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REVIEW ARTICLE

Sealing Ability of Esthetic Post and Core Systems

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ABSTRACT

Aim: To review the literature on the sealing ability of esthetic post systems with different cementation techniques.

Background: An important factor for successful root canal treatment is the development of a coronal seal to the treated root canal system.

Review result: The current literature describes promising results using fiber posts with a dual-cure, self-etch resin cement system. However, none of the published results describe a post system or cementation technique that achieved a homogeneous and tight coronal seal.

Conclusion: Fiber post systems appear to be favorable alternatives to metallic or ceramic post systems. Furthermore, dual-cure, self-etch resin cement systems represent superior alternatives to other cement systems.

Clinical significance: The clinician should be aware of the differences between various post systems and different cement systems to select and apply the most appropriate post and cement in each clinical situation.

Keywords: Coronal seal, Fiber post, Microleakage, Resin luting cement.

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INTRODUCTION

The use of intracanal posts is a common clinical procedure to reinforce the remaining tooth structure and to provide a coronal seal to treated root canals. It has been reported in the literature that the survival of endodontically treated teeth relies significantly more on coronal sealing provided by coronal restoration than it does on apical sealing provided by root canal therapy.[1]

The most common post and core used in the literature is a custom-casted post and core. This type of post and core exhibits a high clinical success rate. However, the laboratory stage of the procedure, after an impression is taken for the tooth, requires more time and an additional visit to cement the post and core. To minimize the time required for the procedure, a prefabricated post and core has been introduced to the dental field.[2,3]

The metallic post and core have long been in use. According to the literature, there are some disadvantages associated with metal posts and cores, including loss of retention, corrosion, necessity of removing more root structure, concentrated stress, and the possibility of an unacceptable esthetic result.[2,3]

These complications have increased researchers' interest in inventing new alternatives, which has led to the introduction of the zirconia, carbon, glass, polyethylene, and quartz fiber post systems.

The fiber post systems exhibit particular advantages, including a modulus of elasticity similar to dentin and more conservative postpreparation. The primary disadvantage is debonding, which is considered a repairable complication.[2,4-8]

In 2005, Mannocci et al[9] presented a study that proved that restorations with fiber posts and composites were more effective than amalgam in preventing root fractures but less effective in preventing secondary caries. For prevention of secondary caries, the extent of microleakage should be taken into consideration while placing adhesively luted fiber posts.

Microleakage of Cemented Fiber Posts

The coronal seal of the root canal treatment improves the treatment's prognosis and is considered one of the primary factors of successful root canal treatment.[4,10-12]

The coronal seal prevents the leakage of bacterial endotoxins into the root canal area. The leakage of

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bacterial endotoxins causes recurrent caries and cement disintegration, which may eventually lead to treatment failure. However, none of the currently used materials for cementing the fiber posts exhibit optimum sealing characteristics.[2,3,13]

The sealing ability of restorative materials and techniques is measured by microleakage evaluation. In the literature, many methods for evaluating the microleakage in both *in vivo* and *in vitro* studies have been reported. For *in vitro* studies, the methods include the use of dyes, chemical tracers, radioactive isotopes, air pressure, bacteria, neutron activation analysis, scanning electron microscopy, artificial caries techniques, and electrical conductivity.[5-8,14-16]

This report will present the recent literature results of microleakage studies *in vitro* for different esthetic posts with different cementation techniques. The difficulty in comparing the recent studies that evaluate microleakage is a result of the different evaluation methods used. Table 1 presents the studies and the evaluation methods used.

Table 1: Microleakage evaluation methods

Study	*Method of microleakage evaluation*
Usumez et al[17]	Fluid filtration method
Demir et al[18]	Fluid filtration method
Jung et al[19]	Dye penetration method
Sari and Özyesil[20]	Modified fluid filtration method
Erkut et al[21]	Dye penetration method
Başaran et al[22]	Dye penetration method
Reid et al[7]	Modified fluid filtration method
Rogić-Barbić et al[23]	Fluid transport method
Tjan et al[24]	Dye penetration
Rogić-Barbić et al[25]	Fluid transport method
Erbaşar et al[26]	Dye penetration
Zicari et al[27]	Fluid filtration method
Moosavi et al[28]	Dye penetration method
Mannocci et al[5]	Dye penetration method

Sealing Ability of Different Esthetic Post Systems

Fiber Post

The use of nonmetallic material for the fabrication of posts is based on the carbon fiber reinforcement principle introduced in France in 1990.[29] The fiber post is a nonesthetic post, and its advantages include its easy manipulation, favorable mechanical properties, low toxicity, and a modulus of elasticity similar to that of dentin.[30] Furthermore, fiber posts exhibit high-impact resistance, shock absorption, and increased fatigue resistance.[31] To overcome esthetic disadvantages, the post is reinforced with glass and quartz.

