Influence of temporary cements on the bond strength of resinous materials to the dental substrate

Influência de cimentos provisórios sobre a união entre materiais resinosos e substrato dental

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ABSTRACT

The growing demand for aesthetics and advances in adhesive materials have contributed to the massive increase in the use of indirect adhesive restorations. Despite the advantages of the indirect technique, one of its disadvantages is the need of using a temporary material between visits, since it may contaminate the dental substrate and affect the bond strength of resinous materials to enamel and dentin. Several authors have investigated this issue, but the results were controversial, especially when temporary cements contained eugenol. This review aims to analyze the literature on this issue and clarify whether temporary cements affect the bond strength of bonding systems to tooth substrates.

Indexing terms: *Dental restoration, temporary. Dentin bonding agents. Eugenol.*

RESUMO

A evolução dos sistemas adesivos tem contribuído para o aumento da utilização de restaurações estéticas adesivas indiretas. Todavia, a necessidade de se interpor uma restauração provisória sobre o substrato dental que irá receber uma restauração adesiva indireta representa um risco potencial de contaminação da superfície dental com resíduos de materiais provisórios que ficariam retidos nas irregularidades criadas pelas pontas diamantadas e que poderiam interferir na resistência adesiva dessas restaurações. Diversos estudos que abordam este assunto têm obtido resultados conflitantes sobre os efeitos dos cimentos provisórios na resistência adesiva de materiais resinosos, sobretudo quando estes cimentos contêm eugenol em sua composição, pois este parece interferir no processo de polimerização das resinas compostas. O presente trabalho de revisão de literatura tem o objetivo de investigar, à luz dos resultados e conclusões dos principais estudos, a influência dos diversos cimentos provisórios com e sem eugenol sobre a união entre os materiais resinosos e o substrato dental.

Termos de indexação: Restauração dentária temporária. Adesivos dentinários. Eugenol.

INTRODUCTION

The advent of adhesive dentistry occurred more than 50 years ago with the introduction of acid etching, initially proposed by Buonocore in 1955, and its advancement resulted in the development of new materials which were greatly improved over the years. Modern adhesive systems can be used in nearly all areas of dentistry. The use of composite resins associated with adhesive systems has increased hugely in the last years because of, among other factors, greatly improved materials, greater demand for aesthetic restorations and reduced use of dental amalgam due to both aesthetic reasons and patients' and dentists' fear of mercury poisoning[1]. The main limitations of direct restorations with composite resins are polymerization shrinkage, microleakage, postoperative sensitivity[2], low wear resistance and technique sensitivity, which limits its use in large Class II cavities and teeth with destroyed crowns[3]. In these situations, indirect aesthetic resin or ceramic restorations are much more indicated because of their advantages, such as less polymerization shrinkage (restricted to resinous cement), better mechanical properties, better contact and proximal contour, excellent occlusal morphology and greater aesthetic resources[4-5]. However, since they need to be done in a dental laboratory and therefore require more time, a temporary restoration is needed to protect the dental substrate.

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Temporary restorations are important because they maintain or reestablish aesthetics and function, protect the pulp, maintain periodontal health and gives the clinician time to prepare the final restoration[6]. However, the use of temporary materials before adhesive restorations is a challenge because they affect the bonding of resinous materials to the dental substrate. According to some studies, mechanical removal of temporary cements is not fully efficient, and even in macroscopically clean surfaces, there may be microscopic remnants that affect the bonding of the resin to the dentin and/or enamel[7-9].

There are divergences in the literature regarding the effect of temporary cement remnants on the bond strength of adhesive systems to enamel or dentin. Some studies show that temporary cements reduce the bond strength of resinous materials, regardless of the presence of eugenol in their composition[10-12]. Other studies suggest that only cements with eugenol affect the bond strength of resinous materials, and this effect is not observed with eugenol-free cements[1,13-15]. There are also studies that show when temporary cement with or without eugenol is adequately removed by mechanical means and the dental substrate is etched with newer adhesive systems, their remnants do not affect the bond strength of the resinous materials[16-18].

