Assessment of Shear Bond Strength of Resin Modified Glass Ionomer on Dentine after Treatment with Different Remineralizing Agents: An In Vitro Study

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Abstract
Purpose: In order to measure and contrast the results of 3 different remineralizing agents (GC toothmousse, SHY-NM and Chitosan) on shear bond strength of (Fuji II LC) resin modified glass ionomer cement to dentine. **Materials and Methods:** This research was performed in al Azhar University; faculty of dentistry including 40 sounds freshly extracted primary molars. They were split up into 4 groups**, Group (I):** (control group) **Group (II):** (GC Tooth Mousse) **Group (III):** (SHY-NM) **Group (IV):** (chitosan). **Results:** The average shear bond strength was found to be highest in tooth mousse group (10.83±4.16), followed by shyNM (7.81±1.06), then chitosan group (6.96±1.41), with the least value recorded in control (5.19±1.01). NOVA test revealed that tooth mousse group was substantially greater than the 3 other groups (p=0.00). **Conclusion:** The shear bond strength of Fuji II LC resin altered glass ionomer to dentine was improved when dentine was pre-treated with: CPP-ACP containing paste. 5 % Novamin containing toothpaste. Chitosan in the form of phosphorylated chitosan and amorphous calcium phosphate (Pchi-ACP).

Keywords: Shear Bond Strength, Resin Modified Glass Ionomer, Remineralizing Agents

Introduction

Tooth decay, often known as dental caries, is a widespread, persistent infection of the tooth enamel and supporting hard tissues. It's important to prevent dental caries and associated consequences since they can worsen or even create systemic disorders that have a substantial influence on people's quality of life and the economy [(1, 2)] . More than 90% of children between the ages of three and five suffer from early childhood caries (ECC), a kind of caries that is more aggressive and develops more quickly. Causes of dental caries may be traced back to a variety of sources, including the host, bacteria, the substrate, and even the passage of time [(3)]. White spot lesions (WSLS) are white opacities on the flat surfaces of teeth that are reversible. WSLS are induced by early enamel demineralization at the surface and subsurface. The stages of a carious process are both reversible and irreversible. Cavitation can develop if the underlying demineralization of the teeth is not treated, since this leads to an increase in porosity and a corresponding alteration in the tooth's optical qualities [(4)]. The benefits of fluoride are enhanced by the introduction of calcium phosphate remineralization technology in light of casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), which strengthens tooth enamel [(5)]. Bioactive glasses (BAG) are another class of remineralizing materials [(6)]. Since its functional group may stimulate apatite nucleation, chitosan is regarded as a bioactive substance that can be put to use in remineralization [(7)]**.** There is a chance that teeth that have been treated with remineralizing chemicals will eventually need to be restored. For dental restorations and luting in adolescents and teens, glass ionomer cement has emerged as a crucial innovation. The initial hardening

period of resin-modified glass ionomer cements is drastically shortened by the photopolymerizable resin component [8].

MATERIALS & METHODS

This study was conducted in al Azhar University, faculty of dentistry including 40 sound freshly Primary molars .

Ethical approval was obtained from the research and ethical committee of the Faculty of Dental Medicine of Al-Azhar University for Girls Cairo-Egypt (**REC-PE-23-06**).

Sample size estimation and statistical power

Assuming that mean +_SD of shear bond strength after application of SHYNM and that of control group is (12.6+_6.7 versus 6.2+_3.7 respectively) so sample size is calculated by openepi program to be 40 teeth (10 teeth in each group) with confidence level of 95% and power of test 80%

I. Materials used:

Table (1): Product name, specification, chemical composition, and manufacturer of used materials:

Product name	Description	Composition	Manufacturer
GC Tooth Mousse strawberry **Figure "1"**	A water-based crème containing recaldent (Casien Phosphopeptie Amorphous Calcium Phosphate)	Pure water, glycerol, CPP-ACP, D-sorbitol, sodium Carboxymethyl cellulose, propylene, glycol, silicon dioxide, titanium dioxide, xylitol, phosphoric acid, flavoring, zinc oxide, sodium saccharin, ethyl p-hydroxybenzoate, magnesium oxide, guar gum, propyl p-hydroxybenzoate, butyl p-hydroxybenzoate.	GC Corporation,Japan
SHY-NM **Figure "2"**	calcium sodium phosphosilicate (5% novamin) containing toothpaste	Glycerin, PEG 400, Silica, calcium sodium phosphosilicate, sodium lauryl sulphate, titanium dioxide, flavor, carbomer,potassiumacesulfame .	SHY, Group Pharmaceuticals,Mumbai , India
Chitosan **Figure "3"**	Chitosan varnish		Nanogate , Egypt
FUJI II LC **Figure "4"**	A light-cured glass ionomer restorative with exceptional flexural strength and bonding to teeth even in the existence of saliva.	Powder: flouroaluminosilicate glass particals Liquid: copolymers of polyacrylic acid and maleic acid , HEMA , water , camphoroquinone , and photoinitiator	GC-Japan

Figure (1):
GC Tooth Mousse paste.

Figure (2):
SHY-NM toothpaste.

Figure (3):
Chitosan

Figure (4):
GC Fuji II LC

II. Methods:

A total number of 40 sound freshly extracted primary molars were included in the present research**.**

II.1. Inclusion criteria of the teeth evaluated in the study:

All teeth should be: Deciduous molars. Teeth had perfect surfaces without any visible damage on the crownfrom extraction forceps.

II.2. Mounting teeth specimens in acrylic blocks:

Specially designed cylindrical Teflon molds will be machine milled to form acrylic blocks in which teeth will be mounted to facilitate their handling **(Figure 5)**. Soft mix of polymethyl-methacrylate resin will be poured inside the Teflon mold. Teeth were mounted in the polymethyl-methacrylate resin. The tooth will be left fixed in its position until the acrylic resin will set. The acrylic block with the tooth will be removed from the mold. The specimens were then stored in saline solution.

Figure (5): The milling machine and different parts of the cylindrical Teflon mold with the ring.

II.3. Specimens preparation:

Enamel surface layer was removed from both proximal surfaces of each specimen to expose the superficial dentine surface just beyond DEJ using Buelher IsoMet 4000 micro-saw.

Teeth grouping and distribution: The prepared deciduous molars were separated into 4 groups, ten each, in accordance with the prescribed protocol: **Group (I): (control group):** Ten teeth have been repaired by resin modified glass ionomer (GC Fuji II LC) without using any remineralizing agents. **Group (II):** Ten teeth were cured with casein phosphopeptide-amorphous calcium phosphate paste (GC Tooth Mousse) then have been repaired by resin modified glass ionomer. **Group (III):** Ten teeth were cured with calcium sodium phosphosilicate containing toothpaste (SHY-NM) then have been repaired by resin modified glass ionomer. **Group (IV):** Ten teeth were cured with chitosan then have been repaired by resin modified glass ionomer.

Restorative procedures: Vinyl catheter tube was cut into 40 symmetric 2 mm length tubes measured by digital caliper and was adapted to the proximal surface of each specimen and glass ionomer was injected inside. **Group (I): (control group):** Ten specimens in this group were treated by the resin modified glass ionomer (FUJI II LC) only without application of any remineralizing agents on proximal surface as follow: (FUJI II LC) was packed 2 mm increment, Then 40 seconds of light curing. The Vinyl catheter tube was removed using dental probe and the specimens were additionally light cured for 20 seconds on each side.

Figure (6): Application of FUJI II LC

Group (II): A thin layer of CPP-ACP. Paste (GC Tooth Mousse) was applied to the exposed dentine surface of the ten specimens on proximal surface using an interdental brush & left to dry for five minutes, according to manufacturer instruction. specimens were rinsed for 30 seconds with water and dried for 30 seconds with oil-free compressed air. Finally, the application of fuji II lc resin modified glass ionomer as

previously mentioned in group I.

Figure (7): Application of GC tooth mousse.