Prefabricated Glass and Quartz Fiber Posts

Esthetic silica-based posts were introduced in 1992. These posts are made of silanized glass or quartz fibers bound by methacrylate or an epoxy-polymer matrix with a high degree of conversion and a highly cross-linked structure that binds the fibers.[32] The fibers provide strength and stiffness, and the matrix transfers load to the fibers.[33]

Fiber posts contain bisphenol A glycidyl methacrylate and epoxy resin, which are suitable for the bonding technique. The bonding to dentin is achieved through chemical and micromechanical bonds that create a uniform stress distribution model.[34] Because of bonding and the similarity of the elastic modulus to dentin, the biomechanical performance is superior to zirconia.[35]

Quartz is a crystalline form of silica, whereas glass is monocrystalline, and both are silica-based fibers. The quartz fiber posts are more radiopaque and exhibit higher flexural strength than fiber posts, and teeth restored with quartz fiber posts exhibit higher fracture strength.[36-38]

The literature reports the favorable sealing ability of fiber post systems. In 2004, Usumez et al[17] reported less microleakage with glass fiber posts relative to systems using prefabricated stainless steel or zirconia posts. A similar result was published by Demir et al[18] in 2014. The authors reported less microleakage with glass fiber posts than with the stainless steel post system. Furthermore, Jung et al[19] found that the cast-post group exhibited a significantly higher level of microleakage relative to the glass fiber post group.

However, Sari and Özyesil[20] reported that the sealing ability of the glass and quartz fiber post systems was not superior to that of stainless steel posts, and there were significant differences among the sealing abilities of various fiber post systems.

Polyethylene Fiber Post

The polyethylene fiber post was introduced in 1992 and is composed of plasma-treated ultra-high molecular weight polyethylene fibers woven into a three-dimensional structure. The fibers are pretreated using cold gas plasma, which improves bonding to resin materials.[39] The advantages of this post type are a high elasticity coefficient; high resistance to stretch, distortion, and traction; and prevention of crack propagation.[40,41] Furthermore, the fibers adapt to the root canal, minimizing the need for canal enlargement and decreasing the perforation potential. However, the high cost of polyethylene fibers limits their use in daily practice.

The idea that improving the adaptation of polyethylene fiber post systems will reduce microleakage has been proven by several different studies. In 2004, Usumez et al[17] reported a smaller degree of microleakage with

resin-supported polyethylene fiber and glass fiber dowels relative to systems using a prefabricated stainless steel or zirconia post. In 2008, Erkut et al[21] presented similar results. In 2014, Demir et al[18] reported less microleakage with resin-supported polyethylene fiber than with the stainless steel dowel system. However, in 2012, Başaran et al[22] detected no significant differences in microleakage among the glass fiber, quartz-glass fiber, zirconia-glass fiber, or polyethylene fiber systems.

Zirconia Post

All-ceramic restorations have become more popular due to their excellent esthetic properties. Therefore, the use of esthetic posts is recommended for restoring root canal-treated teeth that are located in the esthetic zone.[42]

Partially stabilized zirconium dioxide was introduced in 1980. Zirconium dioxide is a ceramic material formed by adding yttrium oxide with high fracture and bending strength.[43,44]

Zirconia posts exhibit advantages that include their biocompatible nature, chemical stability, favorable physical properties, excellent opacity, and light transmission properties. Furthermore, the Young's modulus is similar to that of the stainless steel alloy. The drawback of the zirconia post is that the high elastic modulus causes stress that can lead to root fracture.[42,45-48]

The sealing ability of zirconia post systems compared with that of other systems has been evaluated by different studies. Mitov et al[49] reported that zirconia provides the same level of coronal sealing to that of fiber post and titanium post systems. However, the retention value was inferior to that of fiber posts. Jung et al[19] ranked the microleakage value of the four-post system. The authors reported that the sealing of the zirconia post system was superior to that of casted metal post, prefabricated metal post, and fiber post systems. A similar result was reported by Demir et al[18] in 2014, who observed a lesser degree of microleakage with the zirconia post than with the stainless steel post system. Similarly, Reid et al[7] concluded that titanium posts exhibit greater microleakage than fiber posts and zirconia posts. However, Usumez et al[17] reported that the fiber post system exhibits less microleakage than stainless steel and zirconia posts. Together, these studies suggest that zirconia posts provide acceptable sealing at the level of the coronal structure. However, the mechanical properties do not make zirconia posts a good esthetic choice of post.

