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EVALUATION OF PUSH-OUT BOND STRENGTH OF TWO ESTHETIC POSTS TREATED WITH VARIOUS SURFACE TREATMENT

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ABSTRACT

Objective the purpose of this study was to evaluate the push-out bond strength of ready-made glass fiber post and custom-made e-max pressable post treated with various surface treatments: Sandblasting (SB), Sandblasting in conjunction with silica particles then silane coating (SC) and Etching using hydrofluoric acid then silane coating (E)

Materials and methods: Forty freshly extracted single rooted upper central incisor teeth were selected. All root canals were endodontic treatment according to standard procedure then divided into two main groups (20 samples each) according to the type of posts were used. The first group (G) was restored with ready-made glass fiber post (Glassix plus radiopaque) (n=20), The second group (P) was restored with custom made pressable ceramic (E-max press post) (n=20) (Ivoclar Vivadent).Each group was subdivided to four subgroups (5 samples each) according to the type of surface treatment done: subgroup C: no surface treatment (control), Subgroup SB: sandblasting with 50 μm Aluminum-oxide (AL_2O_3) particles, subgroup SC: sandblasting in conjunction with silica coating particles then silane coating and subgroup E: etching with 9.5% hydrofluoric acid then silane coupling agent. All samples were sectioned by IsoMet into 3sections (2mm each thickness) from coronal to apical then subjected to push-out test by universal test machine. Then all data were calculated, tabulated, and statistically analyzed.

Result: readymade glass fiber post show higher bond strength than custom made e-max press post with no significance different between them

Conclusion: Silica coating then silanization of ceramic e-max post is the best surface treatment that increase bond strength .Etching with hydrofluoric acid then silanization of glass fiber post is the best surface treatment that increase bond strength. Bond strength of glass fiber post was higher than bond strength of ceramic emax post

KEY WORDS: fiber post, IPS e.max press, surface treatment and pushout.

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INTRODUCTION

Esthetic post systems were introduced in the last decade and have gained popularity because of their inherent advantages with respect to biomechanical properties, and because they increase the transmission of light within the root and overlying gingival tissues. They eliminate the potential hazards of corrosion and allergic hypersensitivity associated with metal posts and have a low modulus of elasticity that has been reported to reduce root fracture[(1).].

The carbon fiber posts, firstly introduced in 1990, provided a viable alternative to cast metal posts for the restoration of root filled teeth. These posts are black in colour and do not lend themselves to aesthetic restorations with all-ceramic units. With the increasing demands for aesthetic restorations and in an effort to improve the fracture resistance of endodontically treated teeth restored with a post-and-core system, research has focused on tooth-colored post materials. This led to the introduction of the silica fiber posts, called glass fiber and quartz fiber, which are more tooth colored .Fiber posts consist of fibers (carbon, quartz, silica, zircon, or glass) in a resin matrix with a silane coupling agent binding the fibers and matrix together. The major advantage of fiber post is closer elastic modulus of fiber posts (20 GPa) to dentine, producing a stress field similar to that of natural dentine and high success rates without the occurrence of root fractures [(2, 3)] .

To enhance bond strength of glass fiber and ceramic post to root canal and core material, several surface treatments are used: sandblasting with aluminium oxide particles followed by the application of a silane coupling agent, hydrofluoric acid gel etching and silanization, application of silane coupling agent only were advocated [(4)] .

Modification of the ceramic surfaces after different surface treatment affects the shear bond strength to resin cement .In addition to existing ceramic surface treatment applications, laser irradiation of ceramic surfaces is also investigated. However, there is limited literature regarding the laser application on dental ceramics. During the laser treatment, the exaggerated temperature changes in the heating and cooling phase damage the material by creating internal tensions in the ceramic; therefore, appropriate laser parameters must be applied[(5)].

To prevent the superimposition of stresses during specimen cutting, the push-out test seems to be the most accurate and reliable technique for measurement of the bond strengths of posts to root dentin.

MATERIAL AND METHODS

Forty single rooted upper central incisors with completed root formation were collected from the oral surgery department faculty of dentistry Minia University with normal shape and approximately of same root length. Visual and radiographic examination were performed to assure absence of decay and normal root canal configuration.

