Research Article

AHB Advances in Human Biology

Adv Hum Biol 2014; 4(2):9-13.

Comparative Evaluation of the Tensile Bond Strength of Custom and Pre-Fabricated Posts – An in Vitro Study

Heena Fuletra[1*] Kamal Bagda[2] Suman Makam[3] Kruti Patel[4] Niket Kachhi[5]

[1]Post Graduate Student, Department of Conservative Dentistry, College of Dental Sciences and Research Centre, Ahmedabad, Gujarat, India.
[2]Professor and Head, Department of Conservative Dentistry, College of Dental Sciences and Research Centre, Ahmedabad, Gujarat, India.
[3]Professor, Department of Conservative Dentistry, College of Dental Sciences and Research Centre, Ahmedabad, Gujarat, India.
[4]Senior Lecturer, Department of Conservative Dentistry, College of Dental Sciences and Research Centre, Ahmedabad, Gujarat, India.
[5]Post Graduate Student, Department of Conservative Dentistry, College of Dental Sciences and Research Centre, Ahmedabad, Gujarat, India.

ABSTRACT

Aim: To evaluate the effect of cyclic loading on the tensile bond strength and retention of custom-fabricated cast posts, prefabricated metal posts and glass fiber posts.

Materials and Method: Thirty extracted human maxillary central incisors were decoronated at the cementoenamel junction (CEJ) and randomly divided into three groups (*n*=10). Specimens were instrumented and obturated. Twenty four hours after obturation, post space was prepared upto no. 5 Peeso Reamer. Groups A, B and C were restored using custom cast post and core, Para Post (Whale dent) and Reforpost (Angelus) respectively thereafter. Five specimens from each group were subjected to cyclic loading. Tensile bond strength (TBS) of teeth before and after cyclic loading was evaluated.

Results: For both, with and without loading, Groups A and B were not significantly different from each other but Group C was significantly different from Groups A and B. The results indicated that cyclic loading reduces retention potential of all three types of post, but it was minimum in group C.

Conclusions: Cyclic loading reduced the retention of all posts but was comparatively lesser for the glass fiber post. This system provides sufficient retention required for clinical success.

Keywords: Dental prosthesis retention, tensile strength, Post and core technique.

INTRODUCTION

For the successful rehabilitation of the endodontically treated tooth, it is imperative to understand the disparity and complexity of the relationship of these interfaces with various restorative materials[1]. An endodontically treated tooth that has lost significant tooth structure has less mineralized tissue and thus, in comparison with sound teeth, is weak[2] and may require a post and core for restorative rehabilitation. The high success rates of modern day endodontics have resulted in an increased demand for clinically convenient post core systems to help restore lost tooth structure. Today, the main reason for using posts is recognized to be a connection of the replacement for the missing coronal portion of the tooth to the remaining root structure, thereby providing retention for the crown[3]. Thus a post is placed to provide a substructure that increases the retention of the core and crown[4] where the degree of tooth conservation and ferrule preparation affect the resistance of the restoration[5].

Received: Feb. 19, 2014: **Accepted**: Apr. 26, 2014
***Correspondence**: **Dr. Heena Fuletra**
Department of Conservative Dentistry, College of Dental Sciences and Research Centre, Ahmedabad, Gujarat, India.
E-mail: heena.fuletra@gmail.com

www.aihbonline.com
pISSN 2321-8568
eISSN 2348-4691

Several post core systems have been described in the literature. Previously, posts were cast in a precious alloy, or prefabricated posts made of stainless steel, titanium and other precious alloys were used. The construction of post core castings is relatively more time consuming and demands extra clinic and laboratory time[6]. Prefabricated posts allow fast, cheap and easy techniques[7], but they do not take into account the individual shape of the root canal and their adaptation is not always ideal[8].

The post core systems include components of different rigidity. Because the more rigid component is able to resist forces without distortion, stress is expected to be transferred to the less rigid substrate. The difference between the elastic modulus of dentin and post material may, therefore, be a source of stress for the root structures. Recently, the preference of dentists has changed from very rigid materials to materials that closely resemble dentin to create a mechanically homogenous unit. In comparison to metal posts, the use of fiber reinforced posts are becoming increasingly common as it offers improved esthetics, good fatigue strength and potential to reinforce a compromised root.[9] Its modulus of elasticity is close to that of dentin and hence the distribution of stresses is uniform[10]. Moreover, the fiber post would yield prior to root fracture[11] which makes it possible to salvage the tooth.

