EFFECT OF BONDING QUALITY ON SEALING ABILITY OF GLASS IONOMER RESTORATIVES

Thesis

Submitted to the Faculty of Oral and Dental Medicine

Cairo University

For partial fulfillment of the requirements for the master degree in operative dentistry

By

Haythem samir abd El Kader Moharrum
B.D.S

Cairo University

2005

Supervisors

Dr. Fayez Mohammed Hassan

Professor of operative dentistry
Faculty of oral and dental medicine
Cairo University

Dr. Sherif sayed Abd El Aal

Assistant Professor of operative dentistry
Faculty of oral and dental medicine
Cairo University

The present investigation was of two folds:

First: To assess the effect of the following factors on bonding quality and sealing ability of glass ionomer restoration:

1- Modification of the material: i.e, chemically activated versus resin modified glass ionomer restoratives.

2- Aging of the restoration: i.e, 1 day, 3 months, 6 months.

Second: To verify the relation, if any, between shear bond strength and sealing ability of glass ionomer restoratives.

Glass ionomer cements have certain characteristics that are attractive to the dentist. They have been successfully used for restoration of cervical lesions ***(Tyas, 1994 and Van Dijken, 1996)***. Their main advantage are relative ease of use, bonding potential to enamel and dentin, fluoride ion release and acceptable-long-term esthetic quality ***(Sidhu and Watson, 1995)***. Among the potant disadvantages are sensitivity to dessication and moisture contact during the early setting stages and a tendancy to increased opacity with time ***(Mount, 1994 and Van Noort, 1994)***. Consequently, the restoration surfaces must be protected with a varnish or a sealant for at least 24 hours, which requires a second clinical appointment for final finishing and polishing of the restorations ***(Burgess et al., 1994)***.

With the introduction of resin modified glass ionomer. Addition of resin was able to solve the problem of moisture sensitivity. It has a dual setting reaction consisting of an acid-base reaction and a photochemical polymerization process ***(Mitra, 1991)***. In these dual setting systems, the resin reinforcement provides higher mechanical strength ***(Uno, et al., 1996; Irie and Suzuki, 1999; Irie and Suzuki, 2000 and Yap and others, 2001)*** and higher bond strength to tooth surfaces compared with conventional glass ionomer cements. The resin modified glass ionomer cements claimed to have an improved marginal seal and gap formation of restoration by hygroscopic expansion and improved bonding ability after storage in water ***(Sidhu and Watson, 1997; Irie and Suzuki, 2002).***

This study was carried out to investigate the effect of modification of glass ionomer restoration on the bonding quality and the sealing ability, and assess the effect of aging of the restoration at the different periods. Then, at the end trying to verify the relation, if present, between shear bond strength and sealing ability of glass ionomer restoration.

The ideal restorative material should include the ability to bond to tooth substance were there is a permanent and perfect seal between the margin of the restoration and the tooth tissue ***(Kaplan et al., 1992).*** Conventional glass-ionomers have repeatedly been reported to adequately seal cavity preparations, however, resin modified glass-ionomers appeared to exhibit variable results in microleakage tests and substantially better shear bond strength values ***(Gladys et al., 2001)***.

I. SHEAR BOND STRENGTHS OF DIFFERENT GLASS IONOMER RESTORATIVES:

Holtan et al. (1990) compared the shear bond strength to dentin of one light-cured and two auto-cured polyalkenoate (glass-ionomer). The materials used were Vitrabond, GC lining cement and Ketac-Fil. Shear bond strength testing was conducted exactly 24 hours after the completion of each specimen and was performed using Instron testing machine at cross head speed of 0.5mm/min. They found that Vitrabond showed the greatest variance of all three materials tested however this material's average bond strength was greater than the maximum achieved for the other materials. Although the light cured liner performed much better than either of the auto-cured glass ionomer cements tested, there was still a difference between the auto-cured materials themselves. Ketac-bond having significantly better shear bond strength than the GC lining cement. They concluded that the light-cured glass ionomer liner exhibited significantly better shear bond strength performance than the two auto cured glass ionomer tested. However, contraction of the light-curing ionomers may be greater that the auto-cured materials.

