



Does bond integrity of bleached enamel increases with phototherapy? A systematic review



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ABSTRACT

Background: The aim of the current systematic review was to evaluate the efficacy of phototherapy (PT) on bond strength of bleached enamel.

Methods: Electronic databases including MEDLINE (PubMed), ISI Web of Science, Scopus, ScIELO, LILACS and EMBASE until January 2019. The addressed focused question was: “Does PT increase the bond integrity of bleached enamel?” Only in-vitro studies evaluating the effect of PT compared with bleaching agent or no phototherapy were included. The outcome measures of interest was shear bond strength.

Results: A total of 5 in-vitro studies were included. Different concentrations of hydrogen peroxide were used in the included studies. The frequency of laser used in the included studies ranged from 20 Hz to 60 Hz. Pulse duration was reported in only 3 studies that ranged from 100 μ s to 320 μ s. The overall main outcomes of the included studies showed that in 4 studies, application of phototherapy resulted in significantly higher bond integrity of bleached enamel as compared to enamel which underwent acid etching with bleaching alone, while 1 study showed comparable shear bond strength of bleached enamel achieved by PT as compared to bleaching alone.

Conclusion: The evidence from the current systematic review suggests that phototherapy increases the bond strength of bleached enamel. Further in-vitro studies should be performed in order to obtain stronger conclusions.

1. Introduction

Dental bleaching in modern dentistry plays a very important role in improving esthetics, self-esteem, and social acceptance. There are several simple, cost-effective and conservative bleaching techniques that include home and in-office procedures [1]. However, there are evident unwanted side effects described in the literature in relation to these bleaching techniques [2]. Some of the adverse effects may include enamel erosion, dental sensitivity, gingival burning, increased porosity, and decrease in bond strength [3–5]. The free radicals existing in dental hard tissues after bleaching with hydrogen peroxide reduce the bond strength between the tooth and resin restoration by inhibiting polymerization reaction [6]. It is proposed that a delay in the final composite placement would promote uninhibited polymerization and optimum bond strength [7].

Antioxidant agents such as 10% sodium ascorbate and catalase enzyme have been used to reverse this process [8,9]. However, these agents are not routinely used in the clinical procedures. Contemporary phototherapy have been used in several dental procedures including tooth surface conditioning, tooth caries removal, esthetic procedures,

and periodontal disease treatment [10–15]. These laser beams can revert the unfavourable effect of bleaching by eliminating free radicals, hence improving bond strength [16,17].

Lasers from the Erbium family are same in all aspects except the wavelength. The two erbium lasers (Er:YAG and Er,Cr:YSGG) and Nd:YAG laser have greater affinity with water and hydroxyapatite crystals and are recommended by several studies to accelerate the bleaching process [18,19]. The wavelength of these lasers increases the temperature of the hard tissues with subsequent morphological changes, hence eliminating free radicals and improving the bond strength [9]. To date, there has been no systematic review published and this area of subject remains unexplored. Therefore, the aim of the current systematic review was to evaluate the efficacy of phototherapy on bond integrity of bleached enamel.

2. Materials and methods

2.1. Focused question

The Preferred Reporting Items for Systematic Review and Meta-

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Analysis (PRISMA) guidelines was followed [20], and a focused question was developed. The addressed focused question was: “Does phototherapy increase the bond integrity of enamel after bleaching?”

2.2. Selection criteria

The inclusion criteria of the present review were as follows:

- 1) Only in-vitro studies were included.
- 2) The experimental group in the included studies should have allocated to phototherapy.
- 3) Comparator include samples that were exposed to bleaching agent or no phototherapy.
- 4) The outcome measures of interest was shear bond strength;
- 5) The review was restricted to studies published in English language only.

Animal studies, in-vivo studies, opinion articles, letters to the editor, review articles, interviews, updates, abstract, and unpublished studies were excluded.

2.3. Search strategy

The author searched the electronic database including MEDLINE (PubMed), ISI Web of Science, Scopus, SCIELO, LILACS and EMBASE from January 1, 1983 up to January 1, 2019. The literature search was conducted using the combinations of the following Medical Subject Heading (MeSH) and non-MeSH terms connected with Boolean operators: (laser) AND (bond strength) AND (enamel) AND (bleaching). Manual searching of the following journals was performed: *Photomedicine and Laser Surgery*, *Photodiagnosis and Photodynamic Therapy*, *Lasers in Medical Science*, and *Journal of Lasers in Medical Science*. Additional relevant articles were searched manually from the reference lists of full text.

2.4. Screening methods and data abstraction

Titles and abstracts of studies that fulfil the inclusion criteria were screened and assessed. Data were extracted from the included studies as per following parameters: author/country, total number of samples, study groups, study outcome and phototherapy parameters.

2.5. Quantitative analysis

No meta-analysis could be performed due to the methodological heterogeneity in the included studies, for example, study groups, laser parameters, and a variation in the outcomes. Therefore, the outcomes are reported as a narrative review.

