each group. The roots were instrumented with different rotary systems using crown down technique according to the groups: (Group I) was instrumented with WaveOne files. (Group II) was instrumented with ProTaper Next system and (Group III) was instrumented with ProTaper Universal system. For each group the same irrigation regimen was used, 3 mL of 5.25% sodium hypochlorite and 3 mL of 17% EDTA to remove the smear layer.

Then, Group I was also subdivided randomly into two subgroups of ten samples each, (Group I A) obturated with single cone gutta-percha and (Group I B) filled with GuttaFusion®. Group II was divided into (Group II A) obturated with single cone gutta-percha and (Group II B) filled with GuttaFusion®. Group III was divided into (Group III A) obturated with single cone gutta-percha and (Group III B) obturated with GuttaFusion®. In the present study, TotalFill BC sealer was used for all the tested groups.

Then, the roots were embedded in clear acrylic resin and each root sectioned into three sections of 2mm thick (apical, middle and coronal). The push-out bond strength values represented by (MPa) unit was calculated by dividing the load on the surface area and the last was measured in collaboration with AutoCAD system software program. Failure mode analysis was carried out to examine the type of failure in each sample by using a stereomicroscope.

Results: The results showed highly significant differences among the main groups that instrumented with different rotary systems (WaveOne, ProTaper Next and ProTaper Universal system). There were highly significant differences between the two obturation techniques of the subgroups (single cone gutta-percha versus GuttaFusion®). However; Gutta-Fusion® showed highest bond strength value than single cone obturation technique. The coronal third slices of all groups showed highest value of bond strength in comparison to the middle thirds and apical thirds. In the meantime, the middle third slices showed bond strength higher than that of the apical thirds for all groups. Statistical analysis was performed by using two way ANOVA and LSD tests.

Conclusions: The instrumentation techniques and the obturation materials significantly affected the push-out bond strength values of obturation system. The highest value was appointed in root canals instrumented with ProTaper Universal System; obturated with GuttaFusion® and BC sealer, whereas, the lowest bond strength was appeared at canals instrumented with ProTaper Next; obturated with single cone gutta-percha and BC sealer.

Keywords: BC sealer, GuttaFusion®, push-out bond, WaveOne system, ProTaper Next, ProTaper Universal. **(J Bagh Coll Dentistry 2017; 29(3):17-25)**

INTRODUCTION

Three-dimensional seal of the root canal space is one of the fundamental goals of successful endodontic treatment, therefore various obturation materials and techniques were developed to fill root canal system and obliterate any voids or space within it in order to prevent reinfection of the tooth with bacteria and their by-product [1]. In this study, three rotary systems were employed for preparation of the root canals including, WaveOne (reciprocation motion), ProTaper Next (continuous rotation) and ProTaper Universal (continuous rotation) due to its improved cutting efficiency and safety in comparison with stainless steel files [2].

In addition, TotalFill BC sealer was used for all the experimental groups since; it has been reported that the hydrophilic sealer uses moisture of the root space for completing setting reaction [3]. Moreover, this sealer was adapted perfectly to dentine and formation of a chemical bond with inorganic phase of dentine [4].

In this study, half of the tested groups were obturated using single cone technique, which uses larger master cone that closely match the geometry of the last rotary NiTi files that used during instrumentation; thereby it is facilitating the root canal filling [5]. Nevertheless, gutta-percha is not adhered to the root canal wall compromising the concept of three-dimensional seal, therefore; a nother obturation techniques have been introduced over the past decade to improve the seal of the root canal system.

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However, a three-dimensional seal is important for reducing diseases associated with root canal treatment [(6)].

Thus, carrier based gutta-percha technique is an effective method for obturation of the rest prepared canal with a GuttaFusion® in which the core made from chains of crosslinked polymer of gutta-percha that coated with flowale gutta percha without need for metal or plastic core. The benefit of carrier is to condense gutta-percha which is heated by special devise to enhance its flow into the canal [(7)]. So, half of the groups were obturated with GuttaFusion®.

This study was designed to compare the push-out bond strength exhibited by root fillings performed with either GuttaFusion® and BC sealer or single cone gutta-percha and BC sealer after instrumentation of root canals with either WaveOne (WO) (reciprocating file) or ProTaper Next and Pro Taper Universal (rotation files). The null hypothesis stated that there is no effect of either instrumentation technique or obturation method on the push-out bond strength value.

MATERIAL AND METHOD

Sample selection

Sixty extracted human mandibular permanent premolars were selected from different health centers according to specific criteria. The age (18-24 years) while the status of the pulp, gender and extraction reason were not being considered and the criteria for selection of teeth included the following: straight root canal, mature, patent, centrally located apical foramen and roots devoid of any resorptions [(8, 9)].

Sample preparation

After extraction, all the teeth were stored in distilled water. Afterward, sharp periodontal curette was used to remove remnants of soft tissue on the root surface and magnifying eye lens (10X) was used to verify the root surfaces and any visible cracks or fractures saw by using a light cure device [(10)].

