EFFECT OF TIME AND LIGHT INTENSITY ON THE ADHESION BETWEEN FIBER POSTS AND ROOT DENTIN: A LITERATURE REVIEW

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ABSTRACT:

The characteristics involved in the mechanism of adhesion between fiber post, cementum and root dentin have been extensively studied in different approaches, including treatments on the surface of the post and/or dentine, characteristics of the intraradicular fiber post and also the materials used for its cementation. However, the adhesion depends directly on the polymerization and degree of conversion of the resinous monomers, which are related to the transmission of light through the root canal. Studies that evaluated the amount of light energy transmitted to the root canal found a significant reduction with the increase in depth, where even without the post, the light intensity seems to decrease to insufficient levels for adequate polymerization, especially in the apical third. To overcome these problems, professionals were advised to use a high-intensity light unit and/or prolong the time of exposure to light. In view of the above, it is important to identify how much irradiated light density and time can influence the adhesive properties in restorations with translucent post on pulped teeth.

KEYWORDS:

Polymerization. Fiber posts. Root dentin.

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DOI: https://doi.org/10.14436/2447-911x.15.2.034-043.oar

INTRODUCTION

Fiber posts are commonly the choice for restorations of endodontically treated teeth with great structural loss[1-2], and this is due to the properties of fiber posts, such as: better stress distribution and modulus of elasticity,[3] and adhesion to the wall of the root canal[2].

Intracanal restorations with composite resin and translucent fiber posts should have excellent bond strength to root dentin.[4] However, adhesion is still one of the most critical factors for the success and clinical performance of restorative endodontic treatment[2].

Goracci and Ferrari[2] affirm that several factors related to endodontic treatment — such as the root canal shape, the preparation to receive the post, its choice, handling and polymerization — may influence the result of the bonding process between post-cement-root dentin and, because of this, in bond strength tests, the most commonly occurring type of failure is between the adhesive layer and dentin, with adhesion to apical dentin being the most concearning[5-7].

The introduction of translucent fiber posts brought some advantages in its adhesion to the root canal, due to its main characteristic of transmitting light along the canal[8]. However, the transmission of light through this translucent post shows a significant decrease in the amount of light reaching the apical portion of the canal, which may influence the efficiency of polymerization in root canal depth[9].

Together with the ability of the post to transmit light, attention must still be paid to the choice of the adhesive system and resin cement, preferably of chemical or dual activation, due to the difficulty of direct irradiation of the light in the deep regions of the root canal.[10] For this reason the optical behavior of the posts is taken into account by several authors[11-13].

In relation to the choice of dual-curing adhesive in the cementation of intraradicular posts, Goracci et al[14] demonstrated that there is no real creation of adhesive continuity between cement and dentin, thus impairing bond strength in all root thirds[15]. Akgungor and Akkayan[16] also demonstrated that the dual-curing of the adhesive system did not increase bond strength values.

Some researches relate methods using fiber post with cements and dual-curing adhesives with different times of photopolymerization to improve root canal adhesion[4,17-18], showing that the increase of the light exposure time may improve some properties such as: cement hardness, degree of conversion and the bond strength of the adhesive-post-root dentin complex[17,19-20].

Therefore, the purpose of this literature review was to help clinicians improve their understanding of the effect of time and light intensity on adhesion between fiber post and root dentin.

METHODS

For the development of this study, we searched the databases Pubmed and *Periódicos Capes* (Bireme) using as search terms: Polymerization; fiber posts; root dentin. Of the articles suggested by the search, 61 were selected, which were read and summarized so that the study was developed. Textbooks on the subject were also used. The exclusion criteria were editorials, pilot studies, historical reviews and studies that did not address fiber posts and light intensity; and the inclusion criteria were clinical studies, *in vitro* studies, *in vivo* studies that addressed fiber post and light intensity.