The objective of this literature review is to determine whether temporary cements with and without eugenol affect the bond strength of indirect restorations of the dental substrate, emphasizing on the following aspects: types of temporary cements, types of adhesive systems and bond strength testing methods.

LITERATURE REVIEW

The present review searched the Medline-PubMed and Lilacs databases for articles published between 1984 and 2011. In vitro or clinical studies that a) tested the bond strength of direct and indirect restorations; b) compared the effects of temporary cements with and without eugenol on enamel and dentin; and c) treated the dental substrate chemically and/or physically were included.

In vitro studies on microleakage were excluded since the objective of this paper was to investigate the effect of cements on bond strength, and bond strength has been shown not to be correlated with microleakage[19]. Studies that assessed only the bond strength of materials to enamel or radicular dentin were also excluded.

Temporary cements

The presence of temporary cement remnants on dental substrate that has been prepared for an indirect restoration contaminates the surface and affects the bond strength of the resinous cement. Particles from temporary material remain attached to the rough surfaces resultant from the use of diamond burs and adversely affect bond strength because the mechanism of action of modern adhesive systems is essentially based on micromechanical retention[7]. Temporary cement remnants may affect the resin-dentin bond strength by the following mechanisms: a) act as a physical barrier to the diffusion of adhesive system components[7-8], b) change superficial tension and contact angle, reducing free surface energy and dentin wettability[8,19-20]; c) chemically inhibiting the polymerization of resinous materials by interacting with components of the temporary material, which would diffuse on the dentin along with the monomers (eugenol-containing cements)[21-22].

Cements based on zinc oxide and eugenol constitute the most common temporary materials used in clinical practice. Their main advantages are: ease of manipulation and removal from the dental surface, sedative and antibacterial properties on exposed dentin, efficient immediate marginal sealing and low cost[23-24]. However, a phenol derivative with great affinity for free radicals called eugenol, present in dentinal cement remnants, could chemically inhibit the polymerization of resinous materials. When in excess, eugenol competes with the resinous monomers for polymerization initiators. It can diffuse on the dentin and penetrate the dentinal tubules up to 2 mm[16,22-25].

Studies that assessed the impact of temporary cement remnants on the bond strength of adhesive systems to dentin are contradictory. Many studies confirm that microscopic temporary cement particles with or without eugenol remain on the treated surface even after careful cleansing with manual instruments. Terata[8] used scanning electron microscopy (SEM) to compare manual cleansing with etching with phosphoric acid at 37% for 60 seconds to determine how efficiently they remove remnants with and without eugenol from enamel and dentin. The results showed that manual cleansing did

not remove all remnants and acid etching removed all remnants from enamel, but not from dentin. These results were confirmed by Watanabe et al.[11], who used SEM and x-ray spectroscopy (EDS) to detect temporary cement remnants on bovine dentin. Even after careful cleansing of the dentinal surface with manual instruments and air and water spray, resulting in a macroscopically clean surface, microscopic eugenol-free cement remnants were seen on SEM images and EDS accused the presence of zinc on the surface.

Grasso et al.[7] compared the efficiency of three cleansing techniques in vivo: pumice paste and water, mechanical removal with periodontal probe followed by air and water spray, and a 0.12% chlorhexidine solution administered with cotton balls. The surfaces were then examined with intraoral light microscopy. The use of pumice paste and water removed temporary cement remnants more efficiently than the other methods, but did not remove the remnants entirely. However, the study confirmed the results of other studies that reported that this cleansing technique is more efficient for removing temporary cements from dental surfaces[26].

Temporary cements and adhesive systems

Considering that temporary cement remnants remain on the dentin after cleansing with the usual techniques, many studies were done to assess whether these remnants could affect the bond strength of adhesive systems to enamel or dentin, but the results were contradictory. Xie et al.[12] assessed the tensile bond strength of two adhesive systems after total acid etching of the enamel and dentin contaminated with temporary cements, with and without eugenol, before and after repeating acid etching for 10 seconds. The results showed that bond strength was significantly affected by contamination, being lower in both enamel and dentin. However, once acid etching was repeated, the tensile bond strengths returned to the original values, not differing significantly from the control. Presence or absence of eugenol did not affect the results.

