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Evaluation of Shear Bond Strength of Glass Ionomer Modified with Natural Biological Products:an in Vitro Study

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Restorative Dentistry
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ABSTRACT

Purpose: The aim of this study was to examine the shear bond strength (SBS) of conventional glass ionomer incorporated (GI) with flax fibers and/or ethanolic extract of propolis (EEP) with and without thermo-cycling. **Materials and Methods:** We used 40 extracted sound molars were used in the present study and divided into four equal groups: Group (GI) conventional glass ionomer(control), Group(F)GI incorporated with 5% flax fibers, Group (P) GI incorporated with 1% ethanolic extract of propolis (EEP), Group (FP) GI incorporated with 5% flax fibers and 1% ethanolic extract of propolis (EEP). All samples were prepared for shear bond strength assessment before and after thermocycling. **Results**: Showed that (F),(P) and(FP) groups had statistically significant highest median shear bond strength values before thermo-cycling in comparison to GI group. While (FP) group had the statistically significant highest median shear bond strength (SBS) after thermocycling. **Conclusion:**5% Flax fibers and 1% ethanolic extract of propolis (EEP)improved the shear bond strength of conventional glass ionomer.

KEYWORDS

Flax Fibers, Propolis, Shear Bond Strength

INTRODUCTION

Glass ionomer (GI) had been greatly used in restorative dentistry since its invention. It has a broad anticariogenic effect due to its fluoride release, and perfect adhesive properties in spite of its poor mechanical

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properties that restricted its application in stress-bearing areas[1]. A lot of modifications in the GI liquid and/or powder had been attempted to enhance its properties [2] Many years ago, natural products had been used excessively for medical applications, as they were effective, non-poisonous and served as an alternative source of medicine[3,4]. Flax fibers (lingo-cellulosic) are an example of biological materials and had been considered as multipurpose fibers which are strong, less abrasive and renewable. Moreover, because of their natural origin there is no doubt regarding their safety during application and handling[5].Therefore, their use has recently been expanded to biomedical purposes[6, 7]. In dentistry, Flax fibers were efficient in enhancing compressive strength and decreasing micro-leakage as well as solubility of zinc oxide eugenol cement[8].

Apitherapy is the art and science of treatment by means of honeybee products[9] Propolis is a resin that is collected by the honey bee and could be used in preservation of the hive against microorganisms. It was widely used in medical field as a biological material, due to its anti-inflammatory, antibacterial and antifungal properties. Propolis has an antibacterial impact against different microorganisms of oral cavity[3,4],but its impact of propolis on glass ionomers physical properties is not yet distinctly clarified.

Therefore, the present work was designed to assess the shear bond strength (SBS) of conventional glass ionomer combined with flax fibers and/or ethanolic extract of propolis.

MATERIALS AND METHODS

Preparation of teeth:

40 caries free molars were ground flat to remove the enamel and expose flat dentin surfaces. The long axes of the teeth were perpendicular to the surfaces cut, then the dentinal surfaces were polished manually. Teeth were embedded in pink self-cure acrylic resin so that the occlusal surfaces were parallel to the resin blocks.

Preparation of Flax fibers:

Short flax fibers were cut using sharp ended scissors and measured by digital caliper, Fibers which were more than 1 mm in length were excluded. Fibers less than 1 mm were collected and scanned using Scanning electron microscope (Type XL30; Philips Electron Optics, Eindhoven, SEM Unit, Main Defense Chemical Laboratory) to confirm the fibers length. These fibers were collected to obtain 5 wt.%. Flax fibers powder had been accurately weighed using a sensitive digital balance, then the powder was properly mixed and distributed with the powder of glass ionomer.

Preparation of 1% Ethanolic Extract of Propolis:

20% propolis in 60% ethanol was prepared. Filtration of the propolis sticky product was done before drying it .Propolis was then diluted and prepared to get 1% EEP.Finally,0.08ml of EEP had been added to 7.92 ml of the liquid of glass ionomer.

For shear bond strength testing (SBS):

For conditioning the dentin surfaces, polyacrylic acid was applied for 10 seconds, then all 40 samples were randomly divided into four equal groups (GI), (F), (P), (FP).All GIs were manipulated according to manufactures instructions and placed on the prepared dentin surfaces using a teflon mould (3mm x 4mm). The specimens were kept in distilled water for 24 hrs at 37°C.Shear bond strength (SBS)was assessed using knife-edge blade in a universal testing machine (Instron) with a crosshead speed of 1 mm/minute. The values of(SBS) were calculated as the ratio of fracture load to bonding area. The results were obtained in mega pascals (MPa).

Thermocycling (TC):

Half of the specimens of each group were kept in deionized water for 24 hrs at 37 °C.500 cycles were applied using a thermal cycling machine (SD Mechatronik GmbH) at 5°C and 55°C with 30 seconds dwell time and 20 seconds transfer time to that half of the samples.

Statistical analysis:

Numerical information were investigated for normality by checking the dispersion of information and utilizing tests of typicality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Shear bond strength data appeared non-parametric dissemination which presented as median and range values. Bonferroni's post-hoc test was utilized for pair-wise comparisons. For non-parametric information, Kruskal-Wallis test was utilized to compare between (SBS) of distinctive materials. Dunn's test was utilized for pair-wise comparisons when Kruskal-Wallis test is critical. Mann-Whitney U test was utilized for comparing between (SBS) without and with thermocycling. The significance level was set at $P \leq 0.05$.

RESULTS

Without thermocycling; there was no statistically significant difference between (F),(P), (FP) groups; all showed higher median shear bond strength values in comparison to shear bond strength values of GI group.

With thermocycling;(FP) group showed statistically significant highest median shear bond strength. There was no statistically significant difference between (GI), (F) and (P) groups; all showed the lowest median shear bond strength values.