3. Results

3.1. Study selection

The electronic search based on study titles and their abstracts initially revealed 40 potential studies. Two studies were identified as duplicate studies and hence removed from the selection process. With the screening of abstracts, a total of 28 articles were not relevant to the objective of the current review, and therefore excluded. A total of 10 studies were retrieved and downloaded that underwent thorough full reading. Out of these 10 studies, 5 studies were further removed because they did not match the inclusion criteria. The final selection of the studies resulted the inclusion of 5 in-vitro studies [21–25] in the qualitative assessment. Fig. 1 shows a detailed flow diagram of study selection process according to PRISMA guidelines [20].

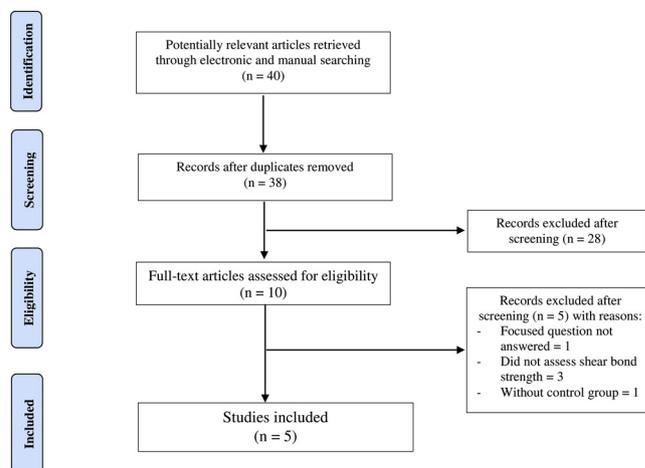


Fig. 1. PRISMA flow diagram for studies retrieved through the searching and selection process.

3.2. General description of the included studies

All included studies were in-vitro studies in which 2 studies were conducted in Saudi Arabia [21,22], 2 studies in Turkey [23,25], while 1 study was performed in Iran [24]. A total of 534 human extracted teeth were selected for the experiments in which 3 studies selected molar teeth [21,22,25], while 2 studies used maxillary central incisors [23] and premolars [24], respectively. Different concentrations of hydrogen peroxide were used in the included studies. Two studies used 30% [24,25], 1 study used 35% [23], while 2 studies used 40% concentration of hydrogen peroxide as bleaching agent [21,22]. Shear bone strength was tested using 1 mm/min cross-over head speed in the Universal mechanical testing machine in all the included studies [21–25] (Table 1).

3.3. Phototherapy related parameters

The details of phototherapy related parameters are presented in Table 2. Only 1 study reported the wavelength of 1064 nm (nm) that was used for phototherapy [24]. The frequency of laser used in the included studies ranged from 20 Hz (Hz) to 60 Hz. Pulse duration was reported in only 3 studies that ranged from 100 to 320 μ s (μ s) [21,23,24]. Power of the laser used in 2 studies was 4.5 W (W) [21,22], whereas the other 3 studies used 4 W [23], 2.5 W [24] and 1 W [25], respectively. Pulse energy of 100 mJ (mJ) was reported in only 1 study [23]. None of the studies reported the overall optic fiber diameter. Energy density was reported in only 3 studies [21–23] that ranged from 0.23 to 11.45 joules per square centimetre (J/cm^2).

3.4. Main outcomes of the studies

The overall main outcomes of the included studies showed that in 4 studies [21,22,24,25], application of phototherapy resulted in significantly higher bond integrity of bleached enamel as compared to enamel which underwent acid etching with bleaching alone, while 1 study [23] showed comparable shear bond strength of bleached enamel achieved by PT as compared to bleaching alone. One study [22] reported superior bond integrity of bleached enamel achieved by phototherapy with the combination of lower frequency and power compared to bleaching alone.

4. Discussion

Tooth bleaching is often followed by replacement of restoration, orthodontic bracket bonding, or veneer placement. As bleaching can

Table 1
Descriptive analysis of the included studies.

Author et al.	Country	Number and type of samples	Bleaching technique	Groups	Shear bond strength test	Main outcome
Alkudhairy et al. [21]	Saudi Arabia	80 extracted human third molars	In-office whitening agent (40% HP; Power Whitening, WHITEsmile, Germany)	Group-A: 10% sodium ascorbate Group-B: no treatment Group-C: PT Group-A: 50 Hz/4.5W Group-B: 50 Hz/6.0W Group-C: 30 Hz/4.5W Group-D: 30 Hz/6.0W Group-E: bleaching only Group-F: no bleaching Group-A: No bleaching Group-B: Bleaching alone Group-C: Bleaching + PT Group-A: No bleaching Group-B: Bleaching alone Group-C: Bleaching + PT Group-D: Bleaching + PT2 Group-A: Acid etch Group-B: PT Group-C: Acid etch + PT Group-D: Adhesive Group-E: PT + adhesive	1 mm/min head speed in the Universal test device	Greater SBS of bleached enamel achieved by PT as compared to bleaching alone
Alkudhairy et al. [22]	Saudi Arabia	120 extracted human third molars	In-office whitening agent (40% HP; Power Whitening, WHITEsmile, Germany)		1 mm/min head speed in the Universal test device	Greater SBS of bleached enamel achieved by PT with lower frequency and power combination compared to bleaching alone.
Akin et al. [23]	Turkey	90 extracted human maxillary central incisors	35% HP office bleaching agent (Whiteness hydrogen peroxide, FGM Produtos Odontolo'gicos Ltda, Joinville, PR, Brazil)		1 mm/min head speed in the Universal test device	Comparable SBS of bleached enamel achieved by PT as compared to bleaching alone
Mirhashemi et al. [24]	Iran	104 extracted human premolars	30% HP (Farafan Diagnostics Co., Tehran, Iran, under license of Heydent, Germany)		0.5 mm/min head speed in the Universal test device	Greater SBS of bleached enamel achieved by PT as compared to bleaching alone
Gurgan et al. [25]	Turkey	140 extracted human molars	30% CP or 16% CP (Vivastyle, Ivoclar Vivadent G, Schaan, Liechtenstein)		1 mm/min head speed in the Universal test device	Greater SBS of bleached enamel achieved by acid etch as compared to bleached enamel with PT

