Effect of Pre-Treatment with CPP-ACP on Shear Bond Strength of Glass Ionomer Restorative Materials to Primary Teeth

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Research Article

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ABSTRACT

Background: Considering desirable characteristics of glass ionomer materials for primary teeth restorations, this study aimed to compare the bond strength of conventional and Nano resins modified glass ionomer restoratives to the primary teeth dentin and evaluate the effect of pretreatment with CPP-ACP paste on their shear bond strength.

Materials and methods: Sixty freshly extracted primary molar teeth were selected. A flat dentinal surface was exposed using a fissure but followed by silicon carbide papers polishing. The specimens were randomly divided into four groups (n=15) based on the materials used (Fuji II LC; GC or Ketac Nano-100; 3M/ESPE) with or without surface pretreatment using CPP-ACP paste. The specimens were prepared and stored in distilled water at 37°C for 24 hours; Shear Bond Strength (SBS) test was performed and calculated using the relevant formula. Data were analyzed using one-way ANOVA and post-hoc LSD test.

Results: A statistically significant difference between different groups of the study was seen (P=0.007). Post-hoc test showed that group II (Ketac N 100 with CPP-ACP) had statistically higher mean SBS values than the groups III and IV and no statistical was found between two RMGIC restorative materials (P=0.07). Pretreatment with CPP-ACP did not significantly affect the SBS of either Ketac Nano-100 (P=0.57) or Fuji II LC (P=0.435).

Conclusion: The SBS of the Ketac Nano-100 and Fuji II LC to the primary teeth dentin was comparable. Pretreatment with CPP-ACP showed no significant effects on the SBS of RMGICs to the primary teeth dentin.

INTRODUCTION

Considering the high rate of tooth decay in children and its consequences, treatment methods and materials used in pediatric dentistry are very important [1]. Generally, a durable bond between tooth structure and the restorative material is crucial for long-term success of restorations [2].The changing face of restorative dentistry has resulted in introduction of numerous materials like glass ionomer based formulations [3]. Glass Ionomer Cements (GICs) were developed in 1972 by Wilson and Kent [4]. The combined characteristics of being self-adhesive to enamel and dentin, fluoride release, ability to have the fluoride within their chemical matrix recharged by outside exposure to other fluoride-containing materials and coefficient of thermal expansion similar to that of the tooth structure , makes the glass ionomer material as an attractive choice for most restorative procedures in pediatric dentistry [3-5]. However, poor mechanical properties of Conventional Glass Ionomer Cements (CGICs), such as low shear punch strength and fracture toughness, limit their extensive use in dentistry as restorative materials in stress-bearing areas [6,7]. In order to expand the clinical uses of CGICs, resin was added to the formulation. Compared to CGICs, Resin Modified Glass Ionomer Cements (RMGICs) provide improved physico-mechanical properties, resistance to early contamination by moisture, less microleakage and improved adhesion to enamel and dentin combined with significant improvement in esthetic properties [8]. Further improvement in order to enhance the performance of RMGIC restorative is the addition of nano-filler particles in which introduced Ketac Nano-100 (3M, ESPE). Ketac Nano-100 restorative is a new technical development that combines the benefits of a resin modified light cure glass ionomer and bonded nano-filler technology [9]. The nano-filler particle size can improve mechanical strength, resistance to surface degradation, while the fluoride release is comparable to other RMGICs [10]. Casein Phosphopeptide Amorphous Calcium Phosphate (CPP-ACP) is a remineralising agent that creates highly concentrated calcium phosphate ions on the tooth surface and provides a reactive substrate [11-13]. Since CPP-ACP produces a highly gradient concentration of mineral content in dental hard tissue, it is assumed that pretreatment of dentin surface with this material could increase the chemical bond of self-adhesive dental materials. Considering this issue, results of a recent study showed that pretreatment with this material increased the bond strength of self-adhesive bioactive materials to the dentin surface [14]. Due to lack of published study on the Shear Bond Strength (SBS) of nano-filled RMGICs in primary dentition and the possible role of CPP-ACP on increasing the bond strength, this study aimed to evaluate the effect of pretreatment of primary teeth dentin with CPP-ACP on the SBS of a conventional RMGIC (Fuji II LC) and a nano-filled RMGIC (Ketac Nano-100). The present study was approved by the ethics committee of Shiraz university of medical sciences (No: #IR.SUMS.DENTAL.REC.019).

