REVISTA DE ODONTOLOGIA DA UNESP

ORIGINAL ARTICLE

Rev Odontol UNESP. 2014 July-Aug; 43(4): 280-285
Doi: http://dx.doi.org/10.1590/rou.2014.044

Fracture resistance of weakened human premolar roots after use of a glass fiber post together with accessory posts

Resistência à fratura de raízes de pré-molares fragilizadas com uso de pinos de fibra de vidro associados a pinos acessórios

Clarissa Estefani SEGATO[a], Flávia Lucisano Botelho do AMARAL[a], Fabiana Mantovani Gomes FRANÇA[a], Flávia Martão FLÓRIO[a], Roberta Tarkany BASTING[a]

[a]Faculdade de Odontologia, SLMANDIC – Instituto e Centro de Pesquisa São Leopoldo Mandic, Campinas, SP, Brasil

Resumo

Objetivo: Avaliar a resistência à fratura de pré-molares com canais alargados restaurados com pinos de fibra de vidro e cimento resinoso com diferentes quantidades de pinos acessórios. **Material e método**: Trinta e seis pré-molares receberam preparos padronizados que simularam raízes fragilizadas e foram separados em três grupos (n=12): G0 - pino de fibra de vidro (Reforpost/Angelus) cimentado com cimento resinoso dual (Rely X ARC/3M ESPE); G1 - pino de fibra de vidro e um pino acessório (Reforpin/Angelus) cimentados com cimento resinoso dual; G2 - pino de fibra de vidro e dois pinos acessórios cimentados com cimento resinoso dual. Núcleos de preenchimento em resina composta foram confeccionados para cada dente. Um coping metálico foi posicionado de forma padronizada sobre o núcleo de preenchimento para a realização dos ensaios de resistência à fratura em máquina de ensaios. Os testes foram realizados com aplicação de força paralela ao longo eixo do dente com velocidade de 0,5 mm/min. O modo de fratura foi avaliado com lupa estereoscópica em escores. **Resultado**: Análise de Variância (ANOVA) foi aplicada e mostrou não haver diferenças significativas nos valores de resistência à fratura entre os grupos (em kgf): G0 = 91,1 ± 56,9; G1 = 104,7 ± 66,6; G2 = 106,1 ± 51,9. Maior frequência de fraturas ou trincas foram observadas no terço cervical das raízes na ausência de pinos acessórios, mas não houve diferenças significativas entre os modos de fraturas entre os grupos. **Conclusão**: A quantidade de pinos acessórios cimentados em raízes fragilizadas não influenciou a resistência à fratura ou modo de falha das raízes de pré-molares.

Descritores: Técnica para retentor intrarradicular; cimentos de resina; raiz dentária.

Abstract

Objective: To evaluate the fracture strength of human premolar teeth with wide root canals, restored with glass fiber posts and resin cement, together with different numbers of accessory posts. **Material and method**: Thirty-six premolars received standardized preparations that simulated weakened roots, and were divided into three groups (n=12): G0 - glass fiber post (Reforpost/Angelus) cementation with dual cure resin cement (Rely X ARC/3M ESPE); G1 - glass fiber post cementation and one accessory post (Reforpin/Angelus), with dual cure resin cement; G2 - glass fiber post cementation and two accessory posts, with dual cure resin cement. Resin composite cores were placed in each tooth. A metal coping was placed in a standardized position on the cores to perform the compressive tests using a test machine. Testing was performed applying a force parallel to the long axis of the teeth at a speed of 0.5 mm/min. Fracture mode was analyzed under a stereoscopic loupe, classified by scores. **Result**: the Analysis of Variance (ANOVA) was applied, and there was no statistical difference in the mean values of fracture strength among the groups (in kgf): G0 = 91.1 ± 56.9; G1 = 104.7 ± 66.6; G2 = 106.1 ± 51.9. Greater frequency of fracture or cracks was observed in the cervical one-third of the root in the teeth without cemented accessory posts, but no statistical difference was observed among the fracture modes. **Conclusion**: The number of accessory posts cemented into debilitated roots had no influence on either fracture strength or type of fracture of pre-molar roots.

