MICROTENSILE BOND STRENGTH OF GIC AND RMGIC RESTORED TO CARIOUS TEETH TREATED WITH CARISOLV AND PAPACARIE- AN IN VITRO STUDY

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ABSTRACT

BACKGROUND

The overall longevity and clinical performance of adhesive restorative materials ultimately depends on the strength of the bond between the restorative material and the tooth surface. This study was performed to evaluate the influence of Carisolv and Papacarie on the microtensile bond strength (µTBS) of conventional glass ionomer cement (GIC) and resin modified glass ionomer cement (RMGIC) restored to caries-affected dentin.

MATERIALS AND METHODS

Sixty-four extracted carious primary molars were randomly divided into four groups depending on the chemomechanical caries removal agent used. Group 1A- conventional GIC with Carisolv, Group 1B- RMGIC with Carisolv, Group 2A- conventional GIC with Papacarie and Group 2B- RMGIC with Papacarie. All of the teeth were then restored with corresponding restorative materials. The samples were sectioned into 1 × 1 mm^2 sticks using a hard tissue microtome and were subjected to tensile forces at a crosshead speed of 1 mm/min until failure of the bond occurred. µTBS were determined and subjected to statistical analysis using an independent sample 't' test.

RESULTS

The microtensile bond strength of conventional GIC was higher with Carisolv as compared to Papacarie, which was statistically significant. RMGIC also showed a higher microtensile bond strength when restored to carious teeth treated with Carisolv, but this was not statistically significant.

CONCLUSION

It was seen that Carisolv did not adversely affect the microtensile bond strength of both conventional GIC and RMGIC.

KEYWORDS

CMCR, Carisolv, Papacarie, µTBS, GIC, RMGIC.

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BACKGROUND

Minimally invasive dentistry adopts a philosophy that integrates prevention, remineralisation and minimal intervention for the placement and replacement of restorations. Minimally invasive dentistry reaches the treatment objective using the least invasive surgical approach with the removal of minimal amount of healthy tissues. It includes the following techniques-

1. Air abrasion.[1]
2. Sono-abrasion.[2]
3. Laser.[3]
4. Chemomechanical caries removal (CMCR).[4]

In air abrasion method, the contamination of the excavated surface with aluminium oxide particles may affect bonding to dentine, loss of operator tactile sensation and there is also a health hazard of inhalation of aluminium oxide particles.[5] With the sonic oscillating system, there is difficulty of verification of complete caries removal.[6,7] In Laser caries excavation, the main drawback other than the cost factor is loss of tactile sensation during excavation and its slow rate of cutting. The conventional drilling techniques are associated with discomfort, especially among children.[8] Normally, the triggering factors are local anaesthesia, low and high speed rotary instruments and previous dental treatment. In children, it is difficult to differentiate between fear and anxiety-originated behaviour problems. Thus, changes in dentistry routines such as the CMCR, sedation with nitrous oxide and general anaesthesia are becoming necessary. The CMCR method was developed specifically to overcome these barriers and to preserve the healthy dentine tissue.[9]

Chemomechanical Caries Removal Method has the following Advantages-

1. Less perception of pain and more comfortable for patient.
2. Less fear and anxiety leads to less discomfort to patients, especially in children.
3. Removes only infected layer and leads to more tissue preservation.
4. No pulpal irritation.
5. Well suited to the treatment of deciduous teeth, dental phobic's and medically compromised patients.

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6. Better removal of caries in uncooperative and specially abled children.
7. Useful in patients with infectious diseases like Tuberculosis (Prevent Droplet Infection).

CMCR agents are classified based on their chemistry into sodium hypochlorite (NaOCl) or enzyme based CMCR agents. The NaOCl-based agents include GK-101, GK-101E (Caridex) and Carisolv, and the enzyme-based CMCR agent includes Papacarie.