Then, the teeth were decorated and left the root with 15mm length using diamond cut off saw with the use of the water coolant to minimize the formation of smear Fig. 1 [(11)]. Then a size 10 k-file (Dentsply, Maillefer, Switzerland) was used to ensure straight canal, patency and central position of apical foramina. The exact location of the apical foramen was determined by advancing the size 10 k-file into the canal until it was visualized at the apical foramen [(10)]. Then Silicon rubber base impression material (heavy-body) was mixed according to manufacturer's instructions (base and catalyst) and inserted inside the plastic containers, then the root was inserted in center of the heavy body to facilitate handling of the roots during instrumentation and obturation procedure [(10)].

Study design

The selected teeth were randomly divided into the following 6 subgroups (n = 60):

1. Group I A: WaveOne instrumentation (Dentsply, Maillefer, Switzerland), followed by obturation using single cone gutta-percha (Dentsply, Maillefer, Switzerland) and TotalFill BC sealer (Brasseler, Savannah, USA).
2. Group I B: WaveOne instrumentation (Dentsply, Maillefer, Switzerland), followed by obturation using GuttaFusion® (VDW, Germany) and TotalFill BC sealer (Brasseler, Savannah, USA).
3. Group II A: ProTaper Next instrumentation (Dentsply, Maillefer, Switzerland) followed by obturation using single cone gutta-percha (Dentsply, Maillefer, Switzerland) and TotalFill BC sealer (Brasseler, Savannah, USA).
4. Group II B: ProTaper Next instrumentation (Dentsply, Maillefer, Switzerland) followed by obturation using GuttaFusion® (VDW, Germany) and TotalFill BC sealer (Brasseler, Savannah, USA).
5. Group III A: ProTaper Universal instrumentation (Dentsply, Maillefer, Switzerland) followed by obturation using single cone gutta-percha (Dentsply, Maillefer, Switzerland) and TotalFill BC sealer (Brasseler, Savannah, USA).
6. Group III B: ProTaper Universal instrumentation (Dentsply, Maillefer, Switzerland) followed by obturation using GuttaFusion® (VDW, Germany) and TotalFill BC sealer (Brasseler, Savannah, USA).

Root canal instrumentation

1. Group I (A and B) WaveOne System instrumentation: (20sample)

Firstly, WaveOne primary file was connected to endo-motor (smart X) (Densply, Maillefer Switzerland) to produce glide path for large WO file (black) which is 40\08 [(12)]. The irrigation regimen which used for all groups was 3 mL of 5.25% NaOCl (Cerkamed, Poland). The smear layer was removed with 3 mL of 17% aqueous EDTA solution (Dental Produits Dentaires SA, Switzerland) for one minute and followed with a final flush with 3 ml of distilled water [(9)].

2. Group II (A and B) ProTaper Next instrumentation: (20sample)

The endo-motor X-smart (Densply, Maillefer Switzerland) was worked at speed of 300 rpm and torque of 2.0 Ncm with X1 20/04. Then, X2

25/06, X3 30/07, were used in same manner to provide glide path for X4 40/06 [12].

3. Groups III (A and B) ProTaper Universal instrumentation (20sample)

Firstly, the canal was instrumented with (S1), 17/04 with endo-motor X-smart (Densply, Maillefer Switzerland) which was operated at speed of 250 rpm and torque of 3.0 Ncm then, (S2) 20/02 was used with speed of 250 rpm and torque of 1.0 Ncm, while F1 20\ 07 was worked at speed of 250 rpm and torque of 1.5 Ncm while F2 25\08, F3 30\09, F4 40\06 were used respectively at constant speed of 250 rpm and constant torque of 2.0 Ncm [12].

Samples obturation:

I.Group I A, II A, III A obturation with single cone technique:

The canal was dried with a corresponding paper point size # 40 (Dentsply, Maillefer, Switzerland).At this time, the canal was ready for obturation with single cone obturation material(Dentsply, Maillefer, Switzerland) and a TotalFill sealer (Brasseler, Savannah, USA) that dispensed through its auto mix syringe tip into the coronal third of the root canal according to the manufacturer's instructions [8], afterwards a single cone gutta-perch size #40 was slowly inserted to full working length of the canal. For these groups (IA, IIA and III A) a heated plugger (Medesey, Italy) was used to remove the access gutta-percha out of the orifice of the canal [13].

I. Group I B, II B, III B obturation with GuttaFusion®:

These groups were obturated with GuttaFusion® after drying the canal with a corresponding paper point size #40(Dentsply, Maillefer, Switzerland) Fig. 2. Next, TotalFill sealer (Brasseler, Savannah, USA) was dispensed through its auto-mix syringe tip into the coronal third of the root canal according to the manufacturer's instructions and hand file size #15 coated with a thin layer of BC sealer dispensed on glass slab, then the file was lightly coat the canal wall with existing sealer. Afterward, the holder of GuttaFusion® oven was raised to hold the GuttaFusion® obturator size # 40 then pushed down to start thermoplasticizing the obturator Fig. 3. Then the oven gave visual and acoustic warning signals which indicated that the obturator was ready to be used. Afterward, the obturator was took out from the obturater holders which can be released easily by pushing it down and placed within the canal to the full working length. Afterward, the obturator handle was bending to right and left until separation took place and then, core material condensated with plugger [14].

