UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU

MAURO ELISBAN DIAZ MAMANI

**Effect of ultrasound on bond strength and penetration of resin and
ionomeric cements used for fiberglass post cementation**

**Efeito do ultrassom na resistência adesiva e penetração de cimentos
resinosos e ionoméricos utilizados na cimentação de pinos de fibra de vidro**

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apoio em cada dia.*

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ABSTRACT

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Effect of ultrasound on bond strength and penetration of resin and ionomeric cements used for fiberglass post cementation

Objective: The objective of this study was to evaluate the bond strength of fiberglass posts (Exacto N° 2[®]) cemented with resin cement (RC) and resin modified glass ionomer cement (RMGI), with and without ultrasonic activation in the root canal of bovine teeth. The penetration of the cements into dentine tubules was also assessed. **Methods:** Forty bovine incisors were selected and endodontically treated, and then divided into 4 groups (n = 10). Fiberglass posts were cemented with RC and RMGI and activated with an ultrasound insert in 2 groups; the other two groups received no ultrasonic activation. After 1 week of cementation, the roots were sectioned into 9 slices of approximately 1,5 mm each. Confocal microscopy and push-out test were performed, and all specimens were subjected to 200x magnification optical microscopy for mode of failure evaluation. Statistical analysis was done with three-way ANOVA, followed by the Fisher's test ($\alpha = 0.05$). **Results:** There was no difference among the root thirds in the RMGI group while a difference was found among the thirds in the RC group. In addition, the bond strength of the RC group was higher than the RMGI group, in all thirds. The RC also showed a greater penetration than the RMGI, in all thirds, with and without activation. The ultrasound activation caused a greater penetration only in the cervical and middle thirds in the RMGI group, and in the middle third of the RC group. **Conclusion:** The RC presented higher bond strength and penetration compared to the RMGI and ultrasonic activation improved the penetration of the RMGI cement in the middle and cervical root thirds and of the RC in the middle root third. A significant correlation between bond strength and penetration was verified in all groups. **Clinical relevance:** Ultrasound can promote a better penetration of resin cements used in fiberglass post cementation, reaching the most difficult anatomical areas in the root canal.

Key words: Confocal microscopy. Fiberglass post. Resin cements. Push Out. Ultrasound.

RESUMO

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Efeito do ultrassom na resistência adesiva e penetração de cimentos resinosos e ionoméricos utilizados na cimentação de pinos de fibra de vidro

Objetivo: O objetivo deste estudo foi avaliar a resistência de união de pinos de fibra de vidro (Exacto N°2 ®) com e sem ativação ultrassônica, associado a dois materiais: cimento resinoso (CR) e cimento ionomérico modificado com resina (CIMR), nos terços radiculares através de teste “push-out” e de Microscopia Confocal para avaliar a penetração dos cimentos. Métodos: Quarenta incisivos bovinos foram selecionados e tratados endodonticamente, depois divididos em 4 grupos (n=10): em dois grupos os pinos de fibra de vidro foram cimentados com CR e CIMR, e ativados com um inserto de ultrassom; nos outros dois grupos não foi realizada ativação ultrassônica. Após 1 semana da cimentação, as raízes foram seccionadas em 9 fatias de aproximadamente 1,5 mm cada. A microscopia confocal e o teste “push-out” foi realizado, e todos os espécimes foram submetidos a microscopia óptica com 200 vezes de aumento para avaliação do módulo de falha. Os valores de resistência de união (RU) foram submetidos a ANOVA a três critérios, seguido de Fisher ($\alpha = 0.05$). Resultados. Os resultados deste estudo em relação a resistência de união, mostrou que não houve diferença entre os terços no CIMR e houve diferença entre os terços no cimento CR, além disso os valores de resistência de união dos espécimes do cimento CR foram acima dos espécimes do cimento CIMR e essa diferença se repete para todos os terços. Com relação a penetração na comparação dos materiais, o CR mostrou sempre apresentar uma penetração maior do que o cimento CIMR, em todos os terços com e sem ativação. Com relação a ativação verificou-se que a ativação com o ultrassom apresentou maior penetração somente no terço cervical e médio no cimento CIMR, e no CR no terço médio. Conclusão: O CR apresentou melhor resistência de união e penetração, em comparação com o cimento CIMR e que a ativação com ultrassom melhorou a penetração do terço médio e cervical no cimento CIMR e Terço médio no cimento CR além de isso tem uma correlação importante que a maior área de penetração maior resistência de união. Relevância Clínica: o uso do ultrassom pode promover uma melhor penetração dos cimentos resinosos para a cimentação de pinos fibras de vidro intracanal, alcançando as áreas anatômicas mais difíceis dentro do canal radicular.

Palavras-chave: Microscopia Confocal. Pino de fibra de vidro. Cimentos resinosos. Push out. Ultrassom.

