IJD ISSN:1806-146X

Bond strength of high viscous glass ionomer cements to primary dentin

Resistência de união dos cimentos de ionômero de vidro de alta viscosidade na dentina primária

Tathiane Larissa Lenzi[1]
Isabela Capparelli Cadioli[1]
Monique Severiano de Benedetto[2]
Márica Turola Wanderley[1]
José Carlos Pettorossi Imparato[1]
Clarissa Calil Bonifácio[3]
Daniela Prócida Raggio[1]

1-Departamento de Ortodontia e Odontopediatria FOUSP, São Paulo, Brazil
2-Departamento de Ortodontia e Odontopediatria, São Leopoldo Mandic, Campinas, Brazil
3 – Departamento de Ortodontia e Odontopediatria ACTA, Holanda

Correspondence:
Daniela Prócida Raggio
Av. Lineu Prestes 2227, Cidade Universitária,
CEP.: 05508-900
E-mail: danielar@usp.br

ABSTRACT

The aim of this study was to assess the tensile bond strength of three glass ionomer cements used for Atraumatic Restorative Treatment (ART) to primary teeth dentin. Forty eight dentinal surfaces of primary second molars were exposed and randomly assigned into 3 groups in according to the material used (n=16). Two Brazilian low cost glass ionomer cements (Group 1 - Maxxion R® - FGM and Group 2 - Vitro Molar® - DFL) and one worldwide high viscosity glass ionomer cement (Group 3 - Ketac™ Molar Easymix - 3M ESPE). Specimens were buildup and submitted to tensile bond strength test (0.5 mm/min) after 24 hours distilled water storage at 37°C. Data obtained were submitted to one-way ANOVA and Tukey *post hoc* test (α=5%). Ketac™ Molar Easy Mix showed higher tensile strength values (3.98 ± 0.70 MPa) ($p<0.05$) compared with Maxxion R® (2.88 ± 0.68 MPa) and Vitro Molar® (2.61 ± 0.91 MPa), that presented similar statistical bond strength values. Ketac™ Molar Easymix has better performance in bonding to primary teeth dentin compared with Vitro Molar® and the Maxxion R®.

Keywords: Glass ionomer cements; Deciduous tooth; tensile strength

RESUMO

O objetivo deste estudo foi avaliar a resistência de união de três cimentos de ionômero de vidro utilizados no Tratamento Restaurador Atraumático (ART) à dentina de dentes decíduos. Quarenta e oito superfícies dentinárias de segundos molares decíduos foram expostas e divididas aleatoriamente em 3 grupos de acordo com o material usado (n=16). Dois cimentos de ionômero de vidro nacionais de baixo custo (Grupo 1 - Maxxion R® - FGM e Grupo 2 - Vitro Molar® - DFL) e um cimento de alta viscosidade universal (Grupo 3 - Ketac™ Molar Easymix - 3M ESPE). Os espécimes foram feitos e submetidos ao teste de tração (0,5 mm/min), após 24 horas de armazenamento em água destilada a 37ºC. Os dados obtidos foram submetidos à ANOVA de um fator e ao Teste de Tukey (α=5%). Ketac™ Molar Easy Mix apresentou os maiores valores de resistência de união (3,98 ± 0,70 MPa) ($p<0,05$) comparado com Maxxion R® (2,88 ± 0,68 MPa) e Vitro Molar® (2,61 ± 0,91 MPa), que apresentaram valores de resistência de união estatisticamente similares.. Ketac™ Molar Easymix apresenta melhor desempenho na adesão em dentina de dentes decíduos em comparação ao Maxxion R® e Vitro Molar®.

Palavras-chave: Cimentos de ionômeros de vidro; Dente decíduo, Resistência à tração

INTRODUCTION

Dental caries still reach a great part of the world pediatric population. The percentage is about 2/3 of entire population and carious lesions are more frequently observed in developing countries.[1] Even after preventive actions, caries is unevenly distributed in children; a small proportion of individuals is affected with more severe lesions.[2,3] The restorative treatment is commonly indicated when the early diagnosis is not possible and the lesion reaches dentin.

