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Journal of Contemporary Orthodontics

Journal homepage: https://www.jco-ios.org/

Original Research Article

Assessing the impact of enamel deproteination on orthodontic bracket survival rate: A split-mouth investigation

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Abstract

Aim: The purpose of this study is to clinically assess the impact of 5.25% sodium hypochlorite enamel deproteinization on the orthodontic bracket survival rate during the initial phase of fixed appliance therapy.
Materials and Methods: Twenty individuals in the 15–30 age range with full permanent dentition were split into two groups. Group A (Left upper and Left lower quadrant): the enamel surface is prepared with 5.25% sodium hypochlorite before bonding (Total number of brackets – 190); Group B (Right upper and Right lower quadrant): brackets were bonded without enamel deproteinization. Up until the point of leveling and alignment, the bond failure rate of the brackets was monitored and evaluated every few months. The bracket failure rate is evaluated using Pearson's Chi-square test. The preset P value was set at < 0.05.
Results: Among the 18 (4.7%) bracket failures that occurred throughout the study period, 4 (2.1%) were debonded in the experimental group, while 14 (7.4%) occurred in the statistically significant control group (p=0.016). There were 8 debonded brackets in the maxillary arches (4.2% failure rate) and 10 debonded brackets in the mandibular arches (5.3% failure rate) (p = 0.629). Bracket failure rates were higher for posterior (premolar) brackets (7.8%) than anterior brackets (2.9%) (p=0.334).
Conclusion: The use of 5.25% sodium hypochlorite prior to attaching orthodontic brackets using Transbond XT might be considered a favorable method for enhancing the bond survival rate.

Keywords: Enamel Deproteinization, Sodium hypochlorite, Bracket survival rate, Bracket location.

Received: 04-05-2024; **Accepted:** 08-07-2024; **Available Online**: 27-05-2025

1. Introduction

Edward Angle revolutionized orthodontic treatment with fixed appliances, specifically the E-arch appliance, transforming the field. This approach involved banding individual teeth with attachments, anchoring archwires, and facilitating tooth movement. In 1955, Buonocore's breakthrough with phosphoric acid improved enamel surface treatment, enabling better resin penetration for enhanced adhesion.[1] Newman's 1965 innovation proposed bonding orthodontic brackets directly onto tooth surfaces using epoxy resins, streamlining the process by eliminating the need for tooth banding.[2]

The success of orthodontic treatments depends on the adhesive bond between enamel and brackets, achieved through acid etching.[3] However, the enamel surface's natural organic salivary pellicles pose a challenge, hindering adhesion.[4,5] Effective enamel etching necessitates removing these organic components, a process known as deproteinization introduced by Sakae.[6] Evolved from dentin conditioning, 5.25% sodium hypochlorite was used to eliminate the organic layer, enhanced adhesion, and applied to hypo calcified cases for improved bond strength.

Various researchers explored this concept in different contexts. For instance, Roberto Espinosa demonstrated the effectiveness of enamel deproteinization in pediatric

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https://doi.org/10.18231/j.jco.2025.033

dentistry.[7] Young patients often have enamel with higher organic content, making this process particularly valuable. Adanir et al. used it to improve bonding in fluorosis of enamel.[8] Justus et al and Pereira et al. suggested that sodium hypochlorite, when used before etching, improved bond strength.[9,10] Other alternatives like Papacarie gel and bromelain gel were also explored.[11,12]

Despite promising in-vitro results, clinical research in restorative and pediatric dentistry is lacking. Additionally, very few orthodontic clinical Researches evaluate the effect of enamel deproteinization on bracket survival rates. In order to fill the gap, this work uses 5.25% sodium hypochlorite to clinically examine the function of enamel deproteinization during the leveling and aligning phase of fixed orthodontic therapy. The goal is to determine its effect on bracket survival rates, providing insights into practical implications for orthodontics.

