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Effect of Laser-Assisted Bleaching Technique on Bond Quality of Enamel to Brackets: A Literature Review

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Abstract

Aim: Tooth bleaching is known as a non-invasive, cosmetic treatment option. It has been noted that bleaching has a detrimental impact on bond quality of enamel. With increasing adult patients who need multidisciplinary treatments, concurrency of bleaching with other treatments such as composite filling or orthodontic treatment in which bond quality to enamel plays an important role, a dilemma has arisen. This review aimed to evaluate the impact of the laser-assisted bleaching technique on bond quality of enamel to brackets drawn from the available literature.
Methods: All original articles that evaluated the effect of laser-assisted bleaching on bond strength of enamel in MEDLINE (NCBI PubMed and PMC), EMBASE, Scopus, Corchane Library, Web of Science, and Google Scholar were assessed until July 2022.
Results: Six in-vitro studies were entered into this review. All of them evaluated bond strength of orthodontic brackets to bleached enamel expect one, in which composite resin bond to bleached enamel was examined. Several laser types including Nd:YAG, Er:YAG, CO2, diode, and LED were used in these studies. A few studies indicated that bond strength of bleached enamel is higher after laser-assisted bleaching compared to the conventional bleaching technique, whereas others did not.
Conclusion: In cases of immediate bonding to bleached enamel, the laser-assisted bleaching approach is recommended. There is still a need for more studies in this field because of the high diversity of laser types, bleaching agents, and type of adhesives that have been introduced to the market recently.

Keywords: Bleaching, Laser, Orthodontic brackets, Shear bond.

1. Background

Demands for dental esthetic procedures such as bleaching to treat tooth discoloration or orthodontics to improve the alignment of teeth as non-invasive treatment options compared to porcelain veneers are increasing because teeth have an important role in facial attractiveness, which affects social relationships and the quality of life (1). Moreover, during a multidisciplinary approach, especially in adult patients, many treatment procedures such as tooth bleaching, composite filling restoration, or compromised and brief orthodontic treatments facilitate prosthodontic replacement of missing teeth or alleviate malalignment of front teeth are needed, altogether (2). With the increase in the number of adult patients visiting dental offices and their demand for cosmetic and non-invasive treatments such as bleaching, composite filling, and orthodontics, concurrency of these therapeutic procedures, which can disrupt bonding quality, is a common challenge for clinicians (2, 3). Reliable bonding is essential for the durability of composite fillings and to control the tooth's position during orthodontic treatments (4).

Tooth bleaching is done in two main ways: at home and in-office. The at-home method can be helpful to treat light or medium tooth discolorations and quickly achieve acceptable results with little chair-time in the dental office (5). Despite studies that could not find the difference in effectiveness and risk of post-treatment sensitivity of these two methods, most patients prefer the in-office method due to gaining more tangible results in a shorter time compared to at-home process (6, 7). In all these techniques, hydrogen peroxides or carbamide peroxide with various concentrations are activated by factors such as heat or laser beam to accelerate the reaction (7, 8).

Promising results have also been reported when phototherapy was applied on the surface of bleached enamel before the bonding procedure (9). One way to accelerate tooth whitening is to use light, heat, or lasers (10). According to Abbots, who first used high-intensity light to increase the temperature of hydrogen peroxide and speed up the bleaching mechanism, power bleaching dates back to the 19th century (11). As a result of the heat and light, hydrogen peroxide bleaches more rapidly, decreasing the time it takes to whiten teeth (12, 13).

The typical temperature increase for these mechanisms is between 10°C and 40°C. Ordinarily, laser-absorption-enhancing particles are inserted into the gel when laser light is used to amplify the bleaching effect. The particles absorb the light energy from the wavelength of light emitted by the laser and retransmit it as thermal energy. During the bleaching process, these particles are allowed to permeate the bleaching composition so that the laser beam passed penetrates the tooth surface while absorbing some of the light energy from the laser and retransmitting it as thermal energy so that the bleaching composition is more effective. Blue lights, such as those produced by argon-ion lasers, typically have wavelengths between 470 nm and 520 nm. Orange is the complementary color to blue and so an orange or red-colored particulate material that absorbs in this range would be practical. Additionally, it is better to use colors that absorb light with a similar wavelength. An example would be a black particulate material that absorbs every wavelength.

Heat-enhanced teeth whitening is typically achieved with diode lasers with wavelengths of 810 nm or 1064 nm (14-16). An example would be a black particulate material that absorbs across all wavelengths. Various lasers have been applied to advance the efficaciousness of bleaching gel, such as Nd: YAG lasers (1064 nm), diode lasers (810 and 980 nm), Kalium-Titanyl-Phosphate lasers (KTP, 532 nm), and Erbium: Yttrium Aluminum Garnet lasers (Er: YAG, 2940 nm) (10- 12).

