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Review

Different Types of Laser use in Teeth Bleaching

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Abstract

The study of the present work aimed to compare between Laser and non laser systems in teeth bleaching, It be found that laser system is better than non laser systems and achieve a better result by selective radiation which can decrease the exposure time during bleaching hence reduces that intra-pulpal temperature. There are other lasers that have been tested for teeth whitening as Alexandrite and Nd:YAG. However, Er:YAG and diode lasers are the most type of lasers used in tooth bleaching specifically the recent types as touchwhite by fotona Er:YAG. The Er:YAG light does not penetrate through the gel and consequently does not directly heat the hard dental tissue or the pulp. The most effect Laser is touchwhite by Fotona Er:YAG as it least effect the dental pulp.

Keywords: Bleaching, Laser, Diode, Er:YAG, Touchwhite fotona.

INTRODUCTION

The desire to have whiter teeth and the bleaching technique has been documented since the mid-nineteenth century. Patients' awareness of options available for changing the color of natural dentition has created an increase in public demand (Farah and Powers, 2000). Bleaching corrects or improves the color of teeth, and is also the least expensive esthetic treatment option. The latest development of power bleaching has resulted in easy-to-use bleaching agents, essentially using highly concentrated hydrogen peroxide mixed with thickening agents or additional buffering agents, catalysts, or coloring agents. The energy source can be derived from blue-colored halogen curing lamps, LED, infrared CO2 lasers, diode, Er:YAG laser (Sun, 2000, Rohanizadeh et al., 1999). These studies showed that tissue ablation requires a high-energy-density beam. Laser irradiation of dental hard tissue can cause morphological and chemical changes (White et al., 2000). The extent of these changes is affected by the absorption characteristics of the tissues, so that the changes can be varied according to the type of laser and dental tissues. Compositional changes were also confirmed to decrease or increase the solubility of irradiated enamel or dentin (CO2, Nd:YAG laser) (Fowler and Kuroda, 1986).

Teeth whitening can be achieved in two ways: firstly, with gels, pastes or liquids (including toothpastes) that are mechanically agitated at the stained tooth surface in order to effect tooth stain removal through abrasive erosion of the stained acquired pellicle; and, secondly, with gels, pastes or liquids that accomplish the tooth bleaching effect by a chemical process while in contact with the stained tooth surface for a specified period of time, after which the formulation is removed (Sun, 2000). The use of high-intensity light for raising the temperature of hydrogen peroxide to accelerate the rate of chemical bleaching of teeth was first reported in 1918 by Abbot (Greenwall, 2001). The heat and light serve to increase the rate of bleaching of the hydrogen peroxide, providing a shorter period of time in which whitening of the teeth is achieved (Tavares et al., 2003; Luk et al., 2004). Typical temperature increases (ΔT) that are desirable in such procedures are between 10 ℃ and 40 ℃.

When laser light is used for the amplification of the bleaching effect, typically laser-absorption-enhancing particles are added to the gel. The particles are capable of absorbing the light energy from the wavelength of light emitted from the laser and of re-transmitting the light energy as thermal energy. These particles are dispersed throughout the bleaching compositions so that the laser beam can pass through the surface of the tooth while the particles absorb a portion of the light energy from the laser and retransmit it as thermal energy, thus increasing the effectiveness of the bleaching composition. For example, an argon ion laser utilizes a blue light with a wavelength in the range of 470 nm to 520 nm. The complementary color to blue is orange, and thus an orange or red-colored or pigmented particulate material that absorbs in this range would be suitable. Also preferred are other colors that absorb at the wavelength of the utilized laser light. For example, a black particulate material absorbs across all wavelengths and would thus also be suitable. Other typically used lasers for heat-enhanced teeth whitening are diode lasers with a wavelength of 810 nm or Nd:YAG lasers with a wavelength of 1064 nm (Wetter et al., 2004; ADA Council on scientific affairs Laser-assisted bleaching, 1998; Dederich and Bushick, 2004; Dostalova et al., 2004; Dostalova et al., 2003; Tsubura and Yamaguchi, 2005; Papathanasiou et al., 2002; Sulieman et al., 2005; Gutknecht et al., 1998; Buchalla and Attin, 2007).