Descriptors: Post and core technique; resin cements; tooth root.

INTRODUCTION

For endodontically treated teeth that have lost a significant portion of coronal structure, it may be necessary to insert an intraradicular post to promote retention of the restoration. Glass fiber posts are used for this purpose and, in addition to their esthetic characteristics, also have a modulus of elasticity close to that of dentin, are relatively easy to insert, and have the advantage of reducing the risk of a more invasive fracture of the tooth[1,2].

Studies have shown that cementation of an intraradicular post may not only facilitate retention of the restoration, but also reinforce the root structure of root canal teeth[3]. However, other studies[4-6] have demonstrated that the fracture strength of teeth is directly related to the amount of remaining healthy dental tissue. Yet other studies have suggested that the preparation and insertion of intraradicular systems may weaken the tooth[1,7].

When the clinician is faced with a tooth that presents a wide root canal, there are some treatment alternatives that may be used. Resin composite may be placed within the root canal, applying it to the root canal walls to reduce its lumen before using an intraradicular post[8,9]; a custom-made post may be fabricated[10,11]; or a strip of glass fiber reinforcement with an adhesive system may be inserted into the canal[12,13]. There are advantages and limitations to every technique indicated, and must be duly evaluated[10].

Another option is to use a glass fiber post cemented together with fiber glass accessory posts[14], making it possible to fill the existing space between the root canal and the glass fiber post. This may provide greater resistance to fracture within the intraradicular canal[15,16]. This method further reduces the resin cement thickness, thus minimizing the effects of polymerization shrinkage[14].

According to Silva et al.[14], the use of accessory posts improves adaptation of the entire post to the prepared canal, and diminishes the cement thickness. Silva et al.[14] also states that the juxtaposition of the posts in relation to the canal walls increases mechanical retention and reduces the cement volume and the stresses during polymerization shrinkage. Although Zogheib et al.[15] and Costa et al.[16] found no improvement in root strength, when comparing the use of fiber glass posts cemented with three accessory posts to other techniques of root reconstruction with intraradicular posts, even after mechanical cycling, no evaluations have been made in regard to the way in which the number of accessory posts inserted in the canal may influence fracture resistance. Therefore, the aim of this study was to evaluate the fracture strength of the weakened roots of human premolars, restored with glass fiber posts and resin cement cemented with different numbers of accessory posts. The null hypothesis to be tested was that there are no differences among fracture strength of weakened roots of human premolars restored with different numbers of accessory posts.

MATERIAL AND METHOD

Since this was an experiment in which human teeth were used, the project was submitted to the Research Ethics Committee and it was approved (Process number 2011/0012).

Human premolars were selected and stored in 0.1% thymol. The roots were cut with water-cooled double-faced diamond discs (KG Sorensen, Cotia, SP, Brazil), and the length of the roots were standardized at 14 mm. The roots had similar dimensions, thus assuring that the quantity of remaining root would not affect the results. For this purpose, the measurements of the largest buccolingual and mesiodistal diameters of the roots were made using a digital measuring device (Mitutoyo Sul Americana Ltda, Suzano, SP, Brazil).

For the purpose of standardizing the internal dimensions of the canals, canal preparation was performed at low speed under water-cooling. The initial reduction of dentin was made to a depth of 9.0 mm in the canal, using a spherical diamond bur (1012HL, KG Sorensen, Cotia, SP, Brazil). The second reduction was made with a spherical diamond bur (1014HL, KG Sorensen, Cotia, SP, Brazil) to a depth of 7.0 mm in the canal. The final reduction was made using a spherical diamond bur (1016HL, KG Sorensen, Cotia, SP, Brazil) to a depth of 4.0 mm, leaving the remaining dental walls 0.5 mm thick. The 9.0 and 7.0 mm measurements were controlled with a rubber stop on the stem of each diamond tip. The 0.5 mm and 4.0 mm thicknesses were determined with a thickness meter and periodontal probe, respectively. The teeth were randomly distributed into three groups according to the number of accessory posts used: G0- weakened root together with a glass fiber post and resin cement (no accessory post); G1- weakened root together with a glass fiber post and resin cement cemented with one accessory post; G2- weakened root together with a glass fiber post and resin cement cemented with two accessory posts.

