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EFFECT OF TWO RETREATMENT SYSTEMS ON THE BOND STRENGTH OF TOTALFILL BIOCERAMIC SEALER: AN IN VITRO STUDY

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KEYWORDS

Bioceramic sealer, Retreatment, Scanning electron microscope

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ABSTRACT

Introduction: Removal of root canal filling from the root canals is important to allow effective irrigation flow inside the root canals, and adaptation of new root canal filling. **Aim:** to evaluate and compare the efficacy of two rotary retreatment systems (D-Race retreatment kit, Neolix kit) on removal of gutta-percha and bond strength of obturation using Totallfill BC sealer. **Materials and methods:** Sixty single rooted teeth were decoronated and shaped using Protaper universal system to size F3, then obturated using cold lateral condensation. Roots were divided into two groups according to the type of retreatment kit used. After retreatment, half of the samples were examined under Scanning Electron Microscope (SEM) and the remaining half were reobturated using Totallfill Bioceramic sealer and tested by pushout bond strength test. Data was statistically analyzed by one- and two-way of variance (ANOVA) followed by Tukey's HSD multiple comparison tests to compare between sub-groups. **Results**: Findings showed that D-race system is more effective in removing root canal filling material compared to Neolix system. The results also showed that the adaptation of bioceramic sealer is affected by the amount of remaining root canal filling material after retreatment. **Conclusions**: This study suggested that D-race system is more effective in removing root canal filling material compared to Neolix system. The adaptation of bioceramic sealer is affected by the amount of remaining root canal filling after retreatment.

INTRODUCTION

The main cause of failure of root canal treatment is the persistence of microorganisms in the root canal system. This occurs due to insufficient cleaning and shaping, coronal or inadequate obturation, and apical leakage [(1)]. The primary objective of non-surgical retreatment is to gain access to the hidden micro-organisms, and to thoroughly disinfect the root canal system [(2)] .

Removal of root canal filling from the root canals is important to allow effective irrigation flow inside the root canals, and adaptation of new root canal filling. There are many techniques for removal of root canal filling; manual stainless-steel files, chemical solvents, ultrasonic tips, heated pluggers, and rotary endodontic file[(3)]. Ni-Ti rotary files have been introduced to decrease time and increase the efficiency of removal of gutta-percha from the root canal system [(4)].

Following removal of old gutta-percha and disinfection of the root canal. Three dimensional obturation is essential to avoid recontamination of the root canal with micro-organisms. The fundamental function of root canal sealer is to fill the spaces between the core filling material and the root canal walls aiming to reform a homogenous mass without voids [5].

Bioceramic sealers have been recently introduced for obturation of root canals. The main advantage of bioceramic sealer over other types of sealers is the high biocompatibility with the surrounding tissues[6]. Bioceramic sealers contain calcium phosphate that may improve binding of sealer to root dentin because it results in a chemical composition and crystalline structure similar to tooth and bone apatite materials [7]. Since the success rate of retreatment is affected by the quality of reobturation after gutta-percha removal, the aim of this study is to evaluate the efficiency of two different retreatment systems in removal of root canal filling, and the subsequent effect on the bond strength of bioceramic sealer and root canal dentin. Since there are insufficient studies about D-race and neolix retreatment files used in retreatment and the effect of remnants of filling material on the reobturation with bioceramic sealer there was a necessity to start this study. The null hypothesis is that the presence of remnants of filling material after retreatment will not affect the pushout bond strength after reobturation with bioceramic sealer.

MATERIALS AND METHODS

Sample size calculation:

This study was approved by ethical committee (number 88/2018) of Faculty of Dentistry, Suez Canal University. Current experiments were carried out to assess and evaluate the remaining obturation material from two retreatment systems D-race and Neolix at different sections. Two main parameters were assessed; area percentage (%) of the remaining obturation material after retreatment by D-race and Neolix using Scanning electron microscope (SEM) and the adaptation of TotallFill bioceramic sealer using Pushout bond strength test. Repeated measures analysis of variance (ANOVA) was proposed. A minimum total sample size of 44 samples was sufficient to detect the effect size of 0.25 according to Cohen[8], a power (1-β=0.95) of 95% at a significance level of $p<0.05$ partial eta squared of 0.06. According to sample size calculations each retreatment system (D-race or Neolix) (A, B) would be represented by a minimum of 15 sample.

