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Evaluation of push-out bond strength of Neosealer Flo bioceramic sealer versus AH Plus sealer with different obturation techniques (A Comparative in- vitro study)

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ABSTRACT

This study was conducted to evaluate push out bond strength of Neosealer Flo bioceramic sealer in comparison to AH Plus sealer with different obturation techniques. Twenty single-rooted human mandibular premolar teeth were decoronated. Samples were mechanically prepared then allocated randomly into two groups based on the type of sealer utilized for obturation; Group I: AH Plus sealer, Group II: Neosealer Flo and each group was then further divided into two subgroups (n=5 per group) based on the obturation technique that was used as follows; Group I a and Group II a: obturated with single cone technique, Group I b and Group II b: obturated with continuous wave of compaction technique. After obturation three dentin slices that have 2-mm thickness were horizontally cut at 3, 7, and 11mm length from the apex surface of each sample then universal testing machine was utilized for performing push-out test. AH Plus demonstrated a much stronger push-out bond strength in comparison to Neosealer Flo when utilizing the continuous wave condensation technique. However, AH Plus and Neosealer Flo did not significantly differ from one another when using the single cone technique. AH plus sealer had higher push-out bond strength when used in CWC technique than Neosealer flo sealer with no significant difference with SC technique.

1. Introduction

To ensure effective management of pulp space infection throughout the time of root canal therapy, it is imperative to accurately shape and cleanse all the root canals prior to three-dimensional filling [1]. Root canal system obturation is crucial for avoiding reinfection of the disinfected canal. This is because it forms a coronal seal, an apical seal, and effectively traps any leftover irritants within the canal [2,3]. Multiple studies have demonstrated that the quality of obturation of the root canals directly affects outcome of endodontic treatment [4,5]. Therefore, various techniques including cold lateral compaction (CLC), warm vertical compaction (WVC), single cone (SC), and others have been used to provide optimal obturation materials' adaption with dentin of the root canal [6].

The resin-based AH Plus sealer is basically considered the gold standard among root canal sealers and is manufactured by Dentsply DeTrey in Konstanz, Germany [7]. Due to their bioactivity and biocompatibility, sealers based on calcium silicate have grown swiftly in the last decade [8]. The makers of Neosealer Flo claim that their premixed bioceramic sealer has more bioactive characteristics than the original bioceramic sealers [9]. The product is made by Avalon Biomed™ in Houston, Texas, USA. There was no data examined for push-out bond strength of Neosealer Flo, based on the literature. In light of that, this research aims to compare the obturation methods used by Neosealer Flo bioceramic sealer and AH-Plus sealer to determine their respective push-out bond strengths.

2. Matrials and Methods

The faculty of dentistry 's ethical committee, Minia university gave this study its approval; (Committee No 93, Decision No 682).

2.1. Sample size calculation

Calculation of the sample size was done upon setting power at 80% and alpha error at 0.008 for four groups comparisons [10] and depending on

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PASS 11th release program for sample size calculation [11], the minimum sample size for four groups comparison would be 5 for each group.

2.2. Samples selection

Twenty single-rooted mandibular premolars with straight canals, as confirmed by radiographs, were recently extracted and chosen for the study. The exclusion criteria encompassed root caries, open apices, or prior root canal therapy. The teeth were thoroughly cleansed of any soft tissue debris and calculus using curette (Roydent curette, USA). They were then rinsed with tap water followed by 5.25% solution of NaOCl for a duration of 30 minutes for the reason of disinfection. Subsequently, the teeth were stored in distilled water until they were ready to be used for instrumentation.

2.3. Samples preparation and obturation

Samples's decoronation was performed using high speed diamond stone with coolant to obtain 16 mm length of the root. Determining the working length of roots was set through inserting K file #10 (Mani, Inc, Tochigi, Japan) to the end of the root until the tip became visible then subtracting 1mm. Root canals was instrumented using Protaper next up to X 3 (Dentsply Maillefer, Ballaigues, Switzerland). Irrigation was applied during instrumentation using 3ml of 5.25% NaOCl using side vented 30-gauge irrigating needle in between each one of the files, after instrumentation 10 ml EDTA solution was used for smear layer removal and distilled water was used in between irrigating solutions and as a final flush. Samples were then allocated into two experimental groups based on sealer type utilized for obturation and each group was then further divided into 2 subgroups based on the obturation technique that was used as follows:

Group I: Epoxy resin based (AH Plus sealer).

a. (n=5) With single cone technique.
b. (n=5) With continuous wave of compaction technique.