Group (III): Calcium sodium phosphosilicate containing toothpaste (SHY-NM) was suspended in a 1:3 aqueous solution and applied to the exposed dentine surface of the ten specimens on proximal surface and left to dry for 5 minutes. Specimens were washed with water for 30 seconds and dried with oil- free compressed air for 30 seconds. Finally, the application of Fuji II lc resin modified glass ionomer as previously mentioned in group I.

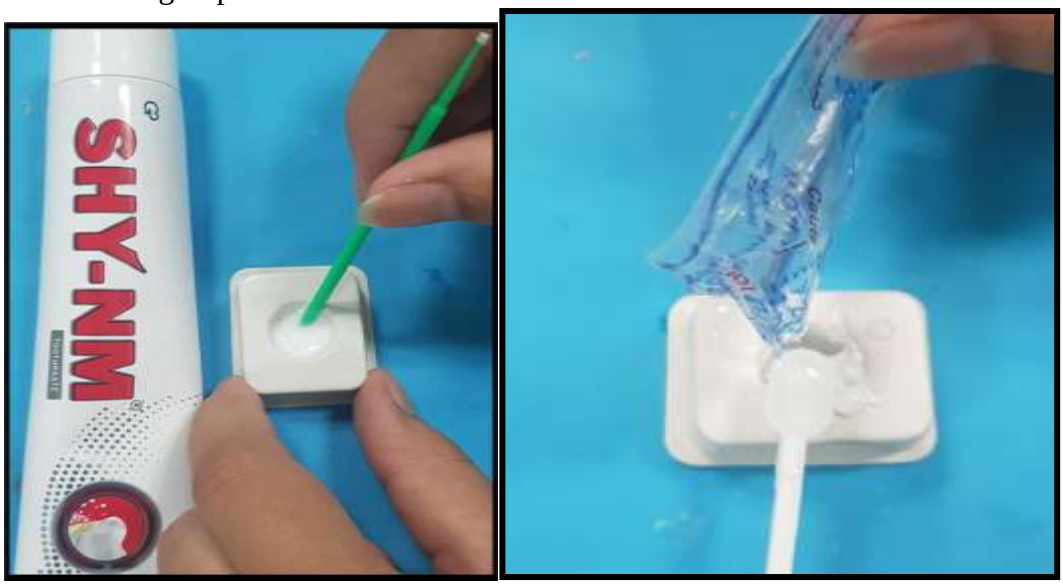

Figure (8): Application of SHY NM.

Group (IV): Chitosan will be utilized for the dentin surface of the ten teeth on proximal surface and left to dry for 5 minutes before application of fuji II lc resin modified glass ionomer as previously mentioned in group I.

Shear bond strength test:

A circular interface shear test was designed to evaluate the bond strength. All samples were individually and horizontally mounted on a computer controlled materials testing machine (Model 3345; Instron Industrial Products, Norwood, USA) with a load-cell of 5 kN and data were recorded using computer software (Bluehill Lite; Instron Instruments).

Samples were secured to the lower fixed compartment of testing machine by tightening screws.
Shearing test was done by compressive mode of load applied at tooth-resin interface using a mono-beveled chisel shaped metallic rod attached to the upper movable compartment of testing machine traveling at cross-head speed of 0.5 mm/min.
The load required for debonding was recorded in Newton.

Figure (9): Shear bond strength test

Statistical Analysis: The current version of the Statistical Package for the Social Sciences (SPSS) was used to organize and analyze the data. Mean, SD, and CIs were calculated to summarize the numerical data. Inquiries into whether or not the data follow a normal distribution were performed using the Kolmogorov-Smirnov and Shapiro-Wilk tests.

RESULTS

Shear Bond Strength (MPa)

I-Comparison between all groups

The greatest average value was documented in tooth mousse group (10.83±4.16), followed by shyNM (7.81±1.06), then chitosan group (6.96±1.41), with the least value recorded in control (5.19±1.01). NOVA test revealed that tooth mousse group was considerably greater than the 3 other groups (p=0.00), **(Table 2, Fig.10).**

II-Pairwise comparisons

Pairwise comparisons are summarized in **Table (3)**

II-a-Control group

Comparing control group with the other groups, revealed that control group was lower than shyNM by a mean value (-2.62 MPa), however the variance among control and ShyNM was not statistically substantial (p=0.095).

