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Microleakage of different dowel systems luted with resin cements

Necla Demir, Tevfik Yavuz, Hasan Orucoglu[1], A Nilgun Ozturk[2], Bora Ozturk[3]

Department of Prosthodontics, and [1]Endodontics, Abant Izzet Baysal Univesity, Bolu, [2]Department of Prosthodontics and [3]Operative Dentistry, Selcuk University, Konya, Turkey

ABSTRACT

Aims: The purpose of this study was to compare microleakage of dowel systems: Stainless steel dowel system (SSD), resin-supported polyethylene fiber dowels (RSPFD), Zirconia dowels (ZD) and glass fiber dowels (GFD) luted with two different resin cements. **Materials and Methods:** The root canals of 96 teeth were restored and two resin cements (Multilink Automix and Clearfil Esthetic cement) were used in cementation procedure. Using the computerized fluid filtration method, microleakage of the specimens was measured at 1 week, and 6 months. **Results:** The data indicated that the microleakage values varied according to the luting cement used ($P < 0.05$). The initial microleakage of ParaPost was similar with the other dowel systems, but this microleakage increased over time ($P < 0.05$). In contrast; microleakage of Ribbond, Cosmopost and Superpost dowels remained constant ($P > 0.05$). **Conclusion:** Esthetic dowels tested exhibited less microleakage compared to stainless steel dowel system. Statistically, Multilink Automix cement showed higher microleakage than Clearfil Esthetic cement.

KEYWORDS: Composite, diffusion, filler, hydration

Introduction

A post-and-core system is often required to provide retention and support for the restoration of teeth lacking coronal tooth structure.[1] Posts are recommended to strengthen weakened endodontically treated teeth which are known to present a higher risk of biomechanical failure than vital teeth.[2-4] The material of post design and the hydrostatic pressure related with the cementation procedure play important roles in the microleakage of the dowel system. To achieve optimum results, the material used for the post should have physical properties similar to that of dentin, be bonded to the tooth structure, and be biocompatible in the oral environment.[5] Post and cores are commonly made from metals because of their superior physical properties; however, metallic posts may produce a gray discoloration of translucent all-ceramic crowns and the surrounding gingivae.[6] This metallic gray color poses an esthetic problem in anterior all-ceramic restorations, particularly when a high lip or broad smile reveals the entire restoration.[7] Disadvantages of the base-metal post and core include their metallic color and complete opacity that gives rise to a grayish blue discoloration and shadowing of both the cervical aspects of the gingiva and root.[8] If non-precious metal alloys were used for post-core restorations, the corrosion products can accumulate in gingival tissues and this may result staining on the root surface. The advent of more advanced composite resin and ceramic materials has led to the development of a wide variety of nonmetal posts, including fiber reinforced posts; Ribbond and Zirconia dowels.[9]

Address for correspondence:
Dr.Necla Demir,
Department of Prosthodontics, Selcuk University, Campus/Konya, Turkey. E-mail: necladt@gmail.com

Christel *et al*.[10] observed that Zirconia dowels, introduced in the late 1980s, exhibited high flexural strength and fracture toughness. Asmussen *et al*.[11] studied Zirconia posts and found that stiffness and resistance to fracture were similar to prefabricated titanium posts. Heydecke *et al*.[12] stated that Zirconia posts with ceramic cores can be recommended as an alternative to metal posts and cores.

Glass fiber-supported resin dowel systems were introduced in 1992.[13] One of the advantages of glass fibers is that they distribute stress over a broad surface area, increasing the load threshold at which the dowel begins to show evidence of microfractures.[14]

Ribbond (Ribbond, Seattle, Wash) is a polyethylene woven fiber ribbon that the manufacturer has suggested for use with composite to fabricate dowels and cores.[15] According to an *in vitro* study, addition of polyethylene woven fibers resulted in significantly fewer vertical root fractures in post-and core-treated teeth.[16]

Rigid posts and cores may support coronal restorations better and distribute stress more uniformly; however, if the tooth is overloaded, a catastrophic failure, such as a vertical or deep root fracture, may result.[17,18] A more elastic post may bend under high loads, resulting in loss or failure of the restoration, but would leave the root intact for retreatment.[19,20] However, an elastic post may allow the restoration to move and compromise the luting cement.

