CRITICAL ANALYSIS OF FIBER POST SURFACE TREATMENT: A REVIEW

ANÁLISE CRÍTICA DO TRATAMENTO DE SUPERFÍCIE DE PINOS DE FIBRA : UMA REVISÃO

Alexandre Coelho MACHADO[1]; Ana Laura Rezende VILELA[2]; Paola Gomes SOUZA[3]; Analice Giovani PEREIRA[4]; Luís Henrique Araújo RAPOSO[5]; André Luís FARIA-E-SILVA[6]; Murilo de Sousa MENEZES[7]; Paulo Vinícius SOARES[8]

1. Postgraduate Student and Member of Nucleus Extension, Research and Teaching at NCCL, Dental School, Federal University of Uberlandia, Brazil. 2. Graduate Student, Dental School, Federal University of Uberlandia, Brazil. 3. Graduate Student and Member of Nucleus Extension, Research and Teaching at NCCL, Dental School, Federal University of Uberlandia, Brazil. 4. Postgraduate Student and Member of Nucleus Extension, Research and Teaching at NCCL, Dental School, Federal University of Uberlandia, Brazil. 5. Professor, Occlusion, Fixed Prosthesis and Dental Materials Department, Dental School, Federal University of Uberlandia, Brazil. 6. Professor, Operative Dentistry, Dental School, Federal University of Sergipe. 7. Professor, Operative Dentistry and Dental Materials Department, Dental School, Federal University of Uberlandia, Brazil. 8. Professor, Operative Dentistry and Dental Materials Department, and Coordinator of Nucleus Extension, Research and Teaching at NNCL; Dental School, Federal University of Uberlandia, Brazil. paulovsoares@yahoo.com.br

ABSTRACT: The surface treatment of fiber posts influence the bonding between composite resin cements and intraradicular retainers, being relevant to the prognostic of teeth without coronal structure. This study aimed to evaluate the different fiber post surface treatment protocols described on literature. The search strategy included a review of PubMed/MEDLINE database using fiber post associated with adhesion; bonding; surface treatment; as keywords. Papers not comprehending English language; assessment of post surface treatment; or testing of materials and their physic-mechanical properties were excluded. Studies about glass and quartz fiber post surface treatment were considered for this literature review. Among the 190 articles included, silane agent was the material most used (60.52%) for the surface treatment of fiber posts, followed by application of alcoholic solutions (38.29%), and primer and/or adhesive systems (36.84%). Sandblasting of post surface was mentioned in (17.89%), but it affected the physical and mechanical properties. Hydrogen peroxide was mentioned only in 5.78% and it was shown to result on adequate exposure of the glass fibers without damaging them. It was concluded that a consensus for fiber post surface treatment still not exist in the current literature. Among the protocols described, the one using hydrogen peroxide followed by application of silane seems the most promising, since it allows increased bond strengths without fiber damage.

KEYWORDS: Adhesion. Hydrogen Peroxide. Intraradicular Retainer.

INTRODUCTION

Endodontically treated teeth present increased risk of failure (SOARES et al., 2008), and when a large loss of dental structure is present, intraradicular posts can be required to retain the coronal restorative material (ASSIF; GORFIL, 1994; CHRISTENSEN, 1996). Prefabricated glass fiber posts are now the most used intraradicular retainers due to their inherent low cost and easy handling, besides good properties (GOMEZ-POLO et al., 2010). The mechanical properties and bonding capacity of fiber posts to dentin using adhesive luting agents allow formation of a homogeneous structure with the tooth resulting in reduced risk of catastrophic fractures (MALFERRARI et al.,2003; SANTOS-FILHO et al., 2008). Moreover, fiber posts permit reduced clinical visits by eliminating laboratory steps and their removal procedure is facilitated compared with metallic posts (FRAZER et al., 2008).

The surface treatment of dental structures (BUONOCORE, 1955; NAKABAYASHI et al., 1991) and restorative materials (HORN, 1983; THOMPSON, 1984) has been used to rough these substrates and increase surface energy, improving bonding mechanisms (OZCAN; VALLITTU, 2003). The success of intraradicular-retained restorations using fiber post depends on the bonding interface between post, resin cement and tooth (LANZA et al., 2005). Thus, to improve this interaction, it is necessary to perform surface treatments of the fiber posts, seeking to remove the superficial epoxy resin matrix and expose the internal glass fibers in order to improve chemical bonding to Bis-GMA based materials through coupling agents (MONTICELLI et al., 2006a).

The several surface treatments available for fiber posts can be basically divided into three categories: rough surface promotion, chemical adhesive optimization and the association of these methods (SAHAFI et al., 2003). The surface

Received: 18/10/13
Accepted: 31/01/14

roughening can be created by mechanical (sandblasting) or chemical treatments (etching with hydrofluoric acids or hydrogen peroxides) to increase the adhesive/cement penetration over the post surface, resulting in improved micro-mechanical bonding. The surface treatments based on chemical optimization (silane coupling agents and adhesive systems) is responsible for improving bonding between the luting resin cements and fiber posts. Finally, the third approach comprises the association of the both methodologies, aiming to increase surface roughness and optimize the chemical bonding to fiber posts (SAHAFI et al., 2003).

Facing the diversity of post surface treatments proposed and the absence of consensus in the current literature, the objective of the present study is to discuss the most prevalent surface treatment for glass and quartz fiber posts and to propose a clinical protocol suitable for treating the surface of prefabricated fiber retainers, based on the data found in this literature review.

DEVELOPMENT

The basic search strategy included a review of the PubMed/MEDLINE database limited by "dental journal" index and conducted using the primary keyword fiber post alone or in association with the following secondary keywords: adhesion; bonding; surface treatment. The review covered the literature until November, 2013. Hand search of the references completed the review. The inclusion criteria excluded papers not comprehending English language; assessment of post surface treatment; or testing of materials and their physic-mechanical properties. Studies about glass and quartz fiber post surface treatment were considered for this review. Subsequently, the protocols of post surface treatment were identified and the manuscripts were categorized into surface micro-roughening or chemical optimization categories.