Control group was lower than tooth mousse group by a mean value (-5.64 MPa). The distinction among control and tooth mousse was statistically substantial (p=0.000).

Control group was lower than Chitosan group by a mean value (-1.77 MPa). The variance among control and Chitosan was not statistically substantial (p=0.571).

II-b-Shy NM group

Comparing shyNM group with the other groups, revealed that shyNM group was higher than control group by a mean value (2.62 MPa), however the variance among control and ShyNM was not substantial (p=0.095).

shyNM group was lower than tooth mousse group by a mean value (-3.02 MPa). The distinction amongst shyNM and tooth mousse was statistically substantial (p=0.037).

shyNM group was higher than Chitosan group by a mean value (0.85 MPa). The variance among shyNM and Chitosan was not substantial (p=1).

II-C-Tooth mousse

Comparing Tooth mousse group with the other groups, revealed that tooth mousse group was higher than control group by a mean value (5.64 MPa). The distinction among Tooth mousse and control was statistically substantial (p=0.000).

Tooth mousse group was higher than shyNM group by a mean value (3.02 MPa). The variance among Tooth mousse and tooth mousse was substantial (p=0.037).

Tooth mousse group was higher than Chitosan group by a mean value (3.86 MPa). The variance amongst Tooth mousse and Chitosan was statistically substantial (p=0.004).

II-d- Chitosan

Comparing Chitosan group with the other groups, revealed that Chitosan group was higher than control group by a mean value (1.77 MPa). The distinction amongst Chitosan and control was not statistically substantial (p=0.571).

Chitosan group was lower than shyNM group by a mean value (-0.85 MPa). The variance among Chitosan and shyNM was not statistically substantial (p=1).

Chitosan group was lower than tooth mousse group by a mean value (-3.86 MPa). The variance among Chitosan and tooth mousse was statistically substantial (p=0.004).

Table (2): Descriptive statistics and comparison of Shear Bond Strength (MPa) between groups (ANOVA test)

	Mean	**SD**	**95% Confidence Interval for Mean**		**Min**	**Max**	**F**	**P-value**
			Lower Bound	**Upper Bound**				
Control	5.19[b]	1.01	4.47	5.91	3.47	6.63	10.348	0.000*
shyNM	7.81[b]	1.06	7.06	8.57	5.97	9.20		
Tooth mousse	10.83[a]	4.16	7.85	13.80	2.90	17.45		
Chitosan	6.96[b]	1.41	5.96	7.97	5.62	10.68		

Significance level p≤0.05, *significant

Post hoc test: symbols with the identical superscript letter do not differ appreciably.

Table (3): Detailed outcomes of Bonferroni's post hoc test to make side-by-side comparisons of Shear Bond Strength (MPa) between groups.

(I)Groups	**(J)Groups**	**Mean Difference (I-J)**	**St. Error**	**95% Confidence Interval**		**P value**
				Lower Bound	**Upper Bound**	
Control	shyNM	-2.62	1.03	-5.51	0.27	0.095[ns]
	Tooth mousse	-5.64	1.04	-8.53	-2.75	0.000*
	Chitosan	-1.77	1.035	-4.66	1.12	0.571[ns]
shyNM	Control	2.62	1.05	-0.27	5.51	0.095[ns]
	Tooth mousse	-3.02	1.03	-5.90	-0.12	0.037*
	Chitosan	0.85	1.04	-2.04	3.74	1.0[ns]
Tooth mousse	Control	5.64	1.04	2.75	8.53	0.000*
	shyNM	3.02	1.035	0.12	5.90	0.037*
	Chitosan	3.86	1.04	0.97	6.75	0.004*
Chitosan	Control	1.77	1.04	-1.12	4.66	0.571[ns]

	shyNM	-0.85	1.03	-3.74	2.04	1.0 ns
	Tooth mousse	-3.86	1.035	-6.75	-0.97	0.004*

*. The mean difference is significant at the 0.05 level.