Decoronization was performed at the CEJ with a high-speed disc under water cooling. Patency and tooth length of each canal were determined by passing sterile ISO K- files size #15 penetrating the apical foramen and pulling back till the file was flushing with the visible apical foramen. This length was measured and working length was calculated by subtracting 1mm from previously measured length. All teeth were mechanically prepared using protaper rotary file up to F3 files, and obturation was done with the protaper gutta-percha-point f3 30#6

Post space of each tooth was prepared at standardized length 10mm leaving 5mm of gutta percha in apical third to maintain apical seal. A pilot reamer (Nordin, H, Nordin, Swiss) was used to remove gutta percha with endodontic stopper by in word and out word movement after determine length at 10mm.then followed by drill N1 (white, Nordin, H, Nordin, Swiss) and N2 (yellow Nordin, H, Nordin, Swiss), ended with drill N3 (red, Nordin, H, Nordin, Swiss)

Samples were divided into 2 groups according type of post each group was composed of 20 samples:

- **Group G: Glass Fiber Post (Ready-made) : (20 sample)**

After reached drill N3 (red- ø1.8-ø0.9),Glassix plus radiopaque & light transmitting fiber post(Glassix radiopaque, H. Nordin, Swiss) post size 3 red that match that drill was used

- **Group P: E-Max Ceramic Post IPS E-max Press (Custom made) :(20 sample)**

After reaching drill N3 (red- ø1.8-ø0.9) to be at same size and diameter of the ready-made post irrigation with saline (Medline Industries,USA) was used to remove depris and the canal was dried using paper point (Meta Biomed Co.Ltd, Korea) canal was ready for intracanal impression that was taken by standard plastic post and using polyvinyl siloxane impression material then post was removed carefully and checked for any tearing then sent to the lab, pouring impression was done by stone (Gemma, premium dental gypsum, korea) and making cast and waxing up (poly wax, dipping wax) was done. They were put in the rubber ring carefully with the sprue former after spruing they invested and heated to high a temperature 960 C in the ivoclar furnace to remove the melted wax. The ceramic ingots (Ivoclar vivadent, scientific report volume I,swiss) were melted at high temperatures at 750 C and injected at 3 bar pressures into the vacant mold with pressable machine (Ivoclar vivadent, scientific report volume I, swiss)

Pressing the heated ceramic ingot and cast into the invested post mold. After the mold cools the stone investment was removed to produce e-max post

After post space preparation in all 40 samples we have 20 ready-made glass fiber posts and 20 custom made E-max posts .those posts received different surface treatment according to their subgroups:

Subgroup GC and PC (5 No. each): no surface treatment was done (control –untreated)

Subgroup GSB and PSB (5 No. each): sandblasting with 50 μm Al2O3 particles (Shera, Germany) was applied perpendicular to each surface of the post for 5 sec at 120 psi pressure at distance 2-3 mm . After sandblasting, the posts were sprayed for 30 sec with water spray to clean the surface of residual AL_2O_3 particles and then dried with oil- free compressed air.

Subgroups GSC and PSC (5 No. each): blasted with mixture of 50 µm Al2O3 particles and 30 µm silica particles (CoJet Sand, 3M-ESPE,USA) perpendicular at each surface of post for 20 sec from distance of 10 mm at 2.8 bar psi pressure. After that posts were painted using silane coupling agent (PPH CERKAMED Wojciech, Pawłowski) by disposable brush (Meta Biomed, Chungcheongubk, Korea) and allowed to air dry for 5 min. after that posts were rinsed of water for 20 sec and dried with oil free compressed air.

Subgroup GE and PE (5 No. each) : posts were etched with 9.5% hydrofluoric acid etching (PPH CERKAMED Wojciech ,Pawłowski) for 90 sec. after that rainsed with water to remove acid etch then the posts were painted with silane coupling agent by disposable brush (Meta Biomed, Chungcheongubk, Korea) and allowed to air dry for 5 min .

After surface treatment of glass fiber posts and ceramic E-max posts, all posts were cemented with G-CEM LinkAce (GC corporation, Tokyo, Jaban) self-adhesive resin cement according to manufacture instruction.