Prefabricated glass fiber posts (Reforpost, Angelus, Londrina, PR, Brazil) 1.1 mm in diameter and 13.0 mm in height were used. A conventional 3-step adhesive system was used (Scotch Bond Multi-purpose, 3M ESPE, St. Paul, MN, USA). Acid etching was performed inside the canal for 15 seconds, followed by rinsing with water for 30 seconds and then drying with absorbent paper. Primer was applied with a disposable paint brush (KG Brush, Barueri, SP, Brazil) and paper point. The adhesive was applied with an unused disposable applicator (KG Brush, Barueri, SP, Brazil) and paper point, and then light activated for 20 seconds. The glass fiber posts and accessory posts (Reforpin, Ângelus, Londrina, PR, Brazil) were cleaned with 70% alcohol followed by silanization according to the manufacturer's instructions (Angelus, Londrina, PR, Brazil) for one minute. This was followed by application of adhesive (Adhesive Scotch Bond Multi-purpose, 3M ESPE, St. Paul, MN, USA), light activated for 20 seconds using a halogen light activation appliance (Demetron HVS1000, São Paulo, SP, Brazil) with an irradiance of 450mW/cm^2 (minimum of 420mW/cm^2 and maximum of 497mW/cm^2). The irradiance was verified after every four cementations. Afterwards, the dual resinous cementation system, shade A1 (Rely X ARC shade A1, 3M ESPE, St. Paul, MN, USA), was mixed and placed into the root canal using a Lentulo spiral (Injecta, Diadema, SP, Brazil). When the canal was filled, the glass fiber posts and accessory posts were put into place, according to the number of posts established for each experimental group, and submitted to light activation for 40 seconds. It was important to ascertain that the accessory posts had a resin cement layer between them, to prevent them from adhering to one another. The adhesion between posts may influence the bond strength values, and the presence of resin cement layer between posts could avoid gaps or empty spaces.

In order to simulate teeth in a periodontal ligament, the teeth were fixed in polystyrene molds according to the manufacturer's instructions using a light condensation silicone elastomeric material[17].

Since the compressive tip of the mechanical testing machine (Emic, São José dos Pinhais, PR, Brazil) would be placed on the posts during the fracture resistance tests and the fiber glass posts had to support the compressive forces without risking possible deformation, it was decided to fabricate the standardized filling cores from resin composite, with chemically activated acrylic resin matrices made in a laboratory, to support the metal coping. The resin composite filling cores were fabricated by applying a conventional 3-step adhesive system to the cores (Scotch Bond Multi-purpose, 3M ESPE, St. Paul, MN, USA), according to the manufacturer's recommendation, to reconstruct the coronal portion of the core. The matrices were previously fabricated by a dental technician, using a resin composite filling core of one of the roots as a mold. This mold was used to standardize the filling cores and later fabricate the metal coping that would be used on all the roots in the fracture test. The matrices were filled with microhybrid resin composite shade A2 (Z 250, 3M ESPE, St. Paul, MN, USA) and put into place on the remainder of the posts in the coronal portion. The excess resin composite was removed with a spatula, followed by light activation of the resin composite and removal of the matrices for complementary light activation, which followed for another 40 seconds. Finishing was then performed with a fine diamond bur. The test specimens were stored in an incubator at 37 °C until such time as the fracture strength test would be performed. To perform the tests, a single coping 0.5 mm thick was cast in nickel-chrome to ensure the coping would fit on all the filling cores for the fracture resistance tests of the roots. The fact that the coping was cast in metal also ensured that it would not become displaced during the test, without interfere with the results.