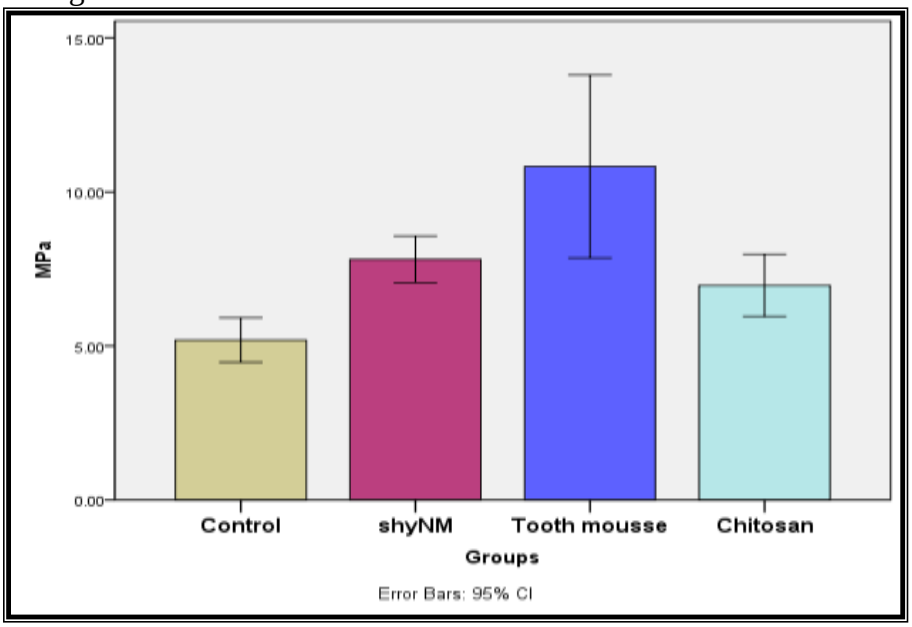

Figure (10): Bar chart illustrating mean shear bond strength (MPa) in different groups.

Although the greatest average was seen in tooth mousse group (10.83±4.16), followed by shyNM (7.81±1.06), then chitosan group (6.96±1.41), with the least value recorded in control (5.19±1.01). NOVA test revealed that tooth mousse group was considerably greater than the 3 other groups (p=0.00), **(Table 2, Fig.10)**

DISCUSSION

In the current study results revealed that, the highest mean value of shear bond strength was recorded in tooth mousse group (10.83±4.16), followed by shyNM (7.81±1.06), then chitosan group (6.96±1.41), with the least value recorded in control (5.19±1.01). NOVA test revealed that tooth mousse group was considerably greater than the 3 other groups (p=0.00).

In agreement with a previous study showed that, using a simple ANOVA, we saw that the SBS of various groups varied greatly, which was affected by the therapies they received, tooth mousse group had the highest mean value of shear bond strength with mean 14.87 ± 4.07 ($p<0.001$) [(9)].

Another study observed that the shear bond strength test (SBS) is well accepted in the field of bonding and adhesion as it provides a useful means of in vitro evaluation, and a comparison between different bonding materials [(10)].

On the other hand, another study found that the use of CPP–ACP may reduce the shear bond strength of light cured adhesives used in bracket bonding [(11)].

Contrary to the current study results was a study observed that, no noticeable changes in SBS values were found among the various adhesive methods using either the one-way ANOVA or the Tukey's post-hoc test, all groups recorded nearing mean value of shear bond strength ($p > 0.05$) [(12)].

In the present research, that, control group was lower than tooth mousse group by a mean value (-5.64 MPa). Making a distinction among control and tooth mousse was statistically substantial (p=0.000). Control group was lower than Chitosan group by a mean value (-1.77 MPa). By comparing the control group to the Chitosan group, there was no discernible change. (p=0.571).

