REVIEW ARTICLE

The effect of light-activation sources on tooth bleaching

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ABSTRACT

Vital bleaching is one of the most requested cosmetic dental procedures asked by patients who seek a more pleasing smile. This procedure consists of carbamide or hydrogen peroxide gel applications that can be applied in-office or by the patient (at-home/overnight bleaching system). Some in-office treatments utilise whitening light with the objective of speeding up the whitening process. The objective of this article is to review and summarise the current literature with regard to the effect of light-activation sources on in-office tooth bleaching. A literature search was conducted using Medline, accessed via the National Library of Medicine Pub Med from 2003 to 2013 searching for articles relating to effectiveness of light activation sources on in-office tooth bleaching. This study found conflicting evidence on whether light truly improve tooth whitening. Other factors such as, type of stain, initial tooth colour and subject age which can influence tooth bleaching outcome were discussed. Conclusions: The use of light activator sources with in-office bleaching treatment of vital teeth did not increase the efficacy of bleaching or accelerate the bleaching.

Key words: Bleaching, carbamide, hydrogen peroxide, in-office bleaching, whitening

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INTRODUCTION

The causes of tooth discolouration are usually various and multifaceted. They have been classified as extrinsic, intrinsic and internalised discolouration.[1] The extrinsic discolouration is associated with the use of tea, coffee, tobacco, some foods such as blueberries, and red wine.[2] 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.[1]

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.[3]

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Tooth bleaching using oxalic acid was first introduced in 1848[4], followed by hydrogen peroxide (HP) in 1884.[5] Contemporary, tooth bleaching systems are primarily based on oxidation by HP or one of its precursors such as, carbamide peroxide (CP).[6] 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).[2] 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).[7]

Home bleaching

Home bleaching is considered a safe and effective treatment.[8-10] 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.[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.[12]

In-office bleaching

Although in-office bleaching is performed using high concentration hydrogen peroxide (15%-40%),[12] it becomes a widely used procedure because of these advantages: Minimally invasive, immediate visible results and no need of patient cooperation.[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 discolouration associated with endodontic therapy.[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.[14] It is believed that most light sources decompose peroxide faster (by increasing the temperature) to form free radicals which whiten teeth.[15-17]

However, some studies reported that the use of light sources did not improve the in-office bleaching treatment of vital teeth.[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.[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.[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.[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 to16, the smaller the numeric value the lighter the tooth.[5] This method is the most common, as it is a quick, simple procedure and has been used successfully in many studies.[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.[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.[5]

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

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

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].[17,18,25-34]

Hein *et al.*, 2003[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[18] 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[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[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).

Lima *et al.*, 2009[17] summarised that non-activated whitening did not differ from activated whitening. Where, approximately 35% HP was used with different light sources (LED/diode laser, a halogen lamp, plasma arc lamp, argon laser). Bruzell *et al.*, 2009[42] reported no difference in efficacy between teeth bleached with or without irradiation for any of the products. The inspection of teeth was performed one week after bleaching using seven bleaching products with or without simultaneous use of seven different bleaching lamps.

Bernardon *et al.*, 2010[36] 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[43] 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[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[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[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[37] reported that a light-activated system produced better immediate bleaching

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.*,[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	The three test lights did not lighten teeth more than their bleach gels alone
Kugel *et al.*,[35] (2006)	A split-arch clinical study	Brite smile system 15% (HP) Opalescence Xtra Boost 38% (HP)	10 subjects	plasma arch light chemical activation	Use of light did not demonstrate any benefit over the chemically activated tooth whitening system
Marson *et al.*,[14] (2008)	Clinical study	35% (HP)	40 subjects. 4 Groups (*n*=10)	(HP) Alone halogen light XL 3000 demetron LED LED/ LASER	Light-activation sources did not affect the outcome of in-office bleaching with 35% hydrogen peroxide
Lima *et al.*,[17] (2009)	*In vitro* study	35% HP (Whiteness HP) 35% HP (OpalescenceXtra) 37% CP (Whiteness Super)	15 groups (*n*=5)	Halogen lamp plasma arc lamp led/diode laser argon laser no light source	Non-activated whitening did not differ from activated whitening
Bernardon *et al.*,[36] (2010)	a split-mouth Clinical study	35% HP	90 subjects 3 groups (*n*=30)	LED/Laser unit chemical activation	The use of light irradiation did not improve bleaching efficacy
He *et al.*,[37] (2012)	A systemtic review	15-20% HP 25-35% HP	11 Studies	Studies involve any kind of light	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
Hahn *et al.*,[32] (2013)	*In vitro* study	Opalescence xtra boost (38% HP)	80 teeth 4 Group (*n*=20)	Halogen LED laser chemical activation	No improvement in tooth whitening as a result of LED or laser light treatments
Nutter *et al.*,[38] (2013)	Clinical Trial	25% HP 10% CP	22 patients 2 groups (*n*=11)	Light activation chemical activation	No significant difference between the shade improvements achieved by the two whitening protocols tested