The search at PubMed/MEDLINE platform retrieved a total of 705 papers, from which 190 (26.95%) were selected according to the inclusion criteria. The qualitative results are shown on Figure 1. The cleaning and roughening surface presented increased amount of protocols with higher citation, with 5 types of surface treatment being reported at least ten times. On the other hand, among the studies using chemical optimization for surface treatment of posts, just two protocols were reported on a higher number of manuscripts, which are, surface treatment using silane and/or primer/adhesive. Other seven surface treatments for fiber posts were cited at most twice. Despite the differences, the number of protocols cited for each category was close, being of 169 for cleaning and roughening surface promotion and 193 for chemical optimization.

From the selected papers, 74 (38.94%) used alcoholic solutions for post surface treatment, presenting variable concentrations with different periods and methods of application. The use of acid etching for surface treatment was reported in 40 papers (21.05%). Phosphoric and hydrofluoric acid etching were used in 30 (15.78%) and 10 (5.26%) manuscripts, respectively. For phosphoric acid, the most prevalent concentration was 37%, applied for 60 seconds. For hydrofluoric acid, a higher diversity between protocols was observed, with concentrations varying from 4% to 10% and diverse application periods.

Sandblasting with abrasive particles was used for post surface treatment in 34 manuscripts (17.89%). Most studies used conventional sandblasting, but some papers employed silane embedded abrasive particles systems, known as CoJet system (3M-ESPE, St. Paul, MN, USA), for surface treatment of fiber posts. Aluminum oxide (Al_2O_3) was the abrasive particle most frequently used with a predominant size of 50-µm; but sandblasting using particles lager than 100-µm was also reported. The silane embedded abrasive particle system employs silica particles with an average size of 30-µm. The sandblasting application period was highly variable among papers, and the period of 5-15 s was often used. However, protocols for shorter (2 s) or longer (up to 32 s) periods were described, with a varying distance of 10 to 50 mm.

Hydrogen peroxide was used in 11 (5.78%) papers, with variable application periods (1, 5, 10 and 20 min) and concentration (10 to 50%). The application method was variable, reported as post immersion in hydrogen peroxide solution, or rubbing the solution in the post with cotton pellets. All studies used hydrogen peroxide etching prior to some chemistry optimization treatment. Unusual cleaning or roughening of fiber post surface were tested by others studies, such as acetone (3/1.57%), potassium permanganate (2/1.05%), methylene chloride (1/0.52%); sodium ethoxide (3/1.57%), and sodium ascorbate (1/0.52%).

Silane coupling agent was used in 115 papers (60.52%) and primer/adhesive systems were utilized in 70 manuscripts (36.84%). Other unconventional chemical optimization surface treatments were also mentioned. Different plasma treatments were presented in the papers evaluated: oxygen plasma; argon plasma; nitrogen plasma, a mixture of helium (20%)/nitrogen (80%) plasma, and argon ethylamide. All plasma treatments were cited in one single manuscript (0.52%), except for the argon plasma (2/1.05%). Surface treatment with low and high ultraviolet radiation was also tested (0.52% each intensity) (Figure 1).

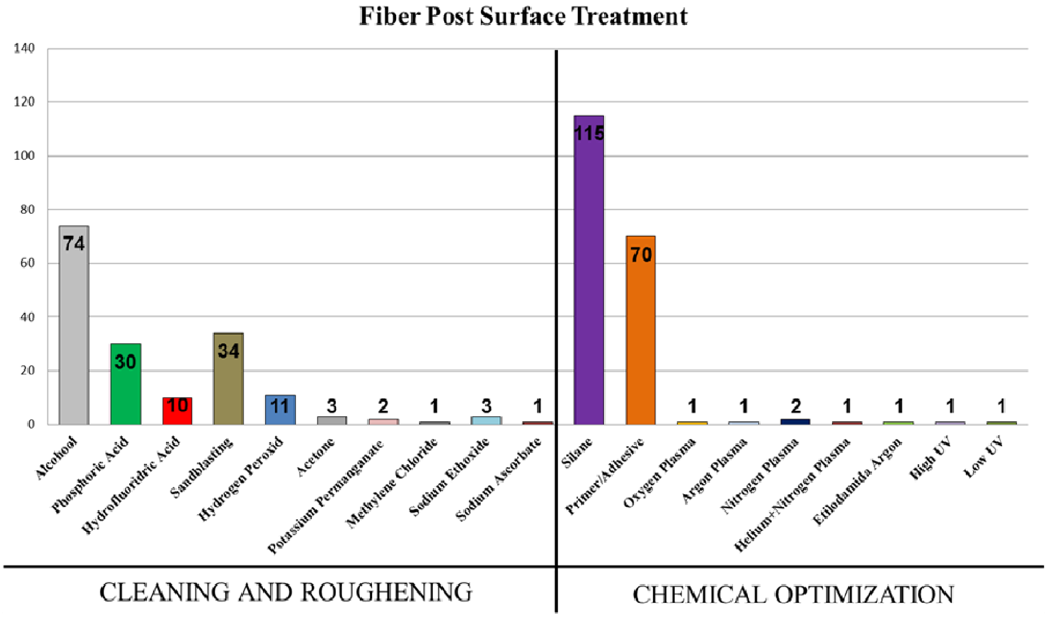

Figure 1. Quantitative analysis of fiber post surface treatments categorized into: cleaning and roughening or chemical optimization protocols.

The findings of the present literature review were discussed in topics according to the main protocols used for surface treatment of fiber posts.