Cacciafesta et al. investigated the efficaciousness of bleaching with 35% hydrogen peroxide on shear bond strength (SBS) of orthodontic brackets that were bonded with resin-modified glass ionomer (RMGI) to enamel and determined that bond strength decreased when bleaching was done a week or less before the bonding procedure (17). Mullins et al. (18) and Akın et al. (19) assessed the shear bond strength of orthodontic brackets bonded with composite resin to bleached enamel and reported the same results. Mullins et al. also reported a higher risk of bond failure, especially during 24 hours post bleaching (18). In a review study by Imani et al. (20), bleaching with hydrogen peroxide reduced the bond strength of brackets to bleached enamel, mainly when the time interval between bleaching and banding procedure was a short or high concentration of hydrogen peroxide.

Some have suggested some solutions to overcome this problem, such as delaying bracket bonding. Mullins et al. (18) stated banding should be delayed for two to three weeks in patients that undergo office bleaching with 38% hydrogen peroxide. Bleached enamel surface pre-conditioning with antioxidant agents previous to bonding is another way to increase the bonding strength. In a review study, Feiz et al. (21) evaluated the effect of antioxidant agents like sodium ascorbate on the bond strength of tooth-colored restorative materials to bleached enamel. They concluded that the application of antioxidants, regardless of their type, form, or concentration, can neutralize the effect of bleaching agents and improve bond strength. Ergün et al. (22) investigated the efficaciousness of antioxidant treatment on the shear bond strength of composite resin to bleached enamel and reported the same result. In a review study, Al-Hamdan et al. (9) suggested that phototherapy of bleached enamel (delayed phototherapy approach) increases the bond integrity of enamel.

Phototherapy can also be done at the same time as bleaching (immediate phototherapy approach) as a way to activate and accelerate the bleaching process and decrease remaining oxygen radicals that may weaken bond integrity in the future. The null hypothesis is that bonding will be possible immediately after laser-assisted bleaching, and additional treatment to increase bond strength is not needed. Also, thermal damage to a dental pulp will be minor by performing phototherapy for both activating the bleaching agent and removing the remaining radicals at once. Due to the non-existence of consistent studies, this review aimed to investigate the effect of the laser-assisted bleaching approach on the bond strength of enamel to brackets.

2. Methods

An electronic search was conducted in PubMed, Cochrane, and Google Scholar from January 2010 to July 2022.

Published articles were identified regarding the efficaciousness of laser-assisted bleaching on bond strength of enamel using the following keywords alone or in combination: (“Bleaching”[Mesh] OR “Teeth bleaching”[Mesh] OR “Tooth bleaching” [Mesh] OR “Tooth Discoloration Therapy”[Mesh] OR “Tooth whitening”[Mesh]) AND (“Laser”[Mesh] OR “Laser Therapy”[Mesh] OR “Laser Phototherapy” [Mesh] OR “Laser Treatment”[Mesh]) AND (“Shear Strength”[Mesh] OR “Dental Bonding”[Mesh] OR “Composite Resin”[MESH] OR “Dental Brace”[MESH] OR “Orthodontic”[MESH] OR “Orthodontic Brackets” [MESH]). All in vitro studies that evaluated the bond strength of laser-assisted bleached enamel, compared it with conventional bleaching techniques, and the results suitable description of the applied laser parameters were included. Studies were performed via the etching process and bonding of brackets immediately after bleaching. Uncontrolled studies, systematic and literature reviews, and letters to the editor were inadmissible. Studies that assessed internal bleaching or applied laser after bleaching as a separate step were also excluded. The keywords, titles, and abstracts of all the articles were studied by two independent, experienced reviewers. Following the first analysis, selected studies were evaluated based on their whole text. Also, the chosen articles' reference lists were searched for relevant content. If lack of agreement existed between the two reviewers, another person was invited to resolve the issue. The studies used different laser parameters for bleaching, so meta-analysis was impossible. Data were categorized as follows: 1) author and year of publication, 2) laser parameters, 3) mean shear bond strength, and 4) study results.

3. Results

Two-hundred thirteen articles were collected from Pubmed and ten from other databases (Fig. 1). Two independent reviewers initially screened a total of 223 studies, and 175 studies were not used because of recurrence and no relevant keywords. After excluding unrelated studies, the full text of 21 articles was evaluated. Fifteen of them were not eligible and thus excluded because they were review studies, case reports, or did not report laser properties. Finally, six studies were selected and analyzed. All these studies are summarized in Table 1.