The test specimens were placed in a stainless steel device that allowed the application of axial compression loading by the testing machine parallel to the long axis of the roots, at a speed of 0.5 mm/min. The load was applied until fracture occurred. At this point, the machine stopped automatically, recording the values of force applied, obtained in kgf. The fracture mode evaluation was performed by observation of the fracture site after removing the root from the polystyrene, using stereoscopic loupes (EK3ST, Eikonal Equip. Ópticos e Analíticos, São Paulo, SP, Brazil) at 30X magnification. The fractures were classified into six types: 1) Fracture or crack in the filling core (FC) and in the cervical one-third of the root; 2) Fracture or crack in the FC; 3) Fracture or crack in the FC and in the apical one-third of the root; 4) Fracture or crack in the apical one-third of the root only; 5) Fracture or crack in the cervical one-third of the root; and 6) Longitudinal root fracture.

The fracture strength data were analyzed by the Analysis of Variance (one-way ANOVA). The Exact Fisher test was applied to determine the fracture mode. The fracture modes considered statistically significant were those that had p-values (probability of Error Type I) equal to or lower than 5%.

RESULT

Table 1 shows the mean fracture strengths for the three groups (G0-G1-G2). There was no statistical difference among the groups. It was observed that the most frequent types of fractures or cracks occurred in the cervical one-third of the root for teeth with no cemented accessory posts. For the groups with one or two accessory posts, fractures or cracks commonly occurred in the cores. Only one longitudinal root fracture was observed among all the specimens. Regarding the fracture pattern, no statistical differences were observed among the groups (Table 2).

DISCUSSION

In this study human teeth were used; therefore, an attempt was made to make laboratory conditions resemble those of a clinical situation, by using teeth having the same mechanical behavior in regard to the dissipation of forces[13,18]. Premolar teeth were used to simulate a clinical condition; the incidence of masticatory forces in premolars occurs in a more parallel manner along the long axis of the tooth[19]. This is different from studies conducted with incisors, in which the force is tangential to the tooth[13,20,21].

Although there are different post diameters, the selected post may not completely suit the root canal, especially in cases where the intraradicular canal is excessively wide, leading to excessive spaces in relation to the intraradicular canal, which must then be filled with cementing material. The disadvantages are that a larger volume of cement may result in increased polymerization shrinkage[2], susceptibility to fatigue, and increased propensity to failure due to the degradation of this cement layer[2]. Alternatives for minimizing both this space and the quantity of cement have been tested, and include using the custom-made post technique[6,10,11] and fiber glass accessory posts[14].

The present study showed that there was no difference in the fracture strength among the groups of premolar roots in which zero, one or two accessory posts were cemented, proving that the use of accessory posts does not reinforce the root structure

Table 1. Mean fracture strength for the experimental groups (kgf)

	Experimental Groups		
	0 (0 accessory post)	**1 (1 accessory post)**	**2 (2 accessory posts)**
Mean	91.1 A	104.7 A	106.1 A
Standard Deviation	56.9	66.6	51.9

Values followed by the same letters did not differ among one another ($p>0.05$).

Table 2. Fracture patterns for each experimental group

	Experimental Groups						
	0 (0 accessory post)		1 (1 accessory post)		2 (2 accessory posts)		Total
Fracture Type	**n**	**%**	**N**	**%**	**N**	**%**	**N**
Fracture or crack in FC	1	9.1	5	45.5	5	45.5	11
Fracture or crack in FC and cervical 1/3 root	3	33.3	2	22.2	4	44.4	9
Fracture or crack in cervical 1/3 root	6	50.0	4	33.3	2	16.7	12
Fracture or crack in FC and apical 1/3 root	2	100.0	0	0.0	0	0.0	2
Fracture or crack in apical 1/3 root	0	0.0	0	0.0	1	100.0	1
Longitudinal root fracture	0	0.0	1	100.0	0	0.0	1

(Exact Fisher Test, p=0.1782).

and does not change the fracture pattern. Zogheib et al.[15] and Costa et al.[16] also showed no differences among different protocols for restoring weakened roots, even with the use of accessory posts. This lack of difference indicates that the intraradicular post does not reinforce the root structure, and that its main function is to retain the coronal restorative material[4,7,14,15]. The present study also appears to show that the intraradicular post did not influence the mechanical behavior of the root, in regard to fracture strength, irrespective of the number of accessory posts inside the root canal.

