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The effect of storage time on the retention of prefabricated metal and fiber posts using different luting agents (An in vitro study)

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ABSTRACT

Aims: The aims of this study were to assess, by tensile bond strength testing the retentive force of prefabricated metal and fiber posts using four dual-polymerizing resin luting agents after six months and one year storage times.

Materials and Methods: One hundred and twenty eight extracted human permanent mandibular first premolars were decoronated, instrumented, and obturated. Standardized post space was prepared in each root, then the roots were randomly divided into two groups (n = 64) according to the prefabricated metal and fiber posts. Each group was further subdivided into four subgroups (n=16) according to the luting cements, Gp.A (Vivaglass®Liner); Gp.B (PermaCem®-Dual); Gp.C (Variolink II); Gp.D (LuxaCore®Z-Dual). After post cementation and composite core build-up on each post, all samples were thermocycled, then each subgroup was further subdivided into two subgroups according to the storage times (n=8), 180 days and one year. The tensile force required to dislodge each post was recorded as retentive strength (N). The collect data were recorded and analyzed statistically. The failed specimens were examined with a 40 X stereomicroscope to assess the failure modes.

Results: In this, study (LuxaCore®Z-Dual) showed the highest mean retentive force than other cements while (Vivaglass®Liner) gives the lowest mean retentive mean. There was no statistically significant difference in mean retentive force between (PermaCem®-Dual) and (Variolink II). Metal post show more retentive force at two storage times than fiber post and the retentive force of both posts reduce with the time.

Conclusions: In this study, a significantly higher tensile load was achieved by metal posts luted with LuxaCore®Z-Dual composite core built-up cement at six months and one year storage times.

Key words: Adhesive resin cement, durability, long term storage time.

INTRODUCTION

Concerning the techniques available for radicular post cementation, several studies have shown that most failures occurred in endodontically treated teeth are due to the post dislodgment as fail in response to mechanical stress before the remaining dental structure did(1,2). Several studies have attempted to explain the divergent results found in the literature regarding the bond strength they provided; to achieve adequate retention, posts are bonded to the root canal with resin cement (2-4). The cement's ability to strengthen the post can influence the complete restoration prognosis(5,6). Concerning the post retention efficiency, there are controversial opinions about the various kinds of cements(1,2,4,7). The ability for post retention of different cements is connected to its mechanical attributions and the durability of the cement, the ability of the cement to bond to the surface with which it is inoculating(1,3,5). Therefore, retention of the post can be critical for the long term success of a restoration(8,9). Most studies that tested the retention of endodontic dowels were performed shortly after cementation without any type of simulation of oral condition or aging(4,8). Therefore, in vitro tests evaluating dowel retention should aim to simulate clinical condition using artificial aging to better predict clinical behavior and as the post retention refers to the ability to post to resist the vertical dislodging force so the purpose of this study was to assess, by tensile bond strength testing the retention force of prefabricated metal and fiber posts using four dual-polymerizing adhesive resin luting agents after six months and one year storage times.

MATERIAL AND METHODS

One hundred and twenty eight extracted human permanent mandibular first premolars with straight, similar root lengths and round canals were selected for this study. The teeth were examined radiographically to discard those with structural defect and roots with two canals. All teeth scaled, polished, and stored in distilled water at 37°C in an incubator until use. The teeth were decoronated at 15 mm from the root apex using a diamond disk under water coolant at 90° to the long axis of the root, then a size 10 K-file (Mani, Inc. Japan) was passed through each canal until being visible at the apical foremen and the working length was recorded as being 1 mm less than that length (14mm).