Terata et al.[10] investigated the effect of temporary cements with and without eugenol on the tensile bond strength of five adhesive systems for enamel and dentin. The results showed that the tensile bond strength of some adhesive systems on enamel decreased, regardless of temporary cement type. However, on dentin, the bond strength decreased very significantly in four of the five adhesive systems analyzed. The authors recommended avoiding the use of temporary cements before restorations that require adhesives.

Paul & Schärer[27] assessed the effect of three temporary materials in vitro, one with eugenol and two without, on the shear bond strength of three different resinous cements and one ionomer cement. The results showed that temporary cements containing eugenol reduced bond strength significantly. Meanwhile, the results regarding eugenol-free cements were confusing and did not differ significantly from the control group. Another similar study confirmed these findings. The authors concluded that temporary cements with eugenol should be avoided before using adhesive restorations[14], corroborating the recommendations of other authors[15].

Ganss & Jung[19] and Jung et al.[24] assessed the effect of dental substrate contamination by temporary cements with and without eugenol on the shear bond strength of a self-etching and total-etch adhesive system to enamel and dentin. Taking into account the limitations of the study, the authors concluded that contamination with temporary cements with or without eugenol did not affect shear bond strength.

Peutzfeldt & Asmussen[16] compared the effect of two temporary cements, one with eugenol and one without, on the shear bond strength and gap formation of two total-etch adhesive systems in vitro, and found that there were no statistical differences between the groups and the control. According to the authors, total etching of the dental substrate with 20% to 35% phosphoric acid for 15 to 30 seconds removed all temporary cement remnants and contaminated enamel and dentin, given that roughly 10µm of enamel and 10 to 15µm of denting are removed by acid etching[28]. The same authors assessed the effect of a temporary zinc oxide cement with eugenol on the bond strength of six different self-etching adhesive systems used for bonding composite resin to dentin[29] and concluded that dentin contamination with temporary zinc oxide cement containing eugenol does not reduce the bond strength of composite resin to dentin when self-etching adhesive systems are used.

Abo-Hamar et al.[18] verified the effect of temporary cement remnants with and without eugenol on the shear bond strength of ceramic restorations to dentin using total-etch and self-etching adhesive systems and two

resinous cements. The results between the groups and control were not statistically significant after the surfaces were cleansed with a manual instrument or stream of aluminum oxide. The authors concluded that the presence of temporary cement remnants with or without eugenol does not affect the bond strength of ceramic restorations to dentin, regardless of cleansing technique (manual or stream). The results of this work confirm some earlier studies[6-28], and contradict others[1-13].

Erkus et al.[30] assessed the effect of two types of temporary cements in vitro, one with eugenol and one without, on the shear bond strength of two resinous cements on dentin. The authors concluded that the bond strength of resinous cements on dentin of the groups contaminated with temporary cements was lower, but the effects of cements with and without eugenol did not differ significantly.

Carvalho et al.[31] compared the microshear bond strength of resin to dentin in vitro using total-etch and self-etching adhesive systems on dentin contaminated with zinc oxide and eugenol. The results showed that the control group and group using the total-etch adhesive system had similar bond strengths. However, the bond strength of the group using the self-etching adhesive system was significantly lower.

Sanabe et al.[32] analyzed the tensile bond strength of adhesive systems to dentin contaminated with temporary cements with and without eugenol. Total-etch and self-etching adhesives were used. The authors concluded that previous use of a temporary cement containing eugenol on dentin affects the tensile bond strength of only self-etching adhesives.

Fiori-Júnior et al.[33] assessed the shear bond strength of ceramic restorations on dentin previously exposed to temporary cements with and without eugenol. The authors used total-etch and self-etching resinous cements. The results showed that temporary cement with eugenol had a negative impact on the bond strength of only the self-etching adhesive system.