Alcoholic solutions

The use of alcoholic solutions for surface treatment of fiber posts previously to cementation was justified as post cleaning procedures (CLAVIJO et al., 2009; LEITUNE et al., 2010; MUMCU et al., 2010; ERDEMIR et al., 2011; REIS et al., 2011; NOVAIS et al., 2012), which may contribute to degrease post surfaces (SCHMITTER et al., 2007; ESCLASSAN NOIRRIT et al., 2008; SCHMITTER et al., 2011; WATZKE et al., 2011) by removing oils and residues (PELEGRINE et al., 2010). Since alcoholic solutions are employed as cleaning agents, they should be applied prior to any roughening and/or chemical surface treatment. Alcoholic solutions used alone, without subsequent surface treatments, may result in negative consequences for adhesive bonding of fiber posts (JONGSMA et al., 2010; ZHONG et al., 2011). A positive influence of cleaning posts with alcoholic solutions associated to chemical optimization surface treatments (silane coupling or adhesive systems) is noted mainly on the bonding between the post and composite core, with no significant differences observed on the post/dentin interface (RATHKE et al., 2009). No significant differences were detected on bonding when alcoholic solutions were used combined only with post surface roughening (JONGSMA et al., 2010). The use of primers for chemical optimization on the surface treatment of fiber posts presented similar results to the use of alcoholic solutions (BALBOSH et al., 2010), because post surface is consisted of different components, such as resin matrix, inorganic filler particles and glass fibers (BALBOSH; KERN, 2006).

Phosphoric Acid

Most of the manuscripts evaluated did not justify the use of phosphoric acid for post surface treatment, or have supported this fact based on the manufacturer's recommendations. The application of phosphoric acid on fiber posts has similar function to alcoholic solutions, which is, surface cleaning (MALLMANN et al., 2007). As well as alcohol, the use of phosphoric acid alone did not promote any change in the fiber post surface (VALANDRO et al., 2005), neither improves its bonding capability. The use of phosphoric acid combined with roughening surface treatments (CHOI et al., 2010) or chemical optimization presents better results than its use alone (MAGNI et al., 2007). Other surface treatment methods, as sandblasting and hydrofluoric acid etching were shown to be more effective than the use of phosphoric acid, even when combined with chemical optimization (VALANDRO et al., 2006b; D'ARCANGELO et al., 2007a). Moreover, there is no standardization in the concentration and application period, with the most adopted protocol indicating 37% phosphoric acid for 60 s. Although, changings in the etching period can promote effects on the post surface cleaning, as the application of 36% phosphoric acid for 15 s generated similar bonding results to untreated fiber post surfaces (ALBASHAIREH et al., 2010).

Hydrofluoric Acid

The surface treatment of fiber posts using hydrofluoric acid etching works forming micro-spaces between the exposed fibers (D'ARCANGELO et al., 2007a; COSTA DANTAS et al., 2012), being considered controversial. Although the satisfactory bond strength results achieved with this surface treatment, the use of this acid may be aggressive for the post fibers. However, some authors believe that fiber post etching with hydrofluoric acid does not promote increased adhesive retention and damaged fibers, not leading to fractures and modified flexural properties (D'ARCANGELO et al., 2007a). On the other hand, despite the related improvements in bond strength, the use of hydrofluoric acid etching can promote aggressive modification of the surrounding epoxy resin, what can effectively damage the fibers, impairing the physic-mechanical properties of the posts (VALANDRO et al., 2006b; GULER et al., 2012). In addition to these damage possibilities, this surface treatment presents lower bond results compared to other treatments, such as sandblasting (SAHAFI et al., 2003; OHLMANN et al., 2008; SCHMAGE et al., 2009). This variation may be explained due to the non-standardized protocols available, either in acid concentration or application period. The use of aggressive acid solutions should then be avoided to prevent damaging the fibers (MAZZITELLI et al., 2008).

Sandblasting

Sandblasting post surfaces with abrasive particles consists of tribological surface treatment that primarily promotes micro-retentions on the superficial epoxy resin (D'ARCANGELO et al., 2007b). Despite the efficiency of this method in roughening post surface, there is a possibility to damage the post (BALBOSH; KERN, 2006; PRITHVIRAJ et al., 2010; ZICARI et al., 2012). The application of abrasive particles on the surface of posts may promote damages and/or fiber fractures, impairing the physical and mechanical properties of posts (ZICARI et al., 2012). Although sandblasting was shown to not change the mechanical properties of fiber posts, it results in discontinuities between the fibers and even in fractures (SOARES et al., 2008). The abrasion promoted by the particles may result in microstructural damage of the reinforcing fibers and surrounding epoxy resin, affecting the mechanical properties and consequently the clinical performance of fiber posts (VALANDRO et al., 2006). This method can be considered an aggressive surface treatment, because it promotes plastic deformation and volumetric reduction of the posts (ZICARI et al., 2012). However, some authors disagree with this fact, showing that even changing the surface and creating microroughening by exposing fibers, this procedure allows subsequent chemical optimization of post surface, suggesting that the mechanical properties of posts are not deeply affected after sandblasting (VALANDRO et al., 2006; D'ARCANGELO et al., 2007a; MAGNI et al., 2007).

The bond strength verified after sandblasting fiber posts with abrasive particles alone showed that this approach in not the best surface treatment in this sense. When sandblasting was applied in combination with chemical optimization of post surfaces, it promoted lower bonding values as compared to chemical optimization alone (SOARES et al., 2008). However, some studies showed efficient bond strength if sandblasting is associated with other surface treatments, and also when it is compared with other surface roughening treatments (BALBOSH; KERN, 2006; KELSEY et al., 2008; OHLMANN et al., 2008; ALBASHAIREH et al., 2010; PRITHVIRAJ et al., 2010). The sandblasting treatment improves the bond strength immediately after the post cementation; however, this effect is reduced with time (RADOVIC et al., 2007a), probably due to the impact in the mechanical properties of the post.