The roots of the teeth were notched on their buccal and lingual surfaces to prevent dislodgement from the embedding material and to facilitate handling and ensure the parallelism during testing. Each root was fixed from the cervical surface with paste to the arm of an adjusted dental surveyor, then a copper ring with (10×20) mm dimensions was filled with self cure acrylic resin, then the vertical arm of the surveyor was lowered until the root was flush with freshly acrylic resin to 1mm below the cervical surface of the root and allowed to remain undistributed until chemical curing of the resin was completed. All the canals were instrumented with ProTaper (NiTi) rotary instrument to size F3 (Endo-Mate DT, JAPAN). Sodium hypochlorite (2.5% NaOCl, 2 ml) was used for irrigation between each file size and as a final irrigation, then the canals were dried with ProTaper paper points (Dentsply, Maillefer's), and obturated using size F3 single cone gutta-percha (Dentsply, Maillefer's) and (AH plus) root canal sealer (Dentsply, Maillefer's). Excess gutta-percha then removed with a heated instrument and cold vertical compaction performed with endodontic plugger. The canal orifices, then sealed with glass-ionomer cement (Voco, Germany), and the roots were stored in distilled water in 100% humidity at 37˚C for 72h..

Consistent post space would be prepared by removing 10 millimeters segment of gutta-percha from each root canal obturation using Peeso drills (Dentsply, Maillefer's) size 1-3 coupled with slow speed hand piece (W&H, Austria) leaving 4mm of gutta-percha, then the post spaces were prepared with the special preparation drills of each system. Radiographs were taken to check the presence of any residual gutta-percha and sealer in the root canal walls along the prepared post space. Each post-space was irrigated with 5 ml of 17%EDTA for 15 Sec. following by 5 ml of distilled water, then thoroughly dried with paper points. After that the roots were randomly divided into two groups (n=64) according to the type of prefabricated post to be used in: Group I. Post space was received a prefabricated serrated tapered titanium post (1.5 mm Euro post, Anthogyr, France). Group II. Post space was received a prefabricated smooth tapered fiber- reinforced composite post (1.4 mm Snowpost, France). Then each group was further subdivided into four subgroups (n=16) according to the different resin-based luting materials used.

Group A: Post cementation with Vivaglass®Liner (Ivoclar, Vivadent/ Liechtenstein). The standard powder/liquid ratio of 1.4 g/1.0 g can be achieved with a level Vivaglass measuring spoon of powder and one drop of liquid. Dispense the required amount of powder and liquid onto the mixing pad. Divide the powder into two equal parts; mix the first half with the liquid for 5-10s., add the second half of the powder and mix for another 10-15s. Total mixing time should not exceed 20s. apply the cement into the post space with a lentulo spiral file.

Group B: Post cementation with PermaCem®-Dual (DMG, Hamgurg, Germany). Acid etching of post space with (37% phosphoric acid) for 15s., rinse with water spray for 20s., gently dry with air and paper points. Applied two coats of Excite bonding (Ivoclar, Vivadent) into post space for 10s., with a brush of compatible size, removed the excess adhesive with paper points, gently air dry, light cured for 20s., apply the automixed paste with the aid of root canal elongated tip.

Group C: Post cementation with Variolink II (Vivadent, Amherst, NY). Applied the acid etching and Excite bonding as describe for (group B). Dispense the required amount of past A&B onto the mixing pad; apply the mixed cement into the post space with lentulo spiral file.

