Copyright by Quintessence
Not for Publication

Benefits of a Two-step Cementation Procedure for Prefabricated Fiber Posts

Leontine A. Jongsma[a]/Peter B. Bolhuis[b]/Prem Pallav[b]/Albert J. Feilzer[c]/Cornelis J. Kleverlaan[d]

Purpose: To determine whether two-step cementation of prefabricated fiber posts leads to higher bond strengths.

Materials and Methods: Forty-eight human canine teeth were divided into six groups and fiber posts were cemented with DC Core, RelyX Unicem and Panavia F2.0, according to a one-step or two-step procedure. Per root, four cross-sections were prepared. The differences in push-out strength between procedure, cement and location within the root were determined.

Results: For all cements, the push-out strengths for the two-step procedure were significantly higher than for the one-step procedure ($p < 0.001$). Differences between the cements for both the one-step and two-step procedure were not statistically significant ($p = 0.05$).

Conclusion: The reduction of the C-factor by means of a two-step cementation, a procedure equivalent to the layering technique of composite restorations, resulted in significantly higher bond strengths. The increase of 60% in bond strength may be beneficial to the retention of post and core restorations.

Keywords: prefabricated fiber post, cementation procedure, C-factor, push-out strength, polymerization shrinkage.

J Adhes Dent 2010; 12: 55-62.
doi: 10.3290/j.jad.a17534

Submitted for publication: 13.08.07; accepted for publication: 29.10.08.

In recent years, the dental profession has made ever-increasing use of fiber posts to restore endodontically treated teeth. Fiber posts have a number of advantages over metal posts. The modulus of elasticity is closer to that of dentin, which means that the high stresses produced by more rigid posts may be prevented and the risk of root fracture reduced. The posts have high tensile strengths, are compatible with the bis-GMA-based bonding procedures,[2,16] and also offer esthetic and practical advantages.[23]

[a] *PhD Student, Department of Dental Materials Science, ACTA, Universiteit van Amsterdam and Vrije Universiteit, Amsterdam, the Netherlands.*

[b] *Lecturer, Department of Dental Materials Science, ACTA, Universiteit van Amsterdam and Vrije Universiteit, Amsterdam, the Netherlands.*

[c] *Professor, Department of Dental Materials Science, ACTA, Universiteit van Amsterdam and Vrije Universiteit, Amsterdam, the Netherlands.*

[d] *Senior Lecturer, Department of Dental Materials Science, ACTA, Universiteit van Amsterdam and Vrije Universiteit, Amsterdam, the Netherlands.*

Correspondence: *C.J. Kleverlaan, ACTA, Department of Dental Materials Science, Louwesweg 1, 1066 EA Amsterdam, The Netherlands. Tel: +31 20 5188237, Fax: +31 20 6692726. e-mail: c.kleverlaan@acta.nl*

An abstract of this paper was presented as a poster at the annual IADR European and Israeli divisions meeting in Thessaloniki, Greece, September 29th, 2007.

Cementing the post is a critical step in the restorative procedure, due to the retention of and leakage along the post restoration.[3] A good dentinal seal is a fundamental step in prevention of bacterial invasion, secondary caries, decementation, and root fracture. Even with the permanently cemented posts, it seems impossible at present to guarantee a hermetic seal.[17] For the cementation of endodontic posts, the configuration factor (C-factor), defined as the ratio between bonded and unbonded area of a restoration,[10] has been described as the worst case scenario.[7,20] The exact C-factor in the post preparation varies between authors, but is estimated between 20 and 200, depending on the diameter and length of the canal, and the thickness of the cement layer.[6,7] Alster et al[1] have shown that when resin composites are used in confined spaces in thin layers, the polymerization contraction stress produced by the polymerizing resin may exceed 20 MPa. This challenges the retention strength of many dentin adhesives on “ideally flat” dentin.[1] The importance of shrinkage stress in situations with a high C-factor is clear from marginal gap formation in Class V restorations.