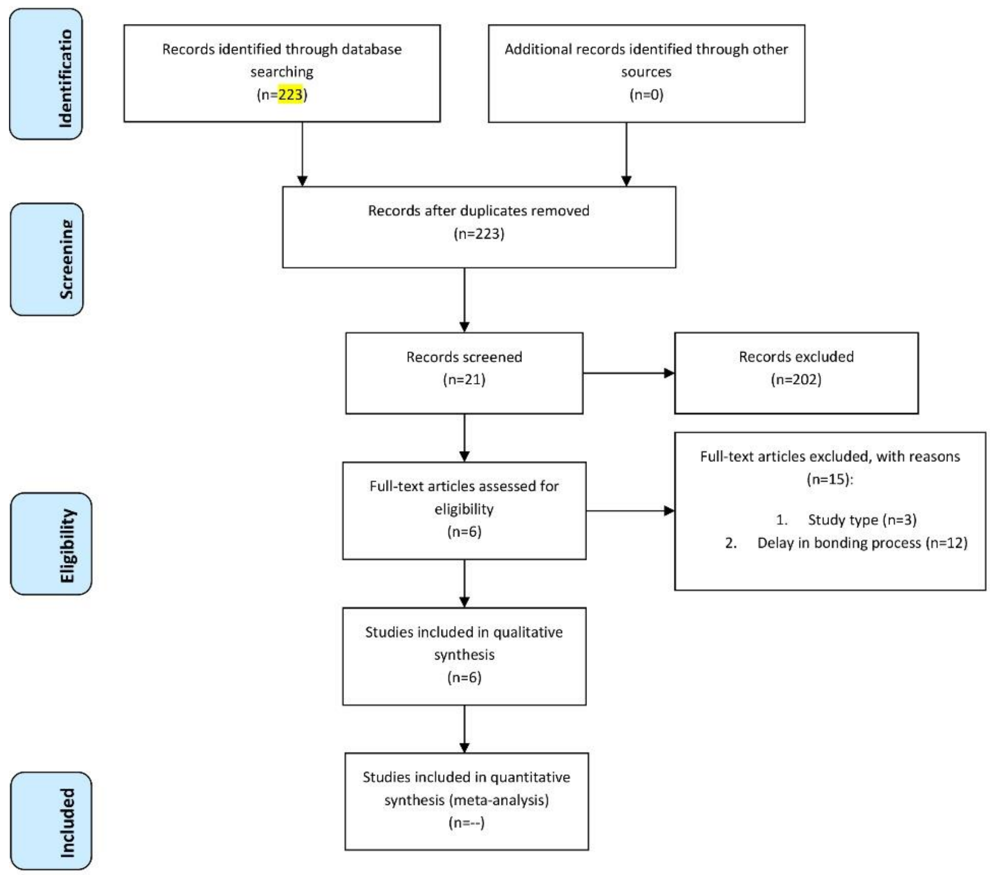

Figure 1. PRISMA flow-chart of selected criteria for the included article reports

Table 1. Physical characteristics of applied laser, and main outcomes of laser-assisted bleaching on the shear bond strength of enamel