Samples collection:

Sixty human single rooted teeth lower second premolar (Vertucci type I) freshly extracted for periodontal, prosthodontic or orthodontic reasons were collected. Teeth were immersed in 2.5% sodium hypochlorite (NaOCl) (Clorox, Egypt) for two hours for disinfection. Tissue fragments and calculus were removed from the external surface of teeth by scaling and then teeth were washed and stored in saline solution until use.

Root canal preparation:

Decoronation of the teeth was done. Roots were held using moist gauze and a K-file size #10 (Mani Inc., Tokyo, Japan) was used to ensure the patency. Then, the working length of the root canals was determined by introducing K-file size #15(Mani Inc., Tokyo, Japan) to the apical foramen and then the length was adjusted at 1mm before the apical foramen. The root canals were prepared using protaper universal kit (DENTSPLY, Ballaigues, Switzerland) till the third finisher file F3.

Root canal filling:

Root canals were obturated using cold lateral compaction with gutta-percha (Mani Inc, Tokyo, Japan) and AD seal (META BIOMED CO.LTD, Korea). The master cone used was F3 (30/0.06) the

spreader size was #25(Mani Inc., Tokyo, Japan). Then teeth were stored in incubator (Ivoclar Vivo dent, Almedica AG, Galmiz, Switzerland) at 37°C and 100% humidity for 7 days to allow the setting of the sealer.

Retreatment technique and grouping:

Roots were divided into two groups (30 each) according to the type of retreatment system that was used: Group A: D-race files (FKG Dentaire, La Chaux De Fonds, Switzerland) were used to remove gutta-percha. Group B: Neolix files (Neolix, Châtres-la-Forêt, France) were used to remove gutta-percha. The first 2-3 mm of gutta-percha was removed using gates glidden drills (ManiInc, Tokyo, Japan) (size 2, 3). A drop of chloroform (Prevest, Ambala city, India) was inserted into the canals for 5 minutes. Half of the specimens was sectioned and investigated under the Scanning Electron Microscope after removal of gutta-percha and were not be refilled.

SEM Preparation:

Half of the samples of each group were grooved vertically in a buccolingual direction, and then split into two halves with a chisel. The samples were dehydrated in graded alcohol concentrations, dried, to be assessed using Scanning Electron Microscopic (FEI Quanta 250 FEG SEM) (FEI company, Hillsboro, OR, USA). The SEM was adjusted at 20 kv (accelerating voltage for electrons), 4.5 nm (spot size), 12.8 mm (working distance), and 414μm (horizontal field width). After a general survey of the root canal walls, one SEM photo of each third (coronal, middle, and apical) of the root canal was taken at magnification 1000x. The images were saved digitally with Photoshop CS 6 where the remnants of gutta-percha and sealer were selected and painted white and the rest of the picture was painted with black. Image J software (NIH, Bethesda, MD) was used to calculate the percentage of the selected remnants of gutta-percha and sealer (white) and scored by trained operator. The amount of residual filling material at the three predetermined portions of each root canal was evaluated by the following scoring system according to Somma et al.[9] : 0 score indicates none to slight presence (0%–25%) of residual debris covered the dentinal surface, 1 score indicates presence of 25% to 50% of residual debris on the surface, 2 score indicates moderate presence (50%–75%) of residual debris, and 3 score indicates high presence (75%–100%) of residual debris on almost the entire surface of dentin. No attempt was made to distinguish between filling material or sealer remnants.