Factors such as the amount of remaining tooth structure, ferrule effect of the crown, and material composition of the crown, as well as magnitude and direction of functional loads, seem to have a greater influence on survival than the specific post system used.[21]

Subsequent leakage would put the tooth at risk for secondary caries and/or root canal reinfection.[22] Higher endodontic failure rates have been reported to be the result of coronal leakage when endodontically treated teeth are not adequately restored.[23] The rationale for using adhesive luting agents is based on the premise that dowels bonded to dentin will reinforce the tooth and help retain the dowel and the restoration.[24] And also adhesive fixation produces a higher fracture resistance in comparison to cemented post and cores; as well as offers a higher leakage resistance.

Little information is available on the seal provided by the new esthetic endodontic dowels cemented with various luting cements. The purpose of this *in vitro* study was to compare sealing properties of 4 adhesively luted dowel systems: Glass fiber dowels (GFD), resin-supported polyethylene fiber dowels (RSPFD), and Zirconia dowels (ZD) and a stainless steel dowel (SSD) system.

Materials and Methods

Ninety-six maxillary central incisor teeth with straight root canals, anatomically similar root segments were used in this study. The teeth were cleaned of soft tissue and calculus, decoronated apical to the cementoenamel junction with a slow-speed diamond saw (Isomet; Buehler, Lake Bluff, III). To standardize root canal lengths, the roots were sectioned to uniform lengths of 12 mm.

Canal working lengths were established 1.0 mm short of the apical foramina. A step-back technique was used for canal instrumentation. Operator instrumented all root canals to the same size (#30 file; Dentsply-Maillefer rotary system). During instrumentation, canals were irrigated with 1 mL of 5% EDTA. The root canals were filled with a resin sealer (AH Plus; Denstply DeTrey, Konstanz, Germany), in conjunction with the laterally condensed gutta-percha technique. Non-standardized fine gutta-percha points were used with lateral condensation until the canals were obturated. The gutta-percha–filled roots were placed in a humidor (100% relative humidity) for 1 week at 37ºC. All dowels were cut to 8-mm length with a water-cooled diamond fissure bur. This procedure standardized the dowel lengths and established diameter similarity between dowels with tapered designs. The dowel spaces were all prepared to a depth of 8 mm using a 1.65 mm-diameter drill supplied with the super-post system.

The 96 prepared roots were randomly assigned to 4 groups of 24 each; Stainless Steel Dowels (SSD) (Group 1), Resin-supported polyethylene fiber dowels (RSPFD) (Group 2), Zirconia dowels (ZD) (Group 3), Super-post glass fiber dowels (GFD) (Group 4) [Figure 1]. And these groups are also divided into two groups according to cement type like Group 1a (Multilink Automix), Group 1b (Clearfil Esthetic Cement).

For the Group 1a and 3a, Multilink Automix cement (Ivoclar, Vivadent) was used according to the manufacturer's instructions. The root canals were thoroughly cleaned and the root canal is ideally coated with the mixed Multilink Primer A/B and waited for 15 seconds. Metal/Zirconia Primer was applied and waited for 180 seconds, then stainless steel endodontic post is placed by finger pressure. The light source was placed directly on the flat coronal tooth surfaces and cement was polymerized for 40 seconds, 1200 mW/cm^2 (Bluephase, Ivoclar, Vivadent, Liechtenstein).