MATERIALS AND METHODS

Specimen preparation

A total of 60 extracted primary molar teeth with intact buccal or lingual surfaces were used in this study. The teeth were debrided and cleaned by rinsing under running water, polished by prophylaxis paste, pumice and rubber cup then stored in 0.1% chloramine T solution. Each tooth was decoronated using a diamond disc (Minitom, Struers A/S, Copenhagen, Denmark) under water coolant. The remaining coronal part of each tooth up to 1 mm from cemento-enamel junction was mounted in a plastic ring and immersed in acrylic resin (Acropars, Kaveh, and Tehran, Iran). From the exposed surface, the enamel was removed using a high-speed fissure bur (#330, MANI, Dia-Burs, Japan) and polished with 400 and 800 grit silicon carbide papers (Struers A/S, Copenhagen, Denmark) until a flat dentinal surface was achieved. The groups' classification and the instruction of preparation are shown in Table

1. The GI-based restorative materials, based on the manufacturer instructions, were placed into clear plastic molds (Tygon tubes, ET, Shandong China) with an internal diameter of 2 mm and height of 2 mm on the dentin surface of specimens in all groups of the study. The excess material was removed, then light-curing was done using a light emitting diode curing unit (Bluephase C5, Ivoclar vivadent clinical, Austria) for 20s.

Table 1. The groups' classification and the instruction of preparation.

Groups	Pretreatment	GI-based restorative material	Restoration Procedure
Group I:Ketac Nano-100	Non	-Nano primer of Ketac N100 (3M ESPE, USA) -Base and catalyst of Ketac N100 (3M ESPE, USA)	-Brushing of Nano primer on the surface for 15s. -Air drying -Curing for 10s. -Mixing of the base and catalyst, inserting into the mold on the dentin surface. -Light-curing for 20s.
Group II:Ketac Nano-100+CPP-ACP	Actively with a CPP-ACP product (MI paste (GC; Tokyo, Japan)) for 3 minutes by using a brush.	-Nano primer of Ketac N100 (3M ESPE, USA) -Base and catalyst of Ketac N100 (3M ESPE, USA)	-The same as group I
Group III:Fuji II LC	Non	-Cavity conditioner (GC; Tokyo, Japan) -RMGIC powder and liquid (Fuji II LC, GC, Tokyo, Japan)	-Applying the cavity conditioner for 10s. - Rinsing and drying. -Mixing of RMGIC powder and liquid in 3.2/1 ratios by weight and inserting into the mold on the dentin surface. - Light-curing for 20s.
Group IV:Fuji II LC+CPP-ACP	Actively with a CPP-ACP product (MI paste (GC; Tokyo, Japan)) for 3 minutes by using a brush.	-Cavity conditioner (GC; Tokyo, Japan) -RMGIC powder and liquid (Fuji II LC, GC, Tokyo, Japan)	-The same as group III

Shear bond strength test

After 24 hours of water storage at 37˚C, shear bond testing was carried out using a universal testing machine (Zwick/Roll Z020, Zwick GmbH Co, Ulm-Einsingen, Germany). The force was applied at a cross-head speed of 1 mm/min for each specimen at the interface between restorative and dentin using a knife-edge blade and the maximum failure load was recorded. Shear bond strength (MPa) was calculated dividing the load (N) by the internal surface area of the tubes (2 mm diameter).