Bioceramic obturation:

The remaining half of specimens were reobturated with Total fill bioceramic sealer (FKG Dentaire, Switzerland (and tested with pushout bond strength test. A premixed TotalFill BC Sealer was applied with bioceramic tip attached to the hub of the syringe and introduced directly into the root canal. The setting time of the TotalFill Sealer is dependent upon the presence of moisture in the dentin. Prior to the application of TotalFill BC Sealer the canals were dried using paper points (Mani Inc, Tokyo, Japan). The master gutta-percha cone (#30 taper 0.04) was coated with sealer and was used to apply the sealer to the canal walls. Spreader size #25 was used for lateral compaction. Auxiliary gutta percha points size #25 were introduced into the canal using cold lateral compaction technique. The master gutta-percha cone is compacted against the canal wall with the spreader. An additional GP point is then placed into the void left by the spreader. The process is repeated until the canal is filled.

Push-out test procedure:

The reobturated specimens were stored at 37°C and 100% humidity for 7 days to allow setting of the sealer. Each specimen was transversely sectioned perpendicular to the long axis of the root using a water-cooled precision saw to obtain a section

2mm±0.1 in thickness from the root thirds (apical 2 to 4mm from the apex, middle 7 to 9 mm from the apex, and coronal 12 to 14 mm from the apex) as measured using a digital caliper (Pachymeter, Electronic Digital Instruments, China) [10]. Each root section was mounted in custom made loading fixture [metallic block with circular cavity at the middle, this cavity for specimen housing having a central whole to facilitate displacement of extruded filling material], then subjected to compressive loading at a crosshead speed of 1 mm/min via a computer-controlled materials testing machine.

The maximum failure load was recorded in Newton and converted into MPa. The bond strength was calculated from the recorded peak load divided by the computed surface area as calculated by the following formula:

$[A = (3.14x\ r^1 X\ 3.14x\ r^2)\ L]$,

Were

r^1 apical radius, r^2 coronal one,

$L= [(r1-r2)^2+h^2]^{0.5}$ and h is the thickness of the sample in millimeters].

Statistical analysis

Statistical analyses were carried out for evaluation of the two-retreatment systems D- race and Neolix. Data were collected, checked, and organized in tables and figures using Microsoft Excel 2016 and SPSS version 23 for Mac OS.

RESULTS

Percentage of residual filling material measured by Scanning Electron Microscope (SEM):

Intragroup analysis:

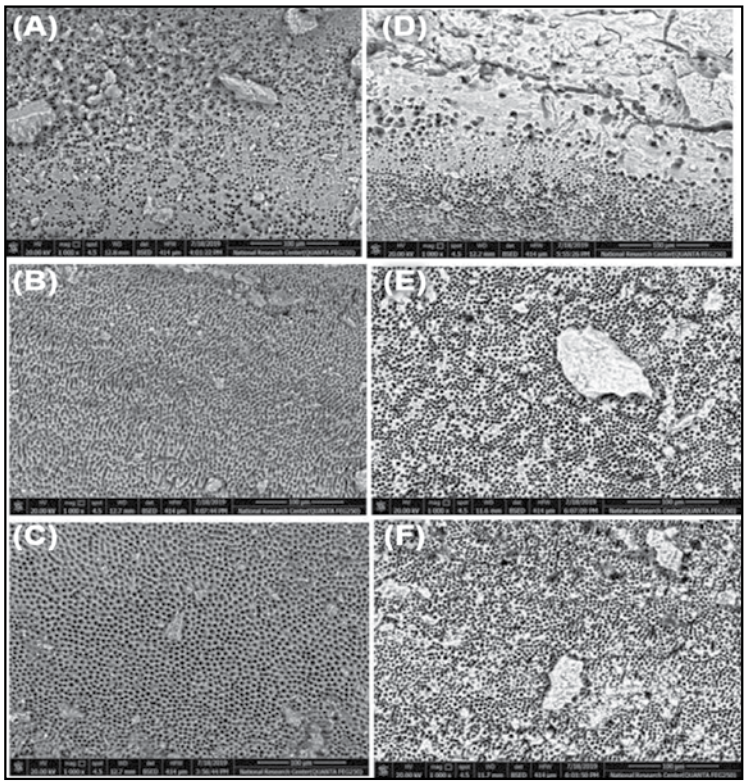

Figure (1): Representative SEM pictures showing: (A) The apical third of the root (D-race group) (B) The middle third of the root (D-race group) (C) The coronal third of the root (D-race group) (D) The apical third of the root (Neolix group) (E) The middle third of the root (Neolix group) (F) The coronal third of the root (Neolix group).