Failure of post and core restorations may occur from fracture or bending of the post, loss of retention, fracture of the core, and root fracture.[18,24] Loss of retention of the post is influenced by several factors, involving the post, the cement, and the adhesion of the cement to the post and to the root canal; it is one of the most common modes

Copyright by Quintessence
Not for Publication

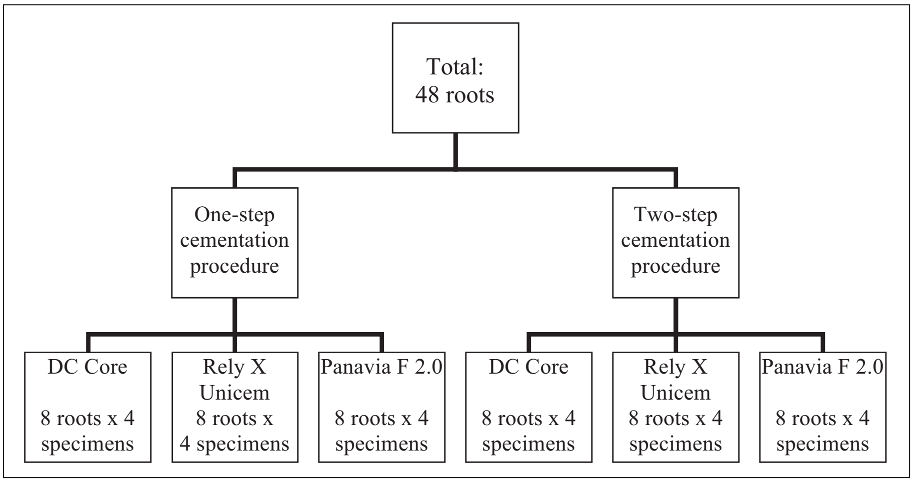

Fig 1 Organization of the investigated groups.

of failure.[19,27] The mechanism of adhesion of the cement to root canal dentin is mainly micromechanical in nature, based on infiltration of the demineralized dentin and the formation of a resin-dentin interdiffusion zone.[16] Conditioning of the dentin, shrinkage and contraction stress of the cement, the unfavorable configuration factor of root canals, and chemical and physical properties of the posts all influence the quality of the bond.[7,21]

The shrinkage and the accompanying contraction stress of direct resin composites with different restorative techniques have been studied extensively.[8,14] The composition of the restorative materials, chemical vs light curing, and different light curing programs on curing devices are aimed to reduce the contraction stress within a restoration. Applying the composite in layers instead of using a bulk technique has been proposed to reduce the contraction stress and the microleakage, although others do not confirm these results. Using layers (C < 1) instead of using a bulk technique (C = 3 to 5) results in a more favorable configuration and potentially to less contraction stress. Dealing with such high C-factors in root canals, it is remarkable that no attempts have been made to solve this problem, although the problem has been recognized.[5,7,22,25] The aim of this study is to investigate whether a reduction of the C-factor, by using a two-step cementation procedure, results in higher bond strengths of fiber posts in root canals. In the first step, the cement is cured with a nonbonding (Teflon) post, so that the cement can shrink towards the root canal walls, allowing for an optimal bonding of the cement to the dentin. After removing the nonbonding post, a very thin, uniform layer of cement is used for final placement of the fiber post. The hypothesis is that decreasing the C-factor in this way will result in an increase of the bond strength.

MATERIALS AND METHODS

Forty-eight extracted single-rooted human canines with almost straight roots and absence of caries were selected and stored in water at 4°C until further processing. The anatomical crowns were removed at the level of the proximal cementoenamel junction and the apex was removed until the root measured 14 mm. The pulp tissue was removed using Rotong files (Densply Maillefer; Ballaigues, Switzerland) 25 mm 04/20. The post space was prepared with DT finishing drills #3 (RTD) to a depth of 12 mm. The canal was rinsed thoroughly with 5% sodium hypochlorite, removing the debris. The apical opening was filled with flowable resin composite (Revolution formula 2, batch #2-1147, Kerr; Orange, CA, USA) to create an apical stop. The flowable resin was used instead of gutta-percha and a root canal sealer, because remnants of these materials may have unpredictable effects on the dentin-cement interface.

The roots were randomly divided in two groups for one- and two-step cementation and further subdivided into three groups for cementation with Clearfil DC Core, RelyX Unicem, and Panavia F 2.0 (Fig 1). Clearfil DC Core is a dual-curing cement and the bond with the dentin was established with an etch-and-rinse system: Clearfil SA primer in combination with Clearfil Photo Bond. Panavia F 2.0 is a dual-curing adhesive system with a primer/bonding system based on MDP, and Rely X Unicem is a self-adhesive resin cement. The products, manufacturers, batch numbers and composition of the materials used are summarized in Table 1.