For the Group 1b and 3b, Clearfil Esthetic cement (Kuraray, Osaka, Japan) was applied according to the manufacturer's instructions. Alloy Primer was applied to the post surface for 2 minutes. Equal amounts of ED Primer 2 Liquid A and B was mixed, applied to the root canal and waited for 30 seconds then the adherent surface was dried entirely. After

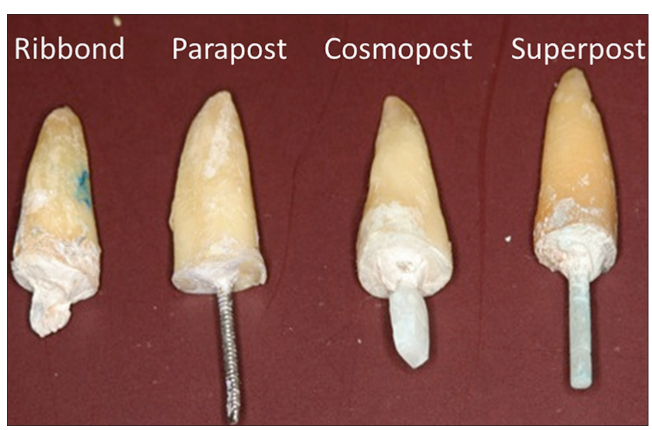

Figure 1: Materials used for post systems

this procedure, Paste A and B mixture was applied to the post and the post was inserted into the root canal quickly. As the last procedure for all the groups, the light source was placed directly on the flat coronal tooth surfaces for 40 seconds.

For the Group 2a, Dowels were made with polyethylene woven fiber ribbon that is composed of two pieces of 2-mm-wide and 16-mm-long ribbon (Ribbond) were chosen. The root canals were thoroughly cleaned and the root canal is ideally coated with the mixed Multilink Primer A/B and left to react for about 15 seconds. The Ribbond material was folded double, twisted, and soaked with unfilled resin (Clearfil Liner Bond; Kuraray). The specimens coated with the mixed Multilink cement are placed by endodontic plugger. The free ends of the ribbons were folded over and condensed into the middle of the coronal opening. Condensation was continued until woven ribbons were pressed as tight as possible into the dowel space.

For the Group 2b, The Ribbond material was folded double, twisted, and soaked with unfilled resin (Clearfil Liner Bond; Kuraray) and the other procedures were the same with the Group 1b.

For the Group 4a, Monobond S was applied to the pretreated surfaces of the posts and let it react for 60 seconds; the root canals were thoroughly cleaned and coated with the mixed Multilink Primer A/B and left to react for about 15 seconds. Superpost GFDs were seated by finger pressure.

For the Group 4b, K-etchant gel was applied to the post surface The gel was left for 5 seconds before washing and drying. Then Clearfil ceramic primer was applied to the post surface. After this procedure, equal amounts of ED Primer 2 Liquid A and B mixture was applied to the root canal and waited for 30 seconds. Paste A and B mixture was applied to the post and the post was inserted into the root canal quickly.

Measurement of the leakage

Using the computerized fluid filtration method, microleakage of the specimens along the dowel space and root canal restorative material was measured at 1 week, and 6 months following dowel insertion. Roots were inserted into the plastic tube from the apical side and connected to 18-gauge stainless steel tube. The cyanoacrylate adhesive was applied circumferentially between the root and plastic tube. A new computerized fluid filtration meter [Figure 2] with a laser system used in this study have had a 25 microliter micropipette (Micro-caps, Fisher Scientific, Philadelphia, PA) mounted in horizontally. This micropipette (Microcaps, Fisher Scientific, Pittsburg, PA) was connected to the pressure reservoir by polyethylene tubing (Microcaps, Fisher Scientific). O_2 from a pressure tank of 120 kPa was applied at the apical side. The pressure was constant throughout the experiment by means of a digital air pressure regulator added to pressure tank. All pipettes, syringes