2. Materials and Methods

The present study was conducted as a prospective single-blinded split-mouth randomized controlled trial, adhering to the CONSORT statement reporting guidelines. (

Figure 1) The research was carried out within the Department of Orthodontics and Dentofacial Orthopaedics, Chettinad Dental College and Research Institute and received ethical approval from the Institutional Human Ethics Committee (Ref. No. 677/IHEC/12-19). Participants provided informed consent after a comprehensive explanation of the treatment protocol. The inclusion criteria were as follows: Age range of 15 to 30 years with complete permanent dentition requiring fixed appliance therapy in both arches, absence of restorations on labial and buccal tooth surfaces, and overall good health without systemic diseases. Exclusion criteria include patients with congenital enamel defects, fillings or hypoplasia, partially erupted teeth, patients in mixed dentition stage, endodontically treated teeth and patients with fixed prosthesis, patients with teeth attrition, and patients who have had previous fixed appliance orthodontic treatmen.

The sample size was calculated using G Power version 3.1.9.4, resulting in a sample of 20 participants. The statistical test's power was set at 80%, and the acceptable α (alpha) error was 5%. The study participants were divided into two groups: Group A (Control) included the right upper and right lower quadrants (total of 190 brackets), and Group B (Experimental) included the left upper and left lower quadrants (also a total of 190 brackets). The study comprised 20 patients, consisting of 13 males and 7 females. In total, 380 brackets were bonded for 20 patients. Additionally, 5 patients underwent therapeutic extraction of both upper and lower first premolars. Each bonded bracket was treated as a unit of measurement, and bracket failures were monitored in both groups for a six-month period. The choice of material and the side of the mouth for bracket bonding were concealed from the participants. This decision was made randomly using a Random Number Table. All participants received 0.022-in slot MBT prescription (Mini Diamond stainless steel brackets, Ormco) for bonding.

In Group A (Control), brackets were bonded to teeth using composite resin without deproteinization. The teeth were etched with 37% phosphoric acid (EAZ etch), rinsed, and dried with oil-free compressed air. A thin layer of Transbond primer (3M) was applied and cured for 10 seconds. The adhesive (Transbond XT) was placed on the bracket base, seated onto the tooth with sufficient force to achieve uniform adhesive thickness, and cured for 40 seconds using a light-emitting diode light cure.In Group B (Experimental), a 5.25% sodium hypochlorite (NaOCl) solution was applied using a micro brush for 60 seconds, followed by rinsing and air drying. The same bonding protocol as in Group A was then followed.

All patients were initially prescribed a 0.012” Niti archwire, regardless of alignment and crowding. Archwires were tied with elastomeric modules approximately 15 minutes after bonding. The study spanned six months, during which the patients were observed and monitored. Subsequent archwire changes (0.014Niti, 0.016Niti, 0.016x0.022Niti, and 0.017x0.025Niti) were made based on observed alignment progress. Patients were educated about diet and oral hygiene after bonding. Follow-up and assessment of bracket bond failure were conducted by the principal investigator. Patients were reviewed at 3-4 week intervals, with prompt appointments advised for bracket failures. If patients were unaware of bracket failure, the appointment date was recorded as the failure date. Bracket failures were categorized based on tooth location (anterior or posterior segments). Debonded brackets were rebonded using conventional adhesive but were not included in the study analysis.

2.1. Statistical analysis

For statistical analysis, the software SPSS v. 17.0 (SPSS Inc., Chicago, USA) was employed. The collected data were organized in an Excel spreadsheet. The survival rates of the brackets were assessed using Pearson’s Chi-Square test, a statistical method for comparing categorical data. The threshold for statistical significance was set at $p < 0.05$, indicating that differences with p-values less than 0.05 were considered statistically significant.

3. Results

The bracket survival rate was monitored for a duration of six months. Throughout this observation period, a total of 18 brackets failed, accounting for a failure rate of 4.7%. Among these, 4 brackets (2.1%) experienced debonding in the experimental group, which utilized enamel deproteinization with 5.25% sodium hypochlorite prior to acid etching and Transbond XT adhesive.