In the same line was a study reported that, the samples from the placebo group had the lowest shear bond strength compared to those treated with Tooth Mouse prior to glueing orthodontic brackets, especially when utilising a self-etching adhesive method; the shear bond strength in this group was much higher than that of the other groups. [(13)].

Comparing shyNM group with the other groups, revealed that shyNM group was greater than control group by a mean value (2.62 MPa), although there was no discernible deviation among the ShyNM group and the control group (p=0.095). shyNM group was lower than tooth mousse group by a mean value (-3.02 MPa). When comparing shyNM and tooth mousse, there was a substantial disparity. (p=0.037).

In a study aimed study was to assess the efficacy of four commercially available remineralizing products (SHY-NM, GC Tooth Mousse Plus, ReminPro, and Colgate Strong Teeth) in restoring lost mineral content in human teeth, Rajan and his collages said that, after statistically evaluating the data, SHY-NM was shown to have the highest remineralizing capacity, followed by ReminPro and GC Tooth Mousse Plus [(14)].

On human teeth that had been stripped of their minerals, the SHY-NM performed better than the GC Tooth Mousse Plus, ReminPro, and Colgate strong teeth [(12)].

Comparing Tooth mousse group with the other groups revealed that tooth mousse group was higher than control group by a mean value (5.64 MPa). The difference among Tooth mousse and control was statistically significant (p=0.000). Tooth mousse group was higher than shyNM group by a mean value (3.02 MPa). The difference between Tooth mousse and tooth mousse was statistically significant (p=0.037).

Recently, Caries prevention and enamel remineralization using (CPP-ACP) have both been advocated for. Since CPP-ACP concentrates the ACP where it can do the best, the enamel structure is fully saturable. In addition to creating a sizable reserve in dental plaque, the presence of CPP ensures that calcium and phosphate will be available in all types of oral cavities, in a biologically soluble form [(12)].

It was concluded that, tooth mousse group was higher than shyNM group by a mean value (3.02 MPa). The difference between Tooth mousse and tooth mousse was statistically significant (p=0.037) [(15)].

Tooth mousse group was higher than Chitosan group by a mean value (3.86 MPa). Statistical analysis revealed a substantial gap among Tooth mousse and Chitosan. (p=0.004).

In agreement with this study results was a previous study observed that, Dentine pretreatment with a CPP-ACP (MI paste) for 3 minutes may boost the bond strength of Adper SE Plus due to the enhanced calcium availability [(16)].

Also, there was another study showed that, to improve remineralization, CPP-ACP might be added to GIC. And increase the shear bond strength of GIC [(17)].

Comparing Chitosan group with the other groups revealed that Chitosan group was higher than control group by a mean value (1.77 MPa). Chitosan did not significantly outperform the placebo. (p=0.571).

Muzzarelli, et al [(18)] reported that many organisms including Streptococcus mutans, have been shown to be susceptible to chitosan's bactericidal effects. In light of the fact that S. mutans is widely accepted as the primary etiological component in dental caries, this is of paramount importance [(19)].

Also, according to the findings of the current research revealed that, Chitosan group was lower than shyNM group by a mean value (-0.85 MPa). Chitosan and shyNM did not vary in a substantially meaningful way. (p=1). Chitosan group was lower than tooth mousse group by a mean value (-3.86 MPa). Statistical analysis revealed a considerable disparity among Chitosan and tooth mousse. (p=0.004).

A previous study showed that, In the event of direct bonding among the hydrogel and the enamel surface contact, the enamel bond strength is enhanced by the bioactive interaction of chitosan with the crystalline hydroxyapatite structure of the enamel layer [(20)].

CONCLUSION

The shear bond strength of Fuji II LC resin modified glass ionomer to dentine was improved when dentine was pre-treated with: CPP-ACP containing paste. 2.5 % Novamin containing toothpaste. Chitosan in the form of (Pchi-ACP).

Declarations

Consent for publication: I attest that all authors have agreed to submit the work.

Availability of data and material: Available

Competing interests: None

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Conflicts of interest: no conflicts of interest.

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