Studies	Title	Laser type	Laser parameters	Main result	Shear bond strength	
					Conventional bleaching	Laser
Akin et al. (2013) (19)	Effect Of Nd:YAG Laser Bleaching and Antioxidizing Agents on the Shear Bond Strength of Brackets	Nd:YAG	4.0 W, 60 Hz frequency, 1 mm distance, 20 sec.	Shear bond strength of orthodontic brackets decreased two weeks post bleaching either activation by Nd:YAG laser was done or not during bleaching	22.13±4.31 MPs	17.49±2.83 MPs
Mirhashemi et al. (2015) (23)	Effect of Laser-Assisted Bleaching With Nd:YAG and Diode Lasers On Shear Bond Strength of Orthodontic Brackets	Nd:YAG/Diode	Nd:YAG laser: 1064 nm, 2.5 W, 25 Hz,100 µs, 6 mm distance. Diode laser: 810 nm, 1 W, CW, 6 mm distance	Shear bond strength of the orthodontic bracket was higher an hour post bleaching with 35% carbamide peroxide combined with Nd:YAG and diode laser remarkably more than the conventional bleaching group	10.04±2.73 MPa	Nd:YAG: 20.53±6.34 MPa Diode: 21.35±3.27 MPa
Mirhashemi et al. (2020) (24)	Effect of Enamel Surface Pretreatment with Different Laser Types and Antioxidizing Agents Office-Bleaching on the Shear Bond Strength of Orthodontic Brackets	Nd:YAG/Er:YAG/CO2	Nd:YAG laser: 1 W, 100 µs, 10 Hz, 30 s. Er: YAG laser: 0.5 W, 230 µs, 10 Hz, 5 mm distance, 30 s. CO2 laser: 0.5 W, 10 Hz, pulse width of 1 ms, 30 s.	Er:YAG and CO2 laser-assisted bleaching enhanced bond strength of the orthodontic bracket to bleached enamel more than Nd:YAG laser bleaching and antioxidant agent groups	8.51±3.46 MPa	Nd:YAG laser: 7.65±3.71 MPa Er: YAG laser: 23.40±3.30 MPa CO2 laser: 15.49±5.88 MPa
Gorucu-Coskuner et al. (2017) (25)	The Effect of Different in-Office Bleaching Techniques and Etching Procedures on Bond Strength of Orthodontic Brackets	Er:YAG/Diode/LED	Diode laser: 940nm, 7W, 1mm distance. Er:YAG laser: 2940 nm, 0.4W, 10 Hz, 30s. LED: 30s.	Shear bond strength of the orthodontic bracket was not improved following Er:YAG, LED, and diode laser assisted bleaching	16.6±5.8MPa	Diode laser: 14.3±5 MPa Er:YAG laser: 15.4 ± 4.5 MPa LED: 14.2±4.6 MPa
Dastjerdi et al. (2015) (26)	Shear Bond Strength of Orthodontic Brackets to Tooth Enamel after Treatment with Different Tooth Bleaching Methods	Diode	2.5 W, 60 sec.	Bond strength decreased following bleaching with 20% and 45% carbamid peroxide either diode laser was applied or not	45% carbamid peroxide: 6.37±0.92 MPa 20% carbamid peroxide: 7.67±1.01 MPa	7.49±1.19 MPa
Sultan et al. (2017) (27)	Influence of Natural Antioxidants on Microshear Bond Strength to Bleached Enamel: Chemical Versus Laser-assisted Bleaching	Diode	940nm, 2W, 30 sec.	Diode laser bleaching enhanced shear bond strength of composite resin to bleached enamel.	11±1.6 MPa	19.1±2.9 MPa

Three studies evaluated the effects of bleaching with Nd:YAG laser on the bond strength of enamel (9, 23, 24). Two studies (23, 24) reported higher shear bond strength of enamel in the laser bleaching group compared to the conventional bleaching group, especially during the first-hour post bleaching. However, the difference between the two groups disappeared over time and no longer existed after two weeks. On the contrary, one study (9) did not find a significant difference between the laser bleaching and the conventional bleaching group, and found that bleached enamel surface pre-conditioned with an antioxidant agent would be beneficial to recovering bond strength in both groups.

Two studies assessed the effects of Er:YAG laser bleaching on the bond strength of enamel. One of them (24) reported that laser bleaching with this type of laser would improve bond strength. In contrast, the other one (25) could not indicate a positive effect of Er:YAG laser bleaching on bond strength.

One study investigated the effect of CO2 laser bleaching on bond strength of enamel and reported higher bond strength when bleaching was done with this laser type compared to the conventional bleaching technique (24).

Four studies examined the effect of diode laser bleaching on the bond strength of enamel (23, 25-27). Three of them evaluated shear bond strength of the orthodontic bracket to bleached enamel (23, 25, 26), and one of them (27) compared shear bond strength of composite resin to bleached enamel. Two studies reported a positive effect of bleaching with diode laser on bond strength (23, 20), whereas two other studies (25, 26) could not find the superiority of bleaching with diode laser on the conventional bleaching technique.

One study (25) assessed the effect of laser bleaching with LED on the bond strength of enamel and did not report any positive role of it in recovering bond strength following bleaching.

4. Discussion

Bonding of composite restorations, porcelain laminates, and orthodontic brackets to bleached enamel is a challenge that many clinicians may deal with it in their clinical practice. Some studies reported a significant reduction in bond integrity and a higher risk of bond failure following bleaching (28-30). Many different solutions have been suggested to improve the bond integrity of enamel, such as pre-conditioning the surface of the enamel with alcohol, removing the superficial layer of enamel, application of organic solvents, or use of biocompatible antioxidants before bonding (24).