In order to ensure an optimal bond with the cement, the posts (D.T. Light-Post Radiopaque #2, RTD; St. Egreve, France) were sandblasted (Danville Engineering; Danville, CA, USA) perpendicular to the long axis for 2 s with 50-µm aluminum oxide particles using a pressure of 4 bar at a distance of 5 cm[15] and cleaned with ethanol. Photo Bond liquid A and B and Porcelain Bond activator were mixed in equal portions, applied to the post with a microbrush and

Copyright by Quintessence
Not for Publication

Table 1 Materials used in this study

Product	Manufacturer	Batch number	Composition
Clearfil DC Core Automix Paste	Kuraray	00014A	Catalyst paste: Bis-GMA, TEG-DMA, silanated colloidal silica, barium glass, D,L-camphorquinone, benzoyl peroxide Universal paste: Bis-GMA, TEG-DMA, silanated colloidal silica, barium glass, N,N-diethanol p-toluidine
Clearfil SA Primer	Kuraray	00047B	Salicylic acid monomer
Clearfil Photo Bond Bonding agent Universal	Kuraray	000475B	N,N-di-ethanol-p-toluidine, sodium benzene sulfinate, ethanol
Clearfil Photo Bond Bonding Agent Catalyst	Kuraray	00373B	MDP, bis-GMA, HEMA, hydrophobic aliphatic dimethacrylate, camphorquinone, benzoyl peroxide
Clearfil Porcelain Bond Activator	Kuraray	00158B	Hydrophobic dimethacrylate, γ-methacryloxy propyltrimethoxy silane (γ-MPS)
RelyX Unicem Aplicap	3M ESPE	209606	Powder: glass fillers,silica, calcium hydroxide, self-cure initiators, pigments, light-cure initiators. Liquid: methacrylated phosphoric esters, dimethacrylates, acetate, stabilis ers, self-curing initiators
Panavia F 2.0 package	Kuraray	41170	
Panavia F 2.0 Paste A	Kuraray	00100A	Hydrophobic aromatic dimethacrylate, hydrophobic aliphatic dimethacrylate, hydrophilic dimethacrylate, sodium aromatic sulfinate (TPBSS), N, N-diethanol-p-toluidine, surface treated (functionalized) sodium fluoride, silanated barium glass
Panavia F 2.0 Paste B	Kuraray	00054A	MDP, hydrophobic aromatic dimethacrylate, hydrophobic aliphatic dimethacrylate, hydrophilic dimethacrylate, silanated silica, photoinitiator, dibenzoylperoxide
Panavia F 2.0 ED Primer II Liquid A	Kuraray	00203A	HEMA, MDP, 5-NMSA, water, accelerator
Panavia F 2.0 ED Primer II Liquid B	Kuraray	00083A	5-NMSA, accelerator, water, sodium benzene sulfinate
D.T. Light-Post	RTD	100US0502B	Radiopaque translucent quartz fiber post

Kuraray Medical: Okayama, Japan; 3M ESPE: Seefeld, Germany; RTD: St. Egrève France. Abbreviations: bis-GMA: bisphenol A diglycidylmethacrylate; TEG-DMA: triethylene glycol dimethacrylate; MDP: 10-methacryloxydecyl dihydrogenic phosphate; HEMA: 2-hydroxyethyl methacrylate; 5 NMSA: N-methacryloxyl-5-aminosalicylic acid.

polymerized with a Translux CL (Heraeus Kulzer; Hanau, Germany) for 10 s. The canal was washed again with 5% sodium hypochlorite followed by water and dried with paper points. 17% EDTA was applied for 1 min, removed with water, and dried with paper points. For Clearfil DC Core the bond to dentin was provided by the etch-and-rinse system; after 15 s etching by 32% phosphoric acid, subsequently washing with water, and drying, the SA Primer was applied to the root canal dentin with a microbrush. After removing the excess with absorbent paper points, the solvent was evaporated by mildly blowing with air. The Clearfil Photo Bond liquids A and B were mixed in equal portions and applied to the root canal dentin with a microbrush. After removing the excess with absorbent paper points, the bonding was light cured for 10 s. For Panavia F 2.0 ED-primer liquids A and B were mixed in equal portions, applied to the root canal dentin with a microbrush and left in place for 30 s. After removing the excess with absorbent paper points, air was mildly blown over the surface. RelyX Unicern was applied without a bonding system. All cements were applied according to manufacturers' instructions.