McCaghren et al. (1990) determined the shear bond strength of a light-cured glass ionomer (Vitrabond) to enamel and dentin and evaluated the enamel and dentin aspects of fractured test specimen by scanning electron microscopy (SEM). Bonding sites on the ground, etched enamel and ground dentin surfaces were demarcated by the punching of a hole, 3mm in diameter, in an adhesive tape. The mixed glass ionomer cement was transferred to the demarcated site, and cured for 30 seconds. The specimens were sheared using Instron machine after storage in water at 37ºC for 24 hours and for four weeks, with and without temperature cycling. They found that shear bond strength of glass ionomer cement to etched enamel was higher than that to dentin. Temperature cycling and duration of storage had no adverse effect on the shear bond strength. Examination of the fractured surfaces revealed that most of the specimens failed partly at the enamel and dentin interfaces and within the glass ionomer cement.

Mitra (1991) determined the adhesion to dentin and physical properties of light-cured glass ionomer liner/base using Vitrabond light-cured glass ionomer liner/base compared to a conventional material 3M glass ionomer liner. Shear bond strength was determined after storage in distilled water at 37°C for 24 hours, 4 weeks, 6 months and 10 months using Instron testing machine at a cross-head speed 2mm/min. Compressive strength and diametral tensile strength for Vitrabond liner/base were determined immediately after light curing and also after storage in water for 24 hours, one week, one month and seven months. She found that adhesion of the light-cured material was higher than that of conventional glass ionomer liner and the compressive strength and diametral tensile strength of Vitrabond liner/base were much higher than those of the self-cured 3M glass ionomer liner. She also found that there was no significant difference in the values of bond strength, compressive and diametral tensile strength obtained immediately after curing and after extended storage in water. Similarly, thermal cycling for up to 500 cycles did not significantly affect the shear bond strength values.

Godoy (1992) evaluated the effect of dentin surface treatment with polyacrylic acid on the shear bond strength of a light-cured glass ionomer lining cement (GIC). The material used was Fuji lining LC. He used a total of 40 human, non carious extracted permanent molars, randomly distributed into four groups of 10 teeth each: Group 1; dentin rinsed with distilled water, dried with oil-free compressed air, placement of cylindrical GIC samples and sheared at 15 minutes post-curing. Group 2; same as group 1, but sheared 7 days post-curing. Group 3; dentin treatment with conditioner for 10 seconds, then same as group 1. Group 4; same as group 3, but sheared 7 days post-curing. The samples were stored in distilled water until sheared using an Instron universal testing machine at cross head speed of 0.5 mm/min. He found that dentin surface treatment with the polyacrylic acid significantly increased the shear bond strength to dentin when tested at 7 days post curing. All samples revealed adhesive-cohesive failure prevailing the adhesive mode.

Lin et al. (1992), in a comprehensive study, investigated the bonding mechanisms of glass ionomer cement to dentin. Mechanical determination of bond strength, analysis of surface morphology by means of scanning electron microscopy (SEM) and thin optical sections below the surfaces of the specimens using laser scanning confocal microscopy, and measurement of chemical change of fracture bond sites by means of x-ray photoelectron spectroscopy (XPS) and secondary ion mass spectrometry (SIMS) were evaluated. The materials used were conventional glass ionomer cement (glass Ionomer Liner) and a light cured glass ionomer cement (Vitrabond). They made flat dentin and enamel surfaces from freshly extracted bovine teeth. The glass, ionomer cements were prepared according to the manufacturer's instructions and placed in center of the exposed area. The bonded assembly were then stored in a humidity oven at 100% humidity at 37°C for 24 hours until tested. Those that were tested for immediate strength were not stored in humidity oven. The specimens were tested using an Instron testing machine. They found that the highest bond strengths were obtained with light-cured glass ionomer cement, both immediately after curing and following 24 hours in ambient conditions. SEM and confocal images showed evidence of mechanical interlocking of cement in dentinal tubules. SIMS depth profiles confirmed the ion-exchanges process between the light-cured glass ionomer cement and the dentin surface, and there was evidence for the movement of ions from the glass ionomer 1.5 µm into the dentin surface and the movement of calcium and phosphorus ions from dentin 1.0 µm into the ionomer. From XPS results it was clear that the adhesion characteristics were significantly affected by light-curing and the chemical structure of the polymer.