Statistical analysis

The collected data were analyzed using SPSS version. 20 (SPSS Inc., IL, USA). Data were analyzed using one-way ANOVA and post hoc LSD test. P value <0.05 was considered statistically significant.

RESULTS

The mean SBS and standard deviations for different groups of the study are presented in Table 2. Based on the results of this study the highest and lowest numerical SBS mean values were recorded for the groups II (Ketac Nano-100+CPP-ACP) and VI (Fuji II LC+CPP-ACP) respectively. Results of the one-way ANOVA analysis showed a statistically significant difference between different groups of the study (P=0.007). Therefore, LSD post hoc test was used to compare the differences.

Table 2. The mean SBS values (MPa) and their respective standard deviations for the different groups of the study.

Group	Number	Mean ± Std. Deviation	P value
I:Ketac Nano-100	15	9.00 ± 4.10	0.57
II:Ketac Nano-100 +CPP-ACP	15	9.79 ± 3.90	
III:Fuji II LC	15	6.13 ± 2.58	0.43
IV:Fuji II LC +CPP-ACP	15	4.80 ± 1.15	
P Value	0.007		

According to the results of the LSD post hoc test, Group II (Ketac Nano-100+CPP-ACP) showed statistically higher SBS values in comparison to the Groups III and IV (Fuji II LC without or with CPP-ACP pretreatment). In spite of a higher value for group I (9.00 MPa) compared to that of group III and IV (6.13 and 4.80 respectively), the difference of the mean SBS value was not statistically significant (P=0.07) even though the value for group. CPP-ACP pretreatment did not significantly improve the SBS of both RMGIC restorative materials used in this study.

DISCUSSION

Nowadays, GICs have become one of the most important dental restorative and luting materials for use in preschoolers, children and teenagers. Unlike early glass ionomers, the new cement systems are more practical to use, show improved physical characteristics and reduced initial hardening time [16].The latest generation of these materials, nano-ionomers, has been introduced recently [16]. Nanotechnology provides some value-added features such as improved polish and aesthetics, abrasion resistance, strength, optical properties, and increased fluoride release [17,18]. In the present study shear bond strength testing was performed to assess the effect of CPP-ACP paste pretreatment on the bond strength of RMGI restoratives. Using this method, specimens are not subjected to additional preparation and stress. So, this measurement is suggested to evaluate bonding performance of the materials with relatively lower bond strength values [19].

Based on the results of the present study no statistically significant difference was observed between the SBS of Fuji II LC and Ketac Nano-100 to the primary teeth dentin (P=0.07). To date, to the best of our knowledge, no research has been conducted evaluating the shear bond strength of nano-filled RMGICs in primary dentition. Although, based on the results of a relevant clinical study in permanent dentition, comparable retention of the nano-filled RMGIC (Ketac Nano-100) and traditional RMGIC (Fuji II LC) restorations was reported [20].

Bonding properties of nano-filled RMGICs are still a matter of concern and controversial results exist. A recent review concluded that commercially available nano-filled RMGIC (Ketac Nano-100) did not hold any significant advantage over conventional RMGICs regarding mechanical properties of flexural strength and tensile strength [21]. Unlike our results [9,22]. Showed significantly higher bond strength of Fuji II LC to the both enamel and dentin than that recorded with Ketac Nano-100. Presence of a smear layer over the dentin surface, lack of hybridization formation and resin tag extensions in the underlying dentin, due to the high pH of the nano-primer, was confirmed by SEMicrographs in the above mentioned studies. The greater resin content of Ketac Nano-100 than that of conventional RMGIs was considered as the reason for the lower dentin bond strength of Ketac Nano-100 compared to that of Vitremer RMGIC in the study by Abo-Hamar and colleagues [23]. The relative increase in the resin and filler contents in Ketac Nano-100 may interfere with the normal acid-bae setting reaction needed for the ion exchange adhesion with tooth structure. This issue was evidenced by the low thickness of the silica gel that surrounds the aluminosilicate glass particles in the study by Perdigao and colleagues [20]. Moreover, the presence of water in Ketac Nano-100 primer, as a solvent, is another explanation for compromising the bond strength of this nano-filled GI-based material to the tooth structure [24].