Clinically, posts are subjected to repeated tension, compression and torquing forces[12]. Ideally, these forces should be uniformly distributed to the remaining tooth structure and supporting periodontal tissues[13]. This and post retention depends on the shape, length, composition, modulus of elasticity and bonding of a post to the root dentin all along the root surface[14].

The most common cause of post failure is loss of retention due to decementation[15]. Cyclic stresses of mastication can affect the bond of post either at the cement–post or cement–dentin interface[16]. The effect of occlusal stresses on bonding of a post into the canal can be evaluated *ex vivo* by change in retention potential of posts before and after cyclic loading[17]. Studies in the literature have focused on the retention of metal, ceramic and prefabricated FRC posts luted with different cements[18-20].

MATERIALS AND METHOD

Thirty extracted human maxillary central incisors with similar root length (approximately 13 mm) and without fracture or cracks were taken. Specimens were decoronated 1 mm above the cemento-enamel junction. Serial instrumentation of the root canal was performed. In this technique, Gates Glidden drills were used to enlarge the coronal portion of the canal. To standardize canal preparation, apex was enlarged to an ISO size of 40 and stepping back with progressively larger instruments to an ISO size of 70. Twenty-four hours post obturation, a post space of 9 mm depth and a diameter of 1.5 mm was prepared, using No. 5 Peeso reamer. Specimens were randomly distributed into three experimental groups (*n*=10).

For Group A, wax-up of the post and core was fabricated on the specimen. Each waxed specimen was then invested with an induction casting machine. After the corrected fit had been ascertained, the surfaces of the cast post cores (NiCr) were surface treated by air abrasion using 50 µm aluminum oxide particles. Post space was etched with 35% phosphoric acid for 1 min. Glass Ionomer Type I cement (GC Gold label lining and luting cement, GC Corporation, Tokyo, Japan) was placed into the canal using lentulo-spiral and simultaneously coated on the post and inner surface of the core and immediately inserted into the canal.

For Group B and Group C, prefabricated metal (ParaPost; Whaledent, International, NY, USA) and glass fiber post (Reforpost; Angelus, Londrina, Brazil) having a diameter of 1.5 mm were used, respectively. The length of prefabricated post was adjusted to 14 mm by a cutting apical end of the post. The metal post was surface treated by air abrasion using 50 µm aluminum oxide particles. No surface treatment was done for glass fiber posts. The post space was etched with 35% phosphoric acid for 1 min. Prime and Bond NT Dual Cure, DENTSPLY, was applied to the etched canal space/post and light cured for 10seconds. Calibra; DENTSPLY/Caulk, Milford, was placed into a prepared canal using a lentulo-spiral and simultaneously coated on the post. This was immediately inserted into the canal to a depth of 9 mm, leaving 5 mm of post for core foundation and light cured for 20 seconds. Light cure composite resin (Esthet X, DENTSPLY International Inc., Milford, DE) cores were made over a portion of the post (5 mm) projecting out of the canal and tried to get approximately same dimensions of the core for all the specimens.

Five specimens from each group, were subjected to cyclic loading on the core at an angle of 45° to a long axis of tooth/post, using an indigenously built cyclic loading machine. This was designed to provide a force of 60–70 N at a frequency of 4–6 Hz. Loading of each specimen was done for 7 hours to complete 1,50,000 cycles, simulating 6 months of clinical usage. Specimens were subjected to pull‑out the tensile bond test on an Instron universal testing machine. A crosshead speed of 1.0 mm per min along the long axis of the post was set until post dislodged. The dislodged posts were examined visually to ascertain failure site and interface. Data were recorded and subjected to statistical evaluation using Kruskal Wallis with post hoc test and SPSS (Statistical Package for Social Science) software version 17.

Table 1: Comparison of tensile bond strength values among the three groups.

TBS (N), mean ± SD	Group A	Group B	Group C	p-value
Pre-loading	435.30 ± 37.43	467.60 ± 45.87	332.77 ± 32.54	0.02*
Post-loading	289.80 ± 19.04	313.90 ± 24.81	247.01 ± 18.35	0.04*
Difference in mean TBS	145.50	153.70	85.76	
p-value	0.03*	0.04*	0.04*	
p<0.05 ? Significant (*), TBS: Tensile bond strength				

RESULTS

On applying the Kruskal–Wallis with post-hoc test, the overall significant difference between three groups with no cyclic loading and after cyclic loading were statistically significant (Table 1). It was found that for both, with and without loading, Groups A and B were not significantly different from each other but Group C was significantly different from Groups A and B. The results indicated that cyclic loading reduces retention potential of all three types of post, but it was minimum in group C.