DISCUSSION

Dental practitioners seem to be well aware of the incompatibility between resinous materials and products containing eugenol. Eugenol, a phenolic substance, is known to inhibit the formation of free radicals during the initial polymerization of composite resins, changing their properties. This is the main reason for contraindicating the use of materials that contain eugenol as base in composite resin restorations. However, the effect of eugenol found in temporary cement remnants on enamel and dentin adhesive systems has not been established.

The statement that the dental substrate remains contaminated with temporary cements even after their mechanical removal by manual instruments or pumice paste seems legitimate. Studies using SEM and x-ray spectroscopy confirmed the presence of microscopic particles of these materials on enamel and dentin surfaces[8-10]. Even acid etching of the dental substrate cannot eliminate these remnants entirely, as evidenced by the presence of a zinc peak in the energy dispersion x-ray spectra[17]. However, one can question whether the presence of microscopic remnants can significantly affect the bonding strength of resinous materials to dentin[19].

Most of the temporary cements used clinically contain zinc oxide in their composition, which may or may not be associated with eugenol. The divergent results regarding the influence of temporary material remnants on adhesive systems can be partially explained by the great diversity of materials - especially of adhesive systems and resinous cements - and of methodologies used in these studies. The effect of cements containing eugenol should be interpreted differently for cements type I (cementing of temporary prosthetic pieces) and type III (temporary restorations and bases) according to specification nº 30 from ADA (American Dental Association). Cements type I are prepared with more fluid and contain a higher concentration of eugenol than type III[29]. Eugenol concentration is an important factor for the inhibition of resinous-material polymerization[26]. Yap et al.[1] showed that increased concentration of eugenol in temporary cements causes a significant reduction in the shear bond strength of the dentinal adhesive system. However, in this same study, the bond strengths of groups pretreated with cements with higher eugenol concentrations and without it did not differ significantly and the bond strengths of both were lower than that of the control group. This is an important data, especially if taken together with the results of many other studies that also demonstrated that reduced bond strength, caused by temporary cement remnants, is not associated with presence or absence of eugenol[6,10,16,27,34-35]. According to Ganss & Jung[19], the concentration of free eugenol in the temporary cement-dentin interface would be of only 10^{-2}

mols. Eugenol concentration would be even lower after the removal of the temporary restoration and cement remnants. The authors wondered whether such a low eugenol concentration could cause any adverse effects on resinous adhesive systems. Their results reinforce the idea that the effect of temporary cement remnants on the bond strength of resinous materials is mainly due to the physical barrier imposed by the remnants, which change the superficial tension and permeability of the dental substrate, especially the dentin, obstructing the diffusion of the adhesive components.

Terata et al.[36] recently assessed the effect of temporary cements without eugenol on the free energy of the dentinal surface. The results showed that all temporary cements reduce dentinal surface energy and the bond strength of resinous cement to dentin. Therefore, this effect would be present whether the temporary cement or resinous materials contain eugenol or not. The results indicate that the inhibition of polymerization by eugenol is not significant. It is possible that trace amounts of eugenol are not enough to change the properties of adhesive systems. However, according to most studies, temporary cement remnants significantly reduce bond strength, regardless if the mechanism is physical or chemical.