Group II: Bioceramic sealer (Neosealer Flo).

a. (n=5) With single cone technique.
b. (n=5) With continuous wave of compaction technique.

Sterile Protaper next X3 paper points (Dentsply Maillefer, Ballaigues, Switzerland) were employed for canal dryness as follows; in group II over dryness was avoided but in group I; root canals were completely dried

In group I: Based on the manufacturer's instructions, AH Plus sealer was mixed [12], then the sealer was applied on the master cone and inserted to reach to the working length.

- Group I (a): The gutta-percha cone was then seared off at the level of the orifice with a hot instrument and compacted with a suitable size plugger.
- Group I (b): A hot plugger was utilized to remove the master cone, the apical portion measuring only 4mm was left. The gutta percha was compressed using the Fast-Pack Pro device (manufactured by Changzhou Sifary Medical Technology Co., Ltd, China) and compacted with an appropriately sized hand plugger (manufactured by Shanghai Fanta Dental Materials Inc., Shanghai, China). The backfill treatment was executed utilizing Fast-Fill, a dental material manufactured by Shanghai Fanta Dental Materials Inc. in Shanghai, China.
- In group II: Neosealer Flo and sealer were delivered using tip delivery method in which the syringe's tip was inserted not deeper than the root canal's coronal third then sealer was injected with small amount, then master cone tip was covered with a layer of the sealer and was inserted to the full working length.
- Group II (a): obturated similarly to group I(a).
- Group II (b): obturated similarly to group I(b).

After the root canal sealers were placed, the samples were radiographed to check obturation quality. Then, for a week, they were placed in an incubator at 37°C and 100% humidity to make sure they were completely set.

2.4. Push out bond strength test

Samples were vertically aligned within self-cure acrylic-resin in a custom-made mold. Three 2mm dentin slices were horizontally cut at 3, 7, and 11mm length from the apex of each sample using a diamond saw with water coolant, resulting in 15 slices per group and total of 60 slices in the four experimental groups. Slices were coded then both coronal and apical aspects of slices were examined under stereomicroscope (Nikon MA100 Japan) and any slice that had voids or non-circular canal shape was replaced by new one. Each slice was measured for its coronal and apical diameter under stereomicroscope, then put under compressive load with a speed of 1mm/min using a 0.9 mm in diameter cylindrical steel punch tip in a 500N load cell utilizing universal testing machine (Instron universal testing machine model 3345 England) in which punch tip was contacting only the filling material (Figure 1). In apical coronal direction the load was applied to avoid any obstruction until the root filling material dislodged. The force of failure (N) was divided by the material-canal wall interface's surface area (mm^2) to get each sample's push-out value (MPa).

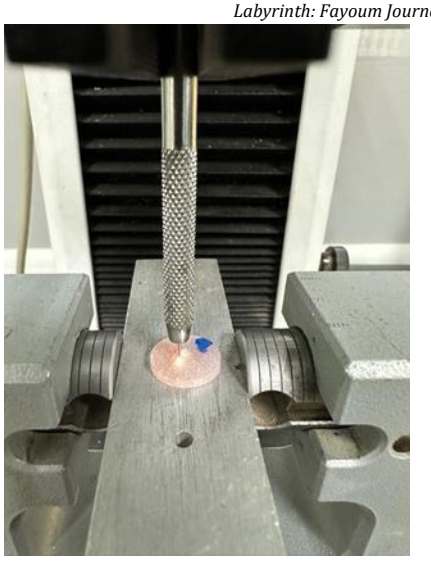

Figure (1) Push-out bond strength test

2.5. Statistical Analysis

The investigation focused on assessing the normality of numerical data by analyzing data dispensation and conducting tests for normality, such as the Kolmogorov-Smirnov and Shapiro-Wilk tests. The push-out test values did not comply with a normal distribution, indicating a non-parametric distribution. The data was displayed using median, range, mean, and standard deviation values. The test that was utilized to compare the two sealers and the two obturation techniques was Mann-Whitney U. Friedman's test was used to compare the 3 levels of the root in all samples within every single group. When the findings of Friedman's test are statistically significant, Dunn's test is used for making pair-wise comparisons. A significance level of $P < 0.05$ was employed. The statistical analysis was conducted using IBM SPSS Statistics for Windows, version 23.0. The location is Armonk, New York, where IBM Corp. is situated.