Hydrogen Peroxide

Etching fiber posts with hydrogen peroxide is considered a surface roughening treatment. Although this method is still not mentioned in a large number of publications, it presents relevant bonding results for fiber posts (YENISEY; KULUNK, 2008; DE SOUSA MENEZES et al., 2011). The etching of fiber posts with hydrogen peroxide acts dissolving and removing partially the superficial epoxy resin matrix, exposing a great number of intact fibers inside the post without damaging them, making fibers available to react with silane coupling agents (chemical optimization) (MANNOCCI et al., 2005; MONTICELLI et al., 2006a; MAZZITELLI et al., 2008; DE SOUSA MENEZES et al., 2011). The selective dissolution of the epoxy resin occurs probably due to the electrophilic attack of hydrogen peroxide (SLOAN, 1992). The spaces created after this surface treatment would promote micromechanical retention of the adhesive resin with the post, and the exposed fibers would be available to chemically react with the adhesive through silane coupling (DE SOUSA MENEZES et al., 2011).

Although good results can be reached by etching fiber posts with hydrogen peroxide, there is no standardization regarding solution concentration and application period. A laboratorial experiment tested the hydrogen peroxide for surface treatment of fiber posts, with concentrations of 24% and 50% and different application periods by post immersion (1 min, 5 min and 10 min). The authors observed that fiber posts immersed in 24% hydrogen for 1 min reached excellent bond strengths, since enough fibers were exposed on the surface without damages, being available for silane coupling. This protocol was sufficient to produce similar bond strengths to higher hydrogen peroxide concentrations or longer application periods, with consequent better clinical applicability (DE SOUSA MENEZES et al., 2011). As hydrogen peroxide is a surface roughening agent, the use of chemical optimization (silane coupling) is required to link the inorganic content of posts with the organic matrix of the adhesive system/resin cement(YENISEY; KULUNK, 2008).

Silane coupling agents

The surface treatment of fiber posts with silane coupling agents is characterized as chemical optimization of the post surface and it works linking the inorganic phase of fiber posts to the organic matrix of adhesive systems/resin cements due to its bifunctional properties (ZICARI et al., 2008), providing increased bond strength (BITTER et al., 2007; BITTER et al., 2008; JONGSMA et al., 2010). Silane coupling was shown to not change adhesion between fiber posts and dentin, but only between the post and composite resin core(RATHKE et al., 2009). The exclusive application of silane agents on the surface of fiber posts resulted in unsatisfactory bond results as compared with different surface roughening treatments (ZICARI et al., 2012). Therefore, silane coupling agents do not improve the bond strength between fiber posts and resin cements (MAGNI et al., 2007; OHLMANN et al., 2008; ZAITTER et al., 2011), unless its application is preceded by fiber exposure through surface roughening treatments (MAGNI et al., 2007). Although, there are studies reporting that silane coupling has no influence on bond strength irrespective of previous treatments (D'ARCANGELO et al., 2007; RADOVIC et al., 2007a), or that silane is more effective when used alone (SOARES et al., 2008).

The temperature of silane agents in the surface treatment of posts is believed to interfere in the quality of adhesion, but this fact is controversial. The application of hot air stream after applying silane agents was showed to not produce changes in the bonding between fiber posts and composite resin core (NOVAIS et al., 2012). However, other studies recommended to volatilize silane agents at 38 °C, justifying that this process promotes condensation of the silane on the post surface, removing some poor absorbed molecules and water-based solutions (MONTICELLI et al., 2006a).

Primer/Adhesive systems

The use of primer and/or adhesive systems for surface treatment of fiber posts is widely indicated by authors, combined or not with other treatments. However, this surface treatment prior to post cementation was reported to not assure significant increase in bond strength values (BALBOSH; KERN, 2006; FERRARI et al., 2006; RADOVIC et al., 2007; ALBASHAIREH et al., 2010). The inefficiency of this surface treatment is justified by the fiber post composition (epoxy resin matrix, inorganic particles and fiberglass particles), which prevents an intimate interaction between the constituents from primer/adhesive systems and fiber posts (BALBOSH; KERN, 2006). On the other hand, the surface treatment of fiber posts with adhesive systems was shown more efficient than when these components are not used (OUNSI et al., 2009). Although expressive positive results are not observed with this approach, the use of adhesive systems as chemical optimization for fiber post surface treatment is recommended because it allows a better adaptation to the post surface than conventional composite resins. The application of composite resins on the post surface without previous treatment with adhesive systems may result in defects along the post/core interface, increasing the risk of micro-cracks and fractures (MONTICELLI et al., 2005). Then, if a high viscosity composite resin will be used to build the core, application of adhesive systems is recommended in order to improve the humectation of the post surface.

Other Post Surface Treatments

Some unusual surface treatments for fiber posts were also described in the literature. Among them, the treatment of posts with acetone works on the principle of cleaning the surface, but it was used previously as a chemical optimization approach (NAUMANN et al., 2007; SIGNORE et al., 2009; SIGNORE et al., 2011). The application of sodium ascorbate is recommended after surface treatment with hydrogen peroxide (OUNSI et al., 2009), because it reduces the negative effect that excessive hydrogen peroxide etching may have on adhesion (LAI et al., 2001).

Other surface roughening approaches such as the application of sodium ethoxide, which removes part of the epoxy resin matrix, resulting in increased surface energy for adhesion (BRORSON, 2001; MAZZITELLI et al., 2008) As well as sodium ethoxide, potassium permanganate presents good results for surface roughening, through partial removal of epoxy-resin matrix, creating micro-retentive spaces (MONTICELLI et al., 2006; MAZZITELLI et al., 2008). Methylene chloride is also a roughening promoter, promoting dissolution of the epoxy resin.

