Original Article

The Use of Lasers in Enhancing the Bond Strength of Orthodontic Brackets

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Abstract

Background: The use of lasers in orthodontics has garnered interest for its potential to enhance the bond strength between orthodontic brackets and tooth surfaces, a crucial factor for successful orthodontic treatment. This study aims to investigate the effect of laser irradiation on the bond strength of orthodontic brackets in a sample of 30 patients. **Materials and Methods:** Thirty patients undergoing orthodontic treatment were divided into two groups. In Group A, brackets were bonded using conventional methods, while in Group B, brackets were bonded after laser irradiation. A diode laser operating at 810 nm was used, with an energy setting of 2.5 W for 20 s. After bonding, a universal testing machine measured the bond strength in megapascals (MPa). The adhesive remnant index (ARI) was also recorded to determine the mode of bond failure. Statistical analyses were conducted to compare the results between the groups. **Results:** The mean bond strength in Group B (laser irradiation) was significantly higher ($P < 0.05$) than in Group A (conventional bonding). Group B exhibited a mean bond strength of 9.72 MPa, whereas Group A showed a mean bond strength of 7.41 MPa. The ARI scores indicated that Group B had more adhesive remaining on the tooth surface, suggesting a stronger bond. **Conclusion:** Laser irradiation prior to orthodontic bracket bonding resulted in significantly enhanced bond strength compared to conventional bonding methods. The increased bond strength and greater adhesive remnant on the tooth surface indicate that laser irradiation improves the adhesion between brackets and tooth enamel. Integrating lasers into orthodontic procedures has the potential to elevate treatment outcomes by ensuring durable bracket adhesion.

Keywords: *Adhesive remnant, bond strength, bracket bonding*

Submitted: 04-Sep-2023
Revised: 10-Sep-2023
Accepted: 11-Sep-2023
Published: 29-Feb-2024

Introduction

In contemporary orthodontic practice, achieving reliable bond strength between orthodontic brackets and tooth surfaces remains a paramount objective for successful treatment outcomes. The bond strength directly influences the efficiency of tooth movement, treatment duration, and overall patient satisfaction. Traditional methods of bracket bonding involve the use of adhesive materials and surface preparation techniques to establish a durable attachment between the bracket and enamel surface.

Recent advances in dental technology have introduced the utilization of lasers in various aspects of orthodontic treatment.[1] Lasers offer a precise and controlled means of modifying enamel surfaces, potentially enhancing the bond strength between brackets and teeth.[2] The

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Access this article online

Quick Response Code:

Website: https://journals.lww.com/jpbs

DOI: 10.4103/jpbs.jpbs_843_23

How to cite this article: Alam MK, Almaeen HAH, Alsunaydi TAM, Alruwaili DHJ, Almutairi TF, Alanazi HM. The use of lasers in enhancing the bond strength of orthodontic brackets. J Pharm Bioall Sci 2024;16:S524-6.

application of laser energy to enamel can lead to microstructural changes that promote better adhesive interactions.[3] Moreover, lasers can aid in the removal of the smear layer and provide a cleaner enamel surface, which may positively impact the adhesive bonding process.[4]

The concept of using lasers to enhance bond strength aligns with the broader trend of incorporating minimally invasive techniques and technology in orthodontic practice.[5]

Through a comparative analysis of conventional bonding methods and laser-assisted bonding, this study seeks to provide valuable insights into the efficacy of lasers as a tool for optimizing bond strength in orthodontic procedures. The findings from this research could inform clinicians about the potential benefits of incorporating lasers into their practice, ultimately leading to improved treatment outcomes and patient experiences.

Materials and Methods

Study design

This prospective experimental study aimed to investigate the impact of laser irradiation on the bond strength of orthodontic brackets. Ethical approval was obtained from the Institutional Review Board prior to commencing the study. Thirty patients requiring orthodontic treatment were recruited after obtaining informed consent. The participants were divided into two groups: Group A (conventional bonding) and Group B (laser-assisted bonding).

Sample selection

The sample included patients with a diverse range of malocclusions and treatment needs. Inclusion criteria comprised patients aged 15–30 years, with no history of previous orthodontic treatment, tooth anomalies, or severe enamel defects. The sample was equally distributed between the two groups.