Table 2: Studies demonstrated that application of light significantly improved the whitening efficacy of some bleaching materials

Author, Ref. (year)	Description of study	Bleaching agent	Subjects/ (specimens)	Methods of activation	Results
Luk *et al.*,[18] (2004)	*In vitro* study	Opalescence xtra quick white laser whitening system starbrite power pack nupro gold teeth whitening gel	250 specimens 25 groups (*n*=10)	No light spectrum halgon curing light prototype infrared light argon laser CO_2 laser	Application of light significantly improved the whitening efficacy of same bleaching materials
Torres *et al.*,[29] (2011)	*In vitro* study	35% HP	180 specimens 8 groups (*n*=20)	Hybrid (LED) and low-intensity infrared diode laser devices. Halogen light chemical activation	Bleaching is more effective with a hybrid light emitting diode (LED) and a low-intensity infrared diode laser than without it
Domínguez *et al.*,[30] (2011)	*In vitro* study	35% HP quick white, 35% HP ena white Power, 35% HP opalescence endo	126 specimens	Halogen lamp LED low- power diode laser (Nd:YAG), second harmonic of Nd:YAG, and Er:YAG lasers	Only diode laser, halogen lamp, and LED lamp showed significant color changes
Kossatz *et al.*,[31] (2011)	clinical study	35% HP	30 patients 2 groups (*n*=15)	LED/laser energy chemical activation	A larger difference in bleaching with (LED)/laser than without after the first session
Polydorou *et al.*,[39] (2013)	Clinical study.	38% HP	60 patients 3 groups (*n*=20)	A halogen unit laser chemical activation	Directly after bleaching, halogen showed better results than laser. One and three months after bleaching, no significant difference was found between the tested methods
Liang *et al.*,[40] (2013)	*In vitro* study	35% HP 38% HP	24 teeth 2 groups (*n*=12)	Halogen light chemically activation	Halogen light and chemically activated in-office bleaching systems were both effective, but halogen light could improve the immediate whitening effect
Henry *et al.*,[41] (2013)	a split-mouth design clinical study	25% HP	49 subjects	A sodium arc bulb lamp chemically activated	A sodium arc bulb lamp produces better results but Subjects could not distinguish differences on each side of the mouth

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[32] 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[39] reported that directly after bleaching, the use of halogen showed better results than laser ($P \leq 0.05$), 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[40] 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.

Nuttera *et al.*, 2013[38] reported that there was no significant difference in shade change between in-office bleaching with light activated 25% hydrogen peroxide gel followed by 2 weeks at home, night-time bleaching with 10% carbamide peroxide gel in a customised bleaching tray and in-office bleaching with 25% hydrogen peroxide without light activation followed by 2 weeks at home, night time bleaching with 10% carbamide peroxide gel in a customised bleaching tray.

Henry *et al.*, 2013[41] 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.[44] This finding is in agreement with the studies of Torres *et al.* 2011,[29] Domínguez *et al.* 2011,[30] and Luk *et al.* 2004[18] who reported that the application of light significantly improved the whitening efficacy of bleaching materials. This may be attributed to tooth dehydration[45,46] 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 vitro*[48] or *in vivo.*[49,50]

Heymann 2005[51] 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.* 2007[44] 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.* 2004[15] 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 extended[52]

In a clinical study using custom-made bleaching trays, Kihn *et al.* 2000[50] 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.* 2000[53] 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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