In the present study, the option was taken to use glass fiber accessory posts that, in conjunction with the dual resin cement, could provide higher fracture strength values. Nevertheless, this behavior was not observed, corroborating the study of Silva et al.[14] and Zogheib et al.[15], which showed that glass fiber posts cemented with resin composite and glass fiber accessory posts presented similar results.

In the study by Maccari et al.[22], the teeth restored with glass fiber posts presented higher fracture strength values than the teeth restored with metal posts and resin composite filling cores, the latter of which presented higher values than the teeth restored with cast metal cores. It was observed that glass fiber posts presented a low modulus of elasticity. This property becomes important when a load falls on the root structure, leading to minimization of the stress generated, because the stresses between the post and the root are better absorbed. Therefore, the ideal system would be one in which the post had a modulus of elasticity equal to or close to that of dentin. Another important mechanical characteristic of glass fiber posts is their flexural strength, which is the ability of a certain material to withstand a force up to a certain limit and to undergo a certain flexion, which also helps distribute and direct the forces that fall on the post. The technique of cementing the glass fiber intraradicular post together with accessory posts used in this study may have led to a reduction in the amount of cement present inside the root canal, considering that a larger amount of cement would compromise the longevity of cementation due to degradation of the material. With time, this degradation could occur as a result of cyclic loads associated with changes in temperature, pH, and the presence of microorganisms[3,18]. A thicker layer of cementing agent could be subject to greater solubility in the oral cavity and to fatigue. Therefore, the use of resin composites (in the post relining technique) and fiber glass accessory posts (cemented with the main glass fiber post) may be alternatives for filling the root canal[9,11,19], minimizing the quantity of cement to be used.

It must also be considered that filling the root canal with resin cement may compromise the bond between the cement and tooth structure, due to the influence of the configuration factor (C Factor), as a result of polymerization shrinkage stresses[23]. In the cementation of fiber glass posts, the C Factor is high. This indicates that there may be gaps in the cementation, which compromise the bond to the intraradicular wall. Resin cement has a larger volume of organic matrix and a lower load in its composition than dental composite. This characteristic increases polymerization shrinkage[24]. Also, although the adhesive apical third is the most critical region for the light-activation to initiate the reaction of the light-cure adhesive, a self-cured cement was used and, thus, may provide a good quality of the adhesive post/dentin substrate interface[25]. In regard to the fracture patterns, it was observed that they were less damaging when located in the filling core or in the cervical one-third of the root; in either case, a new restorative procedure can be performed to maintain the tooth root. This is contrary to what was observed in the teeth restored with cast metal cores, in which the pattern is more destructive and often located longitudinally in the root, leading to loss of the tooth[19]. Ceballos et al.[26] also indicated the use of dual resin cements for cementation of intraradicular posts, since they have been shown to promote the dissipation of stresses and reduce the risk of irreversible root fractures.

Therefore, the use of glass fiber posts may be a feasible option for the restoration of teeth with weakened roots. The accessory posts did not influence the fracture resistance values and fracture pattern; consequently, their use may not be necessary.

CONCLUSION

The number of accessory posts cemented into debilitated roots had no influence on either fracture strength or type of fracture.

