The effect of light-activation sources on tooth bleaching

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INTRODUCTION

The causes of tooth discolouration are usually various and multifaceted. They have been classified as extrinsic, intrinsic and internalised discoloration. The extrinsic discoloration is associated with the use of tea, coffee, tobacco, some foods such as blueberries, and red wine. Intrinsic stains (dentin staining) may be due to systemic conditions, use of medications after the permanent teeth have erupted (e.g., minocycline) or during their development (tetracycline), childhood diseases, infection or trauma to a primary tooth while the underlying tooth is developing, trauma to a permanent tooth or natural aging changes and the accumulation of stain that has entered the teeth.

There is an increase in patient awareness of the ability to improve the appearance of their discoloured teeth. Not only these patients are seeking to improve the esthetic appearance of their smiles, they are also seeking an effective method. There are several ways to manage tooth discolouration, which include crowns, veneers, or tooth bleaching. For crowns and veneers, these treatment options entail a moderate loss of dental hard tissue. Vital tooth bleaching is not only a less costly alternative to bonded restorative dentistry; it is a conservative and non-invasive technique which has been well accepted to be safe and effective.

Tooth bleaching using oxalic acid was first introduced in 1848, followed by hydrogen peroxide (HP) in 1884. Contemporary, tooth bleaching systems are primarily based on oxidation by HP or one of its precursors such as, carbamide peroxide (CP). Hydrogen peroxide releases oxygen that breaks down conjugated bonds in protein chains associated with stain into a single bond. This will result in more absorption of colour wavelengths and resulting in the reflection of little colour (i.e., a whitening effect). In the meantime, various treatment modalities are available which include over-the-counter bleaching (self-administered), in-office bleaching (professionally administered) and dentist supervised take-home bleaching (professionally dispensed).

Home bleaching

Home bleaching is considered a safe and effective treatment. This technique is performed with low concentration hydrogen peroxide (4%-8%) or carbamide peroxide (10%-22%) formulations, which are inserted into
trays. These trays are placed in the mouth for 2-8 hours per day, over the course of 2-6 weeks.\textsuperscript{11}

**Over-the-counter bleaching**

An OTC, 5.3\% hydrogen peroxide-coated polyethylene strip (Crest Whitestrips, Procter & Gamble) was recently introduced to the market. According to the manufacturer’s instruction, the patient applies two strips per day for 30 minutes each. A similar 6.5\% hydrogen peroxide-coated strip is available by prescription. Clinical studies comparing the whitening efficacy of 10\% carbamide peroxide (which breaks down in 3.5\% hydrogen peroxide) with the efficacy of the hydrogen peroxide-coated strips have demonstrated that the polyethylene strips may be an acceptable alternative to the night guard method of at-home whitening.\textsuperscript{12}

**In-office bleaching**

Although in-office bleaching is performed using high concentration hydrogen peroxide (15\%-40\%),\textsuperscript{12} it becomes a widely used procedure because of these advantages: Minimally invasive, immediate visible results and no need of patient cooperation.\textsuperscript{13} Also, in-office whitening is the best for patients who need close monitoring for clinical conditions such as pronounced gingival recession or deep, unrestored abfraction lesions, and necessary for tooth discoloration associated with endodontic therapy.\textsuperscript{2}

Since the introduction of in-office bleaching treatments, the use of curing lights (including halogen curing lights, plasma arches, LED, LED plus lasers, lasers) has been recommended to accelerate the action of the bleaching gel.\textsuperscript{14} It is believed that most light sources decompose peroxide faster (by increasing the temperature) to form free radicals which whiten teeth.\textsuperscript{15-17}

However, some studies reported that the use of light sources did not improve the in-office bleaching treatment of vital teeth.\textsuperscript{17,18} The clinical results obtained with the use of these lights were poor, showing an increase in tooth sensitivity and reduced long-term colour stability, especially when the treatment was done in one appointment.\textsuperscript{14} Recent developments in in-office bleaching systems that use a chemical catalyst combined with light-cured block-out materials and compounds have resulted in decreased tooth sensitivity and enhanced treatment and have demonstrated improved results.\textsuperscript{18} Therefore, the aim of this paper is to review the current literature to evaluate the effect of light-activation sources on in-office tooth bleaching.

