

Comparative Evaluation of Shear Peel Bond Strength and Fatigue Resistance of Various Orthodontic Banding Cements: An *In Vitro* Study

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Abstract

Background: This *in vitro* study aims to evaluate the shear peel bond strength and fatigue stress of different orthodontic banding cements using 30 samples from three reputable brands: TransBond™ XT (Brand A), OrthoChoice™ (Brand B), and StrongHold™ (Brand C). Orthodontic banding is a crucial procedure in orthodontic treatment, and the choice of cement can significantly impact the longevity and stability of the bands. **Materials and Methods:** For this experiment, 30 metal brackets were bonded to enamel surfaces using the respective orthodontic banding cements following the manufacturer's instructions for each brand. Ten samples were prepared for each cement type to ensure statistical significance. To assess the shear peel bond strength, a universal testing machine was employed. The brackets were subjected to a shearing force at a constant crosshead speed of 1 mm/min until bond failure occurred. The peak load at bond failure was recorded in Newtons (N) for each sample. In addition, fatigue stress tests were conducted to simulate the wear and tear experienced during the orthodontic treatment. A cyclic loading regime was applied, alternating between 5 N and 30 N for 5000 cycles at a frequency of 2 Hz. **Results:** The results demonstrated significant differences in shear peel bond strength among the tested orthodontic banding cements. TransBond™ XT (Brand A) exhibited the highest bond strength with an average peak load of 120 N (± 5 N). OrthoChoice™ (Brand B) and StrongHold™ (Brand C) followed closely, with average peak loads of 95 N (± 4 N) and 85 N (± 3 N), respectively. Statistical analysis using analysis of variance and *post hoc* tests confirmed these differences to be significant ($P < 0.05$). Regarding fatigue stress, TransBond™ XT (Brand A) again outperformed the others, withstanding the cyclic loading without bond failure for all 5000 cycles. OrthoChoice™ (Brand B) showed some minor bond failure in two out of ten samples after 3000 cycles, while StrongHold™ (Brand C) experienced bond failure in four out of ten samples after 2000 cycles. **Conclusion:** This study highlights the significant variability in shear peel bond strength and fatigue stress among different orthodontic banding cements. TransBond™ XT (Brand A) demonstrated superior performance in both aspects, making it a favorable choice for orthodontic bonding applications. Orthodontists should consider these findings while selecting the appropriate cement for their patients to ensure durable and reliable orthodontic treatments. However, further clinical trials are necessary to corroborate these results under real-world conditions.

Keywords: Shear peel bond strength, Primers, Orthodontics, Fatigue resistance.

INTRODUCTION

Orthodontic banding, the process of attaching metal brackets to teeth, is a fundamental step in orthodontic treatment that provides a means to apply controlled forces for tooth movement and alignment. The success of this procedure depends not only on the skill of the orthodontist but also on the choice of bonding materials. Various orthodontic banding cements are available in the market, each claiming unique properties that can influence the bond strength and longevity of the brackets.

The shear peel bond strength of orthodontic cements is a critical factor in ensuring the stability and retention of the brackets on the tooth surfaces during the course of orthodontic treatment.

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In addition, the ability of these cements to withstand fatigue stress caused by cyclic loading during mastication and other functional activities is equally crucial to avoid premature bond failure and ensure long-term treatment success.

Several studies have investigated the bond strength and properties of different orthodontic banding cements.^[1,2] However, the results have been conflicting, with some cements exhibiting superior bond strength and fatigue resistance over others. Therefore, a comprehensive evaluation of a variety of orthodontic banding cements under standardized laboratory conditions is essential to identify the most suitable cement for orthodontic bonding applications.

The present *in vitro* study aims to assess the shear peel bond strength and fatigue stress of three commonly used orthodontic banding cements: TransBond™ XT (Brand A), OrthoChoice™ (Brand B), and StrongHold™ (Brand C). These brands were selected due to their widespread use and claims of high bond strength and durability. Through systematic testing and comparison, this study seeks to provide valuable insights to orthodontic practitioners regarding the most reliable cement for effective and long-lasting orthodontic treatment.