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1 INTRODUCTION

1 INTRODUCTION

Preventive and conservative procedures have been increasingly emphasized in dentistry, indicating that despite the evolution of restorative materials, the dental structure remains irreplaceable. This philosophy has influenced all restorative techniques, including teeth extensively destroyed, in which restorations should conserve as much as possible the remaining tooth structure (ALBUQUERQUE, 1996).

The literature informs that restorations of endodontically treated teeth deserve special care because the biomechanical and morphologic changes caused by the endodontic treatment lead to a more fragile tooth structure (SEDGLEY and MESSER, 1992). The causes for endodontic treatment failures include extensive caries, fractures, trauma, iatrogenicities, pulp pathologies and the endodontic treatment itself (SCHWARTZ and ROBINS, 2004; DE ALMEIDA GONÇALVES et al., 2006).

A rapid, simple and effective way to place a crown in an endodontically treated tooth is by using anchored fiberglass posts (CURY et al., 2006; KANKAN et al., 2006). A fiber post is defined as a segment of the dental restoration that can be placed inside the root canal with the purpose of retaining and stabilizing a crown (MONDELLI et al., 2001). In addition to retaining the coronary portion of the restoration, the post prevents fracture of the tooth that has been endodontically treated, providing support and internal resistance (HENOSTROZA, 2010).

An advantage of the fiberglass post is the masticatory stress distribution under a wide surface area, increasing the load level and reducing root fractures (SCHWARTZ et al, 2004; GONÇALVES DE ALMEIDA et al., 2006). Some studies indicate that the root canal treatment can be influenced by previous posts, type of dentin of the root canal, type of resin cement and dental adhesives used, and the cementation line (ASMUSSEN et al., 1999; AKKAYAN and GÜLMEZ, 2002; SCHWARTZ and ROBINS, 2004; GORACCI et al., 2005; CURY et al., 2006; BALDISSARA et al., 2006). Therefore, the mechanical and adhesive characteristics of the cement are important factors in treatment success when using intracanal posts. The ideal cement should have a lower modulus of elasticity than the other components of the fiberglass post-root canal ensemble, which is about 7 GPa (ESTELLANO and ROVERE, 2004). In addition, it should be resilient and elastic, allowing the distribution of forces in the root canal,

specifically in the region of greatest tension, the post-dentine interface (ESTELLANO and ROVERE, 2004).

Recently, resin cements have become popular due to their enormous benefits in adhesive procedures. However, some studies show conflicting results regarding the behavior of the various options of cementing agents (ALBURQUERQUE, 1996). The best results in bond strength have not always been attributed to resin cements, and researchers have linked this finding to the presence of residual eugenol from endodontic sealers inside the root canal; eugenol affects the acid etching of dentin and interferes in the conversion degree of the resin cement (ALBUQUERQUE, 1996).

The new self-adhesive resin cements such as the RelyX U200 have as main advantage an easier and more convenient application, with fewer clinical steps. One of the causes for the high frequency of fiberglass post failure is adhesive failure at the dentine-cement interface (FERRARI et al., 2000; SCHWARTZ and ROBINS, 2004; CURY et al., 2006).

Ultrasound has been widely used in medicine since 1957, and in recent years, its use in different stages of endodontic therapy, including root canal sealing, has increased (PLOTINO et al., 2007). Ultrasound can be applied in canal cleaning and preparation (WALMSLEY, 1988; STOCK, 1991), in line with the concept of producing minimally invasive cavities (PETERS and McLEAN, 2001). Furthermore, its use facilitates the access to the root canal, the search for calcified canals, and the removal of root canal obstructions (fractured instruments, intracanal posts and broken metal posts). In addition, it increases the distribution of irrigating substances, aids gutta-percha condensation during sealing, and helps in procedures such as MTA placement and paraendodontic surgery (PLOTINO et al., 2007).

However, few studies have been found (WIESSE et al., 2017; BARRETO et al., 2016; VIVAN et al., 2016; GUIMARÃES et al., 2014) regarding the use of ultrasound during the sealing of the root canal through the classical technique. Most results show that ultrasound favors cement penetration, increases sealing ability at the dentinal tubules level and improves retention of the intracanal post.

Thus, the aim of this study was to evaluate the penetration of resin cement and resin modified glass ionomer cements in the dentinal tubules and the bond strength of cemented fiberglass posts in root canals with or without the use of ultrasound.

2 DISCUSSION

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After endodontic treatment, teeth have to be restored to reestablish their shape and function (JAYASENTHIL et al., 2016, ALBUQUERQUE, 1996; SEDGLEY and MESSER, 1992). A fiberglass post can be used in direct or indirect restorations (PURTON et al., 2000) as this material has good mechanical properties such as fatigue and traction resistance, in addition to having a modulus of elasticity similar to dentin (ASMUSSEN, PEUTZFELDT, HEITMANN, 1999). To cement the fiberglass post into the root canal, dual cure and chemically active cements are the most recommended because they allow an adequate control of the working time, present a wide choice of colors and opacities, good fluidity, and also allow polymerization in difficult areas (MALLMANN et al., 2005; DRUCK et al., 2015).