Then, the root was radiographed within their silicon rubber base mold to ensure adequate obturation, then moistened gauze with normal saline was wrapped each group. Afterward, all samples were stored in an incubator for 7 days at 100% humidity and 37 ^{O}C to ensure complete setting of the sealer [15].

Teeth sectioning

The samples were embedded in clear orthodontic resin after the period of storage [16]. Firstly, a cylinder mold with four holes was prepared from silicon material (OOMOO® Smooth-On, East Texas), each hole has 25 mm depth and 10 mm width .In general, the width of the cylinder was 6 cm while, the depth of it was 25mm. The root was inserted in the base (center) of each hole with the aid of dental surveyor; however, the coronal surface of the root was fixed with sticky wax to the dental surveyor to ensure accurate and central placement of the root and perpendicular sectioning to the long axis of the roots. As recommended by the manufacturers, the acrylic was prepared by mixing powder and liquid. Evaporation of monomer was prevented by covering the jar. Afterward, the material was left for few minutes to reach the workable stage. Afterward, the freshly prepared cold cure acrylic paste was loaded in cylinder hole and pushed with spatula to ensure that the acrylic sample was devoid from any void with complete coverage of the root with acrylic Fig. 4 [17].

Then, after complete setting of the acrylic sample; it was removed from the cylinder hole and each sample was sectioned horizontally into 2 mm thick slices at each of the three-thirds (coronal, middle and apical) of the root using a diamond disc with continuous water flow to minimize smearing Fig. 5 [11].

Push-out test

After measuring of the apical side diameter of the slice, the cylindrical metal punch tip (either 0.4, 0.6 or 0.8 mm in diameter) was selected to cover as much as possible of the root filling, yet avoiding any contact with the canal walls [18].

After placement of specimens on base, the load was applied by the punch in apico-coronal direction using a universal testing machine at speed 0.5mm/min Fig. 6. The push-out bond strength value represented by (MPa) unit was calculated by dividing the load in Newton on the surface area (mm^2) that calculated in collaboration with Auto CAD system software program [19]. Afterward, a stereomicroscope examined the root canal wall of each samples at 25X magnification to determine the failure mode [20].

Bond strength MPa = Debonding force (N)/ interfacial area mm^2

The interfacial area (mm^2) was calculated by 0.5(circumference of coronal aspect + circumference of apical aspect) * thickness [21].

Analysis of failure modes

Stereomicroscope (Hamilton, Altay) was used to inspect a slice at 25x magnification to determine the failure mode. Each sample was evaluated and placed into one of three failure modes [22] Type I: adhesive failure, either at the sealer-dentin (S/D) or between the sealer-core (S/C) interfaces, Type II: cohesive failure, within the filling material (sealer or core material), Type III: mixed failure, which contains both adhesive and cohesive failures.

Figure 1: Length of tooth was measured with a digital caliper

Figure 2: GuttaFusion® gutta-percha size # 40 & TotalFill sealer

Figure 3: GuttaFusion® oven with GuttaFusion® after pressed its handle

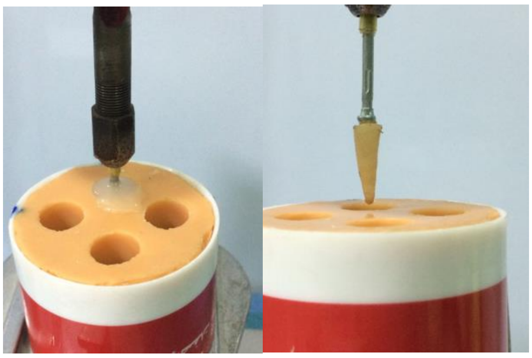

Figure 4: Central placement of the root with a cylinder hole

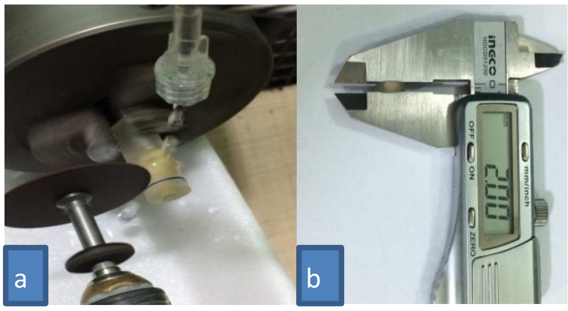

Figure 5: a. Sectioning of the specimen, b. the specimen measured with digital caliper