Group D: Post cementation with LuxaCore®Z-Dual (DMG, Germany). Applied the acid etching and Excite bonding as describe for (group B). Apply the automixed paste with the aid of root canal elongated tip. The compositions of resin luting agents were described in (Table 1). To ensure that the posts were seated at the predetermined length, all posts were carefully marked at 10 mm from the apical end, then all posts were washed with alcohol and dried, then coated with Excite bonding (groups B, C, D) for 10s., and dried with an air syringe, and light cured for 20s., prior to coating with freshly mixed cements. The seating procedures were performed by a single clinician. The metal post was fitted into the canal space by screwing action, remove excess cement with spatula, left it in position for 10 min then light cure for 60s., light curing probe was placed at a right angle to the coronal portion of the root using light curing unit (Astralis, Vivadent, Germany). In the fiber post: inserted the post in position, remove excess cement with spatula and held it in position with finger pressure for 10 min until the cement was set, then light cure for 60s, as described for metal post. Then all fiber posts were cut at a distance of 5mm from the coronal surface of the roots, seating of the post was verified radiographically. Composite core build-up was done on each post by using a plastic tubing (5×10) mm dimension was centered around the protruding coronal aspect of each post to act as a matrix at which composite resin (Tetric, Viva dent) was inserted, after polymerization the tube was removed, this is done to avoid the risk of coronal leakage and to prevent the vice grip of the tensile testing apparatus compromising the physical properties of the post during testing. All specimens were thermocycled for 1000 times at temperature ranging from 5°c ± 2°c to 55°c ± 2°c each cycle lasted 45 second with a dwell time of 15 seconds in each bath, and 15 second intervals between baths. To evaluate the bond durability of the luting agents, each subgroup was further subdivided into two subgroups according to the storage times (n=8), The specimens in the first subgroup were tested after storage in distilled water in an incubator at 37 ◦C for 180 days. The specimens of the second subgroup were stored in the same way, but for one year. The distilled water was changed once after 2 weeks for both subgroups. Figure (1) shows the diagram illustrated the sample grouping. Each resin block and the core were attached firmly to a custom device apparatus which in turn attached respectively to the lower and upper jaws of the testing machine (Figure 2: A) to be held secure in a vertical position and minimize the incidence of non-axial forces, in such a way that traction forces could be applied only parallel to the roots' long axis. Tensile force was applied at a crosshead speed of 1.0 mm/ min until post dislodgement (Figure 2: B). The maximum force (N) required to dislodge the post was recorded. Statistical analyses were performed using a Three-way analysis of variance (ANOVA) and Duncan's multiple range test to determine if there were statistically significant differences among groups at (p=0.05). All failed specimens were examined by stereomicroscope (Motic, TAIWAN) at X 40 magnification to assess the failure modes which was classified[2] as: 1. Adhesive failure at the cement-post interface; 2. Adhesive failure at the dentin-cement interface; 3. Cohesive failure; 4. Combined failure.

RESULTS

Mean failure loads (N) with standard deviation and Duncan's multiple range test and mode of failure for all tested groups are shown in (Table 2) and illustrated graphically in Figure (3). The highest mean retentive force was recorded for roots filled with metal post luted with LuxaCore®Z-Dual composite core built-up cement at 180 day storage time while the lowest mean was recorded for roots filled with fiber post luted with Vivaglass®Liner resin cement at one year storage time. Three-way ANOVA (Table 3) showed that there were statistically significant differences ($p<0.05$) among the subgroups for the factors of post types, resin cements, storage times and their interactions.

Table (4) Show that metal post had significantly higher retentive strength in comparison to fiber post regarding the cement types and storage times. Irrespective to the post types and storage times, Duncan's multiple rang test (Table 5) revealed that LuxaCore®Z-Dual composite core built-up cement showed the highest retentive force value compared with the other resin cements, then followed by PermaCem®-Dual which has no statistically significant difference from Variolink II retentive force while Vivaglass®Liner revealed the lowest retentive force. Table (6) represent that the retentive force will be decreased with increased of storage time for two types of posts for all cement types. The failure modes recorded (Table 2) were mostly cohesive within cement for Vivaglass®Liner subgroups, combined for PermaCem®-Dual and Variolink II subgroups and adhesive at post/cement interface for LuxaCore®Z-Dual subgroups.

DISCUSSION

With regard to factors that influence restoration survival, post retention is believed to be a major factor. Under the condition of the present study, the results show that the Euro post recorded higher retentive values than Snowpost, this higher values can be explained by the good mechanical retention provided by surface serrations on the outer surface of the titanium posts compared with smooth surface of the fiber posts[1,3,4,8].