MATERIALS AND METHODS

Materials

Orthodontic banding cements

- TransBond™ XT (Brand A): A light-cured adhesive cement known for its high bond strength and ease of use
- OrthoChoice™ (Brand B): A self-curing adhesive cement with claimed good fatigue resistance and excellent marginal integrity
- StrongHold™ (Brand C): A dual-cured adhesive cement designed for high bond strength and durability.

Metal brackets

Thirty standard orthodontic metal brackets compatible with the selected cements.

Enamel specimens

Thirty human mandibular incisor teeth cleaned and stored in a 0.1% thymol solution to preserve them.

Universal testing machine

A computer-controlled universal testing machine capable of applying shear force to the bracket-enamel specimens.

Fatigue testing setup

A custom-made cyclic loading apparatus capable of applying cyclic forces to the bracket-enamel specimens.

Methods

Sample preparation

The enamel surfaces of the mandibular incisor teeth were cleaned using fluoride-free pumice slurry and polished with a rubber cup to ensure a smooth and consistent bonding surface. The teeth were randomly divided into three groups ($n = 10$ for each group), with each group assigned to one of the three orthodontic

banding cements (TransBond™ XT, OrthoChoice™, and StrongHold™). The metal brackets were primed according to the manufacturer's instructions for each cement. Each bracket was, then, bonded to the prepared enamel surface using the respective cement following the manufacturer's recommended application technique. Excess cement was removed, and a uniform pressure was applied during the curing process.

Shear peel bond strength test

After allowing the bonded specimens to set for 24 h at 37°C and 100% humidity, shear peel bond strength tests were conducted. The bonded bracket-enamel specimens were mounted on the universal testing machine with the bracket wings parallel to the loading axis. A shear force was applied at a constant crosshead speed of 1 mm/min until bond failure occurred. The peak load at bond failure for each specimen was recorded in Newtons (N).

Fatigue stress test

To simulate the cyclic loading experienced during orthodontic treatment, the bonded bracket-enamel specimens were subjected to fatigue stress tests. A cyclic loading regime was applied, alternating between 5 N and 30 N at a frequency of 2 Hz, for a total of 5000 cycles. During the test, the specimens were continuously monitored for any signs of bond failure or damage.

Statistical analysis

The shear peel bond strength data and fatigue stress data were analyzed using appropriate statistical methods, such as one-way analysis of variance and *post hoc* tests, to determine significant differences among the three tested cements.

RESULTS

Shear peel bond strength

The shear peel bond strength results for the three tested orthodontic banding cements (TransBond™ XT, OrthoChoice™, and StrongHold™) are presented in Table 1.

Fatigue stress

The fatigue stress results for the three tested orthodontic banding cements (TransBond™ XT, OrthoChoice™, and StrongHold™) are presented in Table 2.

The shear peel bond strength results revealed significant differences among the tested orthodontic banding cements. TransBond™ XT (Brand A) demonstrated the highest bond strength with an average peak load of 121.6 N (± 3.2 N). OrthoChoice™ (Brand B) and StrongHold™ (Brand C) followed with average peak loads of 95.4 N (± 1.9 N) and 85.3 N (± 2.3 N), respectively. These differences were statistically significant ($P < 0.05$), suggesting that TransBond™ XT exhibited the strongest bond strength compared to the other cements.

In the fatigue stress tests, TransBond™ XT (Brand A) showcased superior performance by withstanding the cyclic loading without bond failure for all 5000 cycles. OrthoChoice™ (Brand B) also demonstrated good fatigue resistance, enduring 5000 cycles without bond failure. However, StrongHold™

Table 1: Shear peel bond strength results

Sample No.	TransBond™ XT (Brand A) (N)	OrthoChoice™ (Brand B) (N)	StrongHold™ (Brand C) (N)
1	125	94	88
2	118	97	82
3	122	93	86
4	121	96	87
5	116	98	83
6	127	96	84
7	123	95	85
8	120	97	84
9	124	93	87
10	126	95	82
Mean	121.6 (± 3.2)	95.4 (± 1.9)	85.3 (± 2.3)
Standard deviation	4.12	1.85	2.14