Group A (D-race): The highest mean value of percentage of residual filling material was recorded in the middle level (8.91±1.85) followed by the apical level (8.38±0.64). While, the coronal level recorded the lowest mean value of percentage of residual filling material (7.22±1.36). There were no statistically significant differences between the three levels.

Group B (Neolix):

Apical level recorded the statistically significant highest mean value of percentage of residual filling material (30.08±4.35), followed by the coronal level (16.58±4.40), then the middle one (13.78±1.73). There was no statistically significant difference between the middle and coronal level.

Intergroup analysis:

Comparison between D-race and Neolix:

The percentage of residual filling material measured by Scanning Electron Microscope (SEM) after retreatment by D-race and Neolix rotary systems showed an average of 8.29±1.78 and 19.64±1.67 respectively. The Neolix rotary system treatment showed a significantly (p<0.001***) higher percentage of residual filling material area than D-race system at all levels of root canal. Differences between D-race group and Neolix group were found to be statistically significant at both apical and coronal root levels (p<0.05). However, it was non-significant in middle root level.

Table (1) *The percentage of residual filling material measured by Scanning Electron Microscope (SEM) after retreatment by D-race and Neolix systems at three root levels.*

Root sections	SEM area (%) (Mean ± SE)		Independent t-test	
	D race	Neolix	t-stat	*p*-value
Apical	8.38 ± 0.64 b	30.08 ± 4.35 a	-3.61	0.002**
Middle	8.91 ± 1.85 b	13.78 ± 1.73 b	-1.92	0.066n.s.
Coronal	7.22 ± 1.36 b	16.58 ± 4.40 a	-2.1	0.047*
Average	8.29 ± 1.78	19.64± 1.67	<0.001***	

** Significant at p<0.05; ** highly significant at p<0.01; *** very high significant difference at p<0.001; NS nonsignificant different at p>0.05. Means followed by different letters are significantly different according to Tukey's post hoc test at p<0.05.*

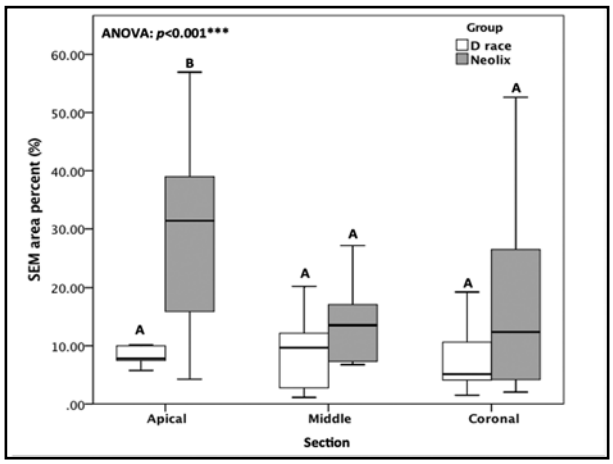

Fig. (2) Boxplot for the percentage of residual filling material measured by Scanning Electron Microscope (SEM) after retreatment by D-race and Neolix systems at three root levels (apical, middle, and coronal).

Pushout bond strength (MPa):

Intragroup analysis:

Group A (D-race):

There was a statistically significant difference in pushout bond strength between all levels of roots retreated with D-race. The coronal level recorded the highest statistically significant mean value of pushout bond strength (1.26±0.13), followed by the middle level (0.91±0.07), then the apical level (0.57±0.09) which recorded the lowest value.

