Research Article

The push out bond strength of bioceramic sealer (Total Fill) after warm and cold obturation techniques An in vitro comparative study

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Abstract: Background**:** The goal of a root canal treatment is three dimensional obturation with a complete seal of the root canal system. The aim of this study was to evaluate and compare the effect of two warm obturation techniques, warm vertical compaction (WVC) and, carrier based obturation technique Gutta Core (GC), versus two cold obturation techniques, cold lateral compaction (CLC) and, single cone (SC) on push-out bond strength of bioceramic sealer (Total Fill) at three different root levels. Materials and Methods: Forty extracted maxillary first molars teeth with a straight round palatal root canal and mature apices were selected for this study. After sectioning the palatal roots to 11 mm from the root apex, the canals were prepared with EDGEENDO X7 rotary system file from size 20 up to size 40 taper 04. The samples were then randomly separated into four groups based on obturation procedures (each group n = 10), with group A: obturated by WVC, group B: GC, group C: CLC, and group D: SC. Following obturation, the teeth were kept in an incubator at 37°C and 100% humidity for two weeks. Three slices of 2 mm thickness were cut horizontally at 2, 4.5, and 7 mm from the root apex in each of the three sections (apical, middle and coronal). The data were investigated using one-way ANOVA and Tukey's test with a significance level ($p < 0.05$). A digital microscope with a magnification of 60 X was used to establish the failure mode. Results: There was a significant increase in push-out bond strength following canal obturation with GC and WVC, particularly at the apical third (9.48, and 8.11 MPa, respectively) , compared to canals obturated with SC and CLC in all root levels except the middle third, at the ($p < 0.05$) significance level. The cohesive mode of failure was the most prevalent in all groups. Conclusio: BC (TotalFill) sealer showed higher bond strength when used in WVC and GC compared to other techniques. SC and CLC were showed comparable bond strength values.

Keywords: TotalFill BC, GuttaCore, Single cone, Push out test.

Introduction

Various obturation procedures have been used to fill the root canal system over the years, but none was perfect. According to Schilder, the optimal root canal obturating material must conform to the canal walls and irregularities [(1)]. According to Grossman, who investigated the physical qualities of filling materials, root canal sealers should have a high degree of adhesion[(2)]. As Caicedo and von Fraunhofer reported, root canal sealants are essential for keeping the root canals from drying out[(3)].

TotalFill® BC Sealer (FKG Dentaire SA, La-Chaux-de-fonds, Switzerland) is a pre-mixed calcium silicate bioceramic sealer that cures to generate hydroxyapatite, which attaches to the root canal dentine surface as well as the bioceramic-coated gutta-percha points.

TotalFill® BC Point, is a recently introduced hydrophilic sealer, composed of zirconium oxide, calcium silicates, calcium phosphate monobasic, calcium hydroxide, and various filling and thickening agents [(4)]. It is possible to employ Hydraulic condensation with a single cone approach because of its zero shrinkage and mild expansion; improved sealing is produced by joining bond bioceramic-coated gutta-percha points to the bioceramic sealer by chemical bonding (5).

Because of the irregular shape of the root canal, a single cone may be unable to completely seal the opening (6). The warm vertical technique and other thermoplasticized obturation are widely used by endodontists because of their efficiency in filling canal irregularities. Because of the new calcium silicate–based sealers, many practitioners may favor a thermoplasticized method rather than the SC technique, despite the producers' advice. The impact of the thermoplasticized process on these sealers' sealing characteristics has yet to be assessed (7).

The GuttaCore support is belongs to patented cross-linked gutta-percha and was created in 2010 (8). A carrier can combine the thermoplasticized GP and sealer horizontally and perpendicularly more quickly using this approach (9). The adhesion strength of the sealer and the appropriate technique used with it is important to achieve single adhesion unit (monoblock) and prevent any leakage. Because there were limited studies regarding the effect of obturation techniques on bond strength and adhesion capacity of bioceramic TotalFill sealer, therefore, the purpose of the current study was to evaluate and compare the effect of two warm obturation techniques, warm vertical compaction (WVC) and carrier-based obturation technique Gutta Core (GC) versus two cold obturation techniques, cold lateral compaction (CLC) and (SC) on the push-out bond strength of bioceramic sealer (TotalFill) at three different root levels. The null hypothesis was that there are no significant differences in the push-out bond strength of TotalFill bioceramic sealer after different obturation techniques.