Sealing Ability of different Cementation Techniques

Literature reports suggest that resin cements are the cement of choice to cement fiber posts because they improve the retention of the post compared with that of conventional cement.[50] Resin cement systems can be divided based on curing methods (light-cured, dual-cured, and chemically cured) and according to the adhesive systems used (total-etch, self-etch, and self-adhesive). The most popular bonding agents have two components: Hydrophilic and hydrophobic. This feature makes the agent bond to intra-radicular dentin and the fiber post with micromechanical and chemical bonds. These bonds minimize microleakage and reduce the incidence of recurrent caries.[51]

To cement the fiber post resin, cement systems can be divided into conventional resin cement and self-adhesive resin cement.

Conventional Resin Cements

Conventional cements provide a bond using either total-etch or self-etch adhesives. Total-etch resin cements use a 30 to 40% phosphoric acid-etch to etch dentin and enamel. There are many cements that fall into this category, including ARC (3M ESPE), Nexus (Sybron-Kerr), Variolink II (Ivoclar Vivadent, Inc.), Choice 2 (BISCO, Inc.), and Calibra (DENTSPLY Caulk). This multistep application technique is complex and, consequently, might compromise bonding effectiveness because each step represents a possible contamination point. The self-etch adhesive minimizes the steps and produces a similar result.[52]

There are many types of cement that fall into the self-etch category, including Panavia 21, Panavia F, Panavia F 2.0 (Kuraray Medical, Inc.), and Multilink (IvoclarVivadent). Because the adhesion proposed is in an intracanal area where the accessibility of light curing is questionable, the recommendation is to use a self-curing or dual-curing adhesive. Comparison of the self-curing and dual-curing adhesives to light-curing adhesives showed that dual- and self-curing adhesives create an acceptable bond and produce a similar shrinkage value.[53,54]

Self-adhesive Cements

Self-adhesive cements were introduced to the dental field in 2002. These cements address the problems associated with the use of conventional and resin cements. The main advantage is their single-step application, with no need to prepare the surface before cementation. This process minimizes the time required and eliminates the technical problems associated with multiple steps. There are many cements that fall into this category, including RelyXUnicem (3M ESPE), BisCem® (BISCO, Inc.), Maxcem Elite™ (Kerr Corporation), and SpeedCEM™ (Ivoclar Vivadent, Inc.).[55-57]

The efficiency by which the resin cements adapt to and seal margins is critical to their success.[53] When

the microleakage of resin cements is analyzed, studies have reported conflicting results due to the different methods of evaluation. However, resin cement exhibits less microleakage than resin-modified glass ionomer and zinc phosphate cements. In 2013, Rogić-Barbić et al[23] compared the sealing ability of Variolink II cement (dual-curing luting composite system), Harvard cement (Zinc phosphate cement), and Fuji PLUS cement (resin-reinforced, glass ionomer luting cement). Resin cement exhibited significantly less fluid movement. Similar results were reported by Tjan et al,[24] who used second generation dental adhesives, such as Gluma (Heraeus Kulzer), Tenure (Kuraray), and Scotchbond 2 (3M ESPE), and observed that posts luted with dentin-bonding resin cement systems exhibited less microleakage than those cemented with nondentin-bonding cements, such as glass ionomer or zinc phosphate.[6,24] Rogić-Barbić et al[25] evaluated the microleakage of different adhesive systems applied to reconstruction systems based on glass fiber posts. Fuji brand cement (glass ionomer) and Variolink II cement (resin-based cement) had the lowest microleakage values.