The composition of dual-cure resin cements unquestionably contributed to cementing quality. Duncan's multiple rang test for the effect of cement types revealed that LuxaCore®Z-Dual showed the highest retentive force. Presently, dual-cure resin composite has been introduced for use as both luting and core build-up materials. LuxaCore®Z-Dual composed of zirconium filler with DMG's patented nanotechnology means it significantly improves strength, flow ability and physical properties and presents 72% (wt) of filler particles in its composition[10-12]. Vivaglass®Liner revealed the lowest retentive force. It is believed that the presence of hydroxyethyl methacrylate (HEMA), a significant monomer component of resin-modified glass-ionomer cements, was the main reason for the hydroscopic expansion which in turn lead to adverse forces acting on the tooth structure and the restoration[1,13], also the mixing method, for example mixing on a paper pad versus auto-mixing of paste-paste resin cements, will generate different amounts of air voids within the resin. These voids will be incorporated into the material and lead to numerous oxygen-inhibition zones of unpolymerized materials, which then affect the solubility of the set cement, the latter then leads to debonding and/or fracture of the restoration[3,9,13-14]. Although PermaCem®-Dual show higher mean retentive force than Variolink II but there are no statistically significant differences among them this is may be due to the mixing method which is auto-mixing for PermaCem®-Dual versus hand on a paper pad for Variolink II. PermaCem®-Dual according to the manufacture information a zero-expansion DMG patented compomer technology in which the advantages of glass-ionomers and composites are combined in one material[7]. Variolink II contains the monomer diluent (TEGDMA) which has high flexibly and low contraction, also provides a high degree of conversion and has hydrophobic properties that prevent substantial water uptake after curing[7,11].

The retentive force in this study show to be reduced with increased of storage time for both types of posts with all cement types. Since all cement used in the present study contain hydrophilic monomers, so water sorption over time can also be regarded as a contributor to the observed reduction in retentive strengths. Solubility and sorption may cause stress induced degradation of the luting cement. As a consequence, the presence of water in the polymer network may have impaired further resin cement polymerization, compromising its mechanical properties(4,5,7,9).

Water permeates through resin-based materials by various mechanisms, such as direct diffusion into the resin matrix, penetration into voids incorporated into the resin and damage already present in the material generated by hydrolysis and cause cohesive failure, or movement of water along the filler-matrix interface and cause adhesive type of failure(7,9,13). The post analysis after its removal from the canal space showed a predominance cohesive failure mode for Vivaglass®Liner subgroups, and this may be associated with its low intrinsic resistance and the presence of bubbles within the cement(2,13). LuxaCore®Z-Dual subgroups showed mainly adhesive failure at post/cement interface, a possible explanation for such result would be the shrinkage stresses that developed from the rapid curing. According to the manufacturer information, the setting time of LuxaCore®Z-Dual ranges from 3-5 min in self-curing mode, and this may indicate that the weak link for LuxaCore®Z-Dual was the bond between the resin cement and the post, but not between the resin cement and the root canal dentin((10-12). PermaCem®-Dual and Variolink II subgroups represented mainly a combined failure.

CONCLUSION

The longevity of the bond between root canal dentin, luting agent and post surface has to be taken into consideration. Based on the findings of the present study, dual cured composite resin core build-up materials might be more reliable for post cementation than the evaluated dual-cured resin cement since it yielded the highest bonding lifetime to titanium and post by means of a pull-out bond strength test.

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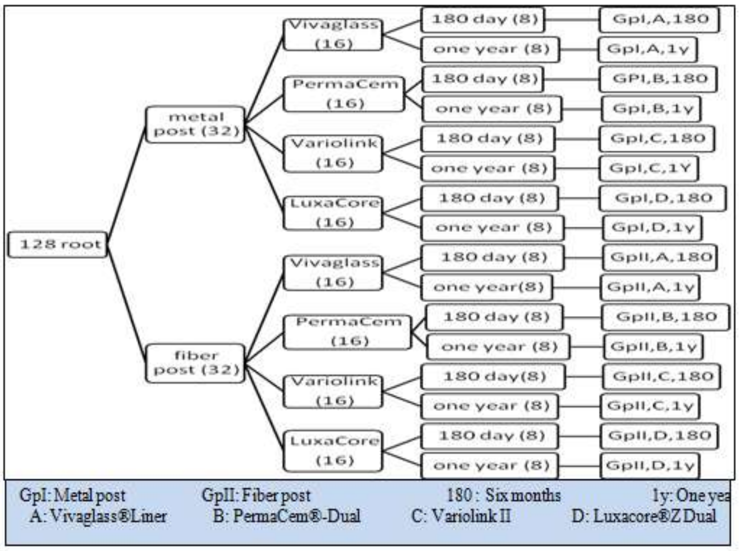