Materials and Methods

For this study, forty extracted maxillary first molars with round and straight palatal root canals and mature apices were used. The palatal roots were split vertically to the root's long axis at the furcation area to take a flat reference point for measurement. Palatal roots were cut to achieve a standard length of 11 mm(10). Size 20 K-file was utilized to define the initial size of the canal, EDGEENDO X7 Rotary system files were used for instrumentation, starting with a size 20/04 rotary file, then 25/04, 30/04, 35/04, and 40/04 with a speed of 300 rpm and torque 300 g-cm till the working length (two–movement were used for each file) by gentle push in and out motion. Between each rotary file, recapitulation was done with a size #20 hand K-file to keep the glide path and help the lubricant to reach the canal terminus. During canal preparation, 1 ml of 2.5%, NaOCl irrigation was used between instruments using a 30-gauge needle (side vented) 2 mm short of the working length to remove debris. After instrumentation, the canals were irrigated with 2 ml of 2.5% NaOCl(11). Finally, 1 ml of EDTA 17% was used for 1 min agitation using sonic endoactivator(Dentsply Maillefer, Switzerland) with irrigation tip size 25 followed by 3 ml of 2.5% NaOCl for 1 min agitation using sonic endoactivator. Final rinsing with 5 ml saline solution(12). The samples were divided randomly into four groups based on the obturation methods (each group n = 10), group A: obturated by WVC, group B: GC, group C: CLC, group D: SC

Group A: Warm vertical compaction

The canals were obturated with a bioceramic coated 40/04 master cone. An intracanal tip was used to apply BC (TotalFill) sealer (FKG, Dentaire, Switzerland). The master cone was cut using a heated plugger (Fi-P, Woodpecker Medical Instrument Co., Guangxi, China)with a binding point of 4 mm short of the working length. It was just the apical portion of the gutta-percha that was maintained (4 mm). An injection of warm gutta-percha (Fi-G, Woodpecker Medical Instrument Co., Guangxi, China) set at 180°C was used for the backfilling of the canal. A needle (40/04) was inserted into the root canal for 5 seconds and then the gutta-percha was extruded before.It could harden. Finally, a plugger was used to compact the gutta-percha at the orifice level. Each canal was treated with two GP pieces that had been heated to a high temperature (3 to 4 mm of GP).

Group B: GuttaCore obturator

The BC sealer was inserted into the coronal one-third of the canal system with an intracanal tip. Size 40 of the GuttaCore obturator was chosen and inserted into the Thermaprep 2 oven's obturator holder (Tulsa Dental Dentsply, Tulsa OK, USA). The temperature of the oven was set according to the size of the obturator and the holder was pushed down in order to start thermoplasticzing the obturater. After several seconds, the obturator was ready to be used. After removing the obturator from the oven, it inserted into the working length of the canal with a downward pressing movement. It was necessary to bend the obturator's handle in both directions to remove extra material from the orifice.

Group C: Cold lateral compaction

Bioceramic coated GP 40/04 master cones, and TotalFill BC sealers (FKG, Dentaire, Switzerland) were used to seal the canals. An intracanal tip was inserted into the canals to insert the sealer in the coronal one-third (4 mm) of the canals. In the next step, a stainless-steel finger spreader size 25 (Dentsply Tulsa) was used to execute cold lateral-compaction, and tiny auxiliary gutta-percha cones (15 and 20) (Diadent, North FraserWay, Burnaby, BC, Canada)were introduced and condensed laterally to fill the canal space. Finally, the cones were cut down to the same level as the orifice(13).