Pushout test

Each root was cross sectioned into three sections (coronal, middle, apical) to create 2mm- thick slices using IsoMet 4000 microsaw (Buehler,USA) mounting diamond disk 0.6mm thickness at speed 2500 rpm and feeding rate 10mm/min under water cooling.

The filling material was then loaded with a 0.9 mm diameter stainless steel plunger selected without stress the surrounding post space walls, the plunger was mounted on the upper part of a universal test machine (instron universal test machine model 3345 England data recorded using computer software Bluehill 3 version 3.3). The samples were aligned over a jig in an apical to coronal direction to avoid any constriction interferences. The tests were conducted at a cross head speed of 0.5mm/min using 500 N load cell until the post was extruded. The highest value recorded was taken as the push-out bond strength

The area under load was calculated by:

(Area= circumference of restoration × thickness)

The push-out value in Mpa was calculated from force (N) divided by area in 2 mm. Then all data were calculated, tabulated, and statistically analyzed.

RESULTS

Results of push out test for glass fiber post, and E-max post treated with various surface treatment were determined by calculations of the mean values and standard deviations. Man-Whitney and Kruskal Wallis test were performed for comparison between groups and classes.

1- Push-out Bond Strength of E-max and Glass Fiber Post Treated with Various Surface Treatment

1- There was significance difference between surface treatment groups and glass fiber glassix plus post as the mean value was 1.09 for SB , 1.14 for(SB+SIC+E+SC) and 1.75 for (E+SC) and for control group was 0.25

2- There is no significance difference between surface treatment groups and E-max post

3- For glass fiber post group E+SC recorded highest value of pushout bond strength 1.75

4- For emax post group SB+SIC+SC recorded highest value of push out bond strength 1.76

TABLE (1) Push out Bond strength of E-max and glass fiber post treated with various surface treatment

Type of post	**Surface treatment**			
	Control	**SB**	**SB+SIC+SC**	**E+SC**
E-Max post:				
Mean ± SD	0.29 ± 0.04	0.82 ± 0.92	1.76 ± 2.22	0.36 ± 0.25
Median (Range)	0.28 (0.23-0.34)	0.38 (0.03-2.83)	0.65 (0.03-6.32)	0.33 (0.07-0.97)
P-value		0.354	0.085	0.508
Glassix plus:				
Mean ± SD	0.25 ± 0.05	1.09 ± 0.76	1.14 ± 1.26	1.75 ± 1.83
Median (Range)	0.23 (0.20-0.32)	0.93 (0.32-2.78)	0.53 (0.08-3.67)	1.30 (0.04-5.99)
P-value		0.000*	0.038*	0.005*

Mann-Whitney test * Statistical significant difference (P < 0.05)

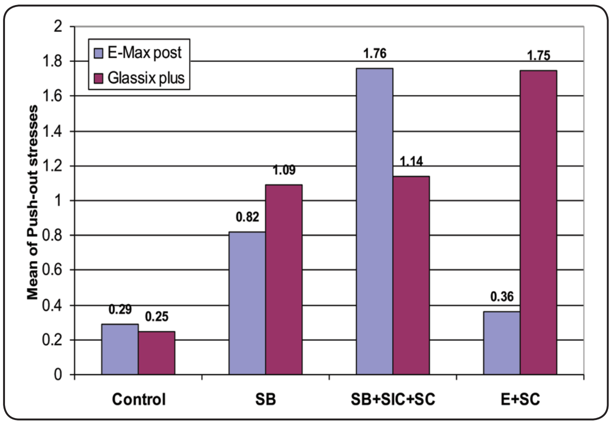

Fig. (1) Histogram showing push out bond strength of E-max and glass fiber post treated with various surface treatment

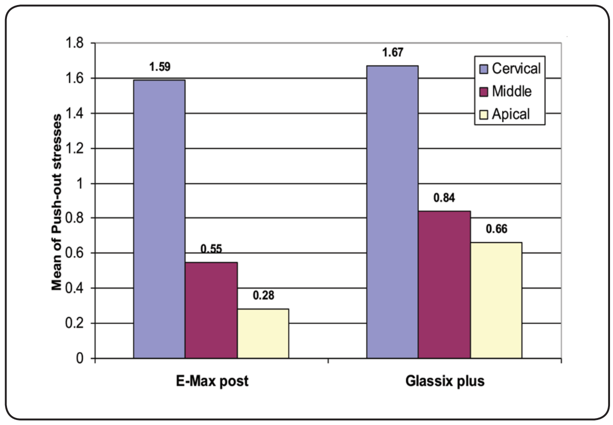

Fig. (2) Histogram Push out according to sections (cervical, middle and apical) and type of posts