3. Results

3.1. Comparative sealers

No significant difference was observed between the mentioned 2 sealers when employing the single cone technique at coronal root level. The P-value was 0.117 and the effect size was 1.141. Both the middle root level (P-value=0.011, Effect size=2.604) and the apical root level (P-value = 0.009, Effect size = 2.928) showed that AH Plus showed significantly higher push-out values compared to NeoSEALER Flo. Between the comparable 2 sealers, there was no statistically significant distinction observed in the total push-out bond strength values (mean of the three levels) (p-value = 0.116, effect size = 1.141). No significant difference was observed in-between the two sealers while utilizing the continuous wave of compaction technique at the coronal level of the root (P-value=0.754, Effect size=0.199). The push-out value of AH Plus was significantly greater than that of NeoSEALER Flo at both the middle root level (P-value=0.009, Effect size=2.928) and the apical root level (P-value=0.016, Effect size =2.336). As regards the overall push-out bond strength, AH Plus exhibited significantly higher push-out bond strength when it was compared to NeoSEALER Flo, as evidenced by its p-value of 0.009 and effect size of 2.928 (Table 1).

Table (1): Descriptive statistics and the results of the Mann-Whitney U test are presented for comparing the push-out bond strength (measured in MPa) of the 2 sealers.

Obturation technique	Root level	AH Plus		NeoSEALER Flo		*P-value*	*Effect size (d)*
		Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
Single cone	Coronal	17.8 (6.8-20.4)	16 (5.3)	9.8 (8.4-10.1)	9.5 (0.7)	0.117	1.141
	Middle	16 (15.9-17.8)	16.4 (0.8)	13.4 (11.2-15.9)	13.2 (1.8)	0.011*	2.601
	Apical	7 (6.5-10)	8 (1.7)	13.8 (12.4-14.6)	13.8 (0.9)	0.009*	2.928
	Overall	14.3 (10.8-14.4)	13.4 (1.5)	12.2 (11.5-12.7)	12.2 (0.4)	0.116	1.141
Continuous wave of compaction	Coronal	10.4 (8-12.7)	10.3 (1.7)	11.5 (3-13.7)	9.7 (4.2)	0.754	0.199
	Middle	13.4 (11.2-15.9)	13.2 (1.8)	7.6 (7.1-8.8)	7.7 (0.7)	0.009*	2.928
	Apical	7.8 (7.3-9.1)	8 (0.7)	6.2 (5.4-7.6)	6.4 (0.9)	0.016*	2.336
	Overall	10.4 (9.6-11.5)	10.5 (0.9)	8.4 (6-9)	7.9 (1.2)	0.009*	2.928

**: Significant at P ≤ 0.05*

3.2. Evaluating different techniques for filling root canals

There were no significant differences in obturation techniques when using AH Plus sealer at the coronal and apical levels of the samples. The p-value was 0.117, and the effect sizes were 1.148 and 0.600 and 0.335, respectively. The push-out value at the middle root level was found to be significantly higher when employing the single cone compared to the continuous wave of compaction technique (P-value = 0.011, Effect size = 2.601). single cone was found to be statistically higher than the other technique as regard the total push-out values. (P-value = 0.028, Effect size = 1.926). No statistically significant distinction was observed between the obturation techniques utilized when NeoSEALER Flo was used at the coronal level of the root (P-value = 0.465, Effect size = 0.475). The single cone technique exhibited significantly higher push-out bond strength at the middle root level (P-value = 0.009) and apical root level (effect size = 2.928) in comparison to the continuous wave of compaction technique. Single cone technique had significantly higher overall push-out bond strength compared to the continuous wave of compaction technique, as evidenced by a p-value of 0.009 and an effect size of 2.928 (Table 2).

Table (2): Descriptive statistics and the results of the Mann-Whitney U test are presented for comparing the push-out bond strength (measured in MPa) after employing the two different obturation strategies.

Sealer	Root level	Single cone		Continuous wave of compaction		*P*-value	*Effect size (d)*
		Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
AH Plus	Coronal	17.8 (6.8-20.4)	16 (5.3)	10.4 (8-12.7)	10.3 (1.7)	0.117	1.141
	Middle	16 (15.9-17.8)	16.4 (0.8)	13.4 (11.2-15.9)	13.2 (1.8)	0.011*	2.601
	Apical	7 (6.5-10)	8 (1.7)	7.8 (7.3-9.1)	8 (0.7)	0.600	0.335
	Total	14.3 (10.8-14.4)	13.4 (1.5)	10.4 (9.6-11.5)	10.5 (0.9)	0.028*	1.926
NeoSEALER Flo	Coronal	9.8 (8.4-10.1)	9.5 (0.7)	11.5 (3-13.7)	9.7 (4.2)	0.465	0.475
	Middle	13.4 (11.2-15.9)	13.2 (1.8)	7.6 (7.1-8.8)	7.7 (0.7)	0.009*	2.928
	Apical	13.8 (12.4-14.6)	13.8 (0.9)	6.2 (5.4-7.6)	6.4 (0.9)	0.009*	2.928
	Total	12.2 (11.5-12.7)	12.2 (0.4)	8.4 (6-9)	7.9 (1.2)	0.009*	2.928