Patient awareness of options available in changing the color of natural dentition has created an increase public demand. One of the most conservative treatment methods to correct or improve the color of teeth is bleaching. It is also the least expensive esthetic treatment option. Indication are acquired superficial stains, penetration and absorbed stains, agerelated stains, patients who desire conservative treatment to improve appearance, color change related to pulpal trauma and necrosis, and interproximal discolorations.

Current techniques involve a broad spectrum approach utilizing hydrogen peroxide (30 – 35 %) with or without heat or laser irradiation, carbamide peroxide (10-22 %), or mixture of sodium perborate and hydrogen peroxide (Haywood, 1992). In bleaching can be done by several energy sources to accelerate the chemical reactions. Energy can be delivered to bleaching gel through plasma-arc, halogen lamp, LED and lasers (Sulieman, 2005). An entire new serie of heating sources like plasma or LED lamps, combined with corresponding bleaching gels, opened the way to the new millenium with names like Brite Smile or generations of Zoom and finally by Laser. Among different lasers used in dentistry, diode lasers are usually used for this purpose. The mechanism of laser-assisted bleaching is called photochemical reaction that results in production of singlet oxygen radicals which have the ability to remove stains (Wetter et al., 2004). On the other hand, these radicals may prevent complete polymerization of adhesive and resin composites (Dishman et al., 1994). So, after bleaching, the interval of 1 to 3 weeks should be considered to have higher bond strength (Tabatabaei et al., 2011). To reduce these problems, antioxidant agents such as sodiumascorbate and other catalyzed enzymes are used, although they are not used routinely in clinical procedures (Torres et al., 2012).

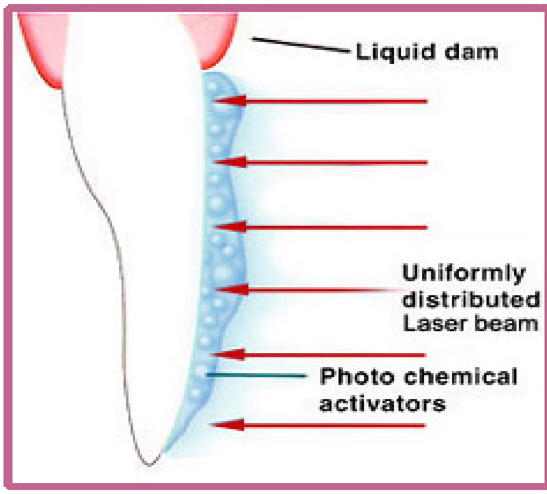
Teeth whitening have become one of the faster developing fields of aesthetic dentistry. The goal of laser teeth whitening is to achieve the ultimate power bleaching process using the most effective energy source without any morphological and chemical changes to enamel and surrounding tissue. The color of teeth is determined by the different optical properties of enamel, dentine and pulp and the interaction between those layers. Some of the causes of teeth discoloration are smoking, too much tea or coffee consumption and soda. Aging can also cause teeth discoloration. A further category of internalized stain may be considered: Intrinsic stains can be due to a change in the structural composition or thickness of the dental tissues. Intrinsic stains may also be caused by a number of metabolic diseases and systemic factors known to affect the developing dentition while extrinsic discoloration is outside the tooth substance and lies on the tooth surface or in the acquired pellicle.

REVIEW OF LITERATURE AND DISCUSSION

The role of laser in teeth whitening is to accelerate the activation of hydrogen peroxide (H_2O_2) in whitening gels which typically contain 30% to 35% H_2O_2 concentration. In reaction to the absorption of photon, the hydrogen peroxide breaks down into particle of water and radical of oxygen. The free radical oxygen chemically reduces larger organic-pigmented molecules (the chromophores) in the enamel matrix into smaller, less pigmented constituents by rapid oxidation. These compounds that originally have double bonds and long carbon chains are subsequently reduced to smaller carbon chains and hydroxyl groups, which eliminate discoloration. Before laser, several other lights such as Xenon Lamp, halogen light, plasma arc lamp light etc. was used to replace the role of light. But due to an inefficient light power output, limited effective lifetime and regular light consumed high electric power, researches kept trying to find new ways to accelerate the activation of H_2O_2. These lights use a tiny percentage of the polychromatic light energy and the rest is wasted as heat and light which is absorbed by adjacent tissue. The properties of laser which include coherent, monochromatic and collimated can reduced the amount of light absorbed by adjacent tissue. This Figure shows the comparison of effectiveness of using laser as opposed to non-laser system.

