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The Measurement of Shear Strength of Composite Resin Bonded After Application of Silane-Coupling Agent on Surface of Biomaterial Containing Calcium Silicate

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Abstract

Objectives : Biomaterials containing calcium silicate have a broad area of utilization in endodontics and in pediatric dentistry. The aim of this study was to comparatively assess the shear strength of biomaterials containing calcium silicate to composite resin material after bondage in the subsequent stage of application of silane-coupling agent on them.

Material Method: Biomaterials containing calcium silicate were placed into cavities in acrylic blocks after 40 acrylic blocks with a diameter of 4 mms and cavities of 2 mms of depth were prepared and those biomaterials (ProRoot MTA and Biodentine) were kept within the recommended duration for hardening. The samples prepared were randomly divided into 4 groups; which were ProRoot MTA on which silane-coupling agent would be applied, Biodentine on which silane-coupling agent would be applied, control ProRoot MTA and control Biodentine. The silane-coupling agent was rubbed with the aid of a brush and dried for 30 seconds with air. After adhesive procedures, restorative materials were applied on biomaterials with the aid of cylindrical moulds with a diameter of 2 mms and a height of 2 mms. After all samples shear bond strength was measured by the usage of a universal testing machine.

Results: The highest average value of shear bond strength among all groups was obtained in the group of Biodentine where Silane-coupling agent was applied; the increase in the value of shear bond strength was found to be statistically significant in the groups where silane coupling agent had been applied.

Conclusion: The bond strength of composite resin increases through application of silane-coupling agent onto the surface of biomaterials containing calcium silicate. In this way, it is demonstrated that restoration can be carried out without the need to apply cement between two materials in the cases of shallow cavities and cases where there is no sufficient distance.

Keywords: Biodentine, Biomaterials, Endodontics, Pediatric Dentistry, ProRoot MTA, Silane Coupling Agent.

Introduction

Mineral Trioxide Aggregate (MTA) is used in pediatric dentistry for coating of pulps of deciduous and permanent teeth[1], in pulpotomy of deciduous teeth[2], in partial pulpotomy[3], in root canal therapy of permanent teeth and of deciduous teeth with no tooth germ below[4,5], in

the mending of internal[6] and external resorption[7], in the mending of perforation[8], in apexification treatment[9] and in regenerative endodontic treatment.[10] When MTA is used for coating of pulps or in pulpotomy, it renders formation of dentine for the purpose of fixation.[11] In a lot of studies carried out, the dentin bridge has been shown to be completed without any finding of inflammation.[12-15] In addition, it is reported that when compared with calcium hydroxide, MTA forms a dentin bridge thicker and less porous in a faster manner, that it causes necrotic pulp more rarely and that such necrosis forms in long-term duration.[16]

Biodentine is successfully used in permanent dentine restoration below inlay/onlay or composite restoration, in temporary restoration of tooth enamel-dentine, in restoration of coronal lesions of decay deep and wide, in restoration of cervical root lesions, in coating of pulps, in pulpotomy, in the mending of perforations in the root and furcation, in the mending of internal and external root resorption, in apexification, as a material for root canals in endodontic surgery and in regenerative treatments of pulps.[17] When the dentine surface is coated very tightly with biodentine, the optimal environment is created for the pulp to sustain its vitality. In this way, the risk of postoperative susceptibility is lessened and durable restorations are rendered in vital teeth. Biodentine is reported to be a good alternative to MTA because of its convenient physical properties, of its being easy to manipulate, of its short hardening period, of its bioactivity, of its potential for biomineralization, of its ability of impermeability and of its being cheaper than MTA.[18]

Bond between pulp coating material and restorative material is quite important in vital pulp treatments. If strong coating is not rendered, bacteria can penetrate into the pulp and cause the treatment to fail.[19] For this reason, the bond strength of cement containing calcium silicate to restorative materials is an important clinical factor.[20] Composite resins are the first option in the choice of a restorative material appropriate for the tooth after pulp coating and especially in areas where the aesthetic feeling is important. It is also the appropriate restorative material to be applied on pulp coating material because it requires low condensation force during implantation of the restorative material.[21] However, it has been demonstrated in studies carried out that the bond strength of composite resins with biomaterials is not sufficient[22]; glass ionomer cement is applied on calcium silicate-based biomaterials for the purpose of sealing. Nonetheless, the bond strength of biomaterials with composite resins must be reinforced especially for the purpose of rendering aesthetic look on anterior teeth[21] and because of the fact that no enough preparation is made in children due to their small tooth cavities.

