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Research Article

A Comparative Evaluation Of Shear Bond Strength Of Orthodontic Brackets Bonded After Conditioning Of Enamel With 5.25% Sodium Hypochlorite And 10% Papain Gel: An *In-Vitro* Study

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Abstract

Objectives: The objective of this research was to evaluate the effect of conditioning the enamel surface with 10% papain gel and 5.25% sodium hypochlorite on the shear bond strength of orthodontic brackets and correlate it with the conventional bonding mechanism utilizing a Universal Testing Machine.

Methodology: 90 extracted human premolars divided into three groups: In group 1, treatment with 5.25% sodium hypochlorite for 60 seconds on enamel surface followed by etchant and primer application. In group 2, treatment with 10% Papain gel for 40 seconds followed by etching and primer application. In group 3, etching was followed by primer application. A universal testing machine was used to record the shear bond strength of the orthodontic brackets.

Results: 5.25% sodium hypochlorite(15.10 ± 2.66) and 10% papain gel (15.66 ± 2.83) treatment on enamel before acid etching when compared to the control group (12.82 ± 2.03) increased the shear bond strength with a statistically significant difference between them ($p = 0.002$, $p < 0.001$). The experimental groups, sodium hypochlorite (15.10 ± 2.66) and papain gel (15.66 ± 2.83) group were comparable but did not show any statistically significant difference between them ($p = 0.665$).

Conclusion: Shear bond strength of orthodontic brackets can be significantly increased if the enamel is deproteinized with 5.25% NaOCl and 10% papain gel before acid etching with 37% phosphoric acid compared to the conventional bonding technique. Deproteinizing enamel can be considered a cost-effective ally to increase orthodontic brackets' bond strength and thereby reduce the duration of orthodontic treatment.

Keywords: Deproteinization; White Spot Lesion; Enamel Conditioning; Shear Bond Strength; Papain Gel; Sodium Hypochlorite

Introduction

Dentistry in general, and orthodontics in particular, strongly rely on advances in material science.Nonetheless, advanced research on material development has had significant effect on the practice of orthodontics since the advent of modern orthodontics by Edward H. Angle [1]. The implementation of direct bonding was another headway in orthodontics. In the early days Brackets and auxillary attachments were welded onto gold or stainless steel bands. Sufficient space should have been made around each tooth before treatment to seat the bands, after which it was cumbersome to close the spaces post orthodontic treatment. This was prolonged and difficult for the patient. Attached and banded attachments ofteninduced gingival damage, and below the band decalcification may occur. Orthodontic bracket bonding to the enamel surface was pioneered by Dr George Newman in the mid-1960s [2]. Enamel etching patters were categorized into 3 byGwinnet (1971) and Silverstone (1975), on the basis of the dissolution of the hydoxyapetite crystals [3].

- **Type 1:** Sequence that dissolves the enamel rods
- **Type 2:** The interrods are dissolved
- **Type 3:** All rods and interrods are dissolved

Clinically, it provides a frosty white appearance that reveals only the quantity but not the quality of the etching. However it was later established by Silverstone that majority of the etching patterns were of types 1 and 2 based on the retentive component produced by the porous layer. The micro retention provided by the other two lacked type 3 pattern.

Organic components are still tethered to the enamel surface (the acquired dental pellicle) even after pumicing of the surface. Through controlling mineral dissolution dynamics on the enamel surface, the acquired pellicle has major role in preserving structure of teeth and offers resilience against chemical depletion and damage by acid etching. Therefore, the pellicle prohibits the enamel surface from being etched completely, contributing to bracket debonding and WSL creation on the bonded surface. Because of its proteolytic properties, sodium hypochlorite (NaOCl) solutions have been used to irrigate wounds from 1915. Various Sodium hypochlorite concentrations (1%-5%) are now commonly recognized as a root canal irrigant [4,5]. In 2008, it was found by Espinosa., *et al.* 2010 that treating the superficial surface with 5.25%.NaOCl before etching increased the quality of the etching pattern because NaOCl separated organic matter from this surface (deproteinization) [6]. Papain was introduced into the dental field recently. The product, Papaca´rie was used in the chemo-mechanical dissolution of carious activity. The objective was of eliminating affected tissue without harming any healthy structure in the oral cavity. Papain is anenzymeobtained from parts of *Carica papaya*. The enzyme has been included in various antibacterial and Deproteinization agents [7]. Because of these properties it was used in the dental field. It can also remove debris from teeth and increase acid penetration of enamel. It produces a rough surface and it is helpfulto enhance the bond strength between adhesive and tooth enamel [6]. Enamel conditioning is an inevitable part in dentistry but the surface area conditioned majorly is only 2% [8]. This is majorly noticed in procedures where in restorations and orthodontic brackets are defective. This results in numerous dental visits thus increasing the treatment time and hiking its cost.