Although some studies[7-10] have showed that usual cleansing techniques do not completely remove temporary cement remnants, other studies have showed that acid etching can neutralize the effect of these remnants on bond strength. According to the adhesive system used and type of smear layer treatment, even traces of these remnants would not affect the bonding interface[17,35]. Since total-etch adhesive systems completely remove the smear layer, they remove temporary cement remnants more efficiently, hence neutralizing their negative effect on the bonding interface[11,16-17,31,37]. On the other hand, the self-etching adhesive systems use acid primers that modify the smear layer, partially dissolving but not removing it[38-40]. Hence, contamination particles, such as temporary cements, would remain in the bonding interface, which could affect the bond strength of resinous materials to dentin[19]. This hypothesis is in agreement with the results of some studies[11,27,32-33,41-42] that suggest that self-etching adhesives would be more susceptible to smear layer variability than the total-etch adhesives. Carvalho et al.[31] found significantly lower shear bond strengths in self-etching adhesive systems contaminated with temporary cements than those of equally contaminated total-etch adhesive systems. Similar results were obtained by Ribeiro et al.[43] who found significantly lower bond strengths in self-etching adhesive systems, and by Sanabe et al.[32], who also found lower bond strengths in self-etching adhesives. However, some studies challenge these results. Abo-Hamar et al.[18], Peutzfeldt & Asmussen[29] and Erkus et al.[30] did not find significant differences in the bond strengths of ceramic restorations cemented with total-etch and self-etching adhesives after contamination with temporary cements with or without eugenol. However, bond strengths were statistically lower in self-etching adhesives, regardless of contamination with temporary cements.

Another aspect that deserves attention is the methodology used for bond strength assessment. Most in vitro studies use shear bond strength test for this purpose[14,16,18-19,24,26,29-30,33]. However, many studies have suggested that the conventional tests, such as the shear bond strength test, have limitations when bond strengths exceed 25MPa, common in newer adhesive systems[44-48]. These authors show that in this type of test, there is a concentration of stress on the bonding interface that induces the early rupture of the bond, which may cause interpretation errors. Smaller bonding areas, as seen in newer tests such as microtensile bond strength or microshear bond strength, could minimize the stress generated on the interface. Therefore, these tests would be more appropriate for assessing the bond strength of the newer bonding systems to dentin.

Although the microtensile or microshear bond strength methodology has been introduced more than a decade ago[47], only a few studies that assessed the effect of temporary cements on the bond strength of resinous materials used this methodology[31-32,34,42-43]. Hence, it is possible to assume that different methodologies are partially responsible for the divergences among studies.

Although experimental studies are not scientific relevant because they are not backed by clinical studies, they should be considered in clinical practice. The fact that microscopic temporary cement particles remain even after careful mechanical cleansing of flat and highly polished dental surfaces allows one to infer that, in a clinical situation, the removal of these remnants is much harder, since the surfaces are irregular and the cavities are angular and difficult to access. Therefore, clinicians should be thorough to minimize the possible effects of

these remnants on bond strength and perform rigorous mechanical cleansing of the dentinal surface.

Literature disagreements do not allow one to state which adhesive system, that is, total etch or self-etching, is more appropriate for cementing indirect aesthetic restorations after contamination of the dental substrate by temporary cements. However, evidence indicates that self-etching systems are more susceptible to dentinal surfaces contaminated with temporary cements. Surface cleansing with manual instruments and abrasive substances, such as pumice, associated with dentinal acid etching, seem to reduce or even neutralize the negative effects of temporary cement remnants.

This topic requires further investigation, especially with longitudinal studies. The recommendation made by some authors[10] of not using temporary restorations before adhesives does not seem reasonable, since temporary restorations are critical for maintaining the aesthetics, function and health of pulpal and periodontal tissues in indirect restorations.

FINAL CONSIDERATIONS

Analysis of the results of many studies reviewed here leads to the following conclusions:

a) temporary cements leave particles on the dentinal surface that remain there even after the usual mechanical cleansing methods are used. These remnants can act as a physical barrier for the diffusion of adhesive system components on the dentin and affect the bond strength of indirect restoration adhesives;

b) the amount of eugenol present in temporary cement particles does not seem enough to change the bond strength of resinous cements to dental substrates;

c) resinous cements that use self-etching adhesives seem to be more susceptible to dentinal contamination by temporary cements;

d) acids from adhesive systems do not fully remove or dissolve temporary cement remnants on the dentin. The clinician must minimize the amount of remnants on the dentinal surface by thorough mechanical cleansing.

Collaborators

JCV RIBEIRO conceived the study and wrote the manuscript. MM SILVA performed the literature research and wrote the manuscript. CAO Fernandes interpreted the data, reviewed the manuscript and supervised the work and writing of the manuscript.

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