The ideal dental filling material for children must require minimal cavity preparation, be easy on handling and to apply, not dislodge easily, have adequate bond strength, besides not be moisture sensitive during placement and setting.[4]

The glass ionomer cements have some of these properties, and also present chemical adhesion, are relatively easy to insert in cavity[4,5], have an inhibitory effect

on cariogenic microbiota[6] and a positive influence on enamel and dentin remineralization.[6,7,8]

The tensile bond strength of some restorative materials had been extensive studied. Cohesive fracture within the cement are predominantly observed when teeth restored with conventional or resin-modified glass ionomer cements are subjected to tensile bond strength tests.[4,9,10,11] Cohesive fracture within the cement implies that the bond strength between the restorative material and dental structure is higher than the tensile strength of the cement itself.[4]

High viscous glass ionomer cements are traditionally indicated for Atraumatic Restorative Treatment (ART) due to increasing the powder/liquid, present better mechanical properties.[5] ART is based on caries removal with hand instruments followed by filling the cavity with high viscous GIC.[13,14] The advantages are elimination of common iatrogenic effects such as overheating and dehydration of pulp-dentinal complex and over-preparation of the cavity, resulting in pulp exposure, postoperative hypersensitivity or pulp necrosis.[13]

However, the high viscous glass ionomers commonly used cost too much to be used in wide scale in developing countries, like Brazil. Among conventional self cured glass ionomer cements, Vitro Molar® (DFL) and Maxxion R® (FGM) are widely sold in Brazil and their prices are more accessible.

Therefore, the aim of this study was to evaluate the tensile bond strength of three glass ionomer cements used for ART to primary dentin.

METHODS

This study protocol was approved by the local ethic's committee in research (220/04).

Thirty extracted or exfoliated primary second molars were selected from the Human Tooth Bank of the University of São Paulo and stored in solution of 0.5% chloramine T at 4 ° C for a minimum period of 30 days.

The teeth were sectioned mesio-distally in two parts, resulting in 30 buccal and 30 lingual teeth surfaces. Some of them were lost during the cut process, resulting in 48 teeth surfaces. The fragments were set with wax (Polidental Indústria e Comércio Ltda., Cotia, SP, Brazil) in plastic molds after applying petroleum jelly (Buehler™ Sample Kup, Like Bluff, Illinois, USA) and embedded in acrylic resin (JET, Artigos Odontológicos Clássico, São Paulo, SP, Brazil).

Flat buccal and lingual dentin surfaces were exposed by removing external enamel using 180 - grit silicon carbide paper. Exposed dentin surfaces were then polished with 600-grit silicon carbide paper under running water during 30 seconds to create a standardized smear layer[15]. The specimens were randomly assigned into 3 groups (n=16) in according to the glass ionomer cement used (Table 1).

The dentin surfaces were conditioned with a cotton pellet containing a drop of the liquid of each material for 10 seconds, washed and dried, simulating the ART restoration technique[1]. A teflon matrix was positioned over the prepared surface for material insertion, resulting in cylindrical specimens with 3mm diameter and 3mm height. The glass ionomer cements were prepared according to the manufactures' instructions and inserted with aid the syringe Centrix® for avoiding inclusion of air bubbles into the material. Finger press technique was performed after the insertion, and surface protection was performed with petroleum jelly (Buehler™ Sample Kup, Like Bluff, Illinois, USA)[16]. After 1 hour, the specimens were stored in distilled water at 37°C for 24 hours.

Tensile bond strength was performed using a Mini Instron testing machine (model 4442, Canton, MA, USA), with speed of 0.5mm/min and a load of 500N (Newtons). After the tensile test, the specimens were analyzed in microscope with 400x magnification (HMV II, Shimadzu, Kyoto, Honshū, Japan) to determine fracture mode: mixed adhesive or cohesive (in dentin or cement).

