Evaluation of Light Activation on In-office Dental Bleaching: A Systematic Review

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ABSTRACT

Aim: This review was undertaken to evaluate the efficacy of light activation on in-office dental bleaching in terms of color change and photosensitivity with available literature evidence.

Materials and methods: The articles were searched from MEDLINE/Pubmed and Journal of Web, which were published from 2001 to 2019.

Results: Out of the 124 references obtained, 13 articles in English language were read in full, which fulfilled the inclusion criteria.

Conclusion: Light activation of hydrogen peroxide on in-office dental bleaching does not affect effectiveness of bleach.

Clinical significance: Though claimed that in-office bleaching activated with light betters color change, the present review did not confirm this belief.

Keywords: Color change, Dental vital bleaching, Hydrogen peroxide, In-office dental bleaching, Sensitivity.

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INTRODUCTION

Dental esthetics and smile play a significant factor in dental treatment seeking, resulting in patient demand for tooth bleaching. Early men too experimented with different chemicals to whiten their teeth.1 The first commercially marketed whitener was 10% carbamide peroxide used way back in 1989.2 Various products and technology are described for bleaching teeth such as differing concentrations of agents, application times, and modes and the activator used with the bleaching agent.3 Dental vital bleaching is available in three categories as in office bleaching (professionally administered), over-the-counter bleaching (self-administered), and dentist-supervised take-home bleaching (professionally dispensed). Of these, the in-office involves direct dentist’s supervision in order to avoid soft tissue trauma, gel ingestion, decreased therapy time, and to yield a rapid whitening result. Patients today desire to visualize the outcome of bleaching immediately, which has resulted in usage of higher concentrations of chemicals added as whiteners with different light sources. These are thought to accelerate the bleaching process. Various sources are used as light activating sources to activate bleaching process like Light emitting diodes (LEDs), Lasers, Plasma arc lamps (PAC) and halogen lamps. The principle of using a light source is that it heats the hydrogen peroxidase (HP), thereby increasing the HP’s disintegration into free radicals that oxidize the complex organic molecules.4

Though light activation of vital bleaching is documented in literature, the effectiveness has been questioned by many authors.4-6 Also, tooth sensitivity is reported in several studies due to the release of excess free radicals that reach the pulp.7-10 Doubts have been raised regarding the role of these activators in increasing efficiency without causing injuries to tooth, periodontium, and oral soft tissues. Hence, this review was undertaken with the objective to evaluate the efficacy of a light source on in-office vital bleaching of tooth.

MATERIALS AND METHODS

An independent researcher explored the electronic databases (MEDLINE via Pubmed) and citation databases (Scopus and Web of science). Reference checks of the primary studies were made for further relevant publications. Terms used for the search were in-office bleaching, dental bleaching, vital bleaching, and light source.

Clinical studies (in vivo and in vitro) conducting in-office dental bleaching with light on adult patients, published between 2000 and January 2019, were included.

Eligibility Criteria

Clinical trials of parallel design and split mouth design, which evaluated in-office dental bleaching with or without light activation, on patients were included. Only articles in full, published in English language, were considered. Randomized trials using a combination of both home bleaching and in-office bleaching were excluded. Dissertations, theses, or abstracts in any annual conferences were not included. Articles eligible for the review were given a separate ID, comprising the first author and the year of study. Parameters of color comparison and tooth sensitivity were noted (Table 1).

Risk of Bias in Selected Studies

In order to have a quality check on selected clinical trials, two independent reviewers assessed the risk of bias using the Cochrane Collaboration tool. The assessment criteria were concealment of group allocation, blinding of outcome parameters, incomplete
**Table 1:** The characteristics of the final articles are mentioned in Table 1