Figure (1): Diagrammatic illustration of the experimental design of groups for the study

Table (1): Composition of the luting materials used in the present study

Resin based cement and manufacturer	Bonding system	Composition
Vivaglass®Liner (Ivoclar, Vivadent) Dual-curing self adhesive glass – ionomer resin cement	No adhesive	**Powder:** Aluminosilicate glass 99.8 wt.%, Catalyst and pigments 0.2 wt.% **Liquid:** Polyacrylic acid 27.5 wt. % , HEMA 38 wt. %, Dimethacrylate 12 wt.%, Catalyst 0.1 wt. %, Water 22.4 wt. %
PermaCem®-Dual (DMG, Germany) Unicersal dual-cured compomer Automix resin cement	Excit (2-step total etch)	Ionomer glass in a Bis-GMA based matrix of dental resins, barium glass, silica (70 wt.%), activator, catalyst, additives.
Variolink II (Ivoclar, Vivadent) Dual-cured resin cement	Excit (2-step total etch)	**Past A**: Bis-GMA, urethane dimethacrylate, triethyleneglycol dimethacrylate (TEGDMA), inorganic filler (73.4 wt. %) , ytterbium trifluoride, initiator, stabilizer. **Past B**: Bis-GMA, urethane dimethacrylate, TEGDMA, inorganic filler (71 wt.%), ytterbium trifluoride, benzoyl peroxide, stabilizer.
LuxaCore®Z-Dual (DMG, Germany) Dual-cured Zirconia-reinforced composite resin	Excit (2-step total etch)	Barium glass, pyrogenic silicic acid, nano fillers (72 wt.%), zirconium oxide in a Bis-GMA-based dental resin matrix

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Table (2): Mean and standard deviation of post retentive force (N) of all subgroups with Duncan's multiple rang test and mode of failure

Groups	N	Mean & Duncan's groups	Std. Deviation	Minimum	Maximum	Mode of failure			
						1	2	3	4
GpI,A,180	8	190.13^{de}	2.36	187	194			5	3
GpI,A,1Y	8	152.75^{e}	8.66	142	165			6	2
GpI,B,180	8	270.13^{bc}	11.99	250	283			1	7
GpI,B,1y	8	179.88^{def}	7.18	169	188				8
GpI,C,180	8	252.63^{c}	46.44	144	286	1		1	6
GpI,C,1y	8	180.25^{def}	3.96	176	187	2			6
GpI,D,180	8	360.13^{a}	15.98	340	379	7			1
GpI,D,1y	8	283.63^{bc}	8.81	266	292	6			2
GpII,A,180	8	169.13^{ef}	7.22	160	180		2	5	1
GpII,A,1y	8	112.75^{g}	9.85	101	128	1		7	
GpII,B,180	8	196.12^{de}	3.87	190	201	2		1	5
GpII,B,1y	8	148.50^{eg}	4.21	141	154	2	2		4
GpII,C,180	8	194.13^{de}	2.90	190	198	3		1	4
GpII,C,1y	8	144.38^{eg}	2.88	140	150	2			6
GpII,D,180	8	290.25^{b}	11.90	268	301	5			3
GpII,D,1y	8	211.87^{d}	11.21	200	230	6			2

GpI: Metal post GpII: Fiber post 180 : Six months 1y: One year
A: Vivaglass®Liner B: PermaCem®-Dual C: Variolink II D: Luxacore®Z Dual
1: Adhesive failure at the cement-post interface 2: adhesive failure at dentin-cement interface 3: cohesive failure 4: combined failure
Different letters indicated significant differences among groups at (p=0.05)