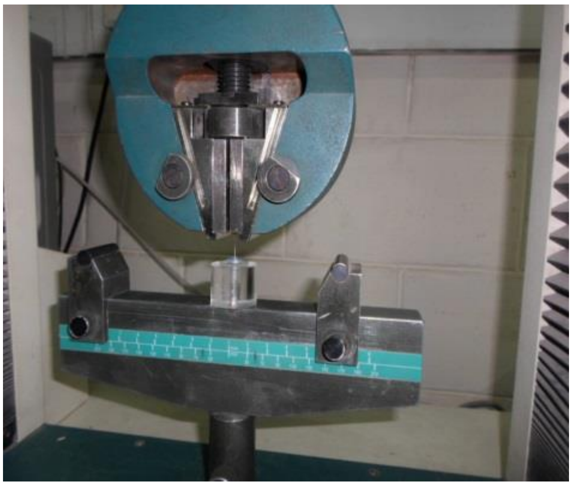

Figure 6: Universal testing machine

RESULTS

Mean values and standard deviation for all groups are presented in (Table 1). Analysis of variance (ANOVA) test was performed and showed that the highest and the lowest mean values of push-out bond strength were seen in (Group III B) at coronal third of root canal that instrumented with PTU system and filled with GuttaFusion® (5.017 MPa) and (Group II A) at apical level of canal filled with single cone gutta-percha after its instrumented with PTN (1.645 MPa) respectively Fig. 7. Other mean values of the study groups were swing between these values.

Analysis of variance (ANOVA) test was preformed to compare between the obturation systems at each level and to identify if there is any statistically significant differences (regarding push-out bond strength) between two obturation systems within each level. Highly significant differences (p≤0.01) were found at all levels and the results showed the followings:

1. ANOVA test showed that among each site, there is highly significant effect of Group, Subgroup and interaction effect of Group* Subgroup on the variability of push-out bond strength with strong Coefficient of determination was found in the coronal site.
2. It was found at each site, ProTaper Universal system has the highest mean of push-out bond strength followed by WaveOne system. While, ProTaper Next system showed the lowest push-out bond strength with highly significant difference among them (regarding instrumentation techniques).
3. There was a highly significant difference of subgroups that obturated with GuttaFusion® than single cone obturation material at all level regardless the instrumentation techniques. However, Group I A (WO instrumentation, single cone obturation) showed highly significant difference than Group II A (PTN instrumentation, single cone obturation). While Group I A (WO instrumentation, single cone obturation) showed no significant difference than Group III A (PTU instrumentation, single cone obturation). While, Group I B(WO instrumentation, GuttaFusion® obturation) was showed no significant difference than Group II B (PTN instrumentation, GuttaFusion® obturation). While Group III B (PTU instrumentation, GuttaFusion® obturation) showed a highly significant difference than Group I B and Group II B Table 12.
4. There was a highly significant difference between all levels within all groups.

The least significance difference test (LSD) was performed to evaluate the significant differences between each obturation system at each level and showed that: at each site and each Subgroup; there is highly significant difference between Groups except between (WO and PTU instrumentation with single cone obturation technique) and (WO and PTN instrumentation with GutaFusion® obturation) however, the result was found to be statistically not significant. The coronal third slices of the groups showed a highest value of bond strength in comparison to the middle thirds and apical thirds. In the meantime, the middle third slices showed bond strength higher than the apical thirds for all groups (Table 3) (Fig. 7).

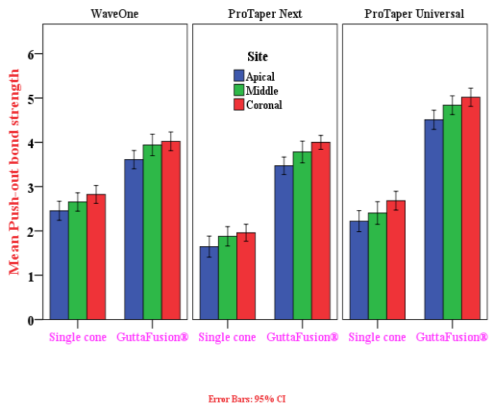

Figure 7: The mean value of push-out bond strength of two obturation systems

The failure mode of the samples is presented in (Table 4). In this study the predominant mode of failure for canal instrumented with different rotary system (WO, PTN, PTU system and obturated with single cone gutta percha) was adhesive failure mainly at dentine / sealer interface. In addition the same groups showed fewer mixed failures followed by cohesive failure mainly within sealer when compared to the other techniques.

However, the predominant mode of failure for canal instrumented with previous rotary systems and obturated with Gutta-Fusion® was mixed failure followed by cohesive failures mainly within gutta-percha and then adhesive failure was less frequent at all the sections of all subgroups that obturated with GuttaFusion®.

Table 1: Descriptive statistics of push-out bond strength (Mean, ±SD, Max, Min) of tooth sites by groups and subgroups.