Silane-coupling agents are materials developed in order to increase the bond strength of structures containing silicon and silicate with composite resins. Silanes are mainly used as adhesion promotions in ceramic restorations and their repairs with resin composites[23-25], glass fiber reinforced polymer composites[26], glassy fillers in resin composite[27] and to form durable bond between resin composite to silica-coated metal and metal alloys.[28] Perhaps, silanes do not have intrinsic toxicity.[29] The purpose of this study is to measure the shear bond strength of composite resins bond after application of silane-coupling agent on the surface of a biomaterial containing calcium silicate.

Material and Methods

40 acrylic blocks with a diameter of 4 mms and with a cavity of 2 mms of depth were prepared. Biomaterials containing calcium silicate prepared in accordance with the instructions by the producing companies were placed

in the cavities in ProRoot MTA (Dentsply Sirona,CH) and Biodentine (Septodont,FR) acrylic blocks and in accordance with the instructions by the manufacturer, cotton pellets were placed on them and they were covered with temporary filling cement (Cavit, 3M Espe, GER) for them to become hardened. Blocks into which biodentine was placed were kept for 4 hours; the groups with ProRoot MTA placed in were kept for 24 hours. At the end of the period, the surface of biomaterials in acrylic blocks were smoothed with polishing disks (Sof-Leks, 3M Espe, GER) after removal of temporary filling cement and cotton.

The samples prepared were randomly divided into 4 groups, which were ProRoot MTA to be applied with silane-coupling agent on, Biodentine to be applied with silane-coupling agent on and Control ProRoot MTA group and Control Biodentine group.

Silane-coupling agent (Clearfil Ceramic Primer, Kuraray, Japan) was rubbed with the aid of a brush in the groups where silane-coupling agent was to be applied and it was dried with air. With bond (Clearfil SE Bond, Kuraray, Japan) applied on it, it was polymerized for 20 seconds via LED light device. Silane-coupling agent was not applied in control groups; bond was applied and after that, polymerization was conducted for 20 seconds with LED light device.

Composite resins(Z250, 3M Espe, GER) were applied on biomaterials with the aid of cylindrical moulds with a diameter of 2 mms and a height of 2 mms after adhesive procedures. All samples were immobilized in the universal testing machine(MOD Dental MIC-101, Esetron Smart Robotechnologies, TR) for the measurement of their values of shear bond strength after being kept for 24 hours in a drying oven at 37°C in distilled water. After that, force was applied in a parallel way to the long axis of the binding site until fracture happened in the form of speed at 1 mm/min and the fracture value of each sample was measured in Newton. The fracture value for each sample was recorded in MPa after calculation by way of force being divided by surface area.

One-way analysis of variance (One-way-ANOVA) was used in the statistical assessment of the data obtained. Tukey test was conducted in order to determine between which groups there was a difference if there was one. The statistical significance level was assumed to be $p<0.05$ in analyses.

Results

Among all groups, the highest average value of shear bond strength was observed in the group of Biodentine applied with Silane coupling agent on(10.13±1.83 MPa); the lowest average value of shear bond strength was observed in ProRoot MTA control group(5.94±1.25 MPa). The lowest value of shear bond strength in Biodentine samples was observed in the control group(8.08±0.70 MPa); a statistically significant difference was detected($p<0.05$).

ProRoot MTA control group samples exhibited an average value of shear bond strength significantly lower than other material groups did($p<0.05$). While no statistically significant difference was observed between the average values of shear bond strength of Biodentine group applied with silane coupling agent on and ProRoot MTA group applied with silane coupling agent on($p>0.05$), it was discovered that the average values of shear bond strength of both groups were significantly higher than those of control groups($p<0.05$).