The use of ultra-violet irradiation for surface treatment of fiber posts can also improve the adhesive properties of coatings as well as humectation and printability of polymers, because of its ability to promote changes on the morphology and chemical proprieties of the polymer surface. Ultra-violet irradiation leads to activation of epoxy resin, inducing chemical adhesion with resin cements without destroying the fibers, and is considered a method more effective than silane coupling alone (ZHONG et al., 2011). The surface treatment of fiber posts with plasma can improve the hydrophilicity of epoxy polymers, due to oxygen-containing functional groups (LAI et al., 2001), improving the humectation of the post surface besides chemically modifying its surface (COSTA DANTAS et al., 2012). The type of plasma treatment, and the interaction between the treatments significantly influenced the bonding of fiber posts (YAVIRACH et al., 2009). Oxygen, argon, nitrogen, helium mixed with nitrogen posts (YAVIRACH et al., 2009) and ethylenediamine plasma were verified to improve the adhesion of fiber posts (COSTA DANTAS et al., 2012).

CONCLUSIONS

Surface roughening and chemical optimization procedures are recommended as surface treatments to improve the bonding capability of fiber posts.

The use of aggressive acids and sandblasting should be avoided, since these surface treatments may damage the reinforcing fibers, consequently affecting the mechanical properties of the posts.

Hydrogen peroxide etching for surface roughening followed by chemical optimization with silane coupling was verified as effective surface treatment for fiber posts.

RESUMO: O processo de tratamento da superfície de pinos pré-fabricados de fibra influencia na união entre cimentos resinosos e esses retentores intra-radiculares, sendo relevante para o prognóstico do tratamento restaurador de dentes sem remanescente coronário. Este estudo objetivou avaliar diferentes protocolos de tratamentos de superfície para pinos de fibra descritos na literatura. Como metodologia, realizou levantamento bibliográfico na plataforma PubMed/MEDLINE, com a palavras-chave *fiber post* associada à *adhesion; bonding; surface treatment.* Excluíram-se artigos não redigidos em inglês; que não trataram a superfície do pino; e testes de propriedades físicas-mecânicas. Estudos que trataram a superfície de pinos de fibra de quartzo ou vidro foram incluídos. Dentre os 190 artigos incluídos nesta revisão, o agente silano foi o material mais utilizado (60.52%) para tratamento de superfície de pinos de fibra, seguido pela aplicação de álcool (38.29%), e sistema adesivo (36.84%). O jateamento do pino foi mencionado em 17.89%, mas esta técnica resultou em alteração das propriedades físicas e mecânicas. O peróxido de hidrogênio foi mencionado em 5.78% dos manuscritos, entretanto este tratamento permite a adequada exposição das fibras sem danificá-las. Concluiu-se que não consta na literatura protocolo padrão do tratamento da superfície de pinos de fibra. Dentre os protocolos descritos, o protocolo utilizando peróxido de hidrogênio seguido da aplicação do silano aparece como o mais promissor, pois permite resistência de união aumentada sem promover danos as fibras.

PALAVRAS-CHAVES: Adesão. Peróxido de hidrogênio. Retentores intra-radiculares.

REFERENCES

ALBASHAIREH, Z. S.; GHAZAL, M.; KERN, M. Effects of endodontic post surface treatment, dentin conditioning, and artificial aging on the retention of glass fiber-reinforced composite resin posts. **J Prosthet Dent**, St. Loius, v. 103, n. 1, p. 31-39, 2010.

ASSIF, D.; GORFIL, C. Biomechanical considerations in restoring endodontically treated teeth. **J Prosthet Dent**, St. Loius, v. 71, n. 6, p. 565-567, 1994.

BALBOSH, A.; KERN, M. Effect of surface treatment on retention of glass-fiber endodontic posts. **J Prosthet Dent**, St. Loius, v. 95, n. 3, p. 218-223, 2006.

BITTER, K.; NOETZEL, J.; NEUMANN, K.; KIELBASSA, A. M. Effect of silanization on bond strengths of fiber posts to various resin cements. **Quintessence Int**, Berlin, v. 38, n. 2, p. 121-128, 2007.

BITTER, K.; NEUMANN, K.; KIELBASSA, A. M. Effects of pretreatment and thermocycling on bond strength of resin core materials to various fiber-reinforced composite posts. **J Adhes Dent**, New Malden, v. 10, n. 6, p. 481-489, 2008.

BRORSON, S. H. Deplasticizing or etching of epoxy sections with different concentrations of sodium ethoxide to enhance the immunogold labeling. **Micron**, Oxford, v. 32, n. 2, p. 101-105, 2001.

BUONOCORE, M. G. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. **J Dent Res**, New Malden, v. 34, n. 6, p. 849-853, 1955.

CHOI, Y.; PAE, A.; PARK, E. J.; WRIGHT, R. F. The effect of surface treatment of fiber-reinforced posts on adhesion of a resin-based luting agent. **J Prosthet Dent**, St. Loius, v. 103, n. 6, p. 362-368, 2010.

CHRISTENSEN, G. J. Posts: necessary or unnecessary? **J Am Dent Assoc**, Chicago, v. 127, n. 10, p. 1522-1524, 1526, 1996.

CLAVIJO, V. G.; REIS, J. M.; KABBACH, W.; SILVA, A. L.; OLIVEIRA JUNIOR, O. B.; ANDRADE, M. F. Fracture strength of flared bovine roots restored with different intraradicular posts. **J Appl Oral Sci**, Bauru, v. 17, n. 6, p. 574-578, 2009.