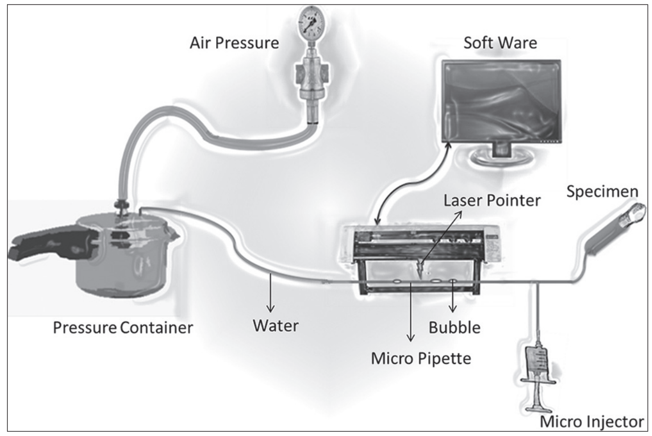

Figure 2: A new computerized fluid filtration meter

and the plastic tubes at the apical side of the sample were filled with distilled water. Water was sucked back with the microsyringe for approximately 2 mm. In this way, an air bubble was created in the micropipette and the air bubble was adjusted to a suitable position in the syringe.[25] This new computerized fluid filtration meter was based on basically light refraction at starting and ending position of air bubble movement inside micropipette. Through one side of the micropipette inside the device, an infrared light was passed. Two light sensitive photodiode was arranged on the opposite side of the micropipette to detect any movement of an air bubble inside micropipette. All operations were controlled with PC-compatible software (Fluid Filtration' 03, Konya, Turkey). A 5-min pressurization preload of the system was completed before taking readings. Measurements of fluid movement were automatically made at 2 min during 8 min for each sample by using PC-compatible software (Fluid Filtration'03, Konya, Turkey). The software converts minute linear movement of the bubble into nanoliter movement at a rate of one measurement. This information is fed into PC-compatible software. Leakage quantity was expressed as $\mu L/cmH_2O/min^{-1}$ and means determined.[25] The fluid transport results were analyzed with statistical software (SPSS PC, Version 10.0; SPSS, Chicago, IL). A repeated-measures analysis of variance (ANOVA) test was used to analyze logarithmic transformations of data (time and dowel material) for significant differences. Tukey HSD and paired 2-tailed tests were used to perform multiple comparisons at a significance level set at $\alpha = 0.05$.

Results

The data indicated that the microleakage values varied according to the dowel system and luting cement used ($P < 0.05$). There was significant interaction between dowel systems and time of testing ($P < 0.05$) [Table 1]. The initial microleakage measurement in stainless steel dowels was similar with the other dowel systems, but became significantly different at 6 months ($P < 0.05$). The microleakage of stainless steel dowels increased

Table 1: Results of repeated-measures ANOVA

	SS	df	MS	F	P
Dowel system	8.10	3	2.70	2.104	0.105
Luting cement	1.42	1	1.42	11.073	0.001
Time of testing	3.69	1	3.69	2.621	0.109
Dowel system-luting cement	1.03	3	3.43	2.670	0.052
Luting cement-time of testing	2.53	1	2.53	1.800	0.183
Dowel system-time of testing	1.42	3	4.73	3.361	0.022

over time ($P < 0.05$), but microleakage of resin-supported polyethylene fiber, Zirconia and glass fiber dowels remained constant ($P > 0.05$). Statistically, Multilink Automix Cement showed the higher microleakage than Clearfil Esthetics Resin cement ($P < 0.05$).

Discussion

Endodontic failures primarily result from the presence of bacteria within root canals caused by incomplete root canal preparation or reinfection through a poor coronal seal.[26] In endodontically treated teeth, the lack of coronal tooth structure often necessitates the placement of a post and core to provide crown retention. In addition to retention, the post should also contribute to a hermetic coronal seal. Microleakage that occurs through a break in the seal is an impeding factor in clinical success.[27,28] The present study compared the leakage of root canals restored with 4 different dowel systems. Specimens used for the study were selected from human teeth. The manufacturer's instructions were followed carefully while dowels were being cemented to ensure that *in vitro* procedures imitate the clinical situations. Wu *et al*.[29] believed that controlling the length of the specimens as well as canal diameters and canal anatomy was necessary to reduce variations in microleakage studies. In the current study, root lengths (12 mm) and dowel space lengths (8 mm) were standardized to avoid anatomical variations and to guarantee standardization. Four preformed dowel systems with different diameters were used in the current study. Although the differences were small (1.5-1.7 mm), this limitation of the current study must also be considered. Certain clinical factors were a challenge to control, such as different root canal anatomies, volume of prepared dowel spaces, smear layer character, and characteristic of the dentinal tubules.[30] In this *in vitro* study, the different root canal sealers' apical leakage was tested using a new computerized fluid filtration meter. The computerized fluid filtration meter used in this study has some advantages over the conventional ones with computer controlling and digital air pressure arrangement.[25] Fluid filtration method values indicate the diameter and length of the void, rather than the length of the void only. This technique allows quantitative measurements of microleakage without the destruction of samples.