<table>
<thead>
<tr>
<th>Study</th>
<th>Study design</th>
<th>No of teeth/patients</th>
<th>Groups</th>
<th>Tooth evaluation</th>
<th>Bleaching procedure</th>
<th>Light type</th>
<th>Color change (assessment and outcome)</th>
<th>Tooth sensitivity (assessment and outcome)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matis</td>
<td>Parallel design</td>
<td>32 patients</td>
<td>Eight groups, six groups with light activation and two groups without light activation</td>
<td>Varying concentration of 15–40% HP in tray and paint on technique</td>
<td>LED activation</td>
<td>Colorimeter data showed a value of 6.77 immediately after treatment. All groups showed a reversal of color irrespective of HP concentration and light activation.</td>
<td></td>
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</tr>
<tr>
<td>Marson</td>
<td>Parallel design</td>
<td>40 patients</td>
<td>Gp I—35% HP</td>
<td>Anterior teeth</td>
<td>35% HP with a 1-week break between sessions for 6 months</td>
<td>Halogen, LED, laser Spectrophotometer and vita classical shade guide</td>
<td>No difference in color stability between groups after 6 months.</td>
<td></td>
</tr>
<tr>
<td>Calatayud</td>
<td>Split mouth design</td>
<td>21 patients</td>
<td>Gp I—H₂O₂ application with light activation for 10 minutes</td>
<td>Central incisor, lateral incisor, canines</td>
<td>Quick white 35% H₂O₂ and activation with a diode lamp</td>
<td>Diode lamp Classic vita guide</td>
<td>No difference in color stability between groups after 6 months.</td>
<td></td>
</tr>
<tr>
<td>Kugel</td>
<td>Split arch</td>
<td>33 patients</td>
<td>Gp I—25% HP + light activation</td>
<td>Anterior teeth</td>
<td>25% HP</td>
<td>White light activation</td>
<td>Slight improvement in the group with light activation.</td>
<td></td>
</tr>
<tr>
<td>Hayward</td>
<td>Clinical study</td>
<td>21 study subjects</td>
<td>Gp III—only light activation</td>
<td></td>
<td>Application of 44% carbamide peroxide gel in chair with LED light activation followed by 35% carbamide peroxide gel for 14 days at home</td>
<td>LED light Spectrophotometer VAS</td>
<td>No difference between light-activated and chemically activated bleach.</td>
<td></td>
</tr>
</tbody>
</table>
### Study Design

- **No of teeth/patients**: 16
- **Groups**
  - Gp I—15% H\(_2\)O\(_2\) and nitrogenous titanium dioxide, light activated
  - Gp II—35% H\(_2\)O\(_2\) with photothermal catalysis by LED–laser system

### Tooth Evaluation

- **Color change of 1.8 units after LED**: 
  - No difference in tooth sensitivity in 1-stick duration with 1-second exposure of 800 mW/cm\(^2\) and 3 minutes, LED/gel, and varnish.
- **Tooth sensitivity**:
  - No difference in tooth sensitivity in 1-stick duration with 1-second exposure of 800 mW/cm\(^2\) and 3 minutes, LED/gel, and varnish.

### Light Procedure

- **Light type**
  - LED composed of 410 nm and 1800 mW, and three IR laser diodes of 830 nm and 450 mW/cm\(^2\).

### Human models

- **Human models**
  - 60 extracted human teeth.
  - LED activation

### VAS—8.68 ± 17.99.

### Study Design

- **Parallel study design**
  - 40 patients.
  - Gp I—35% H\(_2\)O\(_2\) with a bleach.
  - Gp II—35% H\(_2\)O\(_2\) with peroxidase light 6%.
  - Gp III—35% H\(_2\)O\(_2\) with light activation.

### Case Presentation

- **One female patient**.
  - Central incisor.
  - Photocatalytic equipment composed of six violet LEDs and three IR lasers (808 nm).
  - VAS with intensity of 20% in a shock sensation with a 1-second duration at 4 days.
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</tr>
</thead>
<tbody>
<tr>
<td>Omidi</td>
<td>Randomized clinical trial of parallel design</td>
<td>60 healthy humans</td>
<td>Gp I—without light activation</td>
<td>Anterior teeth</td>
<td>H₂O₂ gel of 37.5% concentration</td>
<td>LED and QTH</td>
<td>No significant difference in teeth whitening</td>
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<td></td>
<td></td>
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<td>Gp II—LED light activated</td>
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<tr>
<td>Kury</td>
<td>Case series</td>
<td>Three cases</td>
<td>Gp III—QTH activated</td>
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</tr>
<tr>
<td>Santos</td>
<td>Parallel design RCT</td>
<td>80 patients</td>
<td>Case 1—violet LED without peroxidase agent</td>
<td></td>
<td>H₂O₂ and carbamide peroxide for 3–8 weeks</td>
<td>Violet LED</td>
<td>Case 1—A2 shade</td>
<td>Case 1—score 0</td>
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<td></td>
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<td>Case 2—violet LED light with 37% carbamide peroxide</td>
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<td></td>
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<td></td>
<td>Case 3—violet LED light with 35% H₂O₂</td>
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<tr>
<td>Zouiten</td>
<td>Case report</td>
<td>24-year-old female patient with fluorosed teeth</td>
<td>32% H₂O₂ light activation combined to an ambulatory treatment with white smile home bleaching</td>
<td>Anteriors + premolars</td>
<td>H₂O₂</td>
<td></td>
<td>At 2 week follow-up similar change in color</td>
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</tr>
</tbody>
</table>

All figures placed at the end of text
outcome data, and reporting only selective outcomes. Any disagreements between the reviewers were sorted through discussion. Each criterion was judged as having either a low, high, or unclear risk of bias. If all the outcomes had a low risk of bias, then the study was considered to be of low risk. If any outcome presented an unclear risk, then the authors were contacted to consider the study into either high risk or low risk.