With minimal invasive dentistry, the overall longevity and clinical performance of a restorative material ultimately depends on the strength of the bond between the restorative material and the tooth surface. Hence, enhancing the dentine-adhesive bond seems desirable to achieve longevity of restorations and to minimise the post-operative complications.[10] However, the quality of bonding to dentine could be affected to a great extent by the mode of caries removal.[11] The chemo-mechanical caries removal showed more irregular and rougher surfaces with modified smear layer when compared with the conventional rotary preparation.[12] Moreover, acid etching of the chemo-mechanical treated dentine exposed a clear peritubular and intertubular collagen network. This finding for sure could affect the quality of the formed hybrid layer and therefore the longevity of the adhesive restorations. Some researchers[13,14] registered a comparable adhesion of glass ionomer cements either to the chemo-mechanically or conventionally treated dentine surfaces. At the same time, bonding quality of modern adhesive systems to dentine seems not to be affected in presence of chemo-mechanical caries removing agents.[15,16] However, certain reports[17-19] indicated higher bond strength values with the chemo-mechanically prepared dentine than those exhibited with conventionally prepared dentine. Therefore, this study was undertaken to evaluate the microtensile bond strength (μTBS) of conventional glass ionomer cement (cGIC) and that of a resin modified glass ionomer cement (RMGIC) when they are restored to carious teeth treated with CMCR agents, Carisolv and Papacarie.

MATERIALS AND METHODS

A total of 64 carious primary molars were collected.

Selection Criteria

- Human carious primary molars (Extracted due to caries/ Exfoliated).
- Frank moderate cavitation (code 5, ICDAS, 2013) (Table-1) on the occlusal and/or proximal surfaces.

Code	Classification
0	Sound tooth
1	White opacity visible only when dried
2	White opacity visible when wet
3	Enamel breakdown without visible dentine
4	Dentine discolouration (shadowing) through intact enamel
5	Cavitation
6	Extensive cavitation involving at least half of the surface
7	Restored

Table 1. International Caries Detection and Assessment System for Scoring Tooth Surfaces

All the teeth were randomly divided into two groups depending on the chemomechanical caries removal agent used. For samples in Group 1, caries removal was done using Carisolv and for samples in Group 2 caries removal was done using Papacarie. After complete caries removal all the teeth were trimmed occlusally to the level of the central pit. Each group was further subdivided into two sub-groups based on the restorative material used: Group 1A- conventional GIC with Carisolv, Group 1B- RMGIC with Carisolv, Group 2A- conventional GIC with Papacarie and Group 2B- RMGIC with Papacarie. All of the teeth were then restored with corresponding restorative materials according to the manufacturer's instructions. A protective coat of Vaseline was applied to Groups 1A and 2A. All the teeth were then stored in distilled water for 24 hours before they were sectioned into 1×1 mm^2 sticks using a hard tissue microtome. The sticks were then mounted on a custom made notched jig with the help of cyanoacrylate glue and using a Lloyd's universal testing machine, the sticks were subjected to tensile forces at a crosshead speed of 1 mm/min until failure of the bond occurred. The microtensile bond strength was calculated in MPa using the following equation:

$$\mu TBS = F/A$$

where μTBS is the microtensile bond strength, F is the force applied and A is the area of bond (in mm^2) between the dentin and restorative system.

The μTBS were determined for all the samples and were tabulated and subjected to statistical analysis. An independent sample 't' test was used to carry out the intra and inter group comparison. P-value was calculated for statistical significance.

RESULTS

The results of this in-vitro study demonstrated that the microtensile bond strength of conventional GIC was higher with Carisolv as compared to Papacarie, which was statistically significant. RMGIC also showed a higher microtensile bond strength when restored to carious teeth treated with Carisolv, but this was not statistically significant. It was seen that Carisolv did not adversely affect the microtensile bond strength of both conventional GIC and RMGIC.