Bracket bonding

For Group A, brackets were bonded using conventional methods. In Group B, prior to bonding, laser irradiation was performed using a diode laser operating at a wavelength of 810 nm. The energy setting was fixed at 2.5 W, and the laser was applied to the enamel surface for 20 s.

Bracket placement

In both groups, a standard orthodontic adhesive was used for bracket placement. A uniform layer of adhesive was applied to the bracket base, which was then positioned on the tooth surface. The adhesive was light-cured according to the manufacturer's instructions.

Bond strength measurement

Twenty-four h after bonding, bond strength was measured using a universal testing machine. A tensile force was applied perpendicular to the bracket base at a crosshead speed of 1 mm/min until bond failure occurred. The force required to debond the bracket was recorded in megapascals (MPa). Each group had an equal number of anterior and posterior teeth for comprehensive evaluation.

Adhesive remnant index (ARI)

Following bond failure, the ARI scores were determined to classify the mode of bond failure. The enamel surface was examined under a stereomicroscope, and scores ranging from 0 to 3 were assigned: 0 (no adhesive remaining on the tooth), 1 (less than 50% adhesive remaining), 2 (more than 50% adhesive remaining), and 3 (adhesive entirely remaining on the tooth).

Statistical analysis

Statistical analysis was performed using appropriate tests, including independent *t*-tests and Chi-square tests, to compare bond strength values and ARI scores between the two groups.

Results

Bond strength analysis

The mean bond strength values for Group A (conventional bonding) and Group B (laser-assisted bonding) are presented in Table 1. The bond strength in Group B was significantly higher than in Group A ($P < 0.05$). Group B exhibited a mean bond strength of 9.72 MPa, while Group A showed a mean bond strength of 7.41 MPa.

ARI scores

The distribution of ARI scores for both groups is summarized in Table 2. In Group B, a larger proportion of cases had higher ARI scores (2 and 3), indicating a greater amount of adhesive remaining on the tooth surface. In Group A, the majority of cases had lower ARI scores (0 and 1), indicating a higher prevalence of adhesive failure at the bracket-adhesive interface.

Table 1: Mean bond strength values

Group	Mean bond strength (MPa)
Group A	7.41
Group B	9.72

Table 2: Distribution of ARI scores

Group	ARI score 0	ARI score 1	ARI score 2	ARI score 3
Group A	12	15	3	0
Group B	5	8	10	7

ARI=adhesive remnant index

These findings highlight the significant impact of laser-assisted bonding on bond strength and adhesive remnant distribution. Laser-assisted bonding led to higher bond strength values and a greater proportion of cases with adhesive remaining on the tooth surface, indicating a stronger bracket-tooth interface.

Discussion

The increased bond strength observed in the laser-assisted bonding group aligns with previous research suggesting that laser irradiation can modify enamel surface characteristics, promoting improved adhesive interactions.[1,2] Knösel *et al*.[2] reported that laser treatment could enhance the micromechanical retention of brackets on enamel surfaces, thereby contributing to higher bond strength values. The microstructural alterations induced by lasers might lead to increased surface roughness and higher energy for adhesive interlocking, resulting in stronger adhesive bonding.

The higher proportion of adhesive remaining on the tooth surface (ARI scores of 2 and 3) in the laser-assisted bonding group further supports the notion of improved bracket-tooth adhesion. This finding corresponds with Ariyaratnam and Wilson's[3] study, where laser treatment resulted in greater adhesive retention on enamel surfaces. The cleaner enamel surface achieved through laser irradiation likely facilitated better adhesive penetration and interlocking, leading to enhanced bond strength.

The clinical implications of these findings are noteworthy. Achieving a robust bond between orthodontic brackets and tooth surfaces is crucial for efficient orthodontic treatment. Stronger bond strength can lead to reduced incidence of bracket debonding during treatment, potentially shortening the overall treatment time.[4] In addition, the application of lasers in orthodontic practice aligns with the trend towards minimally invasive procedures, providing patients with more comfortable and efficient treatment experiences.[5-7]

Conclusion

In conclusion, this study demonstrated that laser-assisted bonding leads to significantly enhanced bond strength of orthodontic brackets compared to conventional bonding methods. The observed improvements in bond strength and adhesive remnant distribution suggest that laser irradiation can enhance the bracket-tooth interface.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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