The self-etch resin cement exhibits greater sealing ability than self-adhesive resin cement. This result was reported by Erbaşar et al in 2015. The authors compared Panavia F with Smartcem 2. Panavia F, which is a self-etch resin luting cement exhibited less microleakage than the Smartcem 2, which is a self-adhesive resin cement. The authors also found that the sealing ability of self-etch resin cement was superior to the zirconia post system and the glass fiber post system.[26] Francesca Zicari et al[27] also evaluated the microleakage and bond strength of ParapostFiberLux and luting agents with the self-etch resin cement or self-adhesive resin cement. The authors compared Panavia 21, Clearfil Esthetic Cement, and Variolink II, which are self-etch cements, with RelyXUnicem, which is an adhesive resin cement, at three root areas: Coronal, middle, and apical. That push-out bond strength was correlated with sealing ability, and no significant differences in sealing ability were detected among the three different root areas for each cement type. However, the self-adhesive luting agents exhibited significantly more microleakage. Similar results were reported by Moosavi et al,[28] who evaluated the microleakage of endodontically treated teeth using total-etch and self-etch adhesive systems. The authors found that the self-etch adhesive performed better than the total-etch adhesive.

Using a three-step (fourth generation) adhesive system resulted in better sealing relative to other adhesive systems. Mannocci et al[5] compared the three-step dental adhesive (All Bond 2) to the self-etching primers, Panavia 21 and Panavia F, and reported a higher sealing ability using All Bond 2. However, in 2012, Başaran et al[22] compared the microleakage of the four-post system using three types of adhesive systems: A one-stage self-etch, a two-stage total-etch, and a three-stage total-etch adhesive. The authors reported no significant differences in microleakage among the adhesive systems. Furthermore, the authors observed that the use of endodontic sealers and temporary filling materials containing zinc oxide eugenol had no detrimental effect on the marginal seal.

CONCLUSION

Within the limitations of the presented studies and the different methods of evaluation, the following conclusions were drawn:

- None of the investigated post systems or cementation techniques achieved a homogeneous and tight seal at the post–cement–dentin interface; microleakage was reported for all materials.
- Fiber post systems appear to be favorable alternatives to metallic or ceramic post systems. Furthermore, dual-cure, self-etch resin cement systems represent a superior alternative to other cement systems.
- The clinician should be aware of the differences between post systems and cement systems to select and use the most appropriate post and cement for each clinical situation.

REFERENCES

1. Ray HA, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. Int Endod J 1995 Jan;28(1):12-18.
2. Heling I, Gorfil C, Slutzky H, Kopolovic K, Zalkind M, Slutzky-Goldberg I. Endodontic failure caused by inadequate restorative procedures: review and treatment recommendations. J Prosthet Dent 2002 Jun;87(6):674-678.
3. Bolhuis P, de Gee A, Feilzer A. Influence of fatigue loading on four post-and-core systems in maxillary premolars. Quintessence Int 2004 Sep;35(8):657-667.
4. Susini G, Pommel L, About I, Camps J. Lack of correlation between ex vivo apical dye penetration and presence of apical radiolucencies. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006 Sep;102(3):e19-e23.
5. Mannocci F, Ferrari M, Watson TF. Microleakage of endodontically treated teeth restored with fiber posts and composite cores after cyclic loading: a confocal microscopic study. J Prosthet Dent 2001 Mar;85(3):284-291.
6. Bachicha WS, DiFiore PM, Miller DA, Lautenschlager EP, Pashley DH. Microleakage of endodontically treated teeth restored with posts. J Endod 1998;24(11):703-708.
7. Reid LC, Kazemi RB, Meiers JC. Effect of fatigue testing on core integrity and post microleakage of teeth restored with different post systems. J Endod 2003 Feb;29(2):125-131.
8. Veríssimo DM, do Vale MS. Methodologies for assessment of apical and coronal leakage of endodontic filling materials: a critical review. J Oral Sci 2006 Sep;48(3):93-98.
9. Mannocci F, Qualtrough AJ, Worthington HV, Watson TF, Pitt Ford TR. Randomized clinical comparison of endodontically