The data obtained were submitted to one-way ANOVA and Tukey *post hoc* test at 5% significance, since the previous tests of adherence to the normal distribution (Kolmogorov-Smirnov) and homogeneity of variances (Cochran) justify the choose of parametric test.

RESULTS

Tensile bond strength means and standard deviations are presented in Figure 1. Ketac™ Molar Easy Mix (G3) showed higher tensile strength values (3.98 ± 0.70 MPa) ($p<0.05$) compared with Maxxion R® (G1) (2.88 ± 0.68 MPa) and Vitro Molar®

(G2) (2.61 ± 0.91 MPa), that presented statistical similar bond strength values.

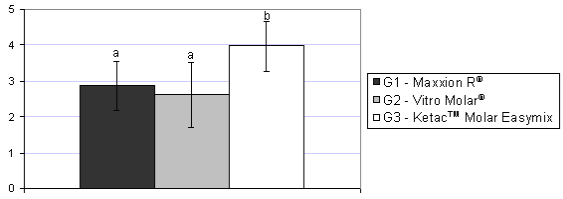

Figure 1 - Mean tensile bond strength (MPa) and standard deviation. Different letters indicate significant differences ($p < 0.05$).

The frequency percentage of fractures for the experimental groups is presented in Figure 2. Predominance of cohesive fracture in cement was observed for the G2 and mixed or adhesive for the G1 and G3. No cohesive fracture in dentin was observed for all groups.

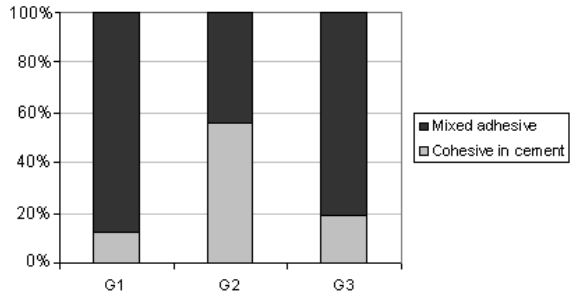

Figure 2 – Fracture mode distribution (%).

DISCUSSION

Glass ionomer cements have chemical bonding to dental structure, by ionic interaction of the carboxyl groups of the polyalkenoic acid with calcium ions of remnant hydroxyapatite that remain attached to the collagen fibrils[17]. Therefore, this material has been widely used in minimally invasive techniques such as ART[13], and preparations limited to the partial removal of carious tissue, showing good results in clinical studies.[18,19]

Nevertheless, the clinical indication depends on bonding performance. Bond strength is an important indicator of an adhesive materials' effectiveness. A great number of studies have already evaluated the bond strength of glass ionomer cements to dentin permanent.[9,11,20] However, since primary and permanent dentin has presented significant differences in composition and structure,[21,22] the results these studies cannot be extrapolated to primary teeth.

The use of glass ionomer cement é encouraged for pediatric patients with caries activity, since it satisfactorily bonded to simulated caries-affected dentin[23]. However, affected and sound dentin coexist in cavity preparations and before that, it is also important to evaluate the performance this material in sound dentin. Additionally, as different types of glass particles, particles size, acid concentration and associations can be used, the comparison of performance of different high viscosity glass ionomer cements also should be investigated.

Thus, this study had the objective to evaluate the tensile bond strength of three glass ionomer cements used for ART to primary dentin, being two national cements. The choice on studying Brazilian brand materials is based on the price of high viscous glass ionomer cements, they have a high cost to be widely used in developing countries. Maxxion R® and Vitro Molar® are the most used materials nowadays in Brazil.

In present study was applied weak acids prior to insertion of materials, in order to clean the tooth surface, remove the smear layer and expose collagen fibrils, allowing glass-ionomer components to inter-diffuse, establish a micro-mechanical entanglement with dentin[24, 25], providing adequate bond strength.

Ketac™ Molar Easymix presented higher tensile bond strength values compared with national glass ionomer cements. This can be attributed to properties and composition these glass ionomer cement. Ketac™ Molar Easy Mix shows a highly improved wettability as a result of the granulation of the powder particles, resulting in easy and fast mixing.[5] Moreover; it has high physical-mechanical properties[5] and a portion of the polyacrilic acid added to the powder, resulting in a less viscous liquid, making the mixing easier.