The cements were applied into the root canals using needle tubes (Centrix; Shelton, CT, USA). In the case of the one-step procedure, the fiber posts were placed 9 mm into the canal according to manufacturers' instructions and the cement was cured. With the two-step procedure, a Teflon post (special design RTD; 30 µm thicker than the #2 post) was used instead. The Teflon post was removed after the recommended curing time according to the manufacturer's instructions, and with the use of a needle tube, freshly mixed cement was inserted into the post space followed by the definitive placement of the fiber post. This procedure is graphically depicted in Fig 2. The reason for

Copyright by Quintessence
Not for Publication

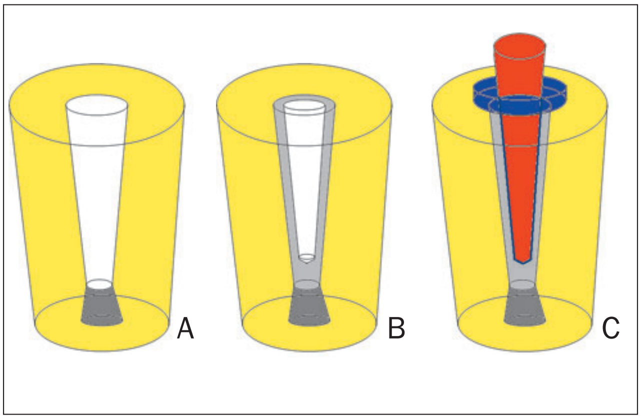

Fig 2 Schematic representation of the two-step cementation procedure. A: Preparation of the post space with apical stop. B: Situation after the Teflon post is removed. C: Cemented fiber post.

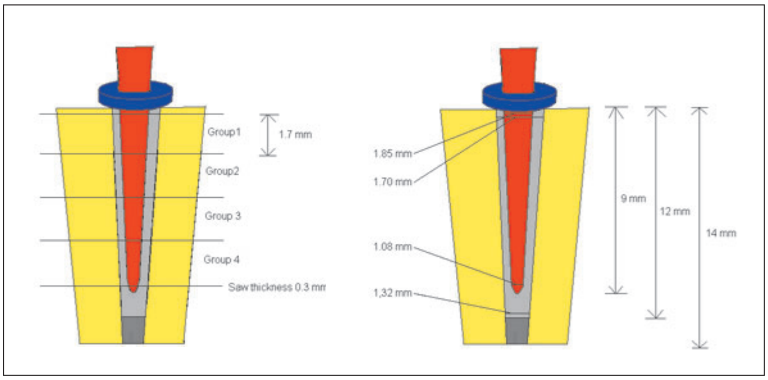

Fig 3 Schematic representation and dimensions of the specimens investigated.

using a #3 bur and placing a #2 post is to simulate the worst-case scenario of a premolar, which often has a thicker cement layer around the post.

Four cross sections were cut from each root (Isomet 11-1180 low speed saw, Buehler; Lake Bluff, IL, USA) each with a height of 1.68 (0.06) mm and numbered 1 for the coronal sections through 4 for the apical ones. The apical sides of the cross sections were marked with a diamond bur. In the push-out tests, the apical sides were placed upwards and the load was applied to the post from the top with a 1-mm punch tip. The specimens were loaded until failure with a Hounsfield H109KM universal testing machine (Hounsfield; Redhill, UK) at a crosshead speed of 1.0 mm·min^{-1}. After the push-out test, the diameter of the cement-post complex was measured and the push-out strength (MPa) was calculated according to:

$$\text{Push-out} = \frac{F}{\pi h d}$$

where F (N) is the failure load, h (mm) is the height of the section, and d (mm) is the diameter of the cement-post complex.

Two-way ANOVA (SigmaStat Version 3.0, SPSS Version 11.0; Chicago, IL, USA) and Tukey post-hoc tests were used to analyze the differences between procedure and cement. One-way ANOVA and Tukey post-hoc tests were used to analyze the differences within the root. Independent t-tests were performed to analyze the differences between the same groups for the one-step and two-step procedures.