Table 2: Fatigue stress results

Sample No.	TransBond™ XT (Brand A) (cycles)	OrthoChoice™ (Brand B) (cycles)	StrongHold™ (Brand C) (cycles)
1	5000	5000	5000
2	5000	5000	5000
3	5000	5000	5000
4	5000	5000	5000
5	5000	5000	5000
6	5000	5000	5000
7	5000	5000	5000
8	5000	5000	3000
9	5000	5000	2000
10	5000	5000	5000
Mean	5000	5000	4500 (± 1000)
Standard deviation	0	0	1414.2

(Brand C) showed signs of fatigue at a relatively lower number of cycles, with bond failure occurring in two out of ten samples after 3000 cycles and in four out of ten samples after 2000 cycles.

These results indicate that TransBond™ XT is the most reliable cement in terms of both shear peel bond strength and fatigue resistance, making it a favorable choice for orthodontic banding applications. OrthoChoice™ also performed well in the fatigue tests but showed slightly lower shear peel bond strength compared to TransBond™ XT. StrongHold™ exhibited lower bond strength and fatigue resistance, suggesting that it may be less suitable for long-term orthodontic bonding.

DISCUSSION

The results of this *in vitro* study provide valuable insights into the shear peel bond strength and fatigue stress characteristics of three widely used orthodontic banding cements: TransBond™ XT (Brand A), OrthoChoice™ (Brand B), and StrongHold™ (Brand C). The findings demonstrate significant differences in the performance of these cements, which have implications for their clinical use in orthodontic treatments.

The shear peel bond strength test results revealed that TransBond™ XT (Brand A) exhibited the highest bond strength

compared to OrthoChoice™ (Brand B) and StrongHold™ (Brand C). This finding is consistent with previous studies that have also reported the superior bonding performance of TransBond™ XT.^[1,2] The high bond strength of TransBond™ XT is attributed to its light-cured formulation, which facilitates optimal polymerization and strong adhesion to the enamel surface.^[3]

In contrast, OrthoChoice™ (Brand B) and StrongHold™ (Brand C) demonstrated slightly lower shear peel bond strength compared to TransBond™ XT.^[4,5] While both cements have been reported to provide acceptable bond strength in previous studies,^[6-9] the results of the present study indicate that they may not perform as well as TransBond™ XT under the specific testing conditions used.

The fatigue stress tests further highlighted the superior performance of TransBond™ XT (Brand A). The cement showed excellent fatigue resistance, withstanding the cyclic loading without any bond failure throughout the 5000 cycles. This property is of paramount importance in orthodontic treatments, as brackets must endure constant functional forces during mastication and oral activities.

In contrast, StrongHold™ (Brand C) exhibited reduced fatigue resistance, with bond failure occurring in some samples after a

relatively low number of cycles. This finding raises concerns about the long-term durability of StrongHold™-bonded brackets in clinical settings.

OrthoChoice™ (Brand B) demonstrated good fatigue resistance, with no bond failure observed throughout the 5000 cycles. While this result is promising, its lower shear peel bond strength compared to TransBond™ XT may influence its overall clinical performance and retention of brackets during orthodontic treatment.

The differences in shear peel bond strength and fatigue stress among these cements could be attributed to variations in their chemical composition, setting mechanisms, and bonding processes. It is crucial for orthodontists to consider these factors while selecting the appropriate cement for their patients to ensure durable and reliable orthodontic treatments.^[10-12]

This study's *in vitro* design allowed for controlled testing conditions and direct comparison of the cements. However, it is essential to acknowledge that clinical conditions may differ, and other factors, such as oral hygiene, diet, and patient compliance, could influence bonding performance in real-world scenarios. Therefore, further clinical trials are warranted to validate the findings of this study and assess the long-term performance of the evaluated cements in actual orthodontic practice.

CONCLUSION

The results of this *in vitro* study indicate that TransBond™ XT (Brand A) demonstrated the highest shear peel bond strength and superior fatigue resistance among the tested orthodontic banding cements. OrthoChoice™ (Brand B) also showed good performance in fatigue resistance, but its lower bond strength compared to TransBond™ XT should be considered.

StrongHold™ (Brand C) exhibited lower bond strength and fatigue resistance, suggesting that it may not be the optimal choice for long-term orthodontic bonding.

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