2- Push out According to Sections (cervical, middle and apical) and Type of Posts:

1- No significane different was found between emax post and glassix plus fiber post at each sections

2- Emax recodrded highest value at cervical section which was 1.59 MPA and lowest at apical section 0.28Mpa

3- Glassix plus fiber post recorded highest value at cervical section 1.67Mpa and lowest at apical 0.66 MPA

TABLE (2) Push out according to sections (cervical, middle and apical) and type of posts:

	Type of post		P-value
	E-Max post	Glassix plus	
Cervical:			
Mean ± SD	1.59 ± 2.00	1.67 ± 1.80	0.525
Median (Range)	0.62 (0.07-6.32)	1.11 (0.04-5.99)	
Middle:			
Mean ± SD	0.55 ± 0.54	0.84 ± 0.81	0.419
Median (Range)	0.34 (0.03-2.04)	0.58 (0.21-2.92)	
Apical:			
Mean ± SD	0.28 ± 0.12	0.66 ± 0.62	0.133
Median (Range)	0.33 (0.03-0.46)	0.53 (0.08-1.97)	

Mann-Whitney test

3- Push-out Bond Strength According to Type of Post :

Man-Whitney test was used for evaluation of the mean and standard deviation of each group and compare between them. So results showed that the mean of push-out values was higher in **Glassix plus** than in **E-Max post** (1.06±1.25 vs. 0.81±1.30 respectively), with no statistical significant difference (P= 0.143).

TABLE (3) Push-out stresses according to type of post

	Type of post		P-value
	E-Max post	Glassix plus	
Mean ± SD	0.81 ± 1.30	1.06 ± 1.25	0.143
Median (Range)	0.33 (0.03-6.32)	0.57 (0.04-5.99)	

Mann-Whitney test

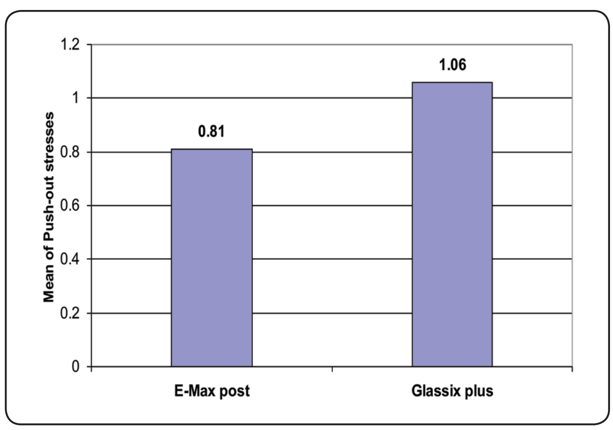

Fig. (3) Histogram shows push-out stresses according to type of post.

4- Push-Out Bond Strength According To Surface Treatment

Mann-Whitney test was used for evaluation of the mean and standard deviation of each group and compare between them. So results showed that:

1. The group SB+SIC+SC has the highest mean value which is 1.45 and control group and there is significant difference as p value 0.010
2. Then group E+SC has mean value 1.05 and there is significant difference as p value 0.007
3. Then group SB has mean value 0.95 and there is significant difference as p value 0.001

TABLE (4) Push-out stresses according to surface treatment

	Surface treatment			
	Control	**SB**	**SB+SIC+SC**	**E+SC**
Mean ± SD	0.27 ± 0.05	0.95 ± 0.83	1.45 ± 1.78	1.05 ± 1.45
Median (Range)	0.27 (0.20-0.34)	0.80 (0.03-2.83)	0.59 (0.03-6.32)	0.49 (0.04-5.99)
P-value		0.001*	0.010*	0.007*