Site	Group	Subgroup											
		Single cone (A)				GuttaFusion® (B)				Total			
		Min.	Max.	Mean	±SD	Min.	Max.	Mean	±SD	Min.	Max.	Mean	±SD
Apical	WO	1.87	2.80	2.46	0.30	3.30	4.26	3.61	0.29	1.87	4.26	3.03	.66
	PTN	1.23	2.09	1.65	0.33	3.19	4.06	3.47	0.28	1.23	4.06	2.56	.98
	PTU	1.74	2.65	2.22	0.33	4.22	5.20	4.51	0.30	1.74	5.20	3.36	1.21
	Total	1.23	2.80	2.11	0.47	3.19	5.20	3.86	0.55	1.23	5.20	2.98	1.02
Middle	WO	2.32	3.24	2.65	0.29	3.45	4.37	3.94	0.34	2.32	4.37	3.30	.73
	PTN	1.46	2.29	1.88	0.31	3.36	4.31	3.78	0.34	1.46	4.31	2.83	1.03
	PTU	2.00	2.96	2.40	0.36	4.46	5.37	4.84	0.30	2.00	5.37	3.62	1.29
	Total	1.46	3.24	2.31	0.45	3.36	5.37	4.19	0.57	1.46	5.37	3.25	1.07
Coronal	WO	2.54	3.28	2.82	0.28	3.55	4.40	4.02	0.29	2.54	4.40	3.42	.68
	PTN	1.56	2.36	1.96	0.27	3.75	4.38	4.00	0.22	1.56	4.38	2.98	1.07
	PTU	2.25	3.14	2.68	0.30	4.55	5.35	5.02	0.29	2.25	5.35	3.85	1.23
	Total	1.56	3.28	2.49	0.47	3.55	5.35	4.35	0.55	1.56	5.35	3.42	1.07
Total	WO	1.87	3.28	2.64	0.32	3.30	4.40	3.86	0.35	1.87	4.40	3.25	.70
	PTN	1.23	2.36	1.83	0.32	3.19	4.38	3.75	0.35	1.23	4.38	2.79	1.03
	PTU	1.74	3.14	2.44	0.37	4.22	5.37	4.79	0.36	1.74	5.37	3.61	1.24
	Total	1.23	3.28	2.30	0.48	3.19	5.37	4.13	0.58	1.23	5.37	3.22	1.06

Table 2: Push-out bond strength variability of subgroups in each group by site by using two ways ANOVA

Site	Group	Subgroup				F	Sig.
		Single cone		GuttaFusion®			
		Mean	SE	Mean	SE		
Apical	Wave one	2.455	.097	3.609	.097	70.872	.000
	Protaper Next	1.645	.097	3.471	.097	177.445	.000
	ProTaper Universal	2.220	.097	4.508	.097	278.595	.000
Middle	Wave one	2.654	.102	3.940	.102	79.571	.000
	Protaper Next	1.879	.102	3.781	.102	174.057	.000
	ProTaper Universal	2.404	.102	4.837	.102	284.810	.000
Coronal	Wave one	2.824	.087	4.022	.087	94.152	.000
	Protaper Next	1.959	.087	3.999	.087	273.008	.000
	ProTaper Universal	2.682	.087	5.017	.087	357.675	.000

Df=1.

Table 3: LSD tests for push out bond strength among groups by subgroups at three sites

Site	Subgroup	Group	Group	Sig.
Apical	Single cone	WaveOne	ProTaper Next	.000
			ProTaper Universal	.092
		ProTaper Next	ProTaper Universal	.000
	GuttaFusion®	WaveOne	ProTaper Next	.319
			ProTaper Universal	.000
		ProTaper Next	ProTaper Universal	.000
Middle	Single cone	WaveOne	ProTaper Next	.000
			ProTaper Universal	.089
		ProTaper Next	ProTaper Universal	.001
	Gutta Fusion®	WaveOne	ProTaper Next	.275
			ProTaper Universal	.000
		ProTaper Next	ProTaper Universal	.000
Coronal	Single cone	WaveOne	ProTaper Next	.000
			ProTaper Universal	.255
		ProTaper Next	ProTaper Universal	.000
	Gutta Fusion®	WaveOne	ProTaper Next	.853
			ProTaper Universal	.000
		ProTaper Next	ProTaper Universal	.000

Table 4: failure mode for different subgroups

Groups	Adhesive	Cohesive	Mixed
Group I A	57%	20%	23%
Group II A	73%	5%	22%
Group III A	70%	10%	20%
Group I B	16%	21%	63%
Group II B	26%	30%	44%
Group III B	13%	30%	57%

DISCUSSION

Successful endodontic treatment is depending on the adhesion of obturation material to the root canal wall which is advantageous for two reasons. First, it must remove any void that permit fluid leakage between core material and dentine in static situation and the second reason is enabling obturation material to resist its dislodgement during subsequent manipulation in dynamic situations [23].The null hypothesis was rejected since both the instrumentation technique and obturation method was affecting the push-out bond strength. Amara *et al* in 2012 stated that push-out test is popular method for measuring the effectiveness of adhesion between dentine wall and intra-canal material [24].