Results

The search strategy was completed in January 2019, with duration of search lasting for 4 months (October 2018–January 2019). A total of 124 studies were identified in the database of which 22 were excluded as they did not meet the eligibility criteria of the review. Of the 102 articles obtained, 26 articles were excluded after the titles were read to include 76 articles. Of which, finally, 13 complete articles published in English language were included in the study after reading the abstract carefully, which met the inclusion criteria of the reviewer.

Nine articles were randomized clinical trial, with two following a split mouth technique and the rest were of concurrent design parallel study, three case reports, and one was an in vitro study. The different methods of in-office activation were LED activation in seven studies, a combination of halogen LED and laser in one study, use of diode lamp in one, a combination of LED and infrared (IR) laser diode in one, violet LED activation in two, and a combination of violet LED and IR laser activation in one study (Flowchart 1).

Of the 13 articles that were reviewed, color change by light activation was slightly better in only one study (Calatayud et al.). In all the other studies, there was no significant difference in the color change between any in-office bleaching activation modality. The study results did not present any association of light activation with in-office bleaching to sensitivity.

Discussion

The current review aimed to evaluate the efficacy of light-activated in-office dental bleaching in terms of color change and tooth sensitivity, based on articles published between 2001 and 2019. Consensus was reached between tooth sensitivity and light activation that the latter did not result in tooth sensitivity. Out of the 76 abstracts read, 63 were excluded making the final selected articles to a total of 13. Of the 13 articles reviewed, 9 were randomized clinical trial of which 7 had parallel design and 2 had split mouth technique, 1 was in vitro study, and 3 case reports.

Tooth sensitivity arises when hydrogen peroxide molecules pass through the enamel and dentin into the pulp chamber resulting in pulpal inflammation. This affects the sensory nerves, which in turn perpetuate an increased response to stimuli. Various factors that affect tooth sensitivity are dental cracks, dentin exposure, or dimensions of the pulp chamber. Tooth sensitivity in all studies was measured by a visual analog scale (VAS), ranging from 0 to 100, where 0 marks no pain and 100 presents extreme pain.

Three studies in the review used violet LED for light activation and presented no photosensitivity.22,24,25 Violet LED is used as a light source to promote bleaching instead of chemical agents. Visible violet light in the wavelength of 405 nm is used in the absence of any peroxide agent. Violet light emits photons that propagate at smaller wavelength and higher frequency, thus exhibits less penetration into the dental tissue and hence presents decreased sensitivity. This property proves to be beneficial as it promotes breakage of the large pigment chains at low heat.24,25 The lower penetration of violet LED leads to lesser molecular alteration and lesser depth operation, thus preserving the pulp.

Three studies5,17,30 used the bleaching protocol in combination with a hybrid light (LED and laser) source. Studies have shown that the time taken for bleaching with hybrid light is less than LED alone. This shows that shorter clinical time is required for bleaching with a hybrid light source. Frietas et al.5 reported in their study that the group with hybrid light source activation showed considerable reduction in pulp inflammation. Although the low-power laser demonstrates anti-inflammatory and biomodulation potentials, still no scientific evidence of its effect on reducing post-bleaching sensitivity is proven.

The study results did not present any association of light activation with in-office bleaching to sensitivity. This is in concordance with the results of a systematic review by Ray26 done on 11 studies that produced weak evidence to the use of light activation with in-office vital bleaching. Regardless of the HP concentration used, light activation used increased tooth sensitivity. Hypothetically, both heat and light sources accentuate the disinintegration of hydrogen peroxide to form oxygen and perhydroxy free radicals, which are thought to increase bleaching efficiency.27,28

In-office bleaching has several advantages like it is a quick procedure and less riskier as performed by procedure. It also presents certain disadvantages like it is expensive and results are unpredictable as they are dependent on several factors. The final result of bleaching is dependent on patient’s age, original tooth color shade, concentration of bleaching agent, and the time factor.

A study done by Hahn et al.29 reported that light activation of HP for bleaching does not prove beneficial as the color is not stable after 3 months, and that the increase in temperature can affect pulp. Torres et al.30 also opine that though photoactivation results in fast bleaching, color regression was observed in less than a year.

The review has two elements of error owing to the subjective analysis of color assessment (shade guide) as the same evaluator can interpret different shades at different times and the objective
analysis of the spectrophotometer, which can give varied results because of mirror changes.

Further studies are recommended to reach a definite consensus on the efficacy of light activation on in-office dental bleaching by using standardized protocols for research like standard concentration of bleaching material, standard application time, assessment time, and duration of the bleaching effect.

**Conclusion**

The present review provides no positive association of light activation of in-office dental bleaching with either increasing efficacy or the risk of tooth sensitivity. The result needs to be interpreted with caution considering the variations in procedure, process, and techniques (hydrogen peroxide concentration, bleaching sessions, light activation sources, and products used).

**References**