treated teeth restored with amalgam or with fiber posts and resin composite: five-year results. Oper Dent 2005 Jan-Feb;30(1):9-15.
10. Hommez GM, Coppens CR, De Moor RJ. Periapical health related to the quality of coronal restorations and root fillings. Int Endod J 2002 Aug;35(8):680-689.
11. Fox K, Gutteridge DL. An in vitro study of coronal microleakage in root-canal-treated teeth restored by the post and core technique. Int Endod J 1997 Nov;30(6):361-368.
12. Fogel HM. Microleakage of posts used to restore endodontically treated teeth. J Endod Jul;21(7):376-379.
13. Hilton TJ. Can modern restorative procedures and materials reliably seal cavities? In vitro investigations. Part 2. Am J Dent 2002 Aug;15(4):279-289.
14. Alani AH, Toh CG. Detection of microleakage around dental restorations: a review. Oper Dent 1997;22(4):173-185.
15. Ruyter IE, Oysaed H. Conversion in different depths of ultraviolet and visible light activated composite materials. Acta Odontol Scand 1982;40(3):179-192.
16. Barthel CR, Moshonov J, Shuping G, Orstavik D. Bacterial leakage versus dye leakage in obturated root canals. Int Endod J 1999 Sep;32(5):370-375.
17. Usumez A, Cobankara FK, Ozturk N, Eskitascioglu G, Belli S. Microleakage of endodontically treated teeth with different dowel systems. J Prosthet Dent 2004 Aug;92(2):163-169.
18. Demir N, Yavuz T, Orucoglu H, Ozturk AN, Ozturk B. Microleakage of different dowel systems luted with resin cements. Eur J Prosthodont 2014 May;2(2):53.
19. Jung SH, Min KS, Chang HS, Park SD, Kwon SN, Bae JM. Microleakage and fracture patterns of teeth restored with different posts under dynamic loading. J Prosthet Dent 2007 Oct;98(4):270-276.
20. Sari T, Özyesil AG. Microleakage of teeth restored with different adhesive dowel systems: an in vitro study. J Prosthodont 2014 Jan;23(1):45-49.
21. Erkut S, Gulsahi K, Caglar A, Imirzalioglu P, Karbhari VM, Ozmen I. Microleakage in overflared root canals restored with different fiber reinforced dowels. Oper Dent 2008 Jan-Feb;33(1):96-105.
22. Başaran EG, Ayna E, Halifeoğlu M. Microleakage of endodontically treated teeth restored with 3 different adhesive systems and 4 different fiber-reinforced posts. J Prosthet Dent 2012 Apr;107(4):239-251.
23. Rogić-Barbić M, Šegović S, Baraba A, Pezelj Ribarić S, Katunarić M, Anić I. Microleakage along glass-fibre posts cemented with three different materials after cyclic loading: a pilot study. Coll Antropol 2013 Jul;37(2):431-435.
24. Tjan AH, Grant BE, Dunn JR. Microleakage of composite resin cores treated with various dentin bonding systems. J Prosthet Dent 1991 Jul;66(1):24-29.
25. Rogić-Barbić M, Segović S, Pezelj-Ribarić S, Borcić J, Jukić S, Anić I. Microleakage along Glassix glass fibre posts cemented with three different materials assessed using a fluid transport system. Int Endod J 2006 May;39(5):363-367.
26. Erbaşar CR, Ozdemir E, Hasanoğlu Erbaşar GN. Effect of various post materials and resin luting cements on microleakage in endodontically treated root canals. J Adhes Sci Technol 2015;29(16):1651-1662.
27. Zicari F, Couthino E, De Munck J, Poitevin A, Scotti R, Naert I, Van Meerbeek B. Bonding effectiveness and sealing ability of fiber-post bonding. Dent Mater 2008 Jul;24(7): 967-977.
28. Moosavi H, Moazzami SM, Loh S, Salari S. Microleakage evaluation of core buildup composite resins with total-etch and self-etch adhesive systems. J Contemp Dent Pract 2010 Mar;11(2):009-16.
29. Duret B, Reynaud M, Duret F. [New concept of coronoradicular reconstruction: the Composipost (1)]. Chir Dent Fr 1990 Nov;60(540):131-141.
30. Torbjörner A, Karlsson S, Syverud M, Hensten-Pettersen A. Carbon fiber reinforced root canal posts. Mechanical and cytotoxic properties. Eur J Oral Sci 1996 Oct-Dec;104(5-6): 605-611.
31. Boschian Pest L, Cavalli G, Bertani P, Gagliani M. Adhesive post-endodontic restorations with fiber posts: push-out tests and SEM observations. Dent Mater 2002 Dec;18(8): 596-602.
32. Kallio TT, Lastumäki TM, Vallittu PK. Bonding of restorative and veneering composite resin to some polymeric composites. Dent Mater 2001 Jan;17(1):80-86.
33. Vallittu PK. A review of fiber-reinforced denture base resins. J Prosthodont 1996 Dec;5(4):270-276.
34. Jongsma LA, Bolhuis PB, Pallav P, Feilzer AJ, Kleverlaan CJ. Benefits of a two-step cementation procedure for prefabricated fiber posts. J Adhes Dent 2010 Feb;12(1):55-62.
35. Lassila LV, Tanner J, Le Bell AM, Narva K, Vallittu PK. Flexural properties of fiber reinforced root canal posts. Dent Mater 2004;20(1):29-36.
36. Goracci C, Ferrari M. Current perspectives on post systems: a literature review. Aust Dent J 2011 Jun;56 (Suppl 1):77-83.
37. Galhano GA, Valandro LF, de Melo RM, Scotti R, Bottino MA. Evaluation of the flexural strength of carbon fiber-, quartz fiber-, and glass fiber-based posts. J Endod 2005 Mar;31(3): 209-211.
38. Akkayan B, Gülmez T. Resistance to fracture of endodontically treated teeth restored with different post systems. J Prosthet Dent 2002 Apr;87(4):431-437.
39. Chaoting Y, Gao S, Mu Q. Effect of low-temperature-plasma surface treatment on the adhesion of ultra-high-molecular-weight-polyethylene fibres. J Mater Sci 1993;28(18):4883-4891.
40. Vitale MC, Caprioglio C, Martignone A, Marchesi U, Botticelli AR. Combined technique with polyethylene fibers and composite resins in restoration of traumatized anterior teeth. Dent Traumatol 2004 Jun;20(3):172-177.
41. Karbhari VM, Strassler H. Effect of fiber architecture on flexural characteristics and fracture of fiber-reinforced dental composites. Dent Mater 2007 Aug;23(8):960-968.
42. Segal BS. Retrospective assessment of 546 all-ceramic anterior and posterior crowns in a general practice. J Prosthet Dent 2001;85(6):544-550.
43. Kwiatkowski S, Geller W. A preliminary consideration of the glass-ceramic dowel post and core. Int J Prosthodont 1989 Jan-Feb;2(1):51-55.
44. Christel P, Meunier A, Heller M, Torre JP, Peille CN. Mechanical properties and short-term in-vivo evaluation of yttrium-oxide-partially-stabilized zirconia. J Biomed Mater Res 1989 Jan; 23(1):45-61.
45. Špehar D, Jakovac M. New knowledge about zirconium-ceramic as a structural material in fixed prosthodontics. Acta Stomatol Croat 2015 Jun;49(2):137-144.
46. Michalakis KX, Hirayama H, Sfolkos J, Sfolkos K. Light transmission of posts and cores used for the anterior esthetic region. Int J Periodontics Restorative Dent 2004 Oct;24(5): 462-469.