There was a highly significant difference between Group I, II, III (B) that obturated with carrier based obturation materials (Gutta-Fusion®) and Group I, II, III (A)(single cone obturation technique). An explanation for these results could be attributed to the decreased sealing ability of obturation materials when the thickness of sealer is increased regardless of the instrumentation technique.

Initially, single cone obturation technique consists of placement of master cone obturation material that matched the last taper and size of file used in instrumentation [25].

It was found that Group I A (canal instrumented with WO, single cone obturation) showed higher push out bond strength value than Group II A (PTN instrumentation and single cone obturation). An explanation for that taper of master large file (WO) is 08 and this is different from taper of PTN that 06. This led to enlargement of the apical third (especially the last 3 mm) of root canals to an 8% taper which is necessary for irrigation displacement and is enhancing a better sealing ability and long-term success for root canal obturations [26]. This agree with Wu who found that reciprocation has better performance than continuous movements (Wu *etal*., 2000) [27] and (De-Deus *et al.*, 2013) [18]. Thus, the results disagreed with (Pawer *et al.*, 2016) [9].

While, Group I A (that instrumented with WO and single cone obturation) showed no significant differences with Group III A (instrumented with PTU, single cone obturation). This might be due to absence of a significant difference with 0.06 and 0.08 final taper [26].While, Group III A (PTU instrumentation with single cone obturation) showed highly significant differences than Group II A (PTN instrumentation and single cone obturation). Thus result might be related to difference in cross section or mode of rotation since, PTU has a convex triangle cross-section and symmetric rotation while, PTN has a patented, off-centred rectangular cross-section and asymmetric 'Swaggering' rotation [28]. This result disagrees with (Li *et al*., 2014b) who indicated that the ProTaper Next is more efficient in cleaning and shaping the canal more than ProTaper Universal [29].

Moreover, Group III B (canal instrumented with PTU, GuttaFusion® obturation) showed highly significant difference compared with Group I B and II B (canal instrumented with WO and PTN, GuttaFusion® obturation). Thus might be due to using of multiple files in some cases to shape and finish the canal completely resulting in more cleaned canal [30].

In contrast, there was no significant difference between group I B and II B (canal instrumented with WO and PTN and obturated with GuttaFusion®) as in previous study on the shaping ability of rotary instrument; it was found that there were no significant differences between ProTaper Next and the WaveOne [31]. Thus agreed with (Zogheib *et al*., 2012) [26].

Independent of the preparation technique and obturation material, the coronal third showed the highest value of bond strength than the middle third. The apical third showed the lowest value of bond strength due to differences in the internal anatomy of each level of the root canal [32]. This disagreed with (Babb *et al*., 2009) [33].

After that, each slice was examined under stereomicroscope X 25 to determine the failure mode. In general, the predominant failure mode for canal instrumented with different rotary system (WO, PTN and PTU) and obturated with single cone gutta-percha was adhesive failure mainly at dentine / sealer interface. This may be related to the high amount of sealer relative to cone volume since, the sealer was not compacted against the root canal wall resulting in void that might be facilitate the separation of sealer from dentine surface [34].In addition the same groups showed fewer mixed failures followed by cohesive failure mainly within sealer when compared to the other techniques.

However, the predominant mode of failure for canal instrumented with previous rotary systems and obturated with GuttaFusion® was mixed; This may be due to a thin layer of sealer that might be incorporated in the dentinal tubule with slight expansion due to the hydrophilic nature of BC sealer [3] and the thermoplastic gutta-percha had penetrated into the dentinal tubules resulting in well adapted root filling [35] followed by cohesive failures mainly within gutta-percha and then adhesive failure mainly at sealer /dentine interface.