LITERATURE REVIEW

Endodontically treated teeth with major coronary destruction require intraradicular posts with the main objective of promoting retention of the restoration.[21] However, a number of biomechanical requirements is needed in order to ensure success in restorative treatment. These factors include: location of the tooth in the buccal cavity, amount of remaining dental tissue, remaining root condition, aesthetics, occlusion, tooth function in the arch, canal configuration, intraradicular post length, post diameter, post shape, amount of bone support, periodontal condition, type of restoration and the final effect that the crowns have on the distribution of force to the remaining tissues[22-24].

Several techniques and materials were proposed for restoration of teeth with endodontic treatment[25]. The professional can opt for the placement of a metallic post —which has been used for decades, demonstrating efficiency for clinical use in restorations of pulped teeth with great loss of dental structure and in elliptical or excessively conical channels[26], because it is tailor-made to adapt to the canal, with its coronary and radicular portion being fused together, showing good longevity results —;[27] or for a prefabricated metal post, where only one diameter of the post is tested to adequately fills the root canal, and the coronary nucleus is constructed with a material applied directly over the post and remaining tooth. As these posts had no mechanical properties similar to the root canal, they increased the risk of root fracture, were difficult to remove and, because they were metallic, the aesthetic result was unsatisfactory, besides not providing any light transmission, a fundamental fact for the intraradicular environment. Depending on the metal alloy used, problems could also occur with respect to biocompatibility, due to the corrosion of some types of alloys[2]. These disadvantages led to the development of new materials that were similar in color to the tooth structure and did not interfere with the transmission of light, in order to make the final work even more imperceptible.

The fiber reinforced posts were introduced into the dental market in the early 90's, proposing a new concept of restorative system for pulped teeth, consisting of post, cement, reconstruction material and dentin, forming the "monoblock", a mechanically homogeneous structural complex, with the ability to adhere to one another[28]. From that time on, non-metallic prefabricated post became popular and a wide variety of systems became available in the dental market: ceramic, carbon fiber, fiberglass, quartz fiber, among others types of posts.[22]

In the attempt to improve the properties of the aesthetic post, the fiberglass post was developed, a composite structure of longitudinal glass fibers enveloped by a polymeric matrix of epoxy resin and inorganic particles[22-23,27,29]. These posts offer aesthetic advantages without sacrificing the functional part, which has led to overcome certain limitations of the other posts — such as ceramic posts, which present difficulties of adhesion; carbon fibers posts, which are opaque; and quartz fiber posts, which have high cost[22,30].

The fiberglass posts can be made of different types of glass, having a modulus of elasticity similar to that of dentin, and dissipating tensions homogeneously through the restorative set, without areas of concentration[2,27]; are easy to remove[31], have shorter working time[32], ability to be cemented with adhesives[8] and resistance to fracture[33]. Basically, they can be classified by the type of fiber that composes them, surface configuration, format and translucency[2,34-35]. Despite all these characteristics, the first fiberglass posts developed were not translucent and, therefore, the use of special resin cements was required.

According to the mode of polymerization, there are three types of resin cements: chemical curing, light curing and dual curing. The chemical curing cements guarantee the polymerization independent of the depth of the root canal, since it is independent of the light; however, present worse handling characteristics due to the absence of control of polymerization time, which can be harmful in the case of post cementation. The light-curing cements do not present this disadvantage, however, they need light for complete polymerization. Thus, the dual-curing cement were developed, in order to obtain a material with better control and longer working time and ability to obtain a high degree of conversion even in the absence of light, thus reconciling the advantages of both cements[36].

Basically, in dual-curing cement, the curing reaction occurs through a chemical process between the base and catalyst pastes, and can be accelerated in the presence of light, so it is safer in cases where there are deep areas in which the access of light is compromised[37], but also ensures immediate polymerization in the cervical third, where the light reaches, creating an immediate bonding of the post with the root canal.

Regarding the cementation of the fiberglass post, it must be done by adhesive technique, with adhesive system associated with resin cement[29], using conventional or self-etching adhesive systems[38]. However, in a recent literature review, Goracci et al[2] indicated that the most reliable results in relation to fiberglass post cementation are obtained by the combination of conventional adhesive systems with dual resin cement[2,24].