COSTA DANTAS, M. C.; DO PRADO, M.; COSTA, V. S.; GAIOTTE, M. G.; SIMAO, R. A.; BASTIAN, F. L. Comparison between the effect of plasma and chemical treatments on fiber post surface. **J Endod**, Ohio v. 38, n. 2, p. 215-218, 2012.

D'ARCANGELO, C.; D'AMARIO, M.; VADINI, M.; DE ANGELIS, F.; CAPUTI, S. Influence of surface treatments on the flexural properties of fiber posts. **J Endod**, Ohio, v. 33, n. 7, p. 864-867, 2007a.

D'ARCANGELO, C.; D'AMARIO, M.; PROSPERI, G. D.; CINELLI, M.; GIANNONI, M.; CAPUTI, S. Effect of surface treatments on tensile bond strength and on morphology of quartz-fiber posts. **J Endod,** Ohio, v. 33, n. 3, p. 264-267, 2007b.

DE SOUSA MENEZES, M.; QUEIROZ, E. C.; SOARES, P. V.; FARIA-E-SILVA, A. L.; SOARES, C. J.; MARTINS, L. R. Fiber post etching with hydrogen peroxide: effect of concentration and application time. **J Endod**, Ohio, v. 37, n. 3, p. 398-402, 2011.

ERDEMIR, U.; SAR-SANCAKLI, H.; YILDIZ, E.; OZEL, S.; BATUR, B. An in vitro comparison of different adhesive strategies on the micro push-out bond strength of a glass fiber post. **Med Oral Patol Oral Cir Bucal**, Valência, v. 16, n. 4, p. e626-634, 2011.

ESCLASSAN NOIRRIT, E.; GREGOIRE, G.; COURNOT, M. Morphological study of fiber-reinforced post-bonding system-root dentin interface by evaluation of two bonding systems. **J Dent**, Bristol, v. 36, n. 3, p. 204-213, 2008.

FERRARI, M.; GORACCI, C.; SADEK, F. T.; MONTICELLI, F.; TAY, F. R. An investigation of the interfacial strengths of methacrylate resin-based glass fiber post-core buildups. **J Adhes Dent**, New Malden, v. 8, n. 4, p. 239-245, 2006.

FRAZER, R. Q.; KOVARIK, R. E.; CHANCE, K. B.; MITCHELL, R. J. Removal time of fiber posts versus titanium posts. **Am J Dent**, San Antonio, v. 21, n. 3, p. 175-178, 2008.

GOMEZ-POLO, M.; LLIDO, B.; RIVERO, A.; DEL RIO, J.; CELEMIN, A. A 10-year retrospective study of the survival rate of teeth restored with metal prefabricated posts versus cast metal posts and cores. **J Dent**, Bristol, v. 38, n. 11, p. 916-920, 2010.

GULER, A. U.; KURT, M.; DURAN, I.; ULUDAMAR, A.; INAN, O. Effects of different acids and etching times on the bond strength of glass fiber-reinforced composite root canal posts to composite core material. **Quintessence Int**, Berlin, v. 43, n. 1, p. e1-8, 2012.

HORN, H. R. Porcelain laminate veneers bonded to etched enamel. **Dent Clin North Am**, Philadelphia, v. 27, n. 4, p. 671-684, 1983.

JONGSMA, L. A.; KLEVERLAAN, C. J.; FEILZER, A. J. Influence of surface pretreatment of fiber posts on cement delamination. **Dent Mater**, Copenhagen, v. 26, n. 9, p. 901-907, 2010.

KELSEY, W. P., 3RD; LATTA, M. A.; KELSEY, M. R. A comparison of the retention of three endodontic dowel systems following different surface treatments. **J Prosthodont**, Philadelphia, v. 17, n. 4, p. 269-273, 2008.

LAI, J.; SUNDERLAND, B.; XUE, J.; YAN, S.; ZHAO, W.; FOLKARD, M.; MICHAEL, B. D.; WANG, Y. Study on hydrophilicity of polymer surfaces improved by plasma treatment. **Appl Surf Sci**, Netherlands, v. 252, n., p. 3375-3379, 2006.

LAI, S. C.; MAK, Y. F.; CHEUNG, G. S.; OSORIO, R.; TOLEDANO, M.; CARVALHO, R. M.; TAY, F. R.; PASHLEY, D. H. Reversal of compromised bonding to oxidized etched dentin. **J Dent Res**, Chicago, v. 80, n. 10, p. 1919-1924, 2001.

LANZA, A.; AVERSA, R.; RENGO, S.; APICELLA, D.; APICELLA, A. 3D FEA of cemented steel, glass and carbon posts in a maxillary incisor. **Dent Mater**, Copenhagen, v. 21, n. 8, p. 709-715, 2005.

LEITUNE, V. C.; COLLARES, F. M.; WERNER SAMUEL, S. M. Influence of chlorhexidine application at longitudinal push-out bond strength of fiber posts. **Oral Surg Oral Med Oral Pathol Oral Radiol Endod**, Sant Loius, v. 110, n. 5, p. e77-81, 2010.

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**, New Malden, v. 9, n. 2, p. 195-202, 2007.

MALFERRARI, S.; MONACO, C.; SCOTTI, R. Clinical evaluation of teeth restored with quartz fiber-reinforced epoxy resin posts. **Int J Prosthodont**, v. 16, n. 1, p. 39-44, 2003.

MALLMANN, A.; JACQUES, L. B.; VALANDRO, L. F.; MUENCH, A. Microtensile bond strength of photoactivated and autopolymerized adhesive systems to root dentin using translucent and opaque fiber-reinforced composite posts. **J Prosthet Dent**, St. Loius, v. 97, n. 3, p. 165-172, 2007.

MANNOCCI, F.; SHERRIFF, M.; WATSON, T. F.; VALLITTU, P. K. Penetration of bonding resins into fibre-reinforced composite posts: a confocal microscopic study. **Int Endod J**, Malden, v. 38, n. 1, p. 46-51, 2005.