REFERENCES

1. Schilder H. Filling Root Canals in Three Dimensions. JOE 2006; 32: 4.
2. Yin LY, Xie XL, Chen MM, Liu LH, Ling TY. Experimental study of preparing curved root canals with different instrument. J West China 2008; 26(6): 660–3.
3. Pawar SS, Pujar MA, Makandar SD. Evaluation of the apical sealing ability of bioceramic sealer, AH plus &epiphany: An in vitro study. J cons Dent 2014; 17(6): 579-82.
4. Malhotra S, Hedge MN, Shetty C. Bio-ceramic technology in endodontics. British J Med & Med Res 2014; 4(12): 2446–54.
5. Nagas E, Altundasar E, Serper A. The effect of master point taper on bond strength and apical sealing abilityof different root canal sealers. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009; 107(1):e61-4.
6. Li GH,Niu LN, Zhang W, Olsen M, De Deus G, Eid AA, Pashley DH, Tay FR. Ability of new obturation materials to improve the seal of the root canal system: a review. Acta Biomater 2014 a; 10 (3): 1050-63.
7. http://www.vdw-dental.com/.
8. Naser, AL-Zaka I. Push-out strength of different root canal obturation materials. J Bagh College dent 2013; 25(1): 14-20.
9. Pawar A. M., Pawar S, Kfir A., Pawar M. & Kokate S. Push-out bond strength of root fillings made with C-Point and BC sealer versus gutta-percha and AH Plus after the instrumentation of oval canals with the Self-Adjusting File versus WaveOne . Int Endod J 2016; 49: 374–81.
10. Al-Ani A, Al-Huwaizi H. Push out bond strength of different obturation systems (An in vitro study). Bagh College Dentistry J 2011; 23(3): 37-43.
11. Ehsani S, Bolhari B, Etemadi Ghorbanzadeh A, Sabet Y, Nosrat A. The effect of Er,Cr:YSGG Laser Irradiation on the Push Out Bond Strength of RealSeal Self-Etch Sealer. Photo-medicine and Laser Surgery 2013; 31(12): 578-85.
12. Bürklein S, Hinschitza K, Dammaschke T, Schäfer E. Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne versus Mtwo and ProTaper. Int Endod J 2012; 45(5): 449-61.
13. Schäfer E, Köster M, Bürklein S. Percentage of gutta-percha-filled areas in canals instrumented with nickel-titanium systems and obturated with matching single cones. J Endod 2013; 39(7): 924-8.
14. Hanna M, Daou M, Naaman A, Zogheib C. Push-out Strength of 3 Warm Obturation Techniques: Warm Vertical Compaction, GuttaCore, GuttaFusion. J Int Oral Health 2016; 8(5): 585-590.
15. Ertas H, Kucukyilmaz E, Ok E, Uysal B. Push out bond strength of different mineral trioxide aggregates. Eur J Dent 2014; 8: 348-2.
16. Al-Kahtani A, Al-Subait S, Anil S. An in vitro comparative study of the adaptation and sealing ability of two carrier based root canal obturators. Sci world J 2013; Article ID 532023: 7.
17. Pane ES, Palamara JE, Messer HH.Critical evaluation of the push-out test for root canal filling materials. J Endod 2013; 39(5): 669–73.
18. De-Deus G, Accorsi-Mendonc_AT, de Carvalho e Silva L, de Souza Leite CA, da Silva D, Moreira EJL. Self-adjusting file cleaning-shaping-irrigation system improves root filling bond strength. J Endod 2013; 39: 254–7.
19. Türker AS, Uzunoğlu E, Yılmaz Z, Effects of dentin moisture on the push-out bond strength of a fiber post luted with different self-adhesive resin cements. Restor Dent Endod 2013; 38(4): 234–240.
20. Carneiro SM, Sousa-Neto MD, Rached FA Jr, Miranda CE, Silva SR, Silva-Sousa YT.Push out strength of root fillings with and without thermo-mechanical compaction. Int Endod J 2012; 45(9): 821-8.
21. Gesi A, Raffaelli O, Goracci C, Pashley DH, Tay FR, Ferrari M. Interfacial strength of resilon and gutta-percha to intraradicular dentine. J Endod 2005; 31(11): 809-13.
22. El Sheikh AM, Mohamed GE and Saba AA. Push out bond strength of glass ionomer-Impregnated gutta percha/glass ionomer sealer System to root canal dentin conditioned with Different endodontic irrigants. Eygpt Dent J 2011; 57(3): 2351-55.
23. Van Meerbeek B, Peumans M, Poitevin A, Mine A, Van Ende A, Neves A, De Munck J. Review relationship between bond strength tests and clinical outcomes. Dent Master 2010; 26(2): e100-21.
24. Amara L, Shivanna V, Rajesh LV. Push out bond strength of the dentine sealer interface with and without a main core: a comparative study using different sealers and cone systems. Endodontology J 2012; 24(1): 56-64.
25. Monticelli F, Sword J, Martin RL, Schuster GS, Weller RN, Ferrari M, Pashley DH, Tay FR. Sealing properties of two contemporary single-cone obturation systems. Int Endod J 2007; 40(5):374-85.
26. Zogheib C, Naaman A, Medioni E, Arbab-Chirani R. Influence of apical taper on the quality of thermoplasticized root fillings assessed by micro-computed tomography.J Clin Oral Investig 2012; 16(5):1493-8.
27. Wu MK, Fan B, Wesselink PR. Leakage along apical root fillings in curved root canals: part I—effects of apical transportation on seal of root fillings. J Endod 2000; 26(4): 210–16.
28. www.dentsply.com.au.