DISCUSSION

The results of this study demonstrated significant lowering of tensile bond strength (TBS) pre and post loading ($p<0.05$). This suggests that loading forces cause weakening of either the post–cement, cement–dentin interface or both, resulting in decreased retention of the post. Bolhuis et al[17] in a SEM study, found crack formation in the adhesive cement layer and a loss of adaptation of cement‑to‑metal and fiber posts after fatigue loading, indicating that posts had to carry a significant part of masticatory load. In this study, cyclic loading resulted in no visible movement or failure of cores of any of the samples as seen in the study by Singh A et al[21], Dietschi et al[22] and Isidor et al[23] After tensile testing, specimens were also analyzed visually for mode of failure.

In Group A and Group B, all failures were mainly at the post–cement interface, both before and after loading, that suggests either weak or no chemical bonding between the metal post and cement. In Group C non-loaded specimens failed at dentin–cement and loaded specimens failed at the post–cement interface, suggesting a stronger bond between the post cement interface before loading. In the case of non-loaded specimens, the post–cement interface was not disrupted. Cement embedded along serrations of the post could have resulted in an increased mechanical retention and thus mode of failure was along the cement dentin interface[18,21]. For loaded specimens, force transmission from the post to dentin along the post–cement interface was not smooth and homogenous; instead it was interrupted at the post–cement interface, causing its weakening, resulting in failure at this interface. Since there was chemical bonding between GIC luting cement and root canal, Group A showed almost similar tensile bond strength as that of Group B specimens which had mechanical retentive features such as serrations on metal posts. Chemical bonding, even if present, is not sufficient to withstand loading[19]. This finding, however, contradicts concept of true mono‑block between fiber post, resin cement and dentin. Calibra (methacrylate based) luting cement and prefabricated fiber-reinforced composite posts 'Reforpost' (an epoxy resin based) were used in this study[20]. Adhesion of resinous material to an already polymerized substrate by free radical polymerization is minor, as no chemical reaction occurs between methacrylate-based luting cements and well-polymerized epoxy polymer[24]. Lower values obtained for customized posts were probably due to post space preparation which is usually not recommended, except for removal of gutta-percha using heat. However in this study, for standardization, parallel post space was prepared, which probably deprived additional mechanical retention provided by small undercuts present in the canal.

The percentage loss of retention for custom made cast post and core and prefabricated metal was in the range of 33-35%, in comparison to 26% for glass fiber posts. Rigid materials have tendency to transfer functional stresses to comparatively less rigid material, causing it to fail first[25]. Therefore, it can be conjectured that since custom made cast post and prefabricated metal posts have a higher modulus of elasticity, they transferred higher load stresses to the post–cement interface, causing its weakening. Glass fiber posts with comparatively similar modulus of elasticity as that of dentin, either absorbed or distributed/transferred load stresses along the dentinal wall so well that the post–dentin interface was least stressed and the resultant loss of retention was minimal.

When placing a post, the best approach that provides maximum fracture resistance for the tooth and retention of the core must be chosen. It was concluded from this study that though retention of customized fiber post was less than prefabricated posts, it provided sufficient retention required for clinical success, i.e. minimum of about 200 N under the masticatory load.