**: Significant at P ≤ 0.05*

3.3. Conducting a comparative analysis of root levels within each group

When comparing the application of AH Plus sealer with either both of the obturation technique used, there was no statistically significant variation in push-out bond strengths across different thirds of the root. The P-value for single cone was 0.074, indicating a moderate level of statistical significance. The effect size for single cone was 0.520, suggesting a moderate magnitude of impact. On the other hand, the P-value for continuous wave compaction was 0.051, indicating a slightly higher level of statistical significance. The effect size for continuous wave compaction was 0.604, suggesting a somewhat larger magnitude of impact compared to single cone. The push-out bond strength at various root segments for NeoSEALER Flo utilizing the single cone technique exhibited a statistically significant disparity (P-value=0.015, Effect size =0.840). Upon analyzing the root levels, it was determined that there was no statistically significant disparity between the middle and apical levels. Nevertheless, both of these levels exhibited markedly greater push-out bond strength in comparison to the coronal root level. The study found no statistically significant variation in the push-out bond strength at different root levels when using the NeoSEALER Flo with continuous wave of compaction technique (P-value =0.165, Effect size=0.360) (Table 3).

Table (3): The study presents descriptive statistics and the findings of Friedman's test to compare the push-out bond strength (measured in MPa) at different root levels within each group.

Sealer	Root level	Single cone		Continuous wave of compaction	
		Median (Range)	Mean (SD)	Median (Range)	Mean (SD)
AH Plus	Coronal	17.8 (6.8-20.4)	16 (5.3)	10.4 (8-12.7)	10.3 (1.7)
	Middle	16 (15.9-17.8)	16.4 (0.8)	13.4 (11.2-15.9)	13.2 (1.8)
	Apical	7 (6.5-10)	8 (1.7)	7.8 (7.3-9.1)	8 (0.7)
	P-value	0.074		0.051	
	Effect size (w)	0.520		0.604	
NeoSEALER Flo	Coronal	9.8 (8.4-10.1) ^{B}	9.5 (0.7)	11.5 (3-13.7)	9.7 (4.2)
	Middle	13.4 (11.2-15.9) ^{A}	13.2 (1.8)	7.6 (7.1-8.8)	7.7 (0.7)
	Apical	13.8 (12.4-14.6) ^{A}	13.8 (0.9)	6.2 (5.4-7.6)	6.4 (0.9)
	P-value	0.015*		0.165	
	Effect size (w)	0.840		0.360	

**: Significant at P ≤ 0.05, Different superscripts in the same column indicate statistically significant difference between root levels*

4. Discussion

The effective root canal filling should securely attach to the wall of the root canal also withstand forces that could cause it to get dislodged [13]. This resistance to dislodgement of the filling material is important because it inhibits the leaking of microorganisms and provides support to the structure of the root [14]. The resistance of dislodgement of the materials that are used for filling the root is assessed using a push-out test [3]. The article offers useful insights into the comparison of sealers and various obturation processes [6,15]. The current study's goal is to assess the push-out bond strength of Neosealer Flo with AH Plus sealer using various obturation procedures. Single-rooted with only one canal teeth were utilized to standardize the experiment and minimize the influence of other variables. This selection was also made to facilitate the sectioning process [16,17]. The Protaper Next file system was chosen to prepare the root canals because to its proven effectiveness, as demonstrated in various studies documented in the literature [18,19].

In the irrigation protocol, NaOCl was selected due to its superior proteolytic effect in endodontic treatment [20]. NaOCl was also chosen for its antimicrobial properties and ability to dissolve tissue [21]. Additionally, EDTA irrigation solution was utilized to eliminate the smear layer's inorganic parts [22,23]. In this investigation, AH Plus resin-based sealer was chosen for comparison because it is widely regarded as the standard sealer against which alternative sealers are evaluated [19,24,25]. The Neosealer Flo, developed by Avalon Biomed™ in Houston, Texas, USA, is a recently launched bioceramic sealer that has undergone assessment to determine its chemical, physical, and bioactive characteristics [26]. This investigation employed two distinct obturation procedures: the single cone obturation approach, recommended by the producers of the latest bioceramic sealers [16,17], was chosen for its higher reproducibility compared to previous obturation techniques [18,27]. The continuous wave of compaction technique (CWC) was employed due of its superior capacity to fill canal imperfections and lateral canals [28]. The specimens were maintained in a moist environment and incubated at a temperature of 37°C with 100% humidity for a period of 7 days to verify full solidification of root canal sealers [29].