But in the same way as for cements, dual-curing adhesive have been the most frequent recommendation. However, the most commonly used adhesives in the Brazilian market are the simplified conventional adhesives and, unfortunately, these materials have incompatibility (chemical and physical)[39-40] and consequent failure of adhesion of aesthetic posts, clinically causing premature failure[27,41].

The chemical incompatibility between the simplified adhesives and dual resin cement occurs due to the formation of the oxygen-inhibited layer, common to all polymeric materials, associated with the low pH of simplified adhesives[42]. Chemical activation and dual activation cements that have not been exposed to light polymerize by an acid-base reaction between benzoyl peroxide and the tertiary amine through the formation of free radicals. When these materials come into contact with the dental surface on which a simplified adhesive system was applied, there is no adequate polymerization of the resin cement layer in contact with the adhesive[43]. The formation of an oxygen-inhibited layer, rich in unpolymerized acidic monomers that become electron receptors[44], interacts with the electron-donor tertiary amine, degrading it by means of a acid-base reaction, with quaternary ammonium formation[45]. In addition, the acidic monomers also react with the benzoyl peroxide, generating CO_2. In this way, the mechanism that guides the polymerization of this type of cement is prevented and/or decreased.

The unreacted monomer layer caused by oxygen also influences what is called physical incompatibility. The large amount of unreacted ions in the adhesive surface layer (inhibited layer) forms a hypertonic layer in relation to the dentin and this, by difference in the osmotic gradient, induces movement of the dentin water towards the adhesive/cement interface, causing the weakening of the interface between these two materials[45].

In addition, the higher permeability of simplified two-step adhesives, due to the high amount of hydrophilic monomers and the smaller thickness of the formed adhesive layer, is the other factor responsible for the physical incompatibility of simplified adhesives and dual resin cements. The higher amount of acidic and hydrophilic monomers in the composition of the simplified adhesives leads to greater absorption of water from the external medium and dentin. These fluids are absorbed by the adhesive film, causing what is conventionally called water-trees. This deposition of water on the surface of the adhesive becomes a physical impediment that compromises adhesion to dentin[45,46]. This phenomenon is mainly observed with dual curing resin cements, due to their slow onset of polymerization (2-3 minutes leading to a long pre-gel phase) or when the initial light-curing is delayed or the light of the light-curing unit is incapable to reach the material in the right way[42,47].

Even though chemically activated adhesives/cements have been suggested, some researchers suggest that only chemical polymerization is not enough to achieve maximum cure. When the resin cement is not adequately polymerized, both the clinical and biological properties of the restoration and cementation may be affected[11]. Due to all these problems, several manufacturers started working on several fronts aiming at improving the polymerization of the adhesive/cement set within the root canal, especially in the apical region. However, it is worth mentioning that stable adhesion to intraradicular dentin, especially at the apical level, is a clinical challenge, due to the negative influence of several drugs and irrigators that can negatively affect cementation adhesion, including sodium hypochlorite, EDTA, hydrogen peroxide, as well as calcium hydroxide and eugenol, altering the structure of the dentin or interfering in the polymerization[2,24].

Another factor that may compromise intraradicular adhesion is the configuration factor (factor C)[48]. Tay et al[49] evaluated the geometric factors that may affect dentin adhesion within the root canals, and concluded that a high C-factor becomes the major obstacle for free intraradicular adhesions, since the tensions generated by the polymerization contraction may exceed the bond strength in the root dentin, thus allowing the rupture of one side in order to relax the stresses, reducing the retention and consequently increasing the infiltration.

In other studies, the adhesive interfaces of glass fiber intraradicular post and root dentin were evaluated using photo curing, chemical curing or dual curing adhesive systems associated with chemical or dual polymerization resin cements. The apical third showed to be the most critical substrate in relation to the criteria evaluated, for all the associations between the materials used, being in general, directly related to the obtained polymerization pattern, that is, the polymerization reaction of the resin cements and adhesives produces direct effects on the quality of the post/dentin adhesive interface[18]. Carvalho et al[50] mentioned some resources to be used to minimize the limitation of light access, among which: light transmitting devices, high power devices and long exposure time.