RESULTS

The mean push-out strengths of the different procedures and cements and the results of the statistical analysis are summarized in Table 2 and graphically depicted in Fig 4.

Two-way ANOVA showed a significant difference for procedure ($F = 56.1$; $p < 0.001$), but not for cements ($F = 2.0$; $p = 0.139$). The interaction between procedure and cements was also not significant ($F = 0.5$; $p = 0.629$). Tukey post-hoc analysis showed that within all three cements, the difference between the one-step and two-step procedure was significant ($p < 0.001$). Furthermore, the differences between the cements were not statistically significant, for either the one-step or two-step procedures.

The mean push-out strengths of the different levels within the root, where group 1 is coronal and group 4 is apical, and the results of the statistical analysis are sum-

Copyright by Quintessence
Not for Publication

Table 2 Mean push-out strength (± SD) in MPa of the different groups

	DC Core	RelyX Unicem	Panavia F 2.0
One-step	4.8 (1.9)a	5.4 (3.2)a	4.9 (3.4)a
Two-step	7.9 (2.4)b	9.4 (3.8)b	8.1 (3.8)b

The same letter means no statistically significant difference ($p < 0.05$).

Table 3 Mean push-out strength in MPa (± SD) of the different groups

	DC Core	RelyX Unicem	Panavia F 2.0
One-step - Group 1	7.1 (1.6)a	6.3 (2.5)c	2.5 (1.5)d*
One-step - Group 2	4.3 (1.3)b*	4.6 (2.4)c	3.1 (1.6)de*
One-step - Group 3	3.5 (1.2)b*	6.5 (4.3)c	6.0 (2.9)ef*
One-step - Group 4	4.2 (1.6)b*	4.0 (3.3)c*	8.6 (3.5)f
Two-step - Group 1	8.4 (1.7)a	8.2 (3.1)b	5.3 (2.7)c*
Two-step - Group 2	7.1 (0.8)a*	7.3 (3.6)b	5.5 (1.0)c*
Two-step - Group 3	6.9 (1.3)a*	10.1 (3.8)b	9.8 (1.7)d*
Two-step - Group 4	9.0 (4.2)a*	12.2 (3.2)b*	11.7 (4.1)d

The same letter means no statistically significant difference ($p < 0.05$) within the cement. * Statistically significant differences between the same groups within the same cement for the direct and indirect methods ($p < 0.05$).

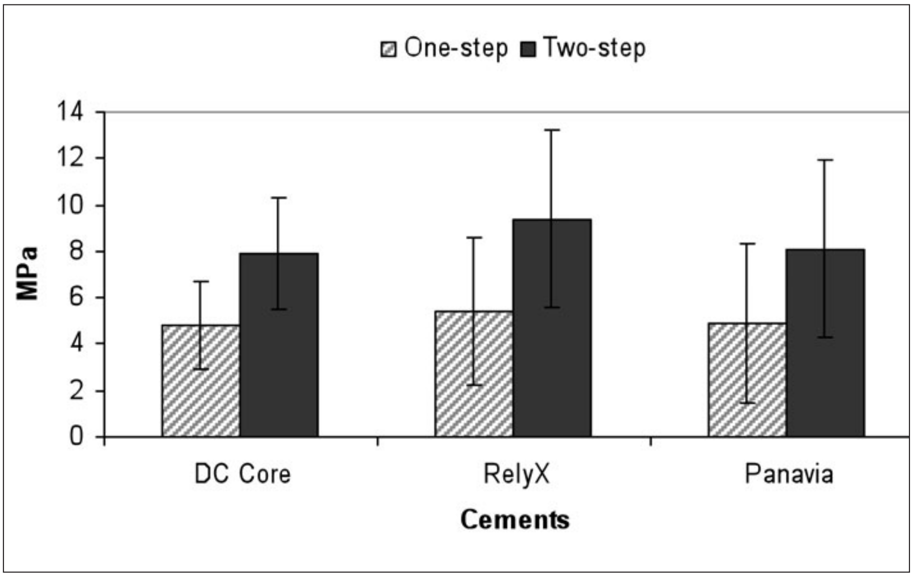

Fig 4 Mean push-out strengths and standard deviations (in MPa) of the cements of the one-step and two-step procedure.

marized in Table 3 and are graphically depicted in Figs 5 and 6.