Groups	Value±Std. Dev.
Silane coupling agent+ Biodentine	*10.13±1.83
Silane coupling agent+ Pro-Root MTA	*8.86±2.12
Biodentine control	8.08±0.70
Pro-Root MTA control	5.94±1.25

*statistically difference

Table 1. Shear bond strength values

Disclusion

When the literature related to the shear bond strength of materials containing calcium silicate is examined, it is observed that most of the studies are about MTA and Biodentine[30], that the studies carried out generally focus on the bond strength of materials containing calcium silicate to composite resins[21,30-32] and that there is no study expounding on the change in bond through the use of silane-coupling agents for the purpose of increasing bond strength.

The most commonly-used method is the assessment of the bond strength of materials in assessing adhesive properties of them. There are studies specifying that MTA is a brittle material, that it is not an appropriate material for tension bond strength test for this reason.[30-32] For all these reasons, shear bond strength test was used in our study in assessing the adhesion of biomaterials containing calcium silicates with various restorative materials.

Cements containing calcium silicates are sensitive against acidic environments[22] and application/scouring of/with an acid may cause translocation of the material, disassembly and dissolution of its filling particles, and alteration of its structure.[30] Self-etch adhesives are simple systems that require less technical precision. Because there is no separate acidification step in self-etch adhesives, they have less count of application steps and shorter uptime than etch&rinse adhesives do.[33] What is more, the decreased count of application steps and decreased application time constitute an advantage in the use of them in pediatric dentistry.[34] For all these reasons, the use of self-etch adhesives was preferred as the binding agent in our study.

It is observed that thickness of 2 mms of biomaterials is reported to be sufficient after examination of studies expounding on shear bond strength of biomaterials containing calcium silicates with restorative materials.[34-36] In a similar way to that of these studies, also in our study, biomaterials containing calcium silicates prepared in accordance with instructions by the producing firms were placed in the cavities in the acrylic blocks in a way that they would be 2 mms in thickness.

Oskoee et al.[35],in their study where they assessed the effect of acid application concerning shear bond strength of ProRoot MTA with composite resins, have reported that the samples with and without acid applied on had similar values and that the bond strength of ProRoot MTA with composite resins without application of an acid was 2.76 MPa after a 24-hour period of hardening. While the bond strength of ProRoot MTA to composite resins was determined to be 3.08 MPa by Savadi Oskoee et al.[35], to be 4.52 MPa by Jaberi-Ansari et al.[21], to be 4.61 MPa by Alzraikat et al.[37] after a hardening period of 48 hours; Cantekin and Avci[31] determined it to be 8.5 and 8.9 MPa after 96 hours. Shin et al.[36], in their study where they assessed the bond strength of ProRoot MTA kept for one week for hardening to composite resins through usage of Clearfil SE Bond, have reported the average bond strength to be 5.29 MPa. The reason why different values of bond strength are observed in studies might be the method used, the kind of adhesive, pH of the acidic monomer it contains, the type of solvent, the content of filler and usage of different periods as the hardening duration of MTA.[38] The values of shear bond strength to composite resins obtained in control groups in our study are close to the ones in studies carried out by Cantekin and Avci[31] and Cantekin.[39]

3-Methacryloxyproyltrimethoxysilane (MPS) is the commonly used in clinical commercial silane primers. Silanes are applied as pre-hydrolysed in a solvent mixture consisting of ethanol and water. The silane content is usually about 1–5 vol%. However, one bottle pre-

hydrolyzed silane solutions have relatively short shelf life. Subsequently, the two-bottle silane systems were introduced into dentistry. These systems consist of an unhydrolyzed silane in ethanol in one bottle and an aqueous acetic acid solution in the other.[40] Two-bottle silane systems were not preferred in this study because they contain acid; instead, Clearfil ceramic primer with the ph of 3 and containing MPS at the rate of 5% was chosen.

The bond strength of silicate-based biomaterials to the composite surface was found to rise by between 25,37% and 49,15% after the use of Silane coupling agents when the data obtained was examined. The reason for the increase in shear strength is that Silane-binding agents are materials developed so as to boost the bond of structures containing silicon and silicates to composite resins and that the silicon atom is found in organic and inorganic structures and forms a bridge between both structures.

Conclusion

Today, materials having physical and chemical properties very different from each other are used altogether in almost all practices of dentistry. Silane coupling agents play a critical role by rendering bond between inorganic and organic structures. Silane coupling agents have shown recent applications in bio-medicine and justified their special role in pediatric dentistry and some may support our idea that silanes will play a leading role in biomaterials science.

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