Since research on the effects of enamel deproteinization and its importance on orthodontic bracket shear bond strength are limited in literature, the ideaof this research is to study the effect of 10% papain gel and 5.25% sodium hypochlorite on the increase of orthodontic bracket SBS and also to correlate it with the standard bonding mechanism by means of auniversal testing machine.

Materials and Methods

Collection of samples

Extracted teeth used in this study were extracted for orthodontic purposes from patients seeking orthodontic treatment at the Department of Orthodontics, JSS Dental College and Hospital. 90 premolar samples extracted for orthodontic treatment purpose was used. It was randomly divided into three groups of 30 samples each The collected specimen are stored at room temperature in distilled water solution of 0.1% thymol for disinfection and to inhibit bacterial growth.

Preparation of 10% papain gel:Papain, an anti-oxidant (α-toc opherolacetate),Emulsifier(amylopectin),thickener (Carbomer) pH adjuster (Triethanolamine) Preservative (methyl paraben and propyl paraben),Metalcomplexing agent (EDTA), Distilled water as a vehicle. Carica papaya extract 25mg was obtained from Hi-media laboratory and 10% papain gel,was then formulated with the above mentioned raw materials in the Department of Pharmacognosy, JSS College of Pharmacy, JSS AHER, Mysuru.

- **Group A (pink):** Initially 5.25% sodium hypochlorite is applied with a applicator tip for 60 seconds washed and dried followed by etching with 37% phosphoric acid. Primer was then applied and light cured.The orthodontic bracket was bonded with 3M Transbond™ XT composite resin.
- **Group B (green):**10% Papain gel is applied on the enamel surface with an applicator tip for 40 seconds, washed and dried. Etching with 37% phosphoric acid is done. Primer was then applied and light cured. The orthodontic bracket was bonded with 3M Transbond™ XT composite resin.
- **Group C (brown):**Etched with 37% phosphoric acid washed and dried. Primer was then applied and light cured.The orthodontic bracket was bonded with 3M Transbond™ XT composite resin.

Evaluation of shear bond strength

After the pre-treatment of enamel using 5.25% sodium hypochlorite,10% papain gel and control group, respectively the brackets are bonded onto the buccal surfaces of the tooth using 3M™ Transbond™ XT composite resin. A Universal Testing Machine with a load cell of 1000 N was used, operating at a cross-head speed of 0.5 mm/min. In the Universal Testing Machine, each sample was placed with its long axis parallel to the direction of the applied force. A jig was made using. 01" stainless steel wire and the end of the wire was embedded in acrylic block (to secure the stainless steel wire), which was fixed to the upperjaw. Loop was engaged under wings of bracket on which shear force is to be applied. The maximum force necessary to debond or initiate bracket failure was recorded in Newton. The shear bond strength (SBS) in Megapascals (MPa) was computed as a ratio of force in Newton to the surface area of the bracket. Profile projector Microscope (Mitutoyo - PJ-A3000), Mitutoyo South Asia Pvt. Ltd., screen 0315 mm, measuring range of 100 mm x 100 mm, 10x projector lens, 100 mm x 100 mm XY stage with linear scales and Halogen lamp of 24 V, 15W was used to measure the bracket base surface area. Bracket base was measured and calculated to derive the total surface area value of 10.5 mm^2.

Statistical analysis

The data obtained was subjected to statistical analysis, which was performed using SPSS (Statistical package for social sciences) version 14 for Windows with one-way ANOVA and Tukeys post hoc tests to compare the shear bond strength values of all the groups. All the tests were performed at 95% confidence level with the level of significance set at 0.05 (5%)

Results

Table 1 shows Statistical differences between test parameters in study according to One-Way-ANOVA. In ANOVA there is statistically significant difference between the groups A, B and C with p < 0.001. The mean shear bond strength of Papain Gel group is (15.66Mpa) which is the highest followed by Sodium Hypochlorite group (15.10Mpa) and least mean shear bond strength was shown by the control group (12.82MPa).From Tukey's post hoc test (Table2) it is observed that there is significant difference in mean bond strength 5.25% sodium hypochlorite (15.10 ± 2.66) treatment on enamel prior to acid etching when compared to the control group (12.82 ± 2.03)where in conventional technique was used did increase the shear bond strength with a statistically significant difference between them (p = 0.002). 10% papain gel (15.66 ± 2.83) treatment on enamel prior to acid etching when compare to the control group(12.82 ± 2.03) where in conventional technique was used did increase the shear bond strength with a statistically significant difference between them (p < 0.001). The experimental groups, sodium hypochlorite (15.10 ± 2.66) and papain gel (15.66 ± 2.83) group were comparable but did not show any statistically significant difference between them (p = 0.665)