Various modalities have been applied in dentistry to improve bond strength of glass ionomer restorations. In attempt to maximize the chemical bonding of GI-based materials, pretreatment of the dentin surface with CPP-ACP may be considered. The results of the present study showed that CPP-ACP did not affect the SBS of Fuji II LC RMGIC and Ketac Nano-100 to the primary teeth dentin. (P values respectively=0.43 and 0.57). CPP-ACP also did not significantly affect the SBS of orthodontic brackets bonded with either phosphoric acid etching or self-etching primer in the study by Park et al. [25].

True chemical bonding of GICs involves the formation of ionic bonds between the carboxylate functional groups on the polyalkenoic acid molecules and calcium ions in the hydroxyapatite surface [26]. Accordingly, the remineralizing function of the CPP-ACP seems to be the reason for more prominent effect of this paste on the SBS of Fuji II LC

RMGIC to the caries affected dentin in the study by Agob et al. in comparison to the sound dentin surface used in our study. Although it was not statistically significant, pretreatment with CPP-ACP reduced the SBS values of Fuji II LC RMGIC in the present study (P value=0.43). The same results are also reported in another [27,28].

In addition to ionic exchange bonding, as it was mentioned earlier, RMGICs adhere to dentin by micro-mechanical retention [29,30]. Probably presence of MI paste residue, due to not thorough rinsing of the treated dentin surface, can affect adhesion and be the cause of slight but not significant reduction of the SBS values observed for the Fuji II LC with CPP-ACP pretreatment group in our study. Similarly, partial superficial occluding of the dentinal tubules after 3minutes application of CPP-ACP paste has been reported in SEM analysis in the study by Pei et al [31]. Further chemical analysis and scanning electron microscopy studies are required to evaluate the real interaction of this pretreatment on tooth surfaces during bonding of GIC-based materials. This is worth mentioning that GIC-based restorations might benefit from the advantages of ACP-CPP pretreatment in the cavities, in term of enhancing remineralization potential of these materials.

However, in *vitro* studies cannot answer questions about in *vivo* longevity of this tooth colored restorations. Long term results with some of these newly developed materials are lacking and remain controversial as studies report heterogeneous findings due to using different restorative materials, testing methods, durations and concentrations of CPP-ACP pretreatment. Further clinical and scanning electron microscopy studies with larger sample sizes are required to evaluate the real interaction of pretreatment with CPP-ACP on bonding durability of RMGICs and nano-filled RMGICs to the primary teeth

CONCLUSION

Within the limitation of this study, no statistically significant difference was observed between SBS values of a conventional RMGIC (Fuji II LC) and a nano-filled RMGIC (Ketac-nano 100) to the primary teeth dentin with or without pretreatment with CPP-AC. The chemical analysis and scanning electron microscopy studies are required to evaluate the real interaction of this pretreatment on tooth surfaces during bonding of GIC-based materials this is worth mentioning that GIC-based restorations might benefit from the advantages of ACP-CPP pretreatment in the cavities, in term of enhancing remineralization potential of these materials

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY

Data used to support the findings of this study are available from the corresponding author upon request

ETHICAL APPROVAL

All procedures performed in this study were in accordance with the ethical standards of the local ethics committee of Shiraz University of Medical Sciences (No: #IR.SUMS.DENTAL.REC.019

AUTHORS' CONTRIBUTIONS

Negar Etminan and Najmeh Mohammadi did the methodology, software, literature review, formal analysis, writing – original draft preparation, supervision, project administration and funding acquisition.

Rafat Bagheri did the supervision, validation, resources, data curation, writing–review & editing.

All authors have read and approved the manuscript

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