It was observed cohesive in cement and adhesive mixed fractures in all 3 groups. The Ketac™ Molar Easymix and Maxxion R® groups had a higher percentage of mixed adhesive fractures (81.3% and 87.5%, respectively). Vitro Molar® had 56.3% of cohesive fracture in cement. This fracture mode has often been interpreted as showing that the bond to the dentin was stronger than cohesive strength of the cement. However, bond rupture is far more complex than this. There are inherent problems with the tensile tests since there are several layers of material bonded together; glass ionomer cement, hybrid-like layer,

demineralized dentin, and dentin, all of which have quite different elastic moduli. In addition, glass ionomer cements always contains numerous air inclusions that can act as stress points, thus giving rise to the increased likelihood of cohesive fracture within the cement which was seen as the common form of fracture mode[15], when using the tensile test, due to a larger area of adhesive and non-uniform distribution of stress.[26]

Maybe if it was used a different method of assessment the bond strength, like microtensile test, the results should be different. However, observed a large percentage of mixed adhesive fractures, especially in G1 and G3, probably due to use of syringe Centrix® for inserting the material, reducing the inclusion of bubbles within the cement.

Accordingly, although the Maxxion R® has presented lower bond strength values compared to worldwide high viscosity glass ionomer cement, few cohesive fracture in cement were observed. Since this cement has price more accessible compared to Ketac™ Molar Easymix, should be evaluated in clinical situations and the manufacturer should improve this material in order to make it possible to use it on a larger scale by applying it in social projects, clinical research and dental public health service.

CONCLUSION

Ketac™ Molar Easymix has better performance in bonding to primary dentin compared national and low price glass ionomer cements.