MAZZITELLI, C.; FERRARI, M.; TOLEDANO, M.; OSORIO, E.; MONTICELLI, F.; OSORIO, R. Surface roughness analysis of fiber post conditioning processes. **J Dent Res**, Chicago, v. 87, n. 2, p. 186-190, 2008.

MONTICELLI, F.; GORACCI, C.; GRANDINI, S.; GARCIA-GODOY, F.; FERRARI, M. Scanning electron microscopic evaluation of fiber post-resin core units built up with different resin composites. **Am J Dent**, San Antonio, v. 18, n. 1, p. 61-65, 2005.

MONTICELLI, F.; TOLEDANO, M.; OSORIO, R.; FERRARI, M. Effect of temperature on the silane coupling agents when bonding core resin to quartz fiber posts. **Dent Mater**, Copenhagen, v. 22, n. 11, p. 1024-1028, 2006a.

MONTICELLI, F.; TOLEDANO, M.; TAY, F. R.; CURY, A. H.; GORACCI, C.; FERRARI, M. Post-surface conditioning improves interfacial adhesion in post/core restorations. **Dent Mater**, Copenhagen, v. 22, n. 7, p. 602-609, 2006b.

MUMCU, E.; ERDEMIR, U.; TOPCU, F. T. Comparison of micro push-out bond strengths of two fiber posts luted using simplified adhesive approaches. **Dent Mater**, Copenhagen, v. 29, n. 3, p. 286-296, 2010.

NAKABAYASHI, N.; NAKAMURA, M.; YASUDA, N. Hybrid layer as a dentin-bonding mechanism. **J Esthet Dent**, Philadelphia, v. 3, n. 4, p. 133-138, 1991.

NAUMANN, M.; STERZENBAC, G.; ALEXANDRA, F.; DIETRICH, T. Randomized controlled clinical pilot trial of titanium vs. glass fiber prefabricated posts: preliminary results after up to 3 years. **Int J Prosthodont**, v. 20, n. 5, p. 499-503, 2007.

NOVAIS, V. R.; SIMAMOTOS JUNIOR, P. C.; RONTANI, R. M.; CORRER-SOBRINHO, L.; SOARES, C. J. Bond strength between fiber posts and composite resin core: influence of temperature on silane coupling agents. **Braz Dent J**, Ribeirão Preto, v. 23, n. 1, p. 8-14, 2012.

OHLMANN, B.; FICKENSCHER, F.; DREYHAUPT, J.; RAMMELSBERG, P.; GABBERT, O.; SCHMITTER, M. The effect of two luting agents, pretreatment of the post, and pretreatment of the canal dentin on the retention of fiber-reinforced composite posts. **J Dent**, Bristol, v. 36, n. 1, p. 87-92, 2008.

OUNSI, H. F.; SALAMEH, Z.; CARVALHO, C. A.; CANTORO, A.; GRANDINI, S.; FERRARI, M. Bond strength of composite core build-up materials to fiber-reinforced posts: a microtensile comparison between conventional and wet-ethanol bonding systems. **J Adhes Dent**, New Malden, v. 11, n. 5, p. 375-380, 2009.

OZCAN, M.; VALLITTU, P. K. Effect of surface conditioning methods on the bond strength of luting cement to ceramics. **Dent Mater**, Copenhagen, v. 19, n. 8, p. 725-731, 2003.

PELEGRINE, R. A.; DE MARTIN, A. S.; CUNHA, R. S.; PELEGRINE, A. A.; DA SILVEIRA BUENO, C. E. Influence of chemical irrigants on the tensile bond strength of an adhesive system used to cement glass fiber posts to root dentin. **Oral Surg Oral Med Oral Pathol Oral Radiol Endod**, Sant Loius, v. 110, n. 5, p. e73-76, 2010.

PRITHVIRAJ, D. R.; SONI, R.; RAMASWAMY, S.; SHRUTHI, D. P. Evaluation of the effect of different surface treatments on the retention of posts: a laboratory study. **Indian J Dent Res**, Ahmedabad, v. 21, n. 2, p. 201-206, 2010.

RADOVIC, I.; MONTICELLI, F.; PAPACCHINI, F.; MAGNI, E.; CURY, A. H.; VULICEVIC, Z. R.; FERRARI, M. Accelerated aging of adhesive-mediated fiber post-resin composite bonds: A modeling approach. **J Dent**, Bristol, v. 35, n. 8, p. 683-689, 2007a.

RADOVIC, I.; MONTICELLI, F.; GORACCI, C.; CURY, A. H.; CONIGLIO, I.; VULICEVIC, Z. R.; GARCIA-GODOY, F.; FERRARI, M. The effect of sandblasting on adhesion of a dual-cured resin composite to methacrylic fiber posts: microtensile bond strength and SEM evaluation. **J Dent**, Bristol, v. 35, n. 6, p. 496-502, 2007b.

RATHKE, A.; HAJ-OMER, D.; MUCHE, R.; HALLER, B. Effectiveness of bonding fiber posts to root canals and composite core build-ups. **Eur J Oral Sci**, Copenhagen, v. 117, n. 5, p. 604-610, 2009.

REIS, K. R.; SPYRIDES, G. M.; OLIVEIRA, J. A.; JNOUB, A. A.; DIAS, K. R.; BONFANTES, G. Effect of cement type and water storage time on the push-out bond strength of a glass fiber post. **Braz Dent J**, Ribeirão Preto, v. 22, n. 5, p. 359-364, 2011.

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**, New Malden, v. 5, n. 2, p. 153-162, 2003.