This review aims to investigate the effect of the laser-assisted bleaching approach on the bond strength of enamel to brackets. Torres et al. reported that laser therapy helps improve recently bleached enamel bond strength to composite resin by altering the superficial layer of enamel and eliminating oxygen radicals that remain (31). Al-Hamdan et al., in a review study, evaluated the effect of post-bleaching laser therapy on the bond strength of bleached enamel and concluded that phototherapy after bleaching is a suitable way to recover bond quality (9). However, delayed use of phototherapy to change the enamel's properties or remove remaining oxygen radicals imposes additional thermal trauma to the dental pulp, which may be more sensitive after bleaching. Laser therapy can activate bleaching materials, remove radicals that interfere with the bonding process in the future, and induce some morphological changes in the surface layer of the enamel simultaneously. Therefore, chair time and sensitivity will decrease, and bonding will be possible immediately as long as the bond strength of the enamel does not reduce post laser-assisted bleaching (32). So, in this study, we reviewed the articles investigating the effect of laser-assisted bleaching on the bond strength of enamel.

Bleaching agents can impact the properties of the superficial layer of enamel, resulting in reduced bond strength (28). Additionally, oxygen radicals remaining after bleaching might prevent composite resin polymerization and interfere with its adhesion to bleached enamel (23, 30). Anaraki et al. (33) studied the effects of conventional versus laser bleaching on enamel micro-roughness; the micro-roughness of enamel increased after bleaching in both techniques. However, the increase in micro-roughness was minor in the laser bleaching group. Hence, they concluded that laser-assisted bleaching preserved enamel characteristics better than conventional bleaching techniques.

Four studies reported that bonding to bleached enamel was not compromised following laser-assisted bleaching. Mirhashemi et al. (23) assessed the effect of tooth bleaching with hydrogen peroxide with a concentration of 35% combined with Nd:YAG lasers on the shear bond strength of orthodontic brackets and reported remarkably higher shear bond strength during the first hour following bleaching, compared to the conventional bleaching group. The bond strength of enamel increased an hour after bleaching in the conventional group, and the difference between the two groups was no longer noticeable. Therefore, if bracket bonding is necessary immediately following bleaching, laser-assisted approach is recommended, or a delay of an hour should be considered before bonding to decrease the risk of bond failure after conventional bleaching technique. In a more recent study by the same author (24), the shear bond strength of orthodontic brackets was assessed post-laser bleaching. In the Er:YAG and CO2 laser bleaching groups, the bond strength was higher than that in the Nd:YAG laser bleaching group and in the group that pre-conditioned the enamel surface with an antioxidant agent before bonding. Sultan et al. (27) evaluated micro-shear bond strength between composite resin and enamel following bleaching with 35% hydrogen peroxide combined with diode laser. They reported that laser-assisted bleaching with a diode laser did not decrease the bond strength of composite resin to bleached enamel, so immediate bonding without the application of antioxidant agents as a separate step is possible (32).

On the contrary, three studies have not reported the superiority of the laser-assisted bleaching technique over the conventional technique on bond integrity of enamel. Akin et al. (19) assessed the bond strength of composite resin to enamel bleached with 35% hydrogen peroxide with or without the Nd:YAG laser after two weeks. Shear bond strength decreased in both groups compared to the control group. It recommended the application of antioxidant agents on the bleached enamel surface to recover bond strength either by bleaching combined with Nd:YAG laser or not. In a study by Dastjerdi et al. (26), the shear bond strength of orthodontic brackets to enamel was significantly reduced after bleaching with carbamide peroxide with a concentration of 20% and 45% combined with diode laser. A concentration of 45% carbamide peroxide had greater negative effect on bond strength than a concentration of 20% carbamide peroxide, and there was no significant difference in the bond strength of enamel between the conventional bleaching and the laser-assisted bleaching groups. Gorucu-Coskuner et al. (25) investigate the effect of different in-office bleaching techniques and acid/laser etching procedures on the bond strength of orthodontic brackets to bleached enamel. They concluded that in-office bleaching either with the LED, Er:YAG, or diode laser would not improve the bond strength of bleached enamel. Among the reasons for the differences in the results are: 1) type of laser, 2) wavelength and other radiation characteristics, 3) duration of radiation, and 4) bleaching material brand.

Conclusion

Laser-assisted bleaching has less negative impact on the bond strength of orthodontic brackets or composite resin to bleached enamel than the conventional bleaching method. In cases of immediate bonding post bleaching, laser-assisted bleaching is recommended. Due to the high diversity of laser types, bleaching agents, and the type of adhesive that has recently been introduced to the market, there is still a need for more studies in this field.

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Conflict of interest

The authors have no conflict of interest to declare.

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