Table 1: Total Number of brackets debonded according to the type of enamel surface preparation

			No. of brackets debonded		Total	p value
			Yes	No		
Group	Control	Count	14	176	190	
		%within Group	7.4%	92.6%	100.0%	
	Experiment	Count	4	186	190	
		%within Group	2.1%	97.9%	100.0%	0.016
Total		Count	18	362	380	
		%within Group	4.7%	95.3%	100.0%	

Table 2: No of brackets deboned based on the dental arch

			No. of brackets deboned		Total	p value
			Yes	No		
Arch	Maxilla	Count	8	182	190	
		%within Arch	4.2%	95.8%	100.0%	
	Mandible	Count	10	180	190	
		%within Arch	5.3%	94.7%	100.0%	0.629
Total		Count	18	362	380	
		%within Arch	4.7%	95.3%	100.0%	

Table 3: of brackets debonded based on the bracket location

			No. of brackets debonded		Total	p value
			Yes	No		
Location		Count	7	233	240	
	Anterior	% within Bracket location	2.9%	97.0%	100.0%	
	Posterior	Count	11	129	140	
		%within Bracket location	7.8%	92.1%	100.0%	0.334
Total		Count	18	362	380	
		% within Bracket location	4.7%	95.3%	100.0%	

In contrast, 14 brackets (7.4%) in the control group, where acid etching and Trans bond XT adhesive were used, exhibited bond failure. A significant difference in bracket failure risk was noted over the six-month period between these two groups (p = 0.016). The comprehensive debonding statistics are provided in (**Table 1**).

In terms of dental arches, the maxillary arches witnessed 8 debonded brackets, reflecting a 4.2% failure rate. On the other hand, the mandibular arches had 10 debonded brackets, translating to a slightly higher failure rate of 5.3%. However, this discrepancy in failure rates between maxillary and mandibular arches did not reach statistical significance (p = 0.629). Further information on the influence of dental arches on the bracket survival rate can be found in (**Table 2**).

Analyzing bracket failure rate based on the location of brackets, posterior brackets (premolars) exhibited a higher bracket failure rate of 7.8%, as opposed to anterior brackets with a failure rate of 2.9%. However, the Pearson Chi-square test did not reveal any significant differences in survival rates between anterior and posterior brackets (p = 0.334). Detailed values are provided in (**Table 3**).

A consolidated overview of overall bracket failure rates across the six-month duration was organized according to the type of enamel surface preparation, bracket location, and dental arch in (**Figure 2**). It's worth noting that a p-value below 0.05 is considered indicative of statistical significance.

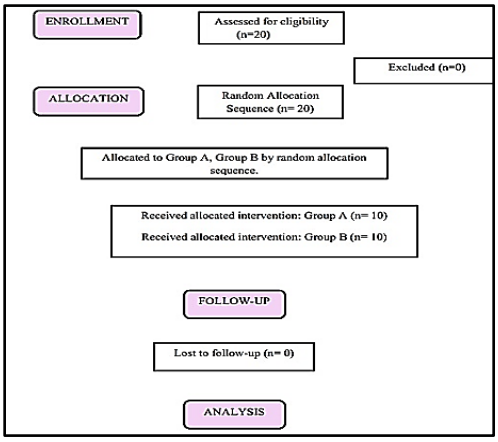

Figure 1: Consort statement.

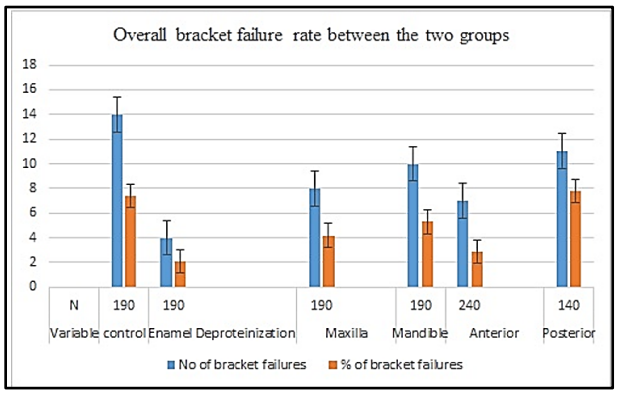

Figure 2: Overall bracket failure rate between the two groups.