Group B (Neolix):

The highest mean value of pushout bond strength was recorded in the middle level (0.91±0.07) followed by the coronal level (0.73±0.07). While, the apical level recorded the lowest mean value of pushout bond strength (0.52±0.09). There was no statistically significant difference between the three levels.

Intergroup analysis:

Comparative Pushout bond strength between two groups:

The pushout bond strength (MPa) after reobturation with Totallfill Bioceramic sealer for D-race rotary system treatment showed higher values in MPa at all root levels than Neolix rotary system at $p<0.05$.

Differences between D-race and Neolix were found to be significant ($p<0.05$) at coronal root levels, however, it was non-significant at apical and middle root levels ($p>0.05$).

Table (2) *Mean and standard error of pushout bond strength (MPa) after reobturation with Totallfill Bioceramic Sealer for all rotary systems at three root levels (apical, middle, and coronal). Differences were assessed by independent samples t-test.*

Sections	Pushout bond strength (MPa)		Independent t-test	
	D race group	Neolix group	t-stat	p-value
Apical	0.57 ± 0.09	0.52 ± 0.09	0.384	0.704
Middle	0.91 ± 0.07	0.76 ± 0.07	1.499	0.146
Coronal	1.26 ± 0.13	0.73 ± 0.07	3.386	0.003**
All	0.91±0.061	0.64±0.058	0.007**	

** Significant at $p<0.05$; ** highly significant at $p<0.01$; *** very high significant difference at $p<0.001$; NS nonsignificant different at $p>0.05$. Means followed by different letters are significantly different according to Tukey's post hoc test at $p<0.05$.*

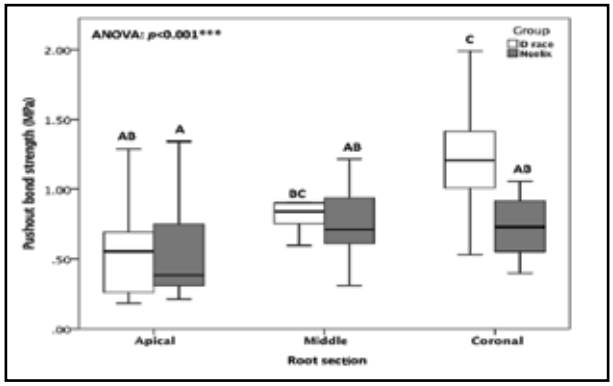

Fig. (3) Boxplot of pushout bond strength (MPa) after reobturation with Totallfill Bioceramic Sealer for rotary systems at three root levels (apical, middle, and coronal).

Correlation between the percentage of residual filling material and pushout bond strength (MPa) after reobturation with Totallfill Bioceramic Sealer:

According to Spearman's correlation the percentage of residual filling material was

significantly (p<0.019*), inversely and strongly correlated to pushout bond strength (MPa) after reobturation with Totallfill Bioceramic Sealer (R= -0.71, sign. (2-tailed=0.019*). A regression trendline were also generated to confirm the direction of linear relationship between both the percentage of residual filling material measured by Scanning Electron Microscope (SEM) and pushout bond strength (MPa) after reobturation with Totallfill Bioceramic sealer. In both groups, the correlation between the percentage of residual filling material measured by Scanning Electron Microscope (SEM) and pushout bond strength (MPa) after reobturation with Totallfill Bioceramic sealer at different section separately (Apical, middle, coronal) showed a negative non-significant correlation, i.e., the more the percentage of residual filling material the less pushout bond strength after reobturation.

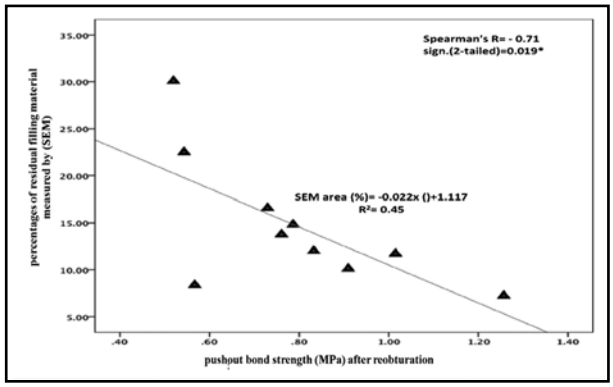

Fig. (4) Regression Trendline showing the interrelationship between pushout bond strength (MPa) after reobturation with Totallfill Bioceramic sealer (On X-axis) and the percentage of residual filling material measured by Scanning Electron Microscope (SEM) (On Y-axis).