Groups	*n*	Min	Max	Mean ± SD	Range	Sig.
Group A	30	11.68	20.61	15.10 ± 2.66	11.68 - 20.61	< 0.001
Group B	30	11.70	20.42	15.66 ± 2.83	11.70 - 20.42	
Group C	30	11.1	20.05	12.82 ± 2.03	0.05	

Table 1: Groups, Minimum, Maximum, Mean and standard Deviation and Range and significance of the shear bond strength values and statistical analysis of the groups evaluated.

*p < 0.05 and **p < 0.01; Significant ***p < 0.001 Highly Significant; p > 0.05 not significant.

(I)G	(J) G	Mean Difference (I-J)	S	Sig level (p < 0.05*)
A	B	-.56533	.65469	.665
	C	2.27233*	.65469	.002
B	A	.56533	.65469	.665
	C	2.83767*	.65469	< 0.001
C	A	-2.27233*	.65469	.002
	B	-2.83767*	.65469	< 0.001

Table 2: Descriptive statistics, including Mean Difference, Standard Error, and P value.

*p < 0.05 and **p < 0.01; Significant ***p < 0.001 Highly Significant; p > 0.05 not significant.

Discussion

Dental enamel is made up of 96%of inorganic matter and less than 1 percent of organic matter, less than 50% protein is present. OrthoPhosphoric acid primarily works on the mineral portion, i.e. the inorganic part of the enamel, although the organic portion of the enamel surface is not removed [9]. Phosphoric acid is prevented from etching the enamel surface successfully because of this additional organic coating, resulting in a variable pattern and a superficial enamel surface for bonding. To multiply the type of etch patterns inturn gave rise about idea of removing protein composition of enamel. Researchers have shown that the organic material and salivary proteins present in saliva are typically located in the superficial zone and can create obstacles in the traditional etching technique as well as in the deepest resin penetration. Researches have shown that the 0rganic material along with saliva components consisting in saliva are attributed in the outermost layer and can create obstacles. It is notable that Gurneyand Rapp in 1946 published an original research paper entitled "A Technique for Observing small Changes on Tooth Surface [10]. These authors did enamel and dentin etching of tooth surface which was previously treated with a sodium hypochlorite (NaOCl)derivate, (NaOH) solution, at various concentrations to procure adequate surfaces evaluated under SEM. The tooth specimens were then immersed for etching with results analyzed at appropriate times by creating additional micro-impressions. The surfaces looked cleaner after application of the NaOH solvent, possibly because of the dissolution of small part of the organic coats from the surfaces [11].

. While the bond strength of traditional etching systems has been tested in several studies, few studies have considered the potential effects of enamel protein levels on etching efficiency.

Pithon., *et al*. 2011 stated that Deproteinization of enamel with 10 percent papaingel tends to multiply the shear bond strength, independent of the etching agent and therefore, this makes papain gel a good alternative for Deproteinization for enamel surface before b0nding orthodontic brackets [12]. The mean shear bond strength recorded after Deproteinization was 23.6 ± 50.88which is not comparable to the results obtained in the present study which is 15.66 ± 2.83. The reason for varying results could be due to the use of bovine incisors in the above study.

The impact of various types of concentrations of gel form of papain on 0rthodontic bonding of bracket were also consequently studied by Pithon., *et al.* 2012 to confirm the hypothesis that Deproteinization of enamel with papain concentrations of 2percent, 4percent, 6percent, 8percent, and 10 percent increases SBS with different concentrations. The conclusion was that the deproteinization with 8percent and 10percent gel of papain strengthens SBS of 0rthodontic brackets bonded with RMGIC [13]. Similarly 10% papain gel was found to be the ideal concentration by Farahnaz Sharafeddin., *et al*. 2019 in their study, Effect of Papain and Bromelain Enzymes on Shear Bond Strength of Composite to Superficial Dentin in Different Adhesive Systems evaluated the 10% papain gel as a deproteinizing agent before the self-etching adhesive system and it showed the highest Shear bond strength [14]. Taking into consideration the results of these studies concentration of 10% was found ideal for papain gel and was used for the present study.