Group D: Single cone

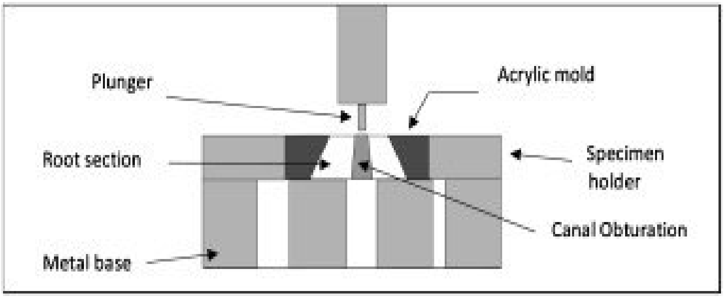
Bioceramic coated GP 40/04 cone and TotalFill BC sealer was used to obturate the canals, as suggested by the manufacturer. The intracanal tip of the BC sealer was inserted into the coronal one-third of the canal. The cone was cut off at the level of the orifice and lightly packed vertically with a plugger to create a tight seal.

The samples were wrapped in gauze and kept in an incubator at 37°C and 100% humidity for two weeks to confirm that the sealer had adequately solidified.(13) After that, three slices of 2 mm thickness were horizontally sectioned using a water-cooled precision saw (Ernst-Leitz, Wetzlar, Germany) with a diamond disk (0.5mm) thickness from root apex to include all roots at points 2, 4.5 and 7 mm level(14,15). For each segment, the apical and coronal diameters of the canal were measured using the ImageJ software analysis program (National Institutes of Health, USA). A digital caliper was used to verify the thickness of the section.

The apical aspect per slice was compressed using a cylindrical plunger (punch pin) installed on a universal testing Machine (Z wick Roell, Germany). The maximal force in Newton was measured at 0.5 mm/min in an apical-coronal direction until the initial dislodgement of obturating substance and a sharp decline along with the load deflection. Punch pins with diameters of 0.7 mm, 0.5 mm, and 0.4 mm were used, calculated as 90% of canal diameter in the apical side of each root slice, the coronal, middle, and apical slices. Punch pins must almost entirely cover the central cone without touching the canal walls or sealer that was used (Fig. 1).

The maximal force (F-max) where the filing materials were dislodged was registered, and the strength of push-out bond (MPa) was computed per sample using the formula:
Strength of push-out bond (MPa) = F-max / area of adhesion surface (mm^2)
F-max: Maximal force.
The formula used to calculate the surface adhesion value is presented below.:
Area of adhesion surface = (D1 + D2/2) ×μ×h
Where D1=apicaldiameter,D2=coronal diameter, μ = 3.14, and h = the section thickness

Figure 1: Schematic illustrates the push-out testing.



Evaluation mode of the failure

Following the push-out test, the specimens were examined under a 60 X magnification digital microscope to determine the failure forms (cohesive, adhesive, and mixed) that happened due to the stopper being displaced from the samples. Failure was considered:

- Adhesive after the sealer has been entirely removed from the dentine (dentine surface without sealer).

- Cohesive if the sealer contained within it has become separated (dentine surface completely was covered by sealer).

- Mixed, implying that both adhesive and cohesive modes are present at the same time (dentine surface partially covered by the sealer).

Statistical analysis: SPSS software for Windows (Version 25.0, IBM Corp., Armonk, NY, USA) was used for statistical analysis. The $p<0.05$ significance level was chosen. The study's primary outcome variable was bond strength in MPa. The information gathered was examined utilizing one way ANOVA test, followed by Tukey HSD comparison test. Failure mode was an additional outcome variable.

Results

Table 1 and Figure 2 display the mean and standard deviation of the bond strength (MPa) in groups. For the first technique (CLC), the highest mean values were recorded in the apical part (4.453)MPa followed by the middle (4.181)MPa, then the coronal part (3.003)MPa with a highly significant difference, for SC the mean strength of push-out was more elevated in coronal (4.205)MPa followed by apical (3.617)MPa then middle part (3.242) MPa.

Regarding the other two obturation techniques, the situation was different, where the mean strength of push-out was higher in the apical part in (GC, WVC) (9.482, 8.119, respectively)MPa followed by the coronal (2.439)MPa, then the middle (2.191)MPa in GC technique and the middle (4.535)MPa, and finally the coronal in WVC (2.439)MPa technique again with highly significant difference ($p<0.05$).

The differences in the strength of push-out bond at different root levels using different obturation techniques, according to one-way ANOVA test, are shown in in Table 1.