4. Discussion

The salivary pellicle is an organic layer formed through protein adsorption in the oral environment, it acts as a barrier that can hinder the penetration of etchant during bonding procedures, potentially leading to bond failure.[13-14] To address the challenge posed by the salivary pellicle, the concept of deproteinization was introduced. This process involves the removal of organic matter, specifically proteins, from the enamel surface. The aim is to prepare the enamel for optimal etching, allowing for better penetration of adhesive materials. Enamel deproteinization can be carried out by using (5.25% sodium hypochlorite, Papacarie, Papain gel, and Bromelain gel) of which sodium hypochlorite is one of the most commonly used deproteinizing agents.[15-16] Sodium Hypochlorite (5.25%) was first used as a root canal irrigant during root canal treatment procedure in operative dentistry because of its deproteinizing action which dissolves the remaining pulpal tissues and bacterial cells thereby providing an antibacterial effect,[17] numerous in vitro studies have been conducted to prove the role of sodium hypochlorite in removing the surface organic matter and aiding in increased mechanical retention.[18-20] There are various factors that influence treatment outcomes in real-life scenarios. These factors include socioeconomic status, habits, facial type, and dietary practices. The study's design, a split-mouth clinical trial, is highlighted as a robust methodology for evaluating the impact of deproteinization on bracket bond strength in a controlled setting.

This study evaluated the bond survival rate of orthodontic brackets during the leveling and aligning stage of fixed orthodontic appliance treatment for a period of six months. Most of the bracket failures occur in the initial months of the start of fixed appliance therapy.[21] Obrien et al (1989) proposed three possible reasons for increased bracket failures during the initial stages of fixed appliance treatment.[22] Bracket failure might be due to improper curing time, and poor isolation after etching leads to salivary contamination, reduced bond strength of any individual bracket/adhesive would result in bracket debonding which is observed within the leveling and aligning stage. The aligning period of treatment is also a time of experimentation and adaptation period for patients to the type of food that can be tolerated by fixed orthodontic appliances. The initial phase of treatment involves correction of overbite correction which can occlude onto the orthodontic attachments leading to a bracket failure.

A total of 20 subjects were selected where the 1st and 4th quadrants of the dental while 2nd and 3rd quadrants undergo enamel deproteinization with 5.25% Sodium hypochlorite followed by acid etching and bonding. The core findings of the study are presented, revealing the bracket failure rates over a six-month period. A total of 18 brackets (4.7%) failed during this timeframe. Notably, the experimental group, which underwent enamel deproteinization with sodium hypochlorite before bonding, exhibited a significantly lower failure rate (2.1%) compared to the control group (7.4%). This statistical difference ($p = 0.016$) underscores the positive impact of deproteinization on bond strength.

With regard to the Influence of Dental Arches and Tooth Location, The data indicate a slightly higher failure rate in the mandibular arch (5.3%) compared to the maxillary arch (4.2%), but this difference is not statistically significant ($p = 0.629$). Similarly, while posterior brackets (premolars) had a higher failure rate (7.8%) than anterior brackets (2.9%), the statistical analysis reveals no significant difference ($p = 0.334$). These findings suggest that tooth location and arch do not significantly affect the outcomes observed.

5. Clinical Implications

Deproteinization with sodium hypochlorite before etching and bonding is identified as a critical step to enhance bracket survival rates. This process contributes to better marginal sealing and adhesion between the enamel surface and the orthodontic attachment.

Limitations of the Study: The observed differences in bracket survival rates can be attributed to a range of factors intrinsic to individual patients. Variations in tooth

morphology, the magnitude of masticatory load experienced during chewing, distinctive chewing patterns, dietary preferences, and the meticulousness of oral hygiene practices collectively contribute to these divergent outcomes. Each patient's oral environment is inherently unique, thus introducing variability into the results.

Prospect for Future Research: Further studies are essential to comprehensively understand the effects of enamel deproteinization. Such studies should encompass its potential impact not only on bracket survival rates but also on the occurrence of white spot lesions—a common concern in orthodontic treatment.

6. Conclusion

The application of 5.25% sodium hypochlorite before bonding orthodontic brackets with the Transbond XT increases the bracket survival rate of orthodontic brackets which is statistically significant. Hence, Enamel deproteinization with 5.25% sodium hypochlorite before etching with 37% phosphoric acid can be preferred to increase the bond survival rate of the orthodontic bracket during the course of orthodontic treatment.

7. Source of Funding

None.

8. Conflict of Interest

None.

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Cite this article: Anbarasu PP, Kumar SS, Bhavana B, Vishnu ES.., Meenakshi J, Saikia T. Assessing the impact of enamel deproteination on orthodontic bracket survival rate: A split-mouth investigation J Contemp Orthod2025;9(2):239-243