Within the one-step procedure, two cements showed differences depending on the location in the root. DC Core had higher push-out strengths in the upper coronal section ($p < 0.001$) and Panavia F2.0 was stronger apically ($p < 0.001$). Within the two-step procedure, only Panavia F2.0 showed some differences between the groups, and was stronger apically ($p < 0.001$).

Copyright by Quintessence
Not for Publication

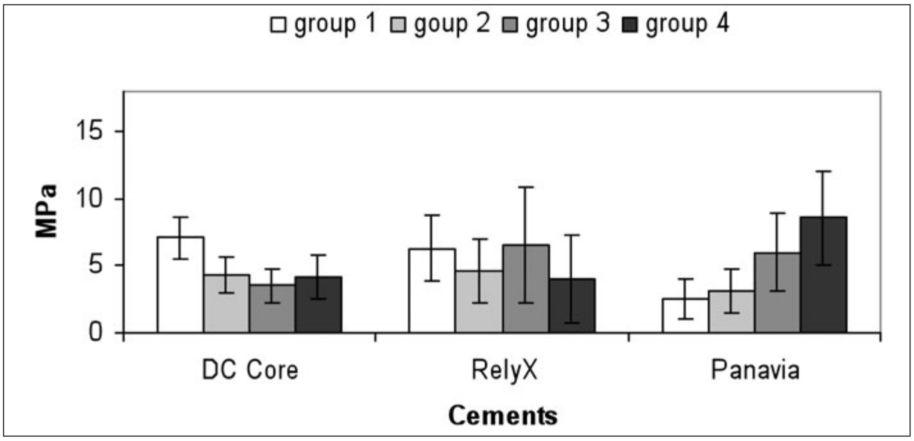

Fig 5 Mean push-out strengths and standard deviations (in MPa) of the different cements of the groups within the one-step procedure.

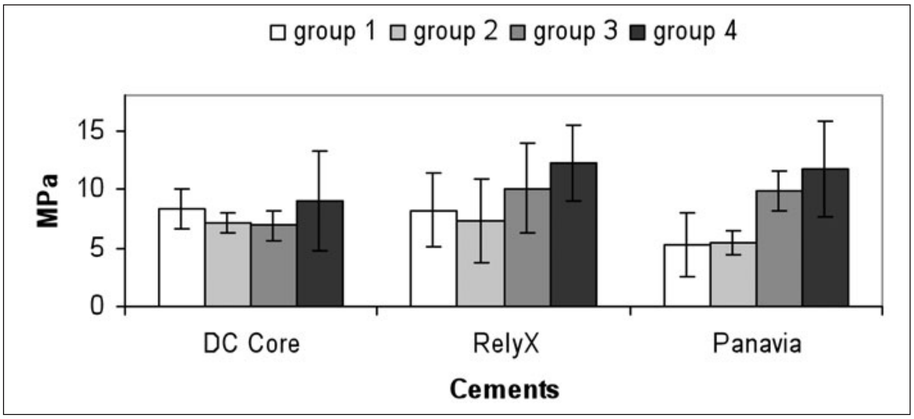

Fig 6 Mean push-out strengths and standard deviations (in MPa) of the different cements of the groups within the two-step procedure.

Table 3 also presents statistical differences between the same groups within the one- and two-step procedures, which are marked with an asterisk. For example, DC Core one-step group 2 is significantly different from DC Core two-step group 2. It shows that within DC core, all groups are different, except for the most coronal one. For RelyX Unicem, only the most apical group is significantly different, and for Panavia F2.0, the most apical group is the only one that is not statistically significant.

A pilot SEM study regarding the bonding interface between the dentin and the cement and the bonding interface between cement and post showed that all interfaces were bonded without gap formation.

DISCUSSION

Reported push-out bond strengths for Panavia range between 0.34 (± 0.11) MPa[13] and 12.7 (± 4.8) MPa,[4] and for Rely X the range is between 5.01 (± 2.63) MPa[11] and 12.4 (± 3.3) MPa.[12] No push-out bond strengths have been reported for Clearfil DC Core. The large variation could be due to several factors; interobserver variability, anatomy, specific preparation, and pretreatment play an important role. Another important factor is the configuration of the preparation. In parallel-sided preparations, the push-out strengths seem to be much higher compared to conical preparations as used in this study. Another important observation is the relatively high standard deviations observed in those studies.[4,11-13] This is in agreement with the high standard deviations found in this study.