In group CLC, a statically significant difference was found between (coronal), (middle), and (apical) groups,(p=0.014). The apical third recorded the highest mean value, then the middle and the coronal third.

In group SC, a statically significant difference was found between (coronal), (middle), and (apical) groups, (p=0.016). The coronal third was recorded as the highest mean value followed by the (apical) third, then the (middle) third.

In group WVC, a statically significant difference was found between coronal, middle, and apical, (p=0.000). The apical third was recorded as the highest mean value followed by (middle) third, then (coronal) third.

In group GC, a statically significant difference was found between coronal,middle,and apical groups, (p=0.000). The apical third was recorded as the highest mean value followed by (coronal) third, then (middle) third.

Table 1: Descriptive and inferential statistics for the difference in the strength of push-out bond at different root levels using different obturation techniques.

techniques	Levels	Descriptive statistics			Levels difference	
		N	Mean	S.D.	F-test	p-value
clc	Apical	10	4.453	0.841	5.029	0.014 S
	Middle	10	4.181	1.410		
	Coronal	10	3.003	0.921		
sc	Apical	10	3.617	0.548	4.834	0.016 S
	Middle	10	3.242	0.726		
	Coronal	10	4.205	0.796		
wvc	Apical	10	8.119	1.136	67.401	0.000 HS
	Middle	10	4.535	1.301		
	Coronal	10	2.439	0.830		
Gc	Apical	10	9.482	1.239	99.426	0.000 HS
	Middle	10	2.191	0.800		
	Coronal	10	4.916	1.386		

S:significant, HS:high significant, NS:non significant

The statistical analysis employed the following levels of significance: NS p>0.05, S 0.05 p<0.01 HS.

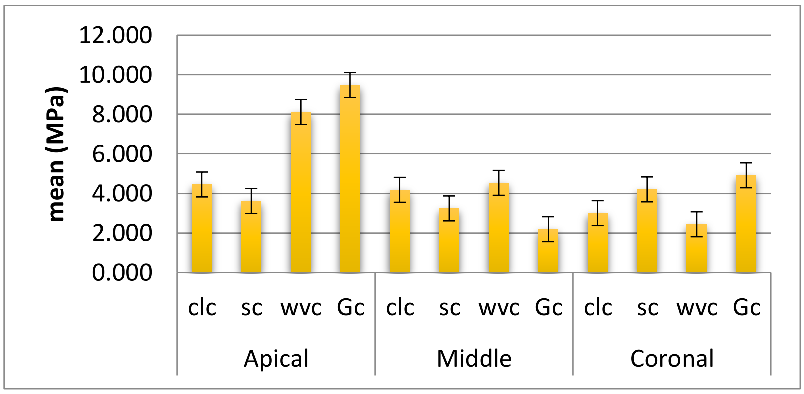


Figure 2: The average bond strength values (in MPa).

Regarding the effect of groups: in Table 2

A) Apical: There was a statistically high significant difference between CLC and each of WVC, GC (p<0.001). A statistically low significant difference was found between WVC and GC (p<0.05). There was no statistical difference between CLC and SC (p=0.242).

B) Middle: There was no statistically significant difference between CLC with SC, WVC and SC with WVC and GC (p>0.05). A statistically high significant difference was found between CLC and GC (p=0.001), and between WVC and GC (p=0.000).

C) Coronal: There was no statistically significant difference between CLC with SC, WVC and between SC with GC (p>0.05). A statistically low significant difference was found between CLC with GC, SC with WVC, WVC with GC (p<0.05).

Table 2: Multiple comparisons among different obturation techniques using Tukey's HSD test

Levels	Obturation techniques		Mean Difference	p-value
Apical	clc	sc	0.836	0.242 NS
		wvc	-3.666	0.000 HS
		Gc	-5.029	0.000 HS
	sc	wvc	-4.502	0.000 HS
		Gc	-5.865	0.000 HS
	wvc	Gc	-1.363	0.018 HS
Middle	clc	sc	0.939	0.243 NS
		wvc	-0.354	0.889 NS
		Gc	1.990	0.001 HS
	sc	wvc	-1.293	0.058 NS
		Gc	1.051	0.162 NS
	wvc	Gc	2.344	0.000 HS
Coronal	clc	sc	-1.202	0.054 NS
		wvc	0.564	0.602 NS
		Gc	-1.913	0.001 HS
	sc	wvc	1.766	0.002 S
		Gc	-0.711	0.407 NS
	wvc	Gc	-2.477	0.000 HS

S:significant,HS: high significant, NS:non significant, Failure mode

The highest failure mode was recorded as follows:
CLC (cohesive), SC (cohesive), WVC (adhesive), and GC (cohesive) with no significant difference (Fig. 3).