REFERENCES

1. Morgano SM, Rodrigues AH, Sabrosa CE. Restoration of endodontically treated teeth. Dent Clin North Am. 2004 Apr; 48(2):vi, 397-416. PMid:15172607. http://dx.doi.org/10.1016/j.cden.2003.12.011
2. Jongsma LA, Ir NJ, Kleverlaan CJ, Feilzer AJ. Reduced contraction stress formation obtained by a two-step cementation procedure for fiber posts. Dent Mater. 2011July; 27(7): 670-6. PMid:21514652. http://dx.doi.org/10.1016/j.dental.2011.03.008
3. Isidor F, Odman P, Brondum, K. Intermittent loading of teeth restored using prefabricated carbon fiber post. Int J Prosthet.1996; 9 (3): 131-6.
4. Gutmann JL. The dentin-root complex: anatomic and biologic considerations in endodontically treated teeth. J Prosthet Dent. 1992 Apr; 67(4): 458-67. http://dx.doi.org/10.1016/0022-3913(92)90073-J
5. Zogheib LV, Pereira JR, do Vale AL, de Oliveira JA, Pegoraro LF. Fracture resistance of weakened roots restored with composite resin and glass fiber post. Braz Dent J. 2008; 19(4): 329-33. PMid:19180323. http://dx.doi.org/10.1590/S0103-64402008000400008
6. Clavijo VG, Reis JM, Kabbach W, Silva AL, Oliveira Júnior OB, Andrade MF. Fracture strength of flared bovine roots restored with different intraradicular posts. J Appl Oral Sci. 2009 Nov-Dec; 17(6): 574-8. PMid:20027429. http://dx.doi.org/10.1590/S1678-77572009000600007
7. Christensen GJ. Posts: necessary or unnecessary? J Am Dent Assoc. 1996 Oct; 127(10): 1522-6. PMid:8908923. http://dx.doi.org/10.14219/jada.archive.1996.0063
8. Lui JL. A technique to reinforce weakened roots with post canals. Endod Dent Traumatol. 1987 Dec; 3(6): 310-4. PMid:3326726. http://dx.doi.org/10.1111/j.1600-9657.1987.tb00641.x
9. Carvalho CA, Valera MC, Oliveira LD, Camargo CH. Structural resistance in immature teeth using root reinforcements in vitro. Dent Traumatol. 2005June; 21(3): 155-9. PMid:15876327. http://dx.doi.org/10.1111/j.1600-9657.2005.00312.x
10. Fokkinga WA, Kreulen CM, Vallittu PK, Creugers NH. A structured analysis of in vitro failure loads and failure modes of fiber, metal and ceramic post-and-core systems. Int J Prosthodont. 2004 Jul-Aug; 17(4): 476-82. PMid:15382786.
11. Genovese K, Lamberti L, Pappalettere C. Finite element analysis of a new customized composite post system for endodontically treated teeth. J Biomech. 2005 Dec; 38(12): 2375-89. PMid:16214485. http://dx.doi.org/10.1016/j.jbiomech.2004.10.009
12. Kimmel SS. Restoration and reinforcement of endodontically treated with a polyethylene ribbon and prefabricated fiberglass post. Gen Dent. 2000 Nov-Dec; 48(6): 700-6. PMid:12004666.
13. Newman MP, Yaman P, Dennison J, Rafter M, Billy E. Fracture resistance of endodontically treated teeth restored with composite posts. J Prosthet Dent. 2003 Apr; 89(4): 360-7. PMid:12690348. http://dx.doi.org/10.1067/mpr.2003.75
14. Silva GR, Santos-Filho PC, Simamoto-Júnior PC, Martins LR, Mota AS, Soares CJ. Effect of post type and restorative techniques on the strain and fracture resistance of flared incisor roots. Braz Dent J. 2011; 22(3): 230-7. PMid:21915521. http://dx.doi.org/10.1590/S0103-64402011000300009
15. Zogheib LV, Saavedra GS, Cardoso PE, Valera MC, Araújo MA. Resistance to compression of weakened roots subjected to different root reconstruction protocols. J Appl Oral Sci. 2011 Nov-Dec; 19(6): 648-54. PMid:22231002 PMCid:PMC3973469. http://dx.doi.org/10.1590/S1678-77572011000600018