Cortes et al. (1993) evaluated the shear bond strength of resin reinforced glass ionomer to enamel etched and unetched. The materials used were two resin modified glass ionomer (Fuji II LC and Photac Fil) and one compomer (Dyract). they prepared flat buccal and lingual enamel surfaces of human, non carious extracted permanent molars. The teeth were distributed at random into six groups; Group 1: Fuji II LC, no enamel etching; Group 2: Fuji II LC, enamel etching with 10% phosphoric acid for 10 seconds; Group 3: Dyract, no enamel etching; Group Dyract, enamel etching with 10% phosphoric acid for 10 seconds; Group 5: Photac-fil enamel etching; Group 6: Photac-Fil, enamel etching with 10% phosphoric acid 10 seconds. All samples were placed in distilled water for 24 hours and sheared with-Instron testing machine at cross-head speed of 0.5mm/minute. They found that on etched enamel, Fuji II LC and Dyract had significantly higher bond strength than all the other tested groups but not significantly different between each other, with these two groups, cohesive failure within the material was recorded in all samples While in the unetched samples, all specimens displayed an adhesive failure. The lowest bond strength was noted for Photac-Fil. All samples with Photac Fil, with or without enamel etching had adhesive failures.

Prado et al. (1994) demonstrated the effect of polyacrylic acid or phosphoric acid conditioning on the shear bond strength to dentin of resin reinforced glass ionomer (Fuji II LC). Flat buccal and lingual surfaces of human, non carious extracted permanent molars were prepared. The teeth were distributed at random into; two groups of 5 teeth (10 surfaces) each; Group 1: Dentin conditioning with 10% polyacrylic acid; Group 2: Dentin conditioning with 10% phosphoric acid. Cylindrical samples of the glass ionomer were prepared in plastic molds and bonded to dentin surface according to manufacturer's instructions. All samples were placed in, distilled water for 24 hours, thermocycled and sheared with an Instron testing machine at a cross head speed of 0.5mm/minute. They found that there was no statistically significant difference in the bond strength of glass ionomer to dentin between the two groups. The scanning electron microscopy (SEM) evaluation of the debonded surfaces revealed cohesive failure within the glass ionomer for all samples in both groups.

Bourke et al. (1994) determined the bond strength to dentin of two light-activated glass ionomer cements shortly after bonding (10 minutes), and examined the effect of changes in the samples thickness on the early bond strength. The materials used were (Vitrebond and XR-Ionomer). The buccal and/or lingual surfaces of non carious human third molar teeth were used for bonding. The samples thicknesses were 0.5mm, 1.0mm, 1.5mm, and 2.0mm. They found that Vitrebond bond strength and reliability were decreased as the sample thickness increased; also XR-Ionomer was affected by change in the thickness of the cement. The bond of XR-Ionomer was much lower than those for Vitrebond for all specimen thicknesses. They concluded that the thickness of light-activated glass ionomer cement has significantly affected its bond strength to dentin. They recommended that for those cements in which thickness was a significant factor, the use of thin layers would result in higher bond strength.

Fritz et al (1996) investigated the effect of storage in water on bonding efficacy to enamel and dentin of four resin modified glass ionomer (Dyract, Fuji II LC, Photac-Fil and Vitremer), one conventional glass ionomer filling material (Ketac-Fil) and resin composite system (Peka fill/Gluma bonding system). They used human permanent teeth which were embedded with a slow setting epoxy resin in cylindrical rubber, molds with the intended side for bonding facing the bottom of the mold. The embedded specimens were ground flat until the exposed enamel or dentin surface was large enough to bond a cylinder of restorative material. They determined the shear bond strength of each material after storage period of 24 hours, 1 week, 1 month, 3 months and 6 months. The cylinder specimens were sheared at cross head speed of 1 mm/minute. The failure modes of the debonded specimens were analyzed with a dissecting microscope. They found that long-term water storage generally had no adverse effect on bonding efficacy of resin modified glass ionomer cement, conventional glass ionomer and resin composite to dentin and enamel. They also found that the shear bond strength to enamel and dentin of the four resin modified glass ionomer cements tested, rank between the low bond strength values of the conventional glass ionomer cement and the comparatively high figure recorded for the bonded resin composite system. The modified glass ionomer cements tested showed higher bond strength to enamel than to dentin when conditioned except for Dyract. Ketac-Fil showed lower shear bond strength after 24 hours for enamel and dentin which was then increased with no differences between 1 month, 3 months and, 6 months. With Photac-Fil, no adhesion to dentin was registered as all Photac-Fil specimens debonded spontaneously during storage in water. Most samples showed cohesive failure patterns in the restorative materials. Adhesive or mixed failure was registered only for Vitremer on dentin and enamel up to 1 week and for Dyract on enamel.