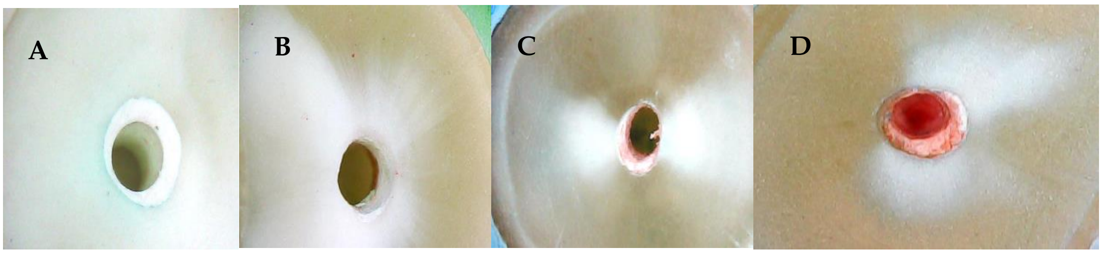


Figure 3: Mode of failure
A : Adhesive (S\G), B: Adhesive (D\S), C: Mixed, D: Cohesive(G).

Discussion

Root canal fillings are used to keep oral bacteria and their products from seeping into the apical periodontium and prevent bacteria that remain in the root canal afterward cleaning and shaping from escaping to the periapex [16]. Schilder conceived and described the thermoplastic root filling techniques, which are based on the vertical compaction of warm gutta-percha [17]. The thermoplastic root filling techniques have been extensively studied and found to be beneficial in root canal system filling, filling material homogeneity, and apical seal [18]. In this study, BC sealer TotalFill+BC coated gutta-percha (TotalFill) was used to improve bonding by forming an actual gap-free seal single cohesive unit (monoblock) as claimed by Trope et al., 2015[5]. But the result demonstrates a reduction in bond strength in single cone and CLC compared to WVC and GC, so the finding in this study disagrees with this monoblock idea. SEM analysis was used to determine the adaptation of BC sealer to BC coated points and revealed an interfacial space between the BC sealer and the coated GP The chemical connection between the BC sealer and the coated gutta-percha point was investigated [19] .Additional research utilizing various analytic tests is necessary to determine the degree of adhesion between the sealer and the coated point, as well as whether or not, it affects the quality of the root canal obturation. In this study, CLC and SC have comparable bond strength mean values with no difference regarding the effect of root levels. This may back up the manufacturer's advice for TotalFill BC, which recommends using TotalFill BC sealer with a single hydraulic technique. According to the findings of this study, the highest mean values were obtained when the thermoplasticized gutta-percha obturation technique (WVC, GC) in all root levels except GC in the middle third which showed low bond value.

These findings could be attributed to an increasing flow of warm gutta-percha, [20] resulting in a well-mixed bulk of gutta-percha and a small amount of sealer. This is frequently associated with an increase in material retention [17]. Several investigations also showed that the softening gutta-percha in thermoplasticized procedures had the flexibility to flow into deep depressions, lateral canals, auxiliary canals, and imperfections not filled by sealer cement [11]. The thermoplasticized procedures produce more gutta-percha, less sealer, and fewer empty gaps than SC and CLC. Because most endodontic sealers are soluble and shrink slightly, it is better to rely on gutta percha material percentage in the apical section as little as possible (13). The result of this study disagrees with (Putrianti et al., 2020) study that found CLC provides better adhesion ability than WVC (21). When there was no statistical significance difference among the tested levels regardless of the obturation materials used, this is in agreement with the results of (Costa et al., 2010) who demonstrated that fluctuations in tubular density along the canal are inadequate to cause sealer adhesion to be affected (22). The most predominant mode of failure is cohesive failure mostly (gutta-percha) in TotalFill BC except in WVC (adhesive) could be attributed to a thin layer of sealer incorporated in the dentinal tubules with some expansion due to the hydrophilic nature of the BC calcium silicate-based sealers have good adhesion to the root canal. WVC, GC reported high bond strength in TotalFill BC with a highly significant difference especially apical third in GC. This could be explained by a very limited widening of the canal in the apical part, making it impossible to perform push-out tests without values having a frictional component with the canal walls (23). The adhesive mode of failure in WVC could be attributed to the sealer not being compacted against the root canal wall. Guttacore's predominant failure mode was cohesive; this could be because the thermoplastic Gutta-percha pierced the dentinal tubules, resulting in well-adapted root obturation, or it could be due to the composition of GuttaCore, which is composed of two layers of Gutta-percha: an inner cross-linked layer and a flowable outer layer(24).