With the help of currently available literature, the electronic database “the National Library of Medicine” PubMed was searched for scientific articles relating to effectiveness of light activation sources on in-office tooth bleaching. The search was carried out between 2003 and 2013.

**Colour evaluation**

Before and after bleaching, the shade is usually assessed using two different methods: Vita Shade Guide, and a spectrophotometer.\textsuperscript{5}

**Standard Vita Shade Guide**

This is a visual and subjective assessment method. The investigator conduct all the shade comparisons using a standard Vita Shade Guide (Vita Zahnfabrik, Germany) before and after bleaching. Shade guide tabs are arranged from B1to C4, each corresponding to a numerical value from 1 to 16, the smaller the numeric value the lighter the tooth.\textsuperscript{5} This method is the most common, as it is a quick, simple procedure and has been used successfully in many studies.\textsuperscript{10,19-23}

**Spectrophotometer**

This is an instrumental method for shade matching and has been preferred over the visual evaluation, because it makes the process more practical and statistically more reliable.\textsuperscript{14} Spectrophotometric colour measurement of specimens was based on the CIE \(L^*a^*b^*\) system. The \(L^*a^*b^*\) system organises all existing colours within a three-dimensional colour space. \(L^*\) represents the degree of lightness and ranges from 0 (black) to 100 (white); \(a^*\) represents the green-red axis while \(b^*\) represents the blue-yellow axis.\textsuperscript{5}

This system was defined by the International Commission on Illumination in 1967\textsuperscript{24} and is referred to as CIE Lab. The colour comparison before and after treatment is given by the differences between the two colours (\(\Delta E\)), which is calculated using the formula:

\[
\Delta E = \sqrt{\left(\Delta L^*\right)^2 + \left(\Delta a^*\right)^2 + \left(\Delta b^*\right)^2}
\]

**The effect of light-activation sources on in-office tooth bleaching**

Strong controversy surrounds the success of light sources has been detected. Some researchers believe that it is effective in the bleaching process, while others believe only certain lights are effective and others reported no effect [Tables 1 and 2].\textsuperscript{17,18,25-34}

Hein et al., 2003\textsuperscript{25} reported no difference in the whitening effect of bleaching gels [25\%-35\% (HP)] with or without three different lights (LumaArch, Optilux 500, and Zoom!). They concluded that the proprietary chemicals added to the bleaching gels acted as catalysts in the whitening process and were solely responsible for activation, where as the lights had no influence.

Luk et al., 2004\textsuperscript{19} reported that colour change were significantly affected by inter action of the bleaching and light variables, and the application of light significantly improved the whitening efficacy of same bleaching materials. Kugel et al., 2006\textsuperscript{35} reported that the use of light did not demonstrate any benefit over the chemically
activated tooth whitening system after a 2-week recall. Marson et al., 2008\textsuperscript{14} reported that the in-office bleaching treatment of vital teeth with 35\% hydrogen peroxide did not show improvement with the use of any auxiliary sources tested (halogen light, LED, LED/Laser).

Bernardon et al., 2010\textsuperscript{16} reported that similar results were observed when teeth bleached using the in-office technique and light irradiation were compared to teeth bleached without light irradiation to evaluating the clinical performance of 35\% HP bleaching gel with and without use of LED/Laser unit. In a study of Browning and Swift 2011\textsuperscript{15} of power bleaching it was stated that light sources used in tooth whitening do not generate sufficient heat to damage teeth. They concluded that high concentrations of chemicals are responsible for faster whitening and that light sources are therefore superfluous in the whitening process.