Espinosa., *et al*. 2010 in the study showed that conditioning of the surface of enamel using 5.25% sodium hypochlorite (NaOCl) for one min, before acid etching, improves the etching pattern quality because Na0Cl eliminates the organic matter which causes Deproteinization of enamel surface. The researchers demonstrated that the outermost organic layer prevents standard 37percent phosphoric acid from etching the enamel surface, resulting in inconsistent etch patterns and a unreliable enameI surface for bonding orthodontic brackets. Type one and two patterns of etching results when NaOCL was used, whereas type three etch pattern was mostly seen when NaOCl was not used. De-proteinizing agent to phosphoric acid etching became twice the enamel's retentive surface notably, from 48.8percent to 94.47percent and more commonly Type-I andType-II etching patterns [6].

Şaroğlu., *et al.* 2006 showed that Deproteinization following the acid etching resulted in enhancement of the enamel bonding in Hypo-calcified amelogenesis imperfect teeth and was used to decrease the high breakage rates of adhesive restorative treatments in Hypo-calcified AmelogenesisImperfecta (HCAI)cases.HCAI enamel may have 3–4percent protein by weight in contrast with 0.5 percent for normal enamel. As the adhesion of enamel with restoration highly depends on the alterations in enamel surface, excess proteins removalmay have provided advantage 0n the adhesion of the restorative procedures [15].Effect of bromelain enzyme for dentin deproteinization on bond strength of adhesive systems was studied by Kirti Chauhan., *et al.* 2019. 30 extracted human premolars were used in the study. In Group 1, teeth were etched; in Group 2, teeth were etched and deproteinized with bromelain enzyme; in Group 3, teeth were etched and deproteinized with 5% NaOCl. The conclusion states that the bond strength results; were significantly influenced by the application of bromelain enzyme. Statistically significant were not demonstrated in the control group and NaOCl-treated group. However, NaOCl may exert different effects on bond strength depending on the chemical structure of the adhesive system and the type of the initiator in the adhesive system used which could be the reason for the contrary results compared to the present study [16].

Enamel surface deproteinization prior to orthodontic bracket bonding was suggested by Justus., *et al*. 2010 using NaOCl. They stated that Enamel-deproteinization with 5.25percent sodium hypochlorite improves the SBS, independent of the etching agent [17]. Transbond XT with Na0Cl Deproteinization recorded mean shear bond strength values of 9.41 ± 4.46 which was comparable to the results achieved in the current study.Enamel Deproteinization after Acid Etching was studied by Ramakrishna., *et al.* 2014 where 5.25% sodium hypochlorite was applied on the enamel surface after acid etching. They concluded that No significant enhancive effect of enamel deproteinization after acid etching with respect to the occurrence of Type I-II etching patterns as well as on the SBS of adhesive resin and composite resin complex to the enamel surface was observed in this study which was in contrast with the present study [18]. The contrary results could be due to the use of extracted permanent molar teeth and bonding of composite resin block on the treated enamel surface differing from the present study where orthodontic brackets were bonded on the buccal surfaces of extracted premolar teeth.

To conclude, this study states that enamel Deproteinization Using 5.25% sodium hypochlorite and 10% Papain gel significantly increased the shear bond strength of orthodontic brackets. As innovations and advancements happen newer deproteinizing agents such as bromelain gel has also been introduced. Deproteinization treatment can be considered a new ally in orthodontic treatment as it helps to decrease bracket failure and treatment duration and can also aid in reducing white spot lesion formations.

Conclusion

Within the limitations of the present study, the following conclusions were drawn:

- Significantly greater shear bond strength of orthodontic brackets can be obtained with conventional composite if the enamel is deproteinized with 5.25% sodium hypochlorite (NaOCl) or 10% papain gel before acid etching with 37% phosphoric acid.
- Similar efficiency was shown by 5.25% sodium hypochlorite and 10% papain gel in deproteinizing enamel and thereby increasing the bond strength
- Deproteinization with 5.25% sodium hypochlorite (NaOCl) and 10% papain gel before acid etching offers a non-invasive and cost-effective method of enhancing bond strength of orthodontic brackets.

Since 10% papain gel and 5.25% sodium hypochlorite has been proved as an effective enamel deproteinizing agent, it will help the orthodontists to achieve effective bonding before orthodontic bracket bonding procedure but newer studies with larger sample sizes and clinical trials are recommended for these deproteinization agents before its clinical application. Increasing the Shear Bond Strength significantly decreases the Treatment time and can be considered a new ally in current Orthodontic perspective.

Conflict of Interest

None.

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