16. Costa RG, De Morais EC, Campos EA, Michel MD, Gonzaga CC, Correr GM. Customized fiber glass posts. Fatigue and fracture resistance. Am J Dent. 2012 Feb; 25(1): 35-8. PMid:22558690.
17. Soares CJ, Martins LR, Fonseca RB, Correr-Sobrinho L, Fernandes Neto AJ. Influence of cavity preparation design on fracture resistance of posterior leucite-reinforced ceramic restorations. J Prosthet Dent. 2006 Jun; 95(6): 421-9. PMid:16765154. http://dx.doi.org/10.1016/j.prosdent.2006.03.022
18. 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 Odont Scand. 2006 Feb; 64(1): 31-6. PMid:16428180. http://dx.doi.org/10.1080/00016350500331120
19. Soares CJ, Soares PV, de Freitas Santos-Filho PC, Castro CG, Magalhães D, Versluis A. The influence of cavity design and glass fiber posts on biomechanical behavior of endodontically treated premolars. J Endod. 2008 Aug; 34(8): 1015-9. PMid:18634938. http://dx.doi.org/10.1016/j.joen.2008.05.017
20. Barjau-Escribano A, Sancho-Bru JL, Forner-Navarro L, Rodríguez-Cervantes PJ, Pérez-González A, Sánchez-Marín FT. Influence of prefabricated post material on restored teeth: fracture strength and tensions distribution. Oper Dent. 2006 Jan-Feb; 31(1): 47-54. PMid:16536193. http://dx.doi.org/10.2341/04-169
21. Maccari PC, Cosme DC, Oshima HM, Burnett Junior LH, Shinkai RS. Fracture strength of endodontically treated teeth with flared root canals and restored with different post systems. J Esthet Restor Dent. 2007; 19(1): 30-6. PMid:17244147. http://dx.doi.org/10.1111/j.1708-8240.2006.00060.x
22. Maccari PCA, Conceição EM, Nunes MF. Fracture resistance of endodontically treated teeth restored with three different esthetic posts. J Esthet Restor Dent. 2003; 15(1): 25-30. PMid:12638770. http://dx.doi.org/10.1111/j.1708-8240.2003.tb00279.x
23. Feilzer AJ, De Gee AJ, Davidson CL. Setting stress in composite in relation to configuration of the restoration. J Dent Res. 1987 Nov; 66(11): 1636-9. PMid:10872397. http://dx.doi.org/10.1177/00220345870660110601
24. Braga RR, Cesar PF, Gonzaga CC. Mechanical properties of resin cements with different activation modes. J Oral Rehabil. 2002 Mar; 29(3): 257-62. PMid:11896842. http://dx.doi.org/10.1046/j.1365-2842.2002.00821.x

25. Abou-Id LR, Morgan LF, Silva GA, Poletto LT, Lanza LD, Albuquerque Rde C. Ultrastructural evaluation of the hybrid layer after cementation of fiber posts using adhesive systems with different curing modes. Braz Dent J. 2012 Mar/Apr; 23(2): 116-21. PMid:22666768. http://dx.doi.org/10.1590/S0103-64402012000200005
26. Ceballos L, Garrido MA, Fuentes V, Rodriguez J. Mechanical characterization of resin cements used for luting fiber posts by nanoindentation. Dent Mater. 2007 Jan; 23(1): 100-5. PMid:16430956. http://dx.doi.org/10.1016/j.dental.2005.12.007

CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

CORRESPONDING AUTHOR

Roberta Tarkany Basting
Departamento de Odontologia Restauradora - Dentística, SLMANDIC – Faculdade de Odontologia, Instituto e Centro de Pesquisa São Leopoldo Mandic, Rua José Rocha Junqueira, 13, 13045-755 Campinas - SP, Brasil
e-mail: rbasting@yahoo.com

Received: December 3, 2013
Accepted: April 27, 2014