In the present study, failure always occurred between cement and dentin, which means that the bond between fiber post and cement was stronger than the bond between cement and dentin. This was accomplished by sandblasting and silanizing the post to maximize the bond strength,[26] hereby making sure that the measured strength was in fact the bond between cement and dentin instead of the bond between post and cement.

The striking difference in push-out strength between the one- and two-step procedures for all investigated cements may be explained by the large difference in C-factor. Although in both procedures the bonded area is equal to the area of the canal walls, the only unbonded area of the one-step procedure is the small coronal opening without the post's crosssection. For the two-step procedure, however, the unbonded area is the same, plus the area of the cement against the Teflon post, because of the lack of

Copyright by Quintessence Not for Publication

bonding of the cement with Teflon. The calculated C-factor, according to the dimensions in Fig 3, is 229 for the one-step procedure in this experiment, while the C-factor for the first composite layer in the two-step procedure is only 1.8.

During curing of the cement, polymerization shrinkage occurs. Shrinkage in the one-step procedure may pull the cement away from the dentin, creating voids and gaps resulting in a weaker bond. In the two-step procedure, the cement can shrink in the direction of the dentin, which reduces the contraction stress, creating a stronger bond and a more uniform structure at the dentinal walls.

The difference with the coronal sections of DC core between the one- and two-step procedures is not statistically significant. This is probably due to the less dramatic effect on the C-factor in the uppermost coronal part of the canal relatively near the unbonded area at the coronal opening. Apically, the differences become more obvious, as might be expected from of the increasing C-factor. With Rely X Unicem, there is a tendency towards higher values in the two-step procedure. Because of the high standard deviations, these differences are not statistically significant, but the second and third groups do have fairly low p-values of 0.095 and 0.091, respectively. The very large difference of the most apical group is clearly significant. The high standard deviations are probably inherent to the material. The bond strength of Panavia F2.0 is higher for the two-step procedure, but with the apical group, the difference is not significant. More coronally, the differences are greater because the rapid light-initiated polymerization leaves a greater shrinkage stress. It seems that the penetration depth of the light correlates negatively with the strength of the bond. Dual-curing cements have a higher conversion rate and therefore better mechanical properties with light curing.[9] It is, however, disputable whether the light reaches the mid-coronal to apical parts of the preparation, so that the cement is properly cured. Slower setting may reduce stress at the bonding interface because it allows flow to relieve polymerization shrinkage stress. The data from Bouillaguet[7] confirm this, as he found that chemically curing cements were less sensitive to high C-factors, which had a much larger effect on light-curing cements.

The cements were selected to test three completely different adhesive systems. DC-core is a traditional system with a three-step bonding procedure, Panavia uses a two-step bonding procedure, and RelyX Unicem is a self-adhesive universal resin cement. Despite the completely different bonding and shrinking properties of these cements, the stresses induced at the dentin/cement interface challenge and preload the bond, resulting in lower push-out values. This is probably a general problem for shrinking cements in high C-factor geometries.

CONCLUSION

We can conclude from these results that decreasing the C-factor has a positive effect on the push-out strength.

ACKNOWLEDGMENTS

The authors gratefully acknowledge 3M ESPE, Kuraray Medical, and RTD for donation of the materials. RTD is further acknowledged for fabricating the Teflon posts. Special thanks to Ms. F.M.C. Mulders for carrying out part of this study.