Table (1): *The median, range values and results of Mann-Whitney U test for comparison between (SBS) values without and with thermocycling.*

Thermocycling	GI		GI + Flax		GI + Propolis		GI + Flax + Propolis	
	Median	Range	Median	Range	Median	Range	Median	Range
Non-thermocycled	0.87	0.24-1.24	2.07	0.78-8.03	2.68	1.2-2.73	2.23	0.24-4.55
Thermocycled	0.73	0.22-1.53	0.76	0.25-3.09	0.71	0.49-1.12	1.17	1-1.9
P-value	0.940		0.049*		<0.001*		0.019*	
Effect size (d)	0.034		0.979		3.162		1.230	

**: Significant at P ≤ 0.05*

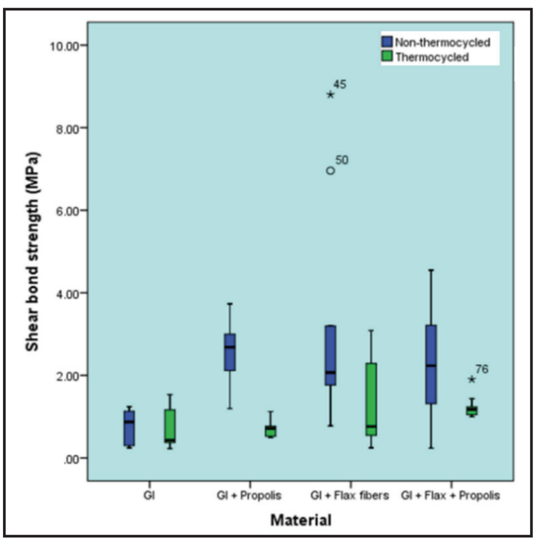

Figure (1): Box plot representing median and range values for shear bond strength without and with thermocycling (Star and circle represents outliers).

DISCUSSION

The present study aimed to modify the glass ionomer with natural flax fibers and/or propolis to produce new formulas with improved mechanical properties. GC Fuji IX gold label (GC Corporation, Tokyo Japan) glass ionomer was chosen for this work because it has high chemical adhesion and good strength as a posterior restorative material.

Flax fibers are one of the bast fibers that are extracted from the linseed/flax plant (Linum usitatissimum L.).They are biologically produced fibers with an antibacterial property and so they can be utilized in biomedical field, due to their antibacterial effect[10,11]. In the dental field, flax fibers were efficient in enhancing the compressive strength and decreasing the degeneration of zinc oxide eugenol cements[12].

When it comes to Propolis, it cannot be used directly because of its complex structure. Water, ethanol, methanol, chloroform, dichloromethane, acetone and ether were used as solvents for its extraction by removing the inefficient material while maintaining the required compounds[13]. Propolis has various forms such as lyophilized or ethanolic extract. Ethanolic extract was used in the present study as it is one of the richest sources of phenolic acids and flavonoids[14]. Authors had suggested that integration of 2% EEP increased the water sorption of glass ionomer which affected its physical properties[15]. Steinberg and Gedalia[16] proved in their study that 0.4% of EEP is the minimum concentration of propolis needed to have efficient antibacterial effect. So 1% ethanolic extract was used for this investigation.

Different mechanical tests were suggested to evaluate restorative material's bonding behavior. Shear bond strength (SBS)testing was performed in this study since it is reproducible, simple and one of the most accepted tests[17]. Also it is less technique sensitive, highlighting the strength at the bonded interface. Thermo-cycling is a commonly used process to simulate intraoral conditions in various previous in-vitro studies, So, it was also chosen for this assessment to evaluate the behavior of GIs under fluctuating temperature[18].

Conventional glass ionomer (GI) group samples showed (SBS) values without thermocycling ranging from 0.24-1.24 Mpa with a median of 0.87Mpa. While in the Flax fibers modified glass ionomer group samples showed (SBS)values ranging from 0.78-8.03 Mpa with a median of 2.07 Mpa. Flax fibers were able to bind to the carboxylic groups of the polyacrylic acid and the hydroxyl groups of the glass particles through hydrogen bonding[19]. When it comes to propolis modified glass ionomer samples, they showed shear bond strength from 1.2Mpa to 3.7Mpa with a median of 2.68Mpa. This may be due to the existence of an intermolecular interaction between the carboxylic groups of the glass ionomer and the functional groups of flavonoid components of propolis[20]. The results in this work noted that the (SBS) of (FP) group without thermocycling showed value ranging from 0.24-4.55 Mpa with a median of 2.23 MPa. This means that the combination of Flax fibers and Propolis had a synergistic impact on improving (SBS) through bonding between Flax fibers and hydroxyl groups of GI and between flavonoid components of Propolis and GI.

The results of the present work showed that thermo-cycling had a significant impact on shear bond strength of all groups. There was a significant descending tendency after 500 TCs of (GI), (F), (P) groups. This may be explained by the fact that thermal cycles produced thermal stresses that participate in destruction of the passive hurdles created at the interface between GI and tooth structure, including incomplete infiltration, incomplete polymerization, excess solvent in interface, hydrolytic breakdown, water sorption and dentin–GI interface degradation. Our explanation was supported by data of another study[21].

While (FP) group showed the statistically significant highest median shear bond strength (SBS). This could be because 5% flax fibers and 1% EEP modified glass ionomer became less sensitive to moisture and more resistant to degradation[22].

CONCLUSION

Under the limitations of the present study we concluded that:

Incorporation of 5% flax fibers and 1% ethanolic extract of propolis (EEP)to conventional GI improved the (SBS) of glass ionomer before and after thermocycling.

Further investigations for the effect of different concentrations of these natural products on conventional GI should be assessed.

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