DISCUSSION

It is important to remove as much root canal filling material as possible during retreatment to uncover the residual necrotic tissue or bacteria that might be in charge for root canal treatment failure[11]. Previous studies assessed the remaining filling material through different techniques and methods[12-14].

The D-Race rotary system consists of 2 files (DR1-DR2) designed for retreatment. DR1 is a 15.8 mm in length, size 30/ 0.10 taper with a cutting tip for coronal third. DR2 is a 25.16 mm in length, size 25/ 0.04 taper to reach the working length [15]. These were designed with alternating cutting edges as well as a triangular cross section.

Neoniti files have been used for both root canal treatment and retreatment cases[16]. The Neoniti rotary system has a nonhomogeneous rectangular cross-section with rounded tips and multiple tapers in a single instrument [17]. Neoniti files are manufactured by electrical discharge machining technology which ensures high flexibility and consequently decrease the risk of fracture [18].

In this study, the root canals were obturated using the lateral compaction technique before retreatment. This technique was used in many retreatments' studies[3,19,20]. During the present study to ensure elimination of possible interference factors, the standard procedures were performed by a single operator [21]. Also, samples were kept at 100% humidity at 37°C for 7 days to simulate oral conditions before retreatment [22].

In this study, chloroform solvent was used during the retreatment because it was proved to be more efficient in dissolving gutta-percha than other solvents [23, 24]. However, some studies reported that chloroform is locally toxic to the periradicular tissues, hepatotoxic, nephrotoxic, and considered as a carcinogen [25, 26]. Gates Glidden were used for coronal part of the root as done in other study which facilitate solvent placement and penetration [26].

In this study, scanning electron microscope (SEM) was used at magnification 1000x because

SEM images is more accurate at detection of the smear layer and remaining root canal filling material in dentinal tubules [27]. The resolution of all other techniques cannot detect these minute features. However, Sample preparation in SEM necessitates coating the specimen with a very thin layer of metal (such as gold) to reflect the electrons, and the sample must be completely dry, which may affect the results [28].

In the present study, none of the retreatment systems used removed all root canal filling material from root canals that is reported in previous studies[1,29,30].

The amount of remaining root canal filling using D-Race system was significantly lower than the Neolix system. The higher root canal cleanliness after retreatment with D-Race in the present study is in agreement with Rödig et al.[31], and Schirrmeister et al.[32] where they reported that Race rotary system is an effective system for retreatment of root canal fillings. This finding may be accredited to the alternating cutting edges, the smooth instrument surface created by a special electrochemical treatment. Moreover, the superior sharpness of the instruments, which allow for efficient drilling through the filling material and optimum loading of the filling material on the file [32].

The better cleaning effect of D-RaCe rotary system could be also accredited to the higher rpm used when compared to the rpm recommended for Neolix rotary system. Removing root canal filling material in retreatment procedures requires higher rpms than for cleaning and shaping procedures [31]. The main advantage of using higher rpm during retreatment is that speed creates sufficient friction which softens the gutta-percha inside the root canals[30].

The results of this study revealed that Neolix rotary system showed the highest amount of remaining filling material was in apical third, this comes in agreement with previous studies[4,33,34] and may be attributed to the anatomical variation of apical third of the root canal and it is less accessible to cleaning [33] as the roots may appear straight from the outside but the root canal contains irregularities from the inside which do not appear from the external surface. This also may be referred to the narrow diameter of the apical part compared to the middle and coronal part which may hinder the flushing action of the irrigant during removal of the filling material [35].