SANTOS-FILHO, P. C.; CASTRO, C. G.; SILVA, G. R.; CAMPOS, R. E.; SOARES, C. J. Effects of post system and length on the strain and fracture resistance of root filled bovine teeth. **Int Endod J**, Malden, v. 41, n. 6, p. 493-501, 2008.

SCHMAGE, P.; CAKIR, F. Y.; NERGIZ, I.; PFEIFFER, P. Effect of surface conditioning on the retentive bond strengths of fiberreinforced composite posts. **J Prosthet Dent**, St Loius, v. 102, n. 6, p. 368-377, 2009.

SCHMITTER, M.; RAMMELSBERG, P.; GABBERT, O.; OHLMANN, B. Influence of clinical baseline findings on the survival of 2 post systems: a randomized clinical trial. **Int J Prosthodont**, v. 20, n. 2, p. 173-178, 2007.

SCHMITTER, M.; HAMADI, K.; RAMMELSBERG, P. Survival of two post systems--five-year results of a randomized clinical trial. **Quintessence Int**, Berlin, v. 42, n. 10, p. 843-850, 2011.

SIGNORE, A.; BENEDICENTI, S.; KAITSAS, V.; BARONE, M.; ANGIERO, F.; RAVERA, G. Long-term survival of endodontically treated, maxillary anterior teeth restored with either tapered or parallel-sided glass-fiber posts and full-ceramic crown coverage. **J Dent**, Bristol, v. 37, n. 2, p. 115-121, 2009.

SIGNORE, A.; KAITSAS, V.; RAVERA, G.; ANGIERO, F.; BENEDICENTI, S. Clinical evaluation of an oval-shaped prefabricated glass fiber post in endodontically treated premolars presenting an oval root canal cross-section: a retrospective cohort study. **Int J Prosthodont**, v. 24, n. 3, p. 255-263, 2011.

SLOAN, F. E. Chemical attack of graphite/epoxy by hydrogen peroxide. **Appl Spectrosc**, Plainfield v. 46, n., p. 524–528, 1992.

SOARES, C. J.; SANTANA, F. R.; PEREIRA, J. C.; ARAUJO, T. S.; MENEZES, M. S. Influence of airborne-particle abrasion on mechanical properties and bond strength of carbon/epoxy and glass/bis-GMA fiber-reinforced resin posts. **J Prosthet Dent**, St Loius, v. 99, n. 6, p. 444-454, 2008.

SOARES, P. V.; SANTOS-FILHO, P. C.; QUEIROZ, E. C.; ARAUJO, T. C.; CAMPOS, R. E.; ARAUJO, C. A.; SOARES, C. J. Fracture resistance and stress distribution in endodontically treated maxillary premolars restored with composite resin. **J Prosthodont**, Philadelphia, v. 17, n. 2, p. 114-119, 2008.

THOMPSON, V. P. Etching of cobalt/chrome alloys for Maryland bridges. **Trends Tech Contemp Dent Lab**, United States, v. 1, n. 2, p. 41-46, 1984.

VALANDRO, L. F.; FILHO, O. D.; VALERA, M. C.; DE ARAUJO, M. A. The effect of adhesive systems on the pullout strength of a fiberglass-reinforced composite post system in bovine teeth. **J Adhes Dent**, New Malden, v. 7, n. 4, p. 331-336, 2005.

VALANDRO, L. F.; OZCAN, M.; DE MELO, R. M.; GALHANO, G. A.; BALDISSARA, P.; SCOTTI, R.; BOTTINO, M. A. Effect of silica coating on flexural strength of fiber posts. **Int J Prosthodont**, United States, v. 19, n. 1, p. 74-76, 2006a.

VALANDRO, L. F.; YOSHIGA, S.; DE MELO, R. M.; GALHANO, G. A.; MALLMANN, A.; MARINHO, C. P.; BOTTINO, M. A. Microtensile bond strength between a quartz fiber post and a resin cement: effect of post surface conditioning. **J Adhes Dent**, New Malden, v. 8, n. 2, p. 105-111, 2006b.

WATZKE, R.; FRANKENBERGER, R.; NAUMANN, M. Different scanning electron microscopic evaluation methods of cement interface homogeneity of adhesively luted glass fiber posts. **Acta Odontol Scand**, London, v. 69, n. 2, p. 101-107, 2011.

YAVIRACH, P.; CHAIJAREENONT, P.; BOONYAWAN, D.; PATTAMAPUN, K.; TUNMA, S.; TAKAHASHI, H.; ARKSORNNUKIT, M. Effects of plasma treatment on the shear bond strength between fiber-reinforced composite posts and resin composite for core build-up. **Dent Mater**, Copenhagen, v. 28, n. 6, p. 686-692, 2009.

YENISEY, M.; KULUNK, S. Effects of chemical surface treatments of quartz and glass fiber posts on the retention of a composite resin. **J Prosthet Dent**, St Loius, v. 99, n. 1, p. 38-45, 2008.

ZAITTER, S.; SOUSA-NETO, M. D.; ROPERTO, R. C.; SILVA-SOUSA, Y. T.; EL-MOWAFY, O. Microtensile bond strength of glass fiber posts cemented with self-adhesive and self-etching resin cements. **J Adhes Dent**, New Malden, v. 13, n. 1, p. 55-59, 2011.

ZHONG, B.; ZHANG, Y.; ZHOU, J.; CHEN, L.; LI, D.; TAN, J. UV irradiation improves the bond strength of resin cement to fiber posts. **Dent Mater**, Copenhagen, v. 30, n. 4, p. 455-460, 2011.

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**, Copenhagen, v. 24, n. 7, p. 967-977, 2008.

ZICARI, F.; DE MUNCK, J.; SCOTTI, R.; NAERT, I.; VAN MEERBEEK, B. Factors affecting the cement-post interface. **Dent Mater**, Copenhagen, v. 28, n. 3, p. 287-297, 2012.