REFERENCES

1. Frencken JE, Holmgren JC. Atraumatic restorative treatment (ART) for dental caries. Nijmegen: STI Book, 1999. p.99.
2. Narvai PC, Frazão P, Roncalli AG, Antunes JLF. Dental caries in Brazil: decline, polarization, inequality and social exclusion. Rev Panam Salud Publica 2006; 19:385–93.
3. Perinetti G, Varvara G, Esposito P. Prevalence of dental caries in schoolchildren living in rural and urban areas: results from the first region-wide Italian survey. Oral Health Prev Dent 2006; 4:199-207.
4. Thean HPY, Mok BYY, Chew CL. Bond strengths of glass ionomer restoratives to primary vs permanent dentin. ASDC J Dent Child 2000; 67:112-6.
5. Peez R, Frank S. The physical–mechanical performance of the new Ketac™ Molar Easymix compared to commercially available glass ionomer restoratives. J Dent 2006; 34:582-7.
6. van Amerogen WE. Dental caries under glass ionomer restorations. J Public Health Dent 1996; 56:150-4.
7. Smales RJ, Ngo HC, Yip KHP, Yu C. Clinical effects of glass ionomer restorations on residual carious dentin in primary molars. Am J Dent 2005; 18:188-93.
8. Amaral MT, Guedes-Pinto AC, Chevitarese O. Effects of glass ionomer cement on the remineralization of occlusal caries – an in situ study. Braz Oral Res 2006; 20:91-6.
9. Erickson RL, Glasspoole EA. Bonding to tooth structure: a comparison of glass-ionomer and composite-resin systems. J Esthet Dent 1994; 6:227-44.
10. Hosoya Y, Garcia-Godoy F. Bonding mechanism of Ketac-Molar Aplicap and Fuji IX GP to enamel and dentin. Am J Dent 1998; 11:235-9.
11. Tanumiharja M, Burrow MF, Tyas MJ. Microtensile bond strengths of glass ionomer (polyalkenoate) cements to dentine using four conditioners. J Dent 2000; 28:361-6.
12. Frencken JE, Holmgren CJ. How effective is ART in the management of dental caries. Community Dent Oral Epidemiol 1999; 27:423-30.
13. Frencken JE. The ART approach using glass-ionomers in relation to global oral health care. Dent Mater 2010; 26:1-6.
14. Frencken JE, Songpaisan Y, Phantumvanit P, Pilot T. An atraumatic restorative treatment (ART) technique: evaluation after one year. Int Dent J 1994; 44:460-4.
15. Burrow MF, Nopnakeepong U, Phrukkanon S. A comparison of microtensile strengths of several dentin bonding systems to primary and permanent dentin. Dent Mater 2002; 18:239-45.
16. Brito CR, Velasco LG, Bonini GA, Imparato JC, Raggio DP. Glass ionomer cement hardness after different materials for surface protection. J Biomed Mater Res A 2010; 93:243-6.
17. Yoshida Y, Van Meerbeek B, Nakayama Y, Snauwaert J, Hellemans L, Lambrechts P, Vanherle G, Wakasa K. Evidence of chemical bonding at biomaterial-hard tissue interfaces. J Dent Res 2000; 79:709-14.
18. van 't Hof MA, Frencken JE, van Palenstein Helderman WH, Holmgren CJ. The atraumatic restorative treatment (ART) approach for managing dental caries: a meta-analysis. Int Dent J 2006; 56:345-51.
19. Mickenautsch S, Yengopal V, Banerjee A. Atraumatic restorative treatment versus amalgam restoration longevity: a systematic review. Clin Oral Investig 2010; 14:233-40.
20. Xie H, Zhang F, Wu Y, Chen C, Liu W. Dentine bond strength and microleakage of flowable composite, compomer and glass ionomer cement. Aust Dent J 2008; 53:325-3.
21. Angker L, Nockolds C, Swain M, Kilpatrick N. Quantitative analysis of mineral content of sound and carious primary dentine using BSE imaging. Arch Oral Biol 2004; 49:99-107.
22. Koutsi V, Noonan RG, Horner JA, Simpson MD, Matthees WG, Pashley DH. The effect of dentin depth on the permeability and ultrastructure of primary molars. Pediatr Dent 1994; 16:29-35.
23. Marquezan M, Osorio R, Ciamponi AL, Toledano M. Resistance to degradation of bonded restorations to simulated caries-affected primary dentin. Am J Dent 2010; 23:47-52.
24. Friedl KH, Powers JM, Hiller KA .Influence of different factors on bond strength of hybrid ionomers. Oper Dent 1995; 20:74-80.
25. Raggio DP, Sônego FG, Camargo LB, Marquezan M, Imparato JC. Efficiency of different polyacrylic acid concentrations on the smear layer, after ART technique, by Scanning Electron Microscopy (SEM). Eur Arch Paediatr Dent. 2010 Oct;11(5):232-5.

26. Van Noort R, Noroozi S, Howard IC, Gardew G. A critique of bond strength measurements. J Dent 1989; 17:61-7.

Recebido em 28/09/2010
Revisado em 02/12/2010
Aprovado em 13/12/2010

Table 1 – Group, material, manufacturer, batch and composition of the glass ionomer cements used.

Group	Material	Manufacturer	Batch#	Composition
G1	Maxxion R®	FGM Brazil	Powder 011007 Liquid: 0011007 (2008/2)	Powder: iron oxide, silica, zirconia, fluoride, strontium glass Liquid: deionized water, polyacrylic acid
G2	Vitro Molar®	DFL Brazil	Powder: 5070823 Liquid: 5070823 (2007/07)	Powder: barium aluminum silicate, dehydrated polyacrylic acid, iron oxide Liquid: polyacrylic acid,tartaric acid,distilled water Conditionator: polyacrylic acid, glycerin, aerosil 200, methylene Blue CI 52015, deionized water
G3	Ketac™ Molar Easy Mix	3M ESPE, Germany	Powder: 315997 Liquid: 309510 (2008/12)	Powder: fluorsilicate glass, strontium, lanthanum Liquid: polycarbonated acid, tartaric acid, water