CONCLUSION

The retention potential of all the post system was reduced by cyclic loading. The effect of cyclic loading on loss of retention was lesser for glass fiber posts than custom cast posts and prefabricated metal posts.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Freeman G. The carbon fibre post: metal free, post-endodontic rehabilitation. Oral Health 1996;86(2):23-30.
2. Sedgley CM, Messer HH. Are endodontically treated teeth more brittle? J Endod 1992;18(7):332–5.
3. Galen WW, Meuller KI. Restoration of endodontically treated tooth. In: Cohen S, Burns RS. eds. Pathways of the pulp. 7th ed. St. Louis: CV Mosby, 1998:691–717.
4. Cohen BI, Pagnillo MK, Newman I, Musikant BL, Deutsch AS. Retention of a core material supported by three post head designs. J Prosthet Dent 2000;83(6):624–8.
5. Naumann M, Preuss A, Rosentritt M. Effect of incomplete crown ferrules on load capacity of endodontically treated maxillary incisors restored with fiber posts, composite build-ups, and all-ceramic crowns: an in vitro evaluation after chewing simulation. Acta Odontologica Scandinavica 2006;64(1):31–6.
6. DeSort KD. The prosthodontic use of endodontically treated teeth: theory and biomechanics of post preparation. J Prosthet Dent 1983;49(2):203–6.
7. Kern SB, Von Fraunhofer JA, Mueninghoff LA. An in vitro comparison of two dowel and core techniques for endodontically treated molars. J Prosthet Dent 1984;51(4):509–14.
8. Chan FW, Harcourt JK, Brockhurst PJ. The effect of post adaptation in the root canal on retention of posts cemented with various cements. Aust Dent J 1993;38(1):39–45.
9. Kimmel SS. Restoration and reinforcement of endodontically treated teeth with a polyethylene ribbond and prefabricated fiberglass post. Gen Dent 2000;48:700-6.

10. Eskitascioglu G, Belli S, Kalkan M. Evaluation of two post core systems using two different methods (fracture strength test and a finite elemental stress analysis). J Endod 2002;28(9):629-33.

11. Cornier CJ, Burns DR, Moon P. In vitro comparison of the fracture resistance and failure mode of fiber, ceramic and conventional post systems at various stages of restorations. J Prosthodont 2002;10:26-36.

12. Cooney JP, Caputo AA, Trabert KC. Retention and stress distribution of tapered-end endodontic posts. J Prosthet Dent 1986;55(5):540-6.

13. Koolstra JH, Van Eijden TMGJ, Weijs WA, Naeije M. A three-dimensional mathematical model of the human masticatory system predicting maximum possible bite forces. J Biomech 1988;21(7):563-76.

14. Assif D, Oren E, Marshak BL, Aviv I. Photoelastic analysis of stress transfer by endodontically treated teeth to the supporting structure using different restorative techniques. J Prosthet Dent 1989;61(5):535-43.

15. Lewis R, Smith BG. A clinical survey of failed post retained crowns. Br Dent J 1988;165(3):95-7.

16. Bolhuis HP, de Gee AJ, Pallav P, Feilzer AJ. Influence of fatigue loading on the performance of adhesive and nonadhesive luting cements for cast post-and-core buildups in maxillary premolars. Int J Prosthodont 2004;17(5):571-6.

17. Bolhuis P, de Gee A, Feilzer A. The influence of fatigue loading on the quality of the cement layer and retention strength of carbon fiber post-resin composite core restorations. Oper Dent 2005;30(2):220-7.

18. Bonfante G, Kaizer OB, Pegoraro LF, do Valle AL. Tensile bond strength of glass fiber posts luted with different cements. Braz Oral Res 2007;21(2):159-64.

19. Arrais CAG, Giannini M, Rueggeberg FA, Pashley DH. Microtensile bond strength of dual-polymerizing cementing systems to dentin using different polymerizing modes. J Prosthet Dent 2007;97(2):99-106.

20. Wang YJ, Raffaelli O, Zhang L, Chen JH, Ferrari M. Effect of different bonding procedures on micro-tensile bond strength between a fiber post and resin-based luting agents. J Oral Sci 2007;49(2):155-60.

21. Singh A, Logani A, Shah N. An ex vivo comparative study on the retention of custom and prefabricated posts. J Conserv Dent 2012;15(2):183-6.

22. Dietschi D, Ardu S, Rossier-Gerber A, Krejci I. Adaptation of adhesive post and cores to dentin after in vitro occlusal loading: Evaluation of post material influence. J Adhes Dent 2006;8(6):409-19.

23. Isidor F, Odman P, Brondum K. Intermittent loading of teeth restored using prefabricated carbon fiber posts. Int J Prosthodont 1996;9(2):131-6.

24. Mannocci F, Sherriff M, Watson TF, Vallittu PK. Penetration of bonding resins into fibre-reinforced composite posts: A confocal microscopic study. Int Endod J 2005;38(1):46-51.

25. Torbjorner A, Karlsson S, Odman PA. Survival rate and failure characteristics for two post designs. J Prosthet Dent 1995;73(5):439-44.