47. Ozkurt Z, Işeri U, Kazazoğlu E. Zirconia ceramic post systems: a literature review and a case report. Dent Mater J 2010 May;29(3): 233-245.
48. Bateman G, Ricketts DN, Saunders WP. Fibre-based post systems: a review. Br Dent J 2003 Jul;195(1):43-48.
49. Mitov G, Draenert F, Schumann P, Stötzer M, von See C. The influence of pressure changes on the retentive force and coronal microleakage of different types of posts in endodontically treated teeth during simulated dives. Diving Hyperb Med 2016 Dec;46(4):247-252.
50. Assif D, Ferber A. Retention of dowels using a composite resin as a cementing medium. J Prosthet Dent 1982 Sep;48(3):292-296.
51. Ralph Z, Cynthia K. Fiber posts: cementation techniques. Smile Dent J 2012;7(2):44-47.
52. Burgess JO, Ghuman T, Cakir D. Self-adhesive resin cements. J Esthet Restor Dent 2010 Dec;22(6):412-419.
53. Ferracane JL, Stansbury JW, Burke FJ. Self-adhesive resin cements – chemistry, properties and clinical considerations. J Oral Rehabil 2011 Apr;38(4):295-314.
54. Christensen GJ. Should resin cements be used for every cementation? J Am Dent Assoc 2007 Jun;138(6):817-819.
55. Simon, JF.; de Rijl, W. Shear bond strength of empress to dentin using four resin cements. AADR Oral Presentation 886, 2006 Annual Meeting, Orlando.
56. de Rijk, W.; Simon, JF. Shear bond strengths of resin cements to dentin and ceramic. Poster, CEREC 20-year celebration in Vegas. Las Vegas, NV, October 14, 2006.
57. Hollis W, Pecora NF, de Rijk WG. An evaluation of the shear bond strength of four universal cements to five prosthodontics substrates [Internet]. Kerr University; [cited 2012 Sep 27]. Available from: http://www.kerrdental.com/index/kerrdental-cements-maxcemelite-3rdparty-2.