The findings of this study showed that there was no significant difference in the push-out bond strength between Neosealer flo and Ah Plus sealer when utilizing the single cone technique. This finding is consistent with previous studies that compared bioceramic sealer to Ah Plus using the same technique [30,31]. However, when applying the other technique continuous wave of compaction, AH Plus sealer demonstrated significantly higher push-out bond strength compared to Neosealer Flo. This finding is as per other previous studies which compared the push-out bond strength of AH Plus sealer with bioceramic sealers using warm vertical compaction technique [7,19,32–34]. The stronger chemical link between AH Plus epoxide rings and the dentinal collagen's amino group was responsible for this, as opposed to the interaction between calcium silicate dentin [35,36]. Simultaneously, there have been reports indicating that the use of heat during the CWC technique has a detrimental impact on the adhesive strength of bioceramic sealers. This is because heat speeds up the setting reaction, resulting in a shorter setting time. Consequently, the flowability of the sealer may be reduced, leading to decreased entering into canal irregularities and to the dentinal tubules [37]. Comparing the overall push-out values of each obturation technique for utilizing the 2 different sealers, it was found that single cone technique possessed significantly higher push-out bond strength values than continuous wave of compaction technique. That was as per other previous studies [38,39]. which can be related to the increased amount of sealer used, particularly when filling root canals that have an uneven shape applying single cone technique [39].

The study found that the Neosealer flo sealer demonstrated a much stronger push-out bond strength in the middle also in apical thirds in comparison with the coronal third when employing the single cone approach. The obtained results were consistent with prior research that assessed the push-out bond strength of bioceramic sealer utilizing single cone technique [24,40–42]. The observed results can be attributed to the reduced viscosity of Neosealer Flo, which enhanced its ability to flow and entering deeper into the irregularities of the root canal and its surrounding structures at the apical and middle thirds. This led to a larger contact area, resulting in stronger micromechanical interaction. Additionally, the development of a mineral infiltration zone further contributed to these effects [43]. According to the study, there was no statistically significant difference in the values of AH Plus sealer when used with both SC and CWC techniques at the three distinct root levels. This finding is consistent with earlier studies [40,43]. The lack of influence on Ah Plus sealer adhesion was attributed to the inadequate changes in tube density along the canal, as indicated [43]. Furthermore, the use of Neosealer Flo sealer with the CWC approach did not result in any notable variation across the three root levels. This finding aligns with a prior study that examined the push-out bond strength of a bioceramic sealer at various levels of the root [44].

5. Conclusions

Considering the constraints of this in vitro study, the subsequent conclusions could be summarized as following; (1) AH Plus demonstrated significantly higher push-out bond strength than Neosealer Flo using continuous wave of compaction technique. (2) No statistical difference was found in bond strength between both sealers with single cone obturation technique. (3) Single cone obturation technique demonstrated significantly higher push out bond strength than continuous wave of compaction technique using both Ah Plus and Neosealer Flo sealers.

Author Contributions

Conceptualization, E.M.M.A. and L.A.I.H.; Methodology, E.M.M.A., E.A.H.A., and L.A.I.H.; Software, E.M.M.A. and E.A.H.A.; Validation E.M.M.A. and L.A.I.H; Formal analysis, E.M.M.A. and L.A.I.H; Investigation, E.M.M.A., E.A.H.A., and L.A.I.H.; Resources, E.M.M.A., E.A.H.A., and L.A.I.H; Data curation, E.M.M.A. and L.A.I.H; Writing—original draft preparation, E.M.M.A., E.A.H.A and L.A.I.H; Writing—review and editing, E.M.M.A., E.A.H.A and L.A.I.H; Visualization, E.M.M.A., E.A.H.A and L.A.I.H. Supervision, E.M.M.A., E.A.H.A., and L.A.I.H. Project administration, E.M.M.A., E.A.H.A., and L.A.I.H; Funding acquisition, E.M.M.A., E.A.H.A., and L.A.I.H. All authors have read and agreed to the published version of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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