Additionally the movement of air bubble can be observed by laser diodes computer controlled rather than visual following. Prefabricated all-ceramic dowels offer excellent esthetic solutions for specific situations. The translucency of all-ceramic crowns is maintained with ceramic dowels and cores, since shade problems caused by opaque dowel and core materials are avoided.[31]

In this study, microleakage of stainless steel dowels group increased over time; this greater microleakage in the stainless steel post and core group may be attributed to lower adhesion between metal and root dentin. In the other groups, composite resin cores would be expected to adhere to the root dentin with a chemical bond. There were no significant differences in microleakage among the Superpost, ParaPost, and CosmoPost groups, the cores of which were made of composite resin, in spite of the fact that each post system had a different elastic modulus. Consequently, the adhesion between cores and root dentin seemed to have a more important role in limiting microleakage compared to the elastic moduli of the posts. This was consistent with previous studies, which concluded that microleakage was affected by the adhesion between post and dentin, or between core and dentin, rather than by the physical properties of the post itself.[32,33]

A resin luting agent may create polymerization shrinkage stresses within the dowel space.[34] Resin luting agents have lower elastic moduli compared to the 2 materials they join.[35] Thus, a zone of highly concentrated loads and stresses is created. RSPFD and GFD systems have elastic moduli lower than ZD and SSDs, and their mechanical characteristics closely resemble dentin. RSPFD and glass fiber systems might have distributed stresses over a wider surface and limited microfractures inside the luting material. This may have resulted in less microleakage. In this study, Multilink Automix Cement showed higher microleakage than Clearfil Esthetics Resin cement. This result can be related with the factor that Multilink Automix has the lowest filler load which was correlated with viscoelastic properties. The polymerization shrinkage is affected by the filler content of resin cement.[36]

Volumetric polymerization shrinkage increased with decreasing filler content. The microleakage of the material is affected by not only the filler content but also the bond strength to the tooth structures. When the bond strength of the self-etching and self-adhesive resin luting cement systems cannot resist to the polymerization shrinkage, the microleakage can occur.[37]

References

1. Carter JM, Sorensen SE, Johnson RR, Teitelbaum RL, Levine MS. Punch shear testing of extracted vital and endodontically treated teeth. J Biomech 1983;16:841-8.
2. Caputo AA, Standlee JP. Biomechanics in clinical dentistry. Chicago: Quintessence Int; 1987. p. 185-203.
3. Caputo AA, Standlee JP. Pins and posts-why, when and how. Dent Clin North Am 1976;20:299-311.
4. Sorensen JA, Martinoff JT. Intracoronal reinforcement and coronal coverage: A study of endodontically treated teeth. J Prosthet Dent 1984;51:780-4.