Attin et al (1996) evaluated the influence of enamel conditioning on bond strength to enamel of resin modified glass ionomer restorative material and polyacid-modified composite. Three resin modified glass ionomer restorative materials (Fuji II LC, Vitremer and Photac Fil), three polyacid-modified composite (Variglass VLC, Dyract and Ionosit Fil), a hybrid composite (Blend-a-lux) and chemical-cured glass-ionomer cement (Chem Fil Superior) were evaluated. Bond strength was determined for specimens of conditioned and unconditioned bovine teeth. Specimens conditioning were performed as recommended by the manufacturer's instructions. The bond strength was tested with a universal testing machine. They found that all materials showed greater adhesion to conditioned tooth structure than to unconditioned specimens and that bond strength of polyacid-modified composites were greater than resin modified glass ionomer restoration material. Moreover, both of them demonstrated lower bond strength to conditioned enamel when compared with hybrid composite and greater bond strength when compared with the chemical-cured glass ionomer cement.

Peutzfeldt, (1996) compared conventional glass ionomer cements, resin modified glass ionomer cements and compomers with respect to the shear bond strength to dentin and mechanical properties. The materials used were seven conventional glass ionomer cements (Base Line, Chem Fil Superior, Fuji II, Fuji IX, Ketac-Fil, Ketac-Silver and Miracle Mix), three resin modified glass ionomer cements (Fuji II LC, Photac-Fil and Vitremer) and two compomers (Dyract and Compoglass). Shear bond strength was determined to untreated as well as pre-treated human dentin. The mechanical properties tested were flexural strength and flexural modulus. He found that with untreated dentin the bond strength of the compomers and resin modified glass ionomer cements were lower than those of the conventional glass ionomer cements. While for pre-treated dentin, Compoglass displayed bond strength gave higher than that of any other material and Photac-Fil displayed the lowest bond strength. Pretreatment of dentin surface improved the bond strength of nine out of 12 materials. The three materials for which pretreatment had no statically significant effect of all conventional glass ionomer cement. Compomers and resin modified glass ionomer cement gave higher flexural strength than conventional glass ionomer cements. For flexural moduli, there was no statistically significant difference between the three categories of materials.

Abdalah and Godoy (1997) measured the shear bond strength of two resin modified glass ionomer (Vitremer and Fuji II LC) and two polyacid modified resin composites (Compoglass and Dyract) when applied to dry dentin, dentin supplied with water pressure from the pulp, and after thermocycling. They used human extracted third molars. The root portion was removed just below the cemento-enamel junction and the occlusal enamel was removed from the crown segment. An artificial root portion was made in Plexiglass, cemented to the crown segment and connected to a 36cm height water column. The tested materials were applied to the surface of dry dentin, dentin supplied with water pressure from the pulp, and after thermocycling. Shear bond strength was measured for the bonded specimens using an Instron testing machine at a crosshead speed of 0.5 mm/minute. They found that there were no significant differences in bond strengths between Fuji II LC, Compoglass and Dyract, which were significantly greater than that of Vitremer. They also found that the bond strength of all materials were slightly increased or not affected by the presence of water pressure from the pulp. After thermocycling, the bond strengths of Fuji II LC, Compoglass and Dyract were not significantly affected, whereas those of Vitremer were significantly decreased.

Miyazaki et al. (1998) investigated the rate of development of shear bond strength of resin-modified glass-ionomer cements, Fuji II LC and Vitremer. A conventional glass ionomer cement, Fuji II, and a resin composite, Herculite XRV. Bovine incisors were mounted in self-curing resin, and the facial surfaces were ground with 600-grit Sic paper to