	Group	N	Mean	Std. Dev.	T-Value	P-Value
Microtensile Bond Strength	Conventional GIC with Carisolv	16	6.8263	0.45256	2.744	0.010
	Conventional GIC with Papacarie	16	6.3063	0.60817		

Table 2. Comparison of the Mean μTBS of Conventional GIC when Restored to Carious Teeth Treated with Carisolv and Papacarie

	Group	N	Mean	Std. Dev.	T-Value	P-Value
Microtensile Bond Strength	RMGIC with Carisolv	16	12.0581	0.61181	1.185	0.245
	RMGIC with Papacarie	16	11.7825	0.70079		

Table 3. Comparison of the Mean µTBS of RMGIC when restored to Carious Teeth Treated with Carisolv and Papacarie

DISCUSSION

CMCR is a non-invasive technique eliminating infected dentine via a chemical agent. With newer materials getting introduced for CMCR, there is renewed interest in this procedure. Restoration of cavities prepared by this technique requires materials such as composite resins or glass ionomers, which bond to the dentine surface rather than materials such as amalgams which involve cutting a cavity designed to mechanically retain the restoration.[20]

Although, the advent of adhesive materials has allowed developments in minimal cavity design, the amount of carious tissue that needs to be excavated in order to successfully treat a lesion is still a challenge.[21,22] In treatment of carious lesions in dentin, the morphology and nature of the prepared dentin surface influences the bonding of adhesive restorative materials.[23] However, little is known about the performance of adhesive systems on caries-affected dentin that has been excavated with these new minimally invasive systems.[24]

Clinical data obtained from randomised and controlled trials is the most reliable source for evaluating bonding systems.[25] However, owing to difficulty in applying this method[26] and since laboratory conditions allows to minimise disturbing factors during cavity preparation, an in-vitro study was performed so as to obtain information regarding the effect of CMCR agent in bonding of conventional GIC and RMGIC to caries affected dentin.

To test the effectiveness of bonding of the restorative materials, the µTBS test has grown in prominence at dental bonding research centres in the last 15 years, because it is seen to exhibit advantages over the traditional inaccurate methods of shear strength and tensile strength test such as better economic use of teeth with multiple microspecimens originating from one tooth, fewer defects occurring at the cement tooth interface because of the small surface area used and better stress distribution at the true interface.[27-30]

A total of 64 extracted carious primary molars were collected for the study. The use of deciduous extracted teeth does not interfere in the bond strength values as demonstrated in previous studies.[31,32]

The samples were stored separately in distilled water as described by Reis et al.[33] The samples were sectioned using a hard tissue microtome with a diamond disk at a speed of 200 rpm as described by Sadek et al[34] to obtain multiple sticks having a cross-sectional area of 1 mm^2 as suggested by Phrukkanon et al.[35] The original design by Sano et al used dumbbell-shaped specimens that allowed the tensile stress to be more uniformly directed toward the weakest interfacial region. However, while producing the dumbbell-shaped specimens from GIC-restored dentin, even slight vibration caused by eccentric movement of a high-speed bur resulted in premature bond failures.[36] Therefore, the 'non-trimming' version of the microtensile bond strength test that uses beam-like specimens with a small but uniform cross-sectional area throughout the entire length of the beam was adopted for this study as given by Shono et al.[37] This technique produces less stress on the bonded interface during specimen preparation,[38] so that we are able to test the materials that have relatively low bond strengths. The sectioned sticks were mounted on a notched jig with cyanoacrylate glue and were subjected to tensile forces at a crosshead speed of 1 mm/min according to Poitevin et al[39] in a Lloyd's universal testing machine until debonding of the restoration occurred.

The mean µTBS values obtained in this study were 6.83 ± 0.45 MPa for conventional GIC with Carisolv and 6.31 ± 0.6 MPa for conventional GIC with Papacarie. As for RMGIC it was 12.06 ± 0.61 MPa for Carisolv and 11.78 ± 0.7 MPa for Papacarie. These values were consistent with the values obtained for caries affected dentin (GIC 6.36 ± 4.38, RMGIC 12.40 ± 7.48) by K Choi et al,[40] where µTBS of conventional GIC and RMGIC built over the sound and artificially created carious dentine using demineralising solution were studied.