Torres et al., 2011\textsuperscript{29} reported that bleaching is more effective with a hybrid light-emitting diode (LED) and a low-intensity infrared diode laser than the control group. This research evaluated the effectiveness of the colour change of hybrid LED and low-intensity infrared diode laser devices for activating dental bleaching, bleaching without light, and bleaching with halogen light. Domínguez et al., 2011\textsuperscript{30} reported that only the diode laser, halogen lamp and LED lamp showed significant colour changes when using six different photo activation systems on three different 35\% hydrogen peroxide whiteners. It was concluded that the light source is more important than the bleaching agent in the whitening process.

Kossatz et al., 2011\textsuperscript{31} reported a larger difference in bleaching with a LED/laser than without it on 35\% HP gel after the first session of bleaching, but after two sessions, the use of LED/laser light activation did not improve bleaching speed. He et al., 2012\textsuperscript{32} reported that a light-activated system produced better immediate bleaching

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Table 1: Studies demonstrated that the use of light-activation sources did not affect the outcome of in-office bleaching

| Author, Ref. (year) | Description of study | Bleaching agent | Subjects/ (specimens) | Methods of Activation | Results |
|---------------------|----------------------|-----------------|----------------------|----------------------|---------|
| Hein et al.,\textsuperscript{25} (2003) | A Split-arch Clinical study | 25\%-35\% (HP) | 15 subjects. 3 groups (n=5) | Bleach plus luma arch, bleach plus Optilux 500 bleach plus zoom bleach alone plasma arc light chemical activation | The three test lights did not lighten teeth more than their bleach gels alone. Use of light did not demonstrate any benefit over the chemically activated tooth whitening system. Light-activation sources did not affect the outcome of in-office bleaching with 35\% hydrogen peroxide. |
| Kugel et al.,\textsuperscript{26} (2006) | A split-arch clinical study | Brite smile system 15\% (HP) Opalescence Xtra Boost 38\% (HP) | 10 subjects | (HP) Alone halogen light XL 3000 demetron LED LED/LASER | Non-activated whitening did not differ from activated whitening. The use of light irradiation did not improve bleaching efficacy. Light may not improve the bleaching effect when high concentrations of HP (25-35\%) are employed, but produced better immediate bleaching effects than a non-light system with lower concentrations of hydrogen peroxide. |
| Marson et al.,\textsuperscript{27} (2008) | Clinical study | 35\% (HP) | 40 subjects. 4 Groups (n=10) | Halogen lamp plasma arc lamp led/diode laser argon laser no light source LED/Laser unit chemical activation Studies involve any kind of light | No improvement in tooth whitening as a result of LED or laser light treatments. No significant difference between the shade improvements achieved by the two whitening protocols tested. |
| Lima et al.,\textsuperscript{28} (2009) | In vitro study | 35\% HP (Whiteness HP) 35\% HP (Opalescence Xtra) 37\% CP (Whiteness Super) | 15 groups (n=5) | Halogen lamp plasma arc lamp led/diode laser argon laser no light source LED/Laser unit chemical activation Studies involve any kind of light | No improvement in tooth whitening as a result of LED or laser light treatments. No significant difference between the shade improvements achieved by the two whitening protocols tested. |
| Bernardon et al.,\textsuperscript{29} (2010) | a split-mouth Clinical study | 35\% HP | 90 subjects 3 groups (n=30) | Studies involve any kind of light | |
| He et al.,\textsuperscript{30} (2012) | A systemic review | 15\%-20\% HP 25\%-35\% HP | 11 Studies | | |
| Hahn et al.,\textsuperscript{31} (2013) | In vitro study | Opalescence xtra boost (38\% HP) | 80 teeth 4 Group (n=20) | Halogen LED laser chemical activation | |
| Nutter et al.,\textsuperscript{32} (2013) | Clinical Trial | 25\% HP 10\% CP | 22 patients 2 groups (n=11) | Light activation chemical activation | |
effects than a non-light system with lower concentrations of hydrogen peroxide. When high concentrations of HP (25-35%) were employed, there was no difference in the immediate bleaching effect or short-term bleaching effect between the light-activated system and the non-light system.