29. Li H, Zhang C, Li Q, Wang C, Song Y. Comparison of cleaning efficiency and deformation characteristics of twisted file and ProTaper rotary instruments. Eur J Dent 2014b; 8(2): 191–6.
30. Ruddle CJ, Machtou P, West JD. The shaping movement: Fifth-generation technology. Dent Today 2013; 32(94): 96–9.
31. Ozsu D, Karatas E, Arslan H, Topcu MC.Quantitative evaluation of apically extruded debris during root canal instrumentation with ProTaper Universal, ProTaper Next, WaveOne, and self-adjusting file systems. Euro J Dent 2014; 8(4): 504-8.40.
32. Ebrahimi SF, Shadman N, Nasery EB, Sadeghian F Effect of polymerization mode of two adhesive systems on push out bond strength of fiber post to different regions of root canal dentine. Dent Res J 2014; 11(1): 32-8.
33. Babb BR, Loushine RJ, Bryan TE, Ames JM, Causey MS, Kim J, Kim YK, Weller RN, Pashley DH, Tay FR. Bonding of self-adhesive (self-etching) root canal sealers to radicular dentine. J Endod 2009; 35(4): 578-82.
34. Robberecht L, Colard T, Claisse-Crinquette A. Qualitative evaluation of two endodontic obturation techniques: tapered single-cone method versus warm vertical condensation and injection system: an in vitro study. J Oral Sci 2012; 54(1): 99-104.
35. Migliau G., Sofan A.A.A., Sofan E.A.A., Cosma S., Eramo S., Gallottini L. Root canal obturation: experimental study on the thermafil system related to different irrigation protocols. Annali di Stomatologia 2014; 5(3): 91-7.

الخلاصة

ختم ثلاثي الأبعاد لنظام قناة الجذرهو أحد الأهداف الأساسية للمعالجة اللبية. وقد أجريت هذه الدراسة لتقييم قوة الدفع للخارج لقوة ارتباط تقنيات مختلفة استخدمت لختم القنوات الجذرية التي تم تحضيرها باستخدام ثلاثة أنظمة دواره مصنوعة من النيكل والتيتانيوم والتي تتضمن WaveOne, ProTaper Next, ProTaper (Universal)

ستين جذرمقلوع من الضواحك السفلية تم قطعه و ترك الجذر مع طول 15ملم. ثم قسمت الجذور بشكل عشوائي إلى ثلاث مجموعات رئيسية، كان هناك عشرون جذر في كل مجموعة رئيسية، والتي تم تحضيرها باستخدام انظمه دوارة مختلفة وفقا للمجموعات: تم تحضيرأسنان المجموعة الرئيسية الأولى مع WaveOne والمجموعة الرئيسية الثانية تم تحضيرها باستخدام ProTaper Next اما المجموعة الرئيسية الأخيرة فقد حضرت باستخدام ProTaper Universal .لكل مجموعة تم استخدام نفس نظام الغسل باستخدام 3 مل من هايبوكلورات الصوديوم بتركيز5.25% ثم يتم غسلها ب3 مل من 17٪ EDTA لمدة دقيقة واحدة ثم تغسل القنوات ب3 مل من الماء المقطر.

بعد ذلك تقسم المجموعة الأولى بشكل عشوائي إلى مجموعتين فرعيتين لكل منهما عشرة عينات ، وتملاء المجموعة الفرعية الاولى مع تقنية المخروط الاحادي وتملأ المجموعة الفرعية الثانية معGuttaFusion® وأيضا قسمت المجموعة الثانية إلى مجموعتين فرعيتين، وتملاء واحدة مع تقنية المخروط الاحادي ، بينما تملاء المجموعة الفرعية الثانية مع GuttaFusion® . ثم تقسم المجموعة الثالثة عشوائيا إلى مجموعتين فرعيتين. واحدة تملاء مع تقنية المخروط الاحادي و الاخرى تملاء مع GuttaFusion® .

بعد ذلك، وضعت الجذور في الحاضنة لمدة سبعة أيام، ثم صبت الجذورفي مادة الاكريليك الشفافة وكل جذر قطعت منه ثلاثة اجزاء ذات سمك 2ملم (القمي، الوسطي و العنقي)وتثبت هذه العينات على قاعدة و يسلط عليها الحمل في الاتجاه القمي-العنقي باستخدام جهاز اختبار عالمي بسرعة 0.5 ملم | دقيقة. تم احتساب اعلى قوة ارتباط لمادة الحشوة قبل ازاحتها التي تقاس بوحدة ميغاباسكال عن طريق قسمة قوة الحمل على المساحة التي يتم احتسابها باستخدام برنامج(AutoCAD).

تم إجراء التحليل الإحصائي وأظهرت النتائج اختلاف كبيرجدا بين المجموعات الرئيسية التي حضرت مع انظمة دوارة مختلفة (WaveOne, ProTaper Next, ProTaper Universal)، وكانت هناك اختلافات كبيرة جدا بين التقنيتين المستخدمة لملأ قنوات الجذورالمجموعات الفرعية (مخروط احادي مقابلGuttaFusion®) و بالنسبة لاجزاء الجذر فقد اظهر الجزءالعنقي قيمة اعلى لقوة ارتباط حشوة الجذر من الجزء الوسطي وأظهر هذا الأخير قيمة عالية لقوة ارتباط حشوة الجذرمن الجزء القمي.