GIC's always contain numerous air inclusions that can act as stress points, thus giving rise to the increased likelihood of cohesive failure within the cement. Phrukkanon et al classified the failure of bonding between GIC and dentin into one of four types: Type 1- an adhesive failure between GIC and dentin (ion exchange layer); Type 2 - partial adhesive failure between the GIC and dentin and partial cohesive failure in GIC; Type 3- partial cohesive failure in dentin; and Type 4- cohesive failure in the GIC. Tay et al[41] stated that laboratory bond strength tests invariably result in cohesive failure of the conventional GIC, most often rather than failure within the ion exchange layer. Yip et al also stated that the laboratory µTBS values represent the weak yield strength of GIC under tension rather than the bond strength of GIC to dentin. Consequently, the true strength of the ion-exchange layer is not known.[42,43] µTBS values in the range 3 - 10 MPa are commonly reported for glass ionomer cements, which is approximately the cohesive strength of GIC.[44] The µTBS values of conventional GIC in this study are also within this range. Furthermore, only a scanning electron microscopic analysis of the tested specimens would confirm whether there is a cohesive failure or an adhesive failure.

The same phenomenon can also occur in the RMGIC, but the number of defects within this system is much lesser than in conventional GIC. This could possibly explain the lower µTBS of conventional GIC as compared to RMGIC, irrespective of the CMCR agent used as found in this study. This is in accordance with Burrow et al,[45] who reported that the µTBS of RMGIC is higher than conventional GIC to caries affected dentin treated with Carisolv.

In our study, it was also seen that both Carisolv and Papacarie did not have significant difference in µTBS of RMGIC. The reason behind this could be that most of the bond strength was due to the resin component of the resin-modified glass ionomer cement infiltrating around the exposed collagen fibres, thereby providing a mechanical bonding of the cement onto the dentin surface after chemomechanical caries removal.

On comparing the μTBS of conventional GIC when treated with Carisolv and Papacarie, it was found that conventional GIC with Papacarie had a statistically significant lower μTBS than with Carisolv. Papain, a proteolytic enzyme, in Papacarie acts only on infected tissues lacking a plasmatic anti-protease called α1-antitrypsin that inhibit proteolysis in healthy tissues, thus preserving the affected (non-infected) layer which produces lower bond strengths than normal dentin, regardless of the type of adhesive system. Chloramine, another component in Papacarie acts to promote the chlorination of collagen in the carious dentin acting only in the portion of necrotic tissue, preserving healthy tissue. Thus, the composition of the product is aimed at synergistic action of papain and chloramine. Furthermore, papain has been shown to reduce the mechanical properties of intact mineralised dentine as a result of degradation of proteoglycans of the matrix, suggesting that the action of papain might be non-specific.[46] On the other hand, the work done by Dammaschke et al[47] demonstrated that Carisolv on carious dentin caused alterations in the odontoblastic processes, but not in the dentinal collagen, thus not affecting the bond strength. As this product contains NaOCl (0.95%) in its composition, it breaks the cross-links between the dentinal collagen fibrils, denaturing them and dissolving the necrotic tissue.[48] The bond between NaOCl and the amino acids reduces the effect of whole collagen denaturation and breaks only the bond between the affected collagen fibrils without causing any molecular alterations. Furthermore, Carisolv removes only the non-remineralisable infected and necrotic dentin, preserving the subjacent non-infected dentin layer, and not causing harm to the sound dentin surrounding the lesion. Somani et al[49] reported that the sodium hypochlorite based CMCR agent Carisolv has higher efficacy in removing the smear layer and highest surface roughness than a Papain based CMCR agent. This difference in mechanism of action of Papacarie and Carisolv in causing alterations in the collagen fibril, removal of smear layer and surface roughness would probably be the reason for lower μTBS with Papacarie than Carisolv.

CONCLUSION

From the clinical point of view, it would seem that the placement of either a conventional GIC or a RMGIC to carious teeth treated with either Carisolv or Papacarie will not compromise the bond strength. There are still issues with respect to the increased time needed to remove the carious dentine compared with conventional instrumentation and the odour and taste of the solution that children may dislike. However, Carisolv and Papacarie appear to be a good material for removing carious tissue conservatively and further clinical trials are necessary to determine if the efficacy of the bond observed in this study is maintained in the clinical setting.

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