Mann-Whitney test **** Statistical significant difference (P < 0.05)***

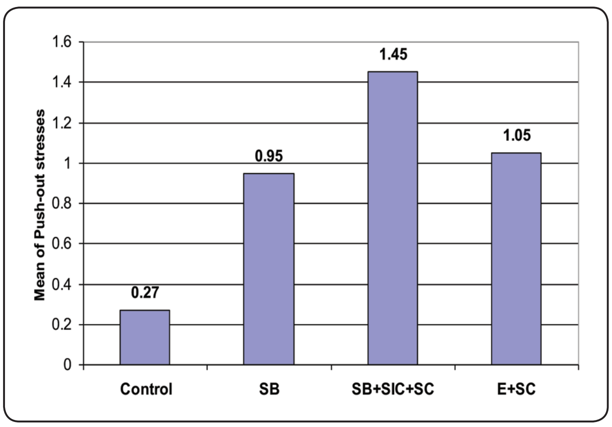

Fig. (4) Histogram showing Push-out stresses according to surface treatment

DISCUSSION

Endodontically treated teeth may be damaged by decay, excessive wear, or previous restorations, resulting in a lack of coronal tooth structure. The restoration of these teeth may require the placement of a post to ensure adequate retention of a core foundation. Recently, the use of esthetic (tooth colored) posts such as fiber and ceramic posts in the restoration of endodontically treated teeth has increased in popularity. Fiber posts are currently perceived as promising alternatives to cast metal posts, as their elastic moduli are similar to that of dentin, producing a favorable stress distribution. These posts have additional advantages, like biocompatibility, mechanical strength, resistance to corrosion, also, increase the light transmission within the root and overlying gingival tissues, thereby, eliminating or reducing the dark appearance often associated with non-vital teeth and metal posts and cores [(6)].

Rovatti et al 1994 [(7)] stated that when loss of retention occurs, it is always at the cement/post junction. In order to maximize the bonding of resin cement to glass fiber posts, several surface treatments of posts have been suggested. These surface treatment may fall within three categories 1) Treatments that result in roughening of the surface i.e. air abrasion with alumina particles and acid etching using Phosphoric acid and hydrofluoric acid 2) Treatments that indent to create chemical bonding between cement and post i.e. coating the posts with silanes and primers & 3) Treatments that have both a roughening and a chemical component either by a combination of two above mentioned treatments or by the unique Co-Jet system. The goal of surface treatment of post is not only to create micro roughness on the surface of the post to achieve high retentive bond strength but also to avoid any micro-leakage along the root canal or post and constantly avoid degradation of fiber posts [8].

The result of present study revealed that glass fiber posts recorded higher bond strength than ceramic post to root canal. This may be due to the fact of the good bond between the resin matrix of the fiber post and the resin cement and the lower bonding affinity of ceramic posts to adhesive resin cements. Also, due to the affinity in terms of bonding between the methacrylate resin matrix of the post and the methacrylate-based adhesives and resin cements. [9]

Regarding to the effect of different surface treatment to the surface of ceramic. The result revealed that silica coating with silanization (tribochemical silica coating) is the best surface treatment in ceramic surface. This was in agreement with **Hatice Özdemir & Lütfü İhsan Aladağ (2017)**[5] , **Mohsen C (2012)**[9] **and Ozcan M and vallittu P K. (2003)** [10]. This method of surface treatment may be due to combined micromechanical retention which produced by airborne-particle abrasion and chemical bonding resulting from silicoating and silanization of ceramic surface. This technique depends on the penetration depth of the silica-modified AL_2O_3 particles into the ceramic material. This type of treatment increases in the silica content of ceramic surfaces which may facilitate siloxane bond formation.

The results in current study were not in accordance with **spohr et al (2003)** [11] who reported that on ceramic surface application of HF acid and silane created the highest bond strength compared to sandblasting only, sandblasting and silanization and HF application only

The result in the present study also found that surface treatment of glass fiber post with HF acid then silane and silica coating (tribochemical silica coating) increase bond strength These results may be due to the efficacy of the sandblasting and HF treatment in modifying the fiber post surfaces These surface treatments may cause surface roughness of posts and an increase in the surface area available for bonding as well as the presence of retentive spaces.Surface roughening increases the total bonding area and also the wetability of posts with the composite resin material. The partial removal of the resin matrix from glass fiber post due to sandblasting in conjunction with silica particles and hydrofluoric acid treatment increased the number of exposed glass fibers and consequently the surface area available for reacting with the silane, allowing for higher bond strengths than untreated posts [9]

Sandblasting in the current study used alone without salinization in accordance with **radovic et al (2007)** [12] who revealed that sandblasting is the important factor for increasing microtensile strength, whereas use of an additional silanization procedure resulted in no further improvement.