REFERENCES

1. Alster D, Feilzer AJ, de Gee AJ, Davidson CL. Polymerization contraction stress in thin resin composite layers as a function of layer thickness. Dent Mater 1997;13:146-150.
2. Asmussen E, Peutzfeldt A, Heitmann T. Stiffness, elastic limit, and strength of newer types of endodontic posts. J Dent 1999;27:275-278.
3. Bachicha WS, DiFiore PM, Miller DA, Lautenschlager EP, Pashley DH. Microleakage of endodontically treated teeth restored with posts. J Endod 1998;24:703-708.
4. Bitter K, Meyer-Lueckel H, Priehn K, Kanjuparambil JP, Neumann K, Kielbassa AM. Effects of luting agent and thermocycling on bond strengths to root canal dentine. Int Endod J 2006;39:809-818.
5. 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;30:220-227.
6. Bouillaguet S, Gysi P, Wataha JC, Ciucchi B, Cattani M, Godin C, Meyer JM. Bond strength of composite to dentin using conventional, one-step, and self-etching adhesive systems. J Dent 2001;29:55-61.
7. 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.
8. Carvalho RM, Pereira JC, Yoshiyama M, Pashley DH. A review of polymerization contraction: the influence of stress development versus stress relief. Oper Dent 1996;21:17-24.
9. Darr AH, Jacobsen PH. Conversion of dual cure luting cements. J Oral Rehabil 1995;22:43-47.
10. Feilzer AJ, De Gee AJ, Davidson CL. Setting stress in composite resin in relation to configuration of the restoration. J Dent Res 1987;66:1636-1639.
11. Goracci C, Tavares AU, Fabianelli A, Monticelli F, Raffaelli O, Cardoso PC, Tay F, Ferrari M. The adhesion between fiber posts and root canal walls: comparison between microtensile and push-out bond strength measurements. Eur J Oral Sci 2004;112:353-361.
12. Huber L, Cattani-Lorente M, Shaw L, Krejci I, Bouillaguet S. Push-out bond strengths of endodontic posts bonded with different resin-based luting cements. Am J Dent 2007;20:167-172.
13. Kalkan M, Usumez A, Ozturk AN, Belli S, Eskitascioglu G. Bond strength between root dentin and three glass-fiber post systems. J Prosthet Dent 2006;96:41-46.
14. Kleverlaan CJ, Feilzer AJ. Polymerization shrinkage and contraction stress of dental resin composites. Dent Mater 2005;21:1150-1157.
15. Magni E, Mazzitelli C, Papacchini F, Radovic I, Goracci C, Coniglio I, Ferrari M. Adhesion between fiber posts and resin luting agents: a microtensile bond strength test and an SEM investigation following different treatments of the post surface. J Adhes Dent 2007;9:195-202.
16. Mannocci F, Innocenti M, Ferrari M, Watson TF. Confocal and scanning electron microscopic study of teeth restored with fiber posts, metal posts, and composite resins. J Endod 1999;25:789-794.
17. 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;85:284-291.
18. Mannocci F, Sherriff M, Ferrari M, Watson TF. Microtensile bond strength and confocal microscopy of dental adhesives bonded to root canal dentin. Am J Dent 2001;14:200-204.
19. Monticelli F, Grandini S, Goracci C, Ferrari M. Clinical behavior of translucent-fiber posts: a 2-year prospective study. Int J Prosthodont 2003;16:593-596.
20. Morris MD, Lee KW, Agee KA, Bouillaguet S, Pashley DH. Effects of sodium hypochlorite and RC-prep on bond strengths of resin cement to endodontic surfaces. J Endod 2001;27:753-757.
21. Nikaido T, Takano Y, Sasafuchi Y, Burrow MF, Tagami J. Bond strengths to endodontically-treated teeth. Am J Dent 1999;12:177-180.
22. Pirani C, Chersoni S, Foschi F, Piana G, Loushine RJ, Tay FR, Prati C. Does hybridization of intraradicular dentin really improve fiber post retention in endodontically treated teeth? J Endod 2005;31:891-894.

23. Purton DG, Chandler NP, Qualtrough AJ. Effect of thermocycling on the retention of glass-fiber root canal posts. Quintessence Int 2003;34:366-369.

24. Qualtrough AJ, Chandler NP, Purton DG. A comparison of the retention of tooth-colored posts. Quintessence Int 2003;34:199-201.

25. Sadek FT, Goracci C, Monticelli F, Grandini S, Cury AH, Tay F, Ferrari M. Immediate and 24-hour evaluation of the interfacial strengths of fiber posts. J Endod 2006;32:1174-1177.

26. Sahafi A, Peutzfeldt A, Asmussen E, Gotfredsen K. Bond strength of resin cement to dentin and to surface-treated posts of titanium alloy, glass fiber, and zirconia. J Adhes Dent 2003;5:153-162.

27. Torbjorner A, Karlsson S, Odman PA. Survival rate and failure characteristics for two post designs. J Prosthet Dent 1995;73:439-444.

Copyright by Quintessence
Not for publication

Clinical relevance: A new cementation procedure showed an increase of 60 % in bond strength of post restorations. Applying this procedure clinically might reduce the failure rate of such restorations.