PT: phototherapy, SBS: shear bond strength, HP: hydrogen peroxide, CP: carbamide peroxide, Hz: hertz, W: watt.

Table 2
Phototherapy related parameters of the included studies.

Author et al.	Wavelength (nm)	Frequency (Hz)	Pulse duration (μ s)	Power (W)	Pulse energy (mJ)	Optic fiber diameter (μ m)	Energy density (J/cm^2)
Alkudhairy et al. [21]	NA	50	NA	4.5	NA	NA	11.45
Alkudhairy et al. [22]	NA	50	NA	4.5	NA	NA	11.45
Akin et al. [23]	NA	60	320	4	100	NA	0.23
Mirhashemi et al. [24]	1064	25	100	2.5	NA	NA	NA
Gurgan et al. [25]	NA	20	150	1	NA	NA	NA

nm: nanometre, Hz: hertz, μ s: microsecond, W: watt, mJ: millijoule, μ m: micrometre, J/cm^2 : joules per square centimetre, NA: not available.

result in physical and chemical, organic and inorganic modification of enamel structure, bond strength of resin to bleached enamel is compromised influencing the success of restorative procedures [26,27]. The current systematic review was designed to hypothesize that phototherapy is effective in significantly increasing the bond strength of bleached enamel surface as compared to the bond integrity of the bleached enamel undergoing acid etching only. This is the first study conducted to investigate the efficacy of phototherapy on the bond strength of enamel structure undergoing chemical bleaching. Overall, all the included studies indicated that the use of phototherapy significantly increase bond strength of bleached enamel as compared to bleaching without phototherapy. However the outcomes of the present review should be interpreted with caution due to several reasons.

The critical factors affecting the bond integrity are the various types of laser and the laser parameters used. There was a significant methodological heterogeneity and lack of data about phototherapy parameters in the included studies. Alkudhairy et al. [22] showed that the output power of the laser and the energy level are critical factors affecting the bond strength. Other factors, for example, fiber diameter could influence power density and energy output in the application of phototherapy and could alter the certain amount of energy released during the process, likely affecting the bonding effect of phototherapy [28]. Since the most important effect of laser is to convert radiant energy to heat (the thermo-mechanical effect), absorption of laser energy by the surface of the material is the most important interaction between the material and phototherapy. Therefore, selection of appropriate laser parameters to change the surface properties of the enamel is of utmost importance.

Multiple factors are reported to influence marginal microleakage, including polymerization shrinkage, coefficient of thermal expansion, bonding agent and liners, polymerization technique, quality of substrate (enamel or dentin), location of margins in the substrate, and the surface topography [29,30]. Laser treatment of tooth surface has shown to significantly increase its surface roughness [31]. As a result, resin restorative materials have shown adaptation to laser treated enamel comparable with acid-etched enamel [31]. Therefore, improved microleakage score can be attributed to enamel surface roughness and optimum resin adaptation to laser-treated bleached enamel. In addition, poor microleakage scores in bleached specimens are related to the presence of residual oxygen, which interferes with resin infiltration into bleached enamel and can inhibit free radical polymerization [32].

There are several limitations that should be taken into account. Worthy of note the number of included studies is a clear limitation that may have skewed the main outcome of the present study. In addition, the initial and late screening of the titles and abstracts in the current review was performed only by one author. The involvement of multiple authors performing independent screening could result in the inclusion of pertinent studies being missed from screening and data extraction by single author alone. Furthermore, no meta-analysis could be performed due to the methodological heterogeneity in the included studies. The search criteria involved articles only in English. This may have resulted in publication bias with potential relevant studies published in other language being missed [33]. These methodologic shortcomings should be considered when interpreting the findings as the reported data was heterogeneous in terms of laser parameters.

5. Conclusion

The evidence from the current systematic review suggests that phototherapy increases the bond strength of bleached enamel. Further in-vitro studies should be performed in order to obtain strong conclusions.

Conflict of interest

None.

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