5. Deutsch AS, Musikant BL, Cavallari J, Lepley JB. Prefabricated dowels: A literature review. J Prosthet Dent 1983;49:498-503.
6. Zalkind M, Hochman N. Esthetic considerations in restoring endodontically treated teeth with posts and cores, J Prosthet Dent 1998;79:702-5.
7. Hunt PR, Gogarnoiu D. Evaluation of post and core systems. J Esthet Dent 1996;8:74-83.
8. Meyenberg KH, Lüthy H, Schärer P. Zirconia posts: A new all-ceramic concept for nonvital abutment teeth. J Esthet Dent 1995;7:73-80.
9. Fredriksson M, Astbäck J, Pamenius M, Arvidson K. A retrospective study of 236 patients with teeth restored by carbon fiber-reinforced epoxy resin posts. J Prosthet Dent 1998;80:151-7.
10. 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;23:45-61.
11. Asmussen E, Peutzfeldt A, Heitmann T. Stiffness, elastic limit, and strength of newer types of endodontic posts. J Dent 1999;27:275-8.
12. Heydecke G, Butz F, Hussein A, Strub JR. Fracture strength after dynamic loading of endodontically treated teeth restored with different post-and-core systems. J Prosthet Dent 2002;87:438-45.
13. Goldberg AJ, Burstone CJ. The use of continuous fiber reinforcement in dentistry. Dent Mater 1992;8:197-202.
14. 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;18:596-602.
15. Sirimai S, Riis DN, Morgano SM. An *in vitro* study of the fracture resistance and the incidence of vertical root fracture of pulpless teeth restored with six post-and-core systems. J Prosthet Dent 1999;81:262-9.
16. Testori T, Badino M, Castagnola M. Vertical root fractures in endodontically treated teeth: A clinical survey of 36 cases. J Endod 1993;19:87-90.
17. Vire DE. Failure of endodontically treated teeth: Classification and evaluation. J Endod 1991;17:338-42.
18. Pilo R, Cardash HS, Levin E, Assif D. Effect of core stiffness on the *in vitro* fracture of crowned, endodontically treated teeth. J Prosthet Dent 2002;88:302-6.
19. Cormier CT, 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 restoration. J Prosthodont 2001:10:26-36.
20. Maccari PC, Conceição EN, Nunes MF. Fracture resistance of endodontically treated teeth restored with three different prefabricated esthetic posts. J Esthet Restor Dent 2003;15:25-30; discussion 31.
21. Loney RW, Moulding MB, Ritsco RG. The effect of load angulation on fracture resistance of teeth restored with cast post and cores and crowns. Int J Prosthodont 1995;8:247-51.
22. Stricker EJ, Göhring TN. Influence of different posts and cores on marginal adaptation, fracture resistance, and fracture mode of composite resin crowns on human mandibular premolars: An *in vitro* study. J Dent 2006;34:326-35.
23. Swartz DB, Skidmore AE, Griffin JA Jr. Twenty years of endodontic success and failure. J Endod 1983;9:198-202.
24. Duncan JP, Pameijer CH. Retention of parallel-sided titanium posts cemented with six luting agents: An *in vitro* study. J Prosthet Dent 1998;80:423-8.
25. Oruçoğlu H, Sengun A, Yilmaz N. Apical leakage of resin based root canal sealers with a new computerized fluid filtration meter. J Endod 2005;31:886-90.
26. Ravanshad S, Ghoreeshi N. An *in vitro* study of coronal microleakage in endodontically-treated teeth restored with posts. Aust Endod J 2003;29:128-33.
27. Usumez A, Cobankara FK, Ozturk N, Eskitascioglu G, Belli S. Microleakage of endodontically treated teeth with different dowel systems. J Prosthet Dent 2004;92:163-9.
28. 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;85:284-91.
29. Wu MK, De Gee AJ, Wesselink PR, Moorer WR. Fluid transport and bacterial penetration along root canal fillings. Int Endod J 1993;26:203-8.
30. Derkson GD, Pashley DH, Derkson ME. Microleakage measurement of selected restorative materials: A new *in vitro* method. J Prosthet Dent 1986;56:435-40.
31. Hochman N, Zalkind M. New all-ceramic indirect post-and-core system. J Prosthet Dent 1999;81:625-9.
32. Drummond JL, Bapna MS. Static and cyclic loading of fiber-reinforced dental resin. Dent Mater 2003;19:226-31.
33. Cohen BI, Pagnillo MK, Newman I, Musikant BL, Deutsch AS. Pilot study of the cyclic fatigue characteristics of five endodontic posts with four core materials. J Oral Rehabil 2000;27:83-92.
34. 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.
35. Eskitaşcioğlu 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;28:629-33.
36. Miyazaki M, Hinoura K, Onose H, Moore BK. Effect of filler content of light-cured composites on bond strength to bovine dentine. J Dent 1991;19:301-3.
37. Dauvillier BS, Aarnts MP, Feilzer AJ. Developments in shrinkage control of adhesive restoratives. J Esthet Dent 2000;12:291-9.

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