Hahn et al., 2013 could not find an improvement in tooth whitening as a result of LED or laser light treatments, when evaluating the colour stability of bleaching with Opalescence Xtra Boost (38% hydrogen peroxide) using four different methods: activation with halogen, LED, laser or chemical activation. Polydorou et al., 2013 reported that directly after bleaching, the use of halogen showed better results than laser (P ≤ 0.05), on evaluating the colour stability of vital bleaching using a halogen unit, laser, or only chemical activation up to 3 months after treatment.

Liang et al., 2013 concluded that halogen light and chemically activated in-office bleaching systems were both effective for tooth whitening; however, halogen light activation could improve the immediate tooth whitening.

Henry et al., 2013 reported that on a split-mouth design study, the use of a sodium arc bulb lamp with 25% hydrogen peroxide for in-office whitening produces better results on maxillary teeth up to 1 week after whitening is completed. Using only gel for whitening could not distinguish differences on each side of the mouth.

**DISCUSSION**

This review summarises the present literature about the effect of light-activation sources on in-office tooth bleaching. Bleaching has been accepted as the least aggressive method for treating discoloured teeth. However, the effectiveness of in-office systems has been controversial. Manufacturers have introduced “bleaching” lights that are reported to accelerate the bleaching process.
process.44 This finding is in agreement with the studies of Torres et al. 2011,29 Dominguez et al. 2011,30 and Luk et al. 200418 who reported that the application of light significantly improved the whitening efficacy of bleaching materials. This may be attributed to tooth dehydration45,46 that presumably is greater with increased tooth heating on using light activation source.

However, some researchers have stated that no acceleration or increase in efficacy occurs when using light sources.35,36,42 Light-activated whitening systems add cost, occupy operatory space, can cause burning of the soft tissue, and can increase operatory temperature.2 The use of a light for in-office whitening may not be justified due to the risks involved.

The controversial results which are reported with different tooth bleaching systems can be attributed to various factors such as: Base-line colour of the teeth of the chosen subjects, the type and concentration of the bleaching product, the time period for the in-chair treatment as well as the treatment period.7

The more yellow the teeth at baseline, the better the outcome of tooth bleaching.47 In the study of Gerlach and Zhou 2001 on 600 subjects, they demonstrated a significant relationship between the subject’s age and the magnitude of bleaching response with younger subjects experiencing better tooth-bleaching results.47

The efficacy of hydrogen peroxide containing products are approximately the same when compared with carbamide peroxide-containing products with equivalent or similar hydrogen peroxide content and delivered using similar format and formulations, either tested in vitro48 or in vivo.49,50

Heymann 200551 has suggested that the concentration and contact time of the bleaching agent to the tooth are very important for the bleaching outcome. The study by Matis et al. 200744 agreed that the contact time of the bleaching agent appears to be an important factor; however, the concentration is not as important as a factor for the bleaching outcome. This may be attributed to the longer bleaching time which allow bleaching agent to react more thoroughly with coloured compound.5

Moreover, Sulieman et al. 200419 compared the in vitro tooth bleaching efficacy of gels containing 5-35% hydrogen peroxide. He found that the higher the concentration, the lower the number of gel applications required to produce uniform bleaching. Similar results were found by Leonard et al. 1998 who compared the in vitro tooth bleaching efficacy of 5%, 10% and 16% carbamide peroxide gels and found the whitening was initially faster for the 16% and 10% than the 5% concentration. However, the efficacy of the 5% carbamide peroxide gel approached the highest concentrations when the treatment time was extended32

In a clinical study using custom-made bleaching trays, Kihn et al. 200050 concluded that a 15% carbamide peroxide gel showed significantly more tooth whitening than a 10% carbamide gel after use for 2 weeks. This result was in agreement with another clinical study reported by Matis et al. 200053 who extended the treatment time for 6 weeks and the differences in tooth lightness were no longer of statistical significance. The initial faster rate of bleaching for higher concentrations of carbamide peroxide has also been observed when bleaching tetracycline stained teeth in vivo over a 6-month period.54

CONCLUSIONS

The in-office bleaching treatment of vital teeth did not show improvement with the use of light activator sources for the purpose of accelerating the process of the bleaching gel and achieving better results.

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