The results of the present study were contradictory to the results of Khoshbin et al. [36], and Fatima et al. [18] where they stated that the Neolix system is efficient in removal of root canal filling material. These contradictory results may be due to the different system compared with the Neolix system as the cleaning efficiency of Neolix in the first study was compared to Reciproc, and Protaper systems while in the second study was compared to Wave one system.

After appropriate removal of root canal filling during retreatment, reobturation of root canal space with gutta-percha and sealer is important to attain hermetic seal and prevent any bacterial colonization of the root canal system[37]. For that reason, the adaptation of the root canal sealers to the gutta-percha and the root canal dentin walls is important. Consequently, the root canal sealers should achieve ideal filling to all empty spaces between gutta-percha and root canal walls to avert microleakage and also, should fill all irregularities of the root canal dentinal walls which the gutta percha cannot fill. This sealing is paramount to prevent both coronal and apical leakage [38].

Bioceramic sealers have good physical properties which allow good flow of the sealer into the root

canal irregularities. Furthermore, their biochemical properties lead to formation of hydroxyapatite layer on hydration that initiates the chemical bonding between dentin and the sealer. In different words, these bioceramic sealers have shown favorable biocompatibility and bioactivity properties [39].

The most widely used method for measuring the bond strength between root canal filling and root canal dentin wall is the pushout bond strength test because it is a relatively simple technique which allows comparing different sealers and obturation techniques[40], and is used for recording the interfacial bond strengths of root canal filling material [41,42] at different levels of the root canal. For that reason, the quality of root canal obturation was evaluated in the current study at the coronal, middle and apical levels. Universal testing machine was used according to Tuncer et al. [43]. However, this test is of no match to any clinical performance thus, it is not able to show any correlation between bond strength and clinical success.

In the current study, the pushout bond strength after reobturation with Totallfill Bioceramic Sealer for D-race rotary system treatment showed higher significant values compared to Neolix rotary system along three sections.

These findings could be attributed to the less amount of remaining root canal filling material of D-race than Neolix groups. Thus, the remaining root canal filling acts as a barrier between the root canal walls and the sealer which affect the adaptation of the sealer to the canal walls [44]. These results come in agreement with another study [45] which showed that the remaining root canal filling material affected the penetration of the sealer into the dentinal tubules after retreatment. Therefore, it affected the push out bond strength of the sealer.

This comes in agreement with Topcuoglu et al.[46] who showed that the pushout bond strength of different sealers was affected after retreatment. This also might be attributed to the negative effect of chloroform as solvent for 5 minutes.

Bioceramic sealer adhesion depends mainly on the infiltration of dentinal tubules [47], however, the fact that dentinal tubules density decreases towards the apical part which has less number and less open dentinal tubules with more sclerotic dentin so sealer cannot properly infiltrate the apical part compared to the coronal part. This is in accordance with Nagas et al.[48], and Al-Shaheen et al.[49].

Another finding regarding bond strength was that the mean of the pushout bond strength increases in an apical to coronal direction. This finding may be due to the patency of the coronal dentinal tubules than the apical dentinal tubules. This comes in agreement with Paque et al.[50], and Lottanti et al.[51]. Another reason for this finding is the presence of tubular sclerosis more in apical level other than any other level [51, 52].

In this study, the correlation between the remaining filling material and the pushout strength after reobturation was obvious. As the residual filling material increase, the pushout bond strength of TotallFill bioceramic sealer after reobturation decreases. This may be related to the blockage of the remaining filling material which hinders the ability of the sealer to flow inside dentinal tubules. Consequently, the sealer dentin interface decreases which decreases the results of pushout bond strength test. Within the limitation of the present study, the presence of remnants of filling material after retreatment decrease the pushout bond strength after reobturation with bioceramic sealer. Further studies are recommended to investigate different types of retreatment systems on the pushout bond strength of different bioceramic sealers.

CONCLUSION

We concluded that D-race system is more effective in removing root canal filling material compared to Neolix system and the adaptation of bioceramic sealer is affected by the amount of remaining root canal filling after retreatment.

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