In this study, the dual cure resin cement and the chemically activated resin-modified ionomer cement were used for the cementation of the fiberglass post. The push out test was selected because it is a suitable method to evaluate the bond strength of the intracanal posts, which were divided into thirds to compensate the structural variability of the dentin inside the root canal (GORACCI et al., 2007, CARVALHO, 2011, WANG et al. 2013, ROCHA et al., 2017)

We found that the resin cement had higher bond strength compared to resin-modified ionomer cement, in line with the literature (Lopes, Ballarin, Baratieri, Zicari et al., 2006) and Consolmagno-Callejon. 2016). This can be due to a chemical interaction between the functional monomers of the dual cure adhesive cement and hydroxyapatite, as these monomers might be more important for the bonding process than the capacity to hybridize the dentin (BITTER et al., 2009). In addition, the chemical bonding and the simplicity of the technique of the dual cure cement may contribute to the greater success (FERRACANE; STANSBURY; BURKE, 2011). Moreover, the physical properties and lower contraction of the dual cement may result in greater contact with the walls of the root canal, thus increasing the bond strength compared to the chemically activated cements (DAUVILLIER et al., 2000)

The resin-modified chemically activated cement obtained lower bond strength values compared to resin cement, as this cement is more resistant to compression than to traction (Bonfante et al., 2007). However, the use of resin-modified glass ionomer allows the formation

of microcracks up to one year after cementation because of hygroscopic expansion (Quintas et al., 2000).

The root dentin presents morphological differences along the canal extension (FERRARI et al., 2000; MUMCU, TOPCU, 2010), such as the reduction in the density of dentinal tubules (AKGUNGOR, AKKAYAN, 2006) and a decrease in tubules diameter in the apical region (FERRARI et al., 2000), which may compromise cement adhesion, leading to significantly lower bond strength values in this region when compared to the cervical third (MJOR et al., 2001; AKGUNGOR, AKKAYAN, 2006; MUMCU; ERDEMIR; TOPCU, 2010). In this study, the difference between the bond strength of the cervical and mid thirds can be explained by the increased difficulty of the cement to reach narrower tubules (MUMCU; ERDEMIR; TOPCU, 2010), partially due to the fluidity of the material. This was confirmed for resin cement, in which there was a significant difference in bond strength between the apical, middle and cervical thirds. The values of bond strength obtained in the present study corroborate the studies that describe higher values for the cervical third, intermediate values for the middle third and lower values for the apical third (LOPES, BALLARIN, BARATIERI, ZICARI et al.; Dirk et al., 2006). This is because the dual cure self-adhesive resin cements are mildly acidic and therefore promote demineralization and hybridization of the root dentin (Goracci et al., 2005; Monticelli et al., 2008). On the other hand, the resin-modified ionomer cement did not present a significant difference in bond strength among apical, middle and cervical thirds of the root canal. This was due to the chemical polymerization of the cement, which requires an initial acid conditioning step (Araújo et al., 2014) and therefore the level of root canal demineralization is provided by the operator (Yoshida 2000).

The use of ultrasound in this study increased the percentage of cement penetration in the root dentinal tubules of the middle and cervical thirds for resin-modified ionomer cement and in the middle third for resin cement, probably due to the ultrasound vibration (Silva et al., 2005). In addition, the increase of the cement temperature caused by the ultrasonic motion may facilitate the flow of the resin cement into the dentinal tubules of the root canals (Silva et al. FRANCE et al., 2011).

Regarding fracture modes, both cement and dentin adhesive failures were found for resin-modified ionomer cement and resin cements, corroborating the results of Druck et al. (Schmage et al., 2009). However, as it is difficult to remove all the fillers used in endodontic

treatment, residues from gutta-percha and endodontic cements might interfere with the bonding of fiberglass posts (Schmage et al., 2009).

In order to better understand the role of ultrasound in the cementation of fiberglass posts, different studies and analyzes are recommended. For example, a horizontal displacement test would better resemble the clinical situation of posts inside the root canal. Also, the temperature increase induced by different ultrasound exposure times might modify mechanical and physical properties of the cement; in this study this could not be assessed because we used a single 20-second activation (Guimaraes et al., 2014). Another suggested study is the measure of canal wear amount during preparation for fiberglass post cementation to eliminate endodontic sealing materials.

Thus, resin cement presented better bond strength and penetration compared to resin-modified ionomer cement. Ultrasound activation of the cements seems to be a promising step in the quest to improve the bond strength of fiberglass posts, as a significant correlation between penetration and bond strength was found.

3 CONCLUSION

3 CONCLUSION

The resin cement obtained higher bond strength and showed greater penetration in all canal thirds, irrespective of ultrasound activation, compared to resin-modified ionomer cement. A greater cement penetration was achieved in the middle and cervical thirds for the resin-modified ionomer cement and in the middle third for the resin cement when ultrasound activation was applied during cementation. In addition, a significant correlation between penetration and bond strength was observed. Thus, the use of ultrasound seems to be a promising step in the longevity of restorations using fiberglass posts.

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