Without doubt, the most interesting technique, regarding the attempt of polymerization within the intraradicular environment, was the development of fiberglass posts that allowed the transmission of light to the apical region. Thus, translucent post were created, which, according to the manufacturer, allow the passage of light through their interior, allowing photoactivated materials to be polymerized within the root canal[51,52]. Some studies have evaluated the light transmission capacity of these posts and observed that there is better light transmission from the translucent posts, when compared to the opaque posts; however, there is a decrease in the amount of light in the apical direction[51,53,54].

The use of light transmission by the fiber post is necessary for the activation of light-curing cement agents, recommended with the use of some dual-curing cements, which have been mentioned because they reach inadequate conversion degrees in the absence of light[12,55,56]. However, the transmission of light through this translucent post shows a significant decrease in the amount of light reaching the apical portion of the canal, which may influence the effectiveness of the polymerization in the depth of the root canal[9,12].

The increase in polymerization time is an alternative for conventional restorations in restorative dentistry, as a way to improve the degree of conversion of the adhesive layer[57]. The results of studies in this regard indicated that increasing the polymerization time of the adhesive from 20 to 60 seconds generated a significant improvement in the degree of conversion of the adhesive layer.

Following this alternative of increasing the polymerization time, several studies evaluated the polymerization of dual-curing resin cements under different light intensities[20,58,59] and activation times[9,12,20,33,60] using translucent posts, demonstrating an increase of light reaching the root apex, also improving properties such as modulus of elasticity[37], toughness[17] and bond strength[4,20].

Bahari et al.[61] evaluated the effect of different luminous intensities on the degree of conversion of dual-curing resin cement in different depths of translucent fiber posts and concluded that, compared to the light intensity of 600 mW/cm^2, the light intensity of 800 mW/cm^2 significantly increased the degree of conversion of the dual-curing resin cement in the apical region.

Szesz et al.[20] evaluated the effect of different light exposure values delivered to two simplified etch-and-rinse adhesive systems on shear bond strength of fiber posts to root canal, as well as nanoleakage and *in situ* degree of conversion within the hybrid layer, and concluded that the increase in light exposure delivered to the cervical third of root canals during post cementation improved the

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adhesive performance of simplified etch-and-rinse adhesive systems in the apical and middle thirds.

A recent study by Camilotti et al[54] in the area of physics confirmed the amount of light passing through a glass fiber post. In the present study, it was observed that there is a difference in light dispersion, revealing that 45.5% of the light intensity reaches the coronal level, 14.2% for the medium level, and 5.3% for the apical level. The explanation for the above result is the diffuse reflection at the post/air interface, and the same process explains the increasing intensity of light dispersed at the coronary level.

Regarding the factors related to the variation in intensity of light incident on the fiber post, it was also verified that there is a correlation with the studies already mentioned, because when different light intensities were simulated in this experiment, it was demonstrated that a gain is obtained in the luminous intensity in the apical region by simply increasing the intensity of light of the source of excitation, being similar to the pattern of intensity variation tested in the present studies.

CONCLUSION

The results of the studies selected for this review demonstrated that the light transmission in the root third is critical, compromising the polymerization performance in this region, in the cementation of fiberglass posts. But the use of translucent fiber posts and the increase in light intensity and photoactivation time can improve the bond strength values and the degree of conversion of the dual-curing resin cements and adhesive systems at the root third.

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How to cite: Borges GA, Martins LC, Ferraz AGB, Szesz AL, Valentino TA, Borges LH, Calabrez-Filho S. Effect of time and light intensity on the adhesion between fiber posts and root dentin: A literature review. J Clin Dent Res. 2018 May-Aug;15(2):34-43.

Submitted: April 26, 2018 - Revised and accepted: July 18, 2018.

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