Difference between laser and non-laser whitening system

There are two methods of laser bleaching. One is the photothermal bleaching which is also known as the "power-bleaching". Photothermal is a process of transformation of absorbed light energy to heat leading to a local temperature increases. Photothermal bleaching is activation of a gel using high intensity light source (laser) that give controlled heating of the gel and break down the peroxide compounds within it. Another type of laser bleaching is the photochemical. Photochemical interaction induces chemical effects and reaction within



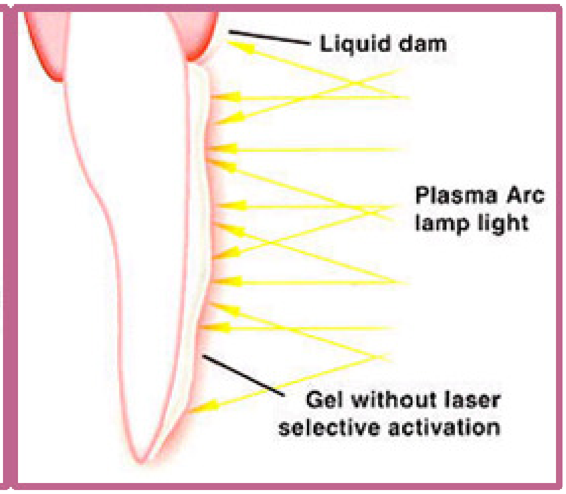
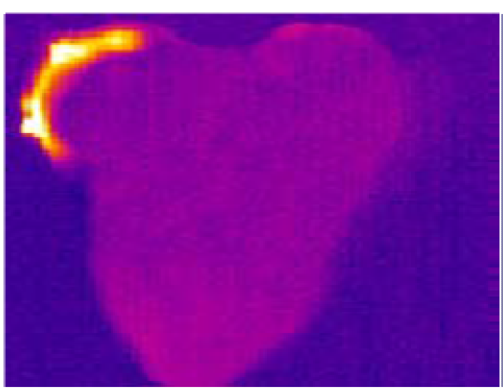


Figure 1 **Figure 2**

Difference between laser and non-laser whitening system

Table 1. Light-assisted bleaching agent ("+" indicate tissue lightening and shortening procedure time) (after Dostolova et al., 2004)

Activation of bleaching agent	Number of applied pulses	Laser energy	Pulse length	Repetition rate	Fluence	Duration of application	Lightened teeth 2-3 shades
Alexandrite 375 nm	1200	3 mJ	70 µs	2 Hz	0.2 J/cm2	625 s	-
Alexandrite 750 nm	1200	50 mJ	70 µs	3 Hz	2.5 J/cm2	400 s	+
Nd:YAG 1.064 µm	310	27 mJ	20 ns	1 Hz	1.4 J/cm 2	310 s	-
Er : YAG 2.94 µm	250	60 mJ	150 □s	1.5 Hz	3.0 J/cm2	195 s	+

A 

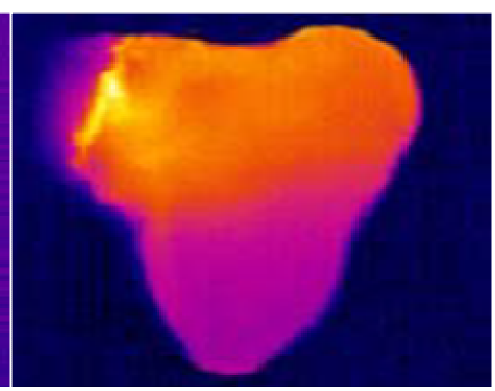
 B

Figure 3 **Figure 4**

Figure 3 and 4: a) Er:YAG whitening, and b) diode whitening. The Er:YAG laser directly heats the gel only, while the diode laser directly heats the whole tooth (After Guteknecht et al., 2011).

the macromolecules or tissue. Photochemical bleaching uses the visible light energy to directly energize oxygen molecule. Between these two, the photothermal bleaching is more well-known and most used these days. Today, there are 3 dental lasers that have been cleared by Food and Drug Administration (FDA) for tooth

Figure 5. (Fotona Er:YAG Laser)

whitening: argon laser, CO_2 laser and diode laser. But there are other lasers that have been tested for teeth whitening.