Conclusion

The bond strength of TotalFill BC sealer had a considerable influence on the obturation methods used in this study. To provide a high bond strength value,TotalFill BC can be used with warm obturation procedures (GuttaCore, warm vertical technique).

Conflict of interest: None.

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قوة رابطة الدفع للخارج للسداد الخزفي الحيوي (الملء الكلي) بعد تقنيات السد الدافئ والبارد دراسة مقارنة في المختبر

بتول باسم مؤنس، رغد الهاشمي

المستخلص:

كان الهدف الأساسي لهذه الدراسة هو تقييم ومقارنة تأثير تقنيتي السد الدافئ ، الضغط العمودي الدافئ (WVC) و Gutta Core (GC) القائم على الناقل ، مقابل تقنيتي السد البارد ، الضغط الجانبي البارد (CLC) و ، مخروط مفرد (SC) ، بناءً على قوة رابطة دفع مانع التسرب الخزفي الحيوي عند ثلاثة مستويات جذر مختلفة.

المواد والطرق: تم اختيار لهذه الدراسة أربعين ضرسًا مستخرجًا من الفك العلوي مع قناة جذر حنكي مستديرة مستقيمة بنهاية ناضجة. بعد تقسيم جذور الحنك إلى ١١ ملم من قمة الجذر. بعد تقسيم الجذور الحنكية إلى ١١ مم من قمة الجذر ، تم تحضير القنوات باستخدام ملفات EDGEENDO X7 Rotary System من ٢٠ حتى ٤٠ تفتق ٠٤ .

ثم تم فصل العينات بشكل عشوائي إلى أربع مجموعات بناءً على إجراءات السد (كل مجموعة ن = ١٠) ، مع المجموعة أ: مسد بواسطة WVC ، المجموعة B: GC ، المجموعة C: CLC ، والمجموعة D: SC. بعد الانسداد ، تم الاحتفاظ بالأسنان في حاضنة عند ٣٧ درجة مئوية ورطوبة ١٠٠٪ لمدة أسبوعين. تم قطع ثلاث شرائح بسمك ٢ مم أفقياً عند ٢،٤،٥،٧ مم من قمة الجذر في كل قسم من الأقسام الثلاثة (قمي ، وسط ، إكليلي). تم تحليل البيانات باستخدام اختبار ANOVA أحادي الاتجاه واختبار Tukey بمستوى معنوية (P <0.05). تم استخدام مجهر رقمي مع تكبير ٦٠ X لتحديد وضع الفشل.

النتائج: كانت هناك زيادة كبيرة في قوة رابطة الدفع بعد انسداد القناة باستخدام GC و WVC ، لا سيما عند الثلث القمعي (٩،٤٨،٨،١١) ميجا باسكال ، مقارنة بالقنوات المسدودة بـ SC و CLC في جميع مستويات الجذر باستثناء الثلث الأوسط ، (P< 0.05) مستوى معنوية. كان النمط المتماسك للفشل هو الأكثر انتشارًا في جميع الفئات.

الاستنتاجات: مقارنة بالتقنيات الأخرى ، يُظهر مانع التسرب BC (الملء الكلي) قوة رابطة فائقة في WVC و GC. كانت قيم قوة الرابطة لـ SC و CLC قابلة للمقارنة.