Push-out bond strength for the cervical section in this study was higher than for the apical section, in agreement with the results of **Bouillaguet et al (2003)**[13]**, Mallmann et al (2005)**[14] **and Ohlamnn et al (2008)**[15]**.** The reasons could be the better accessibility of the cervical segments, better photo-activation compared with chemical activation alone, or tubule orientation and density in the cervical parts of the root canal.[9]

CONCLUSION

Within the limitation of this in vitro study, it following conclusion can be drawn that:

1. Bond strength of glass fiber post was higher than bond trength of ceramic emax post
2. Surface treatment of glass fiber post and ceramic post enhance bond strength than non-treated post

REFERENCE

1. Silness J, Gustavsen F, Hunsbeth J. Distribution of corrosion products in teeth restored with metal crowns retained by stainless steel posts. Acta- Odontol Scand 1979;37:317-21.
2. Lassila LV, Tanner J, Le Bell AM, Narva K, Vallittu PK. Flexural properties of fiber reinforced root canal posts. Dent Mat 2004;20:29–36.
3. Vano M, Goracci C, Monticelli F, Tognini F, Gabriele M, Tay FR, et al. The adhesion between fiber posts and composite resin cores: the evaluation of microtensile bond strength following various surface chemical treatments to posts. Int Endo J 2006;39:31–9.
4. Cekic-Nagas I, Sukuroglu E, Canay S. Does the surface treatment affect the bond strength of various fibre-post systems to resin-core materials? J Dent 2011;39:71-9.
5. Hatice Özdemir & Lütfü İhsan Aladağ :Effect of different surfacetreatments on bond strength of different resin cements to lithium disilicate glass ceramic an invitro study, Biotechnology & Biotechnological Equipment, 2017 31:4, 815-820, DOI
6. Purton D, Chandler N, Qualtrough A. Effect of thermocycling on the retention of glass-fiber root canal posts. Quintessence Int 2003;34:366e9
7. Rovatti L, Mason PN, Dallari A. New research on endodontic carbon fiber posts. Minerva Stamotol. 1994; 43:557e563.
8. Kamble V, Desai R, Arabbi K and Dhopre S, "Evaluation of the effect of different surface treatments on the surface morphology of two commercially available glass fiber posts: Ascanning electron microscopy study," Indian Journal of Dentistry, 2013.pp. 1-8.
9. Mohsen C, "evaluation of push-out bond strength of various surface treatments of two esthetic posts," E.D.J, 2012.vol. 57.
10. Ozcan M and Vallittu P K. Effect of surface conditioning methods on the bond strength of luting cement to ceramics. J Dent Mat. 2003; 19: 725–731.
11. Spohr AM, Sobrinho LC, Consani S, Sinhoreti MA, KnowlesJC. Influence of surface conditions and silane agent on the bond of resin to IPS Empress 2 ceramic. Intl J Prosthodont2003; 16:277–82
12. Radovic I, Monticelli F, Goracci C, Cury AH, Coniglio I, Vulicevic ZR, et al. The effect of sandblasting on adhesion of a dual-cured resin composite to methacrylic fiber posts: microtensile bond strength and SEM evaluation. J of Dent., 2007;35:496–502.
13. Bouillaguet S, Troesch S, Wataha JC, Krejci I, Meyer JM, Pashley DH. Microtensile bond strength between adhesive cements and root canal dentin. Dent Mater 2003; 19:199– 205.
14. Mallmann A, Jacques LB, Valandro LF, Mathias P, Muench A. Microtensile bond strength of light- and self-cured adhesive systems to intraradicular dentin using a translucent fiber post.Op Dent 2005;30:500–6.
15. Ohlmann B, Fickenscher F, Dreyhaupt J, Rammelsberg P, Gabbert O and Schmitter M, "The effect of two luting agents, pretreatment of the post,and pretreatment of the canal dentin on the retention of fiber-reinforced composite posts," journal of dentistry, 2008 vol. 36, p. 8 7 – 92.