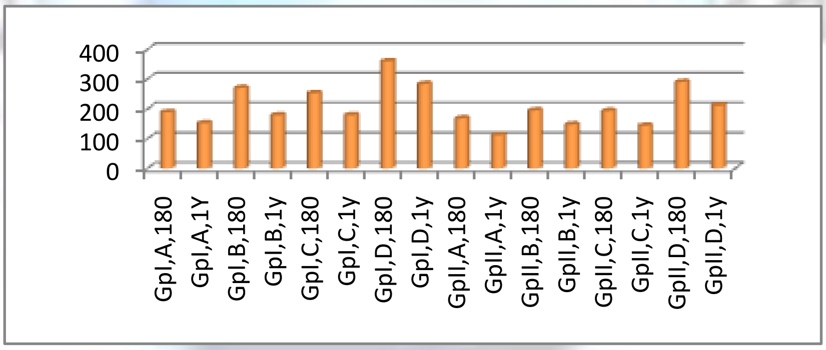

Figure (3): Bar chart graph representing the mean of tensile (N) force of testing groups

Table (3): Three-way analysis of variance for the factors of post types, resin cements, storage times and their interactions

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Posts types	80952.82	1	80952.82	398.947	0.000*
Cement types	293047.523	3	97682.508	481.394	0.000*
Storage times	129349.695	1	129349.695	637.454	0.000*
Posts × Cements	6625.523	3	2208.507667	10.884	0.000*
Posts × Storages	984.57	1	984.57	4.852	0.030*
Cements × Storages	4049.023	3	1349.674	6.651	0.000*
Posts × Cements × Storages	4402.023	3	1467.341	7.231	0.000*
Error	22726.625	112	202.916		
Corrected Total	542137.802	127			

DF: Degree of freedom F: Calculated F. value *: Highly significant

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Table (4): Mean retentive force (N) with standard deviation of tested samples for the post types with Duncan's multiple rang test.

Post types	N	Mean	Std. Deviation	Duncan's groups
Metal	64	233.688	68.36	A
Fiber	64	183.391	51.45	B

Different letters indicated significant differences at (p=0.05

Table (5): Mean retentive force with standard deviation of tested samples for the cement types with Duncan's multiple rang test.

Cement types	N	Mean	Std. Deviation	Duncan's groups
Vivaglass®Liner	32	156.19	29.70	C
PermaCem®-Dual	32	198.66	45.95	B
Variolink II	32	192.84	45.43	B
Luxacore®Z Dual	32	286.47	54.56	A

Different letters indicated significant differences at (p=0.05)

Table (6): Mean retentive force with standard deviation of tested samples at two storage times with Duncan's multiple rang test.

Storage time	N	Mean	Std. Deviation	Duncan's groups
180 days	64	240.33	63.74	A
One year	64	176.750	49.90	B

Different letters indicated significant differences at (p=0.05)

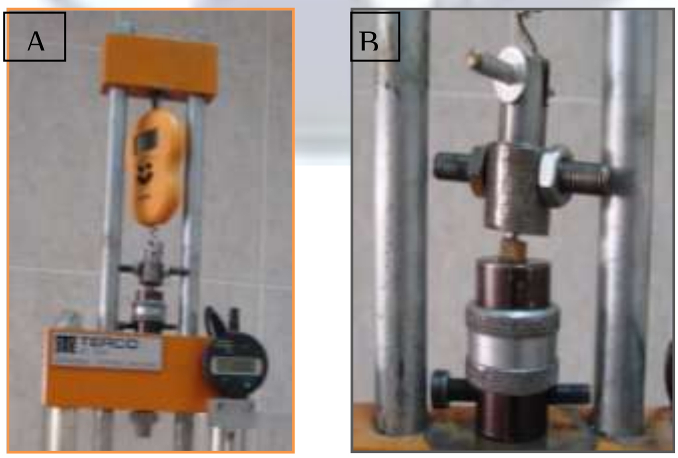

Figure (2): (A) Tensile loading performed using a computer controlled universal testing machine (TERCO, MT, Sweden). (B) Tensile force was applied