Photothermal bleaching uses a high energy laser. The most common type of laser for photothermal bleaching is the blue light diode laser (810-980 nm) and CO_2 laser (10600nm).

Other lasers that the effects have been studied in photothermal bleaching are CO_2 laser, Nd:YAG laser (1064nm), Alexandrite laser (750nm) and Er:YAG laser (2940nm).

Alexandrite laser (750nm) , Nd:YAG laser (1064nm):

The Alexandrite laser together with whitening agent whitens the teeth in 2-3 shades change after 6-7 minutes bleaching process. The enamel also was observed to be smoother. However, when Nd:YAG laser was used, there we no effect of longevity of the bleaching process after almost 5 min of bleaching process. There was also no difference on the surface of the enamel. When the Er:YAG was used in the bleaching process together with the bleaching agent, it gave the same effect as the Alexandrite laser in shorter time interval which was about 3 minutes. However, the Er:YAG laser radiation activation, the overheating of the bleaching agent was observed. The effect was very local, there were no cracks or essential surface modification observed. This study shows the difference between lasers types use in tooth bleaching.

Er:YAG Laser

The laser parameters are adjusted for the bleaching treatments so that the laser fluence of every laser pulse is below 0.5 J/cm^2 which is significantly below the ablation threshold of dental tissues. Since the ablation threshold for enamel is in the range of 3.5 J/cm^2 [27] there is no risk of accidentally damaging the hard dental tissue.

The erbium laser-whitening method offers solutions to problems which are related to the use of laser sources for heat activation of a teeth whitening process. The use of the Er:YAG laser wavelength that is absorbed in the major component of the aqueous bleaching gel, i.e., in water, eliminates the need for any additional absorbing particles in the gel. Also, due to the high absorption in bleaching gels, the Er:YAG laser beam is absorbed already in the first 10-50 microns of the gel. Deeper gel layers are then heated up by means of heat diffusion away from the laser heated surface layer. The Er:YAG light does not penetrate through the gel and consequently does not directly heat the hard dental tissue or the pulp. All of the laser energy is thus effectively used for the direct heating of the gel.

Figure 6. (Before bleaching)

Figure 7. (During bleaching)

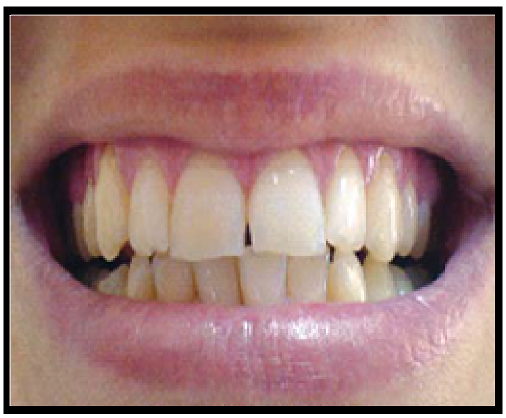
Figure 8. (After bleaching**)**

Table 2. Laser-assisted bleaching using hydrogen peroxide as the bleaching agent (After Dostalova et al. , 2004)

Laser systems	Power	Time of application	Lightened Teeth , 2-3 shades
None	-	5 min	-
None	-	15 min	+
Diode laser, wavelength 790 nm 8 blue light emission diodes, wavelength 467 nm	40mW	10 min	+
Diode laser, wavelength 790 nm 8 blue light emission diodes, wavelength 467 nm	40mW	5 min	+
Diode laser, wavelength 970 nm	40mW	5 min	+
Diode laser, wavelength 970 nm	1W	5 min	+
Diode laser, wavelength 970 nm	2W	2.5 min	+

The use of the Er:YAG laser wavelength, which is strongly absorbed in the major component of the aqueous bleaching gel, i.e., in water, eliminates the need for any additional absorbing particles in the gel. Due to the high absorption in the bleaching gel, the Er:YAG laser beam is fully absorbed in the gel. The Er:YAG light does not penetrate through the gel and consequently does not directly heat the hard dental tissue or the pulp. All the laser energy is thus effectively used for the direct heating of the gel. The TouchWhite™ procedure thus represents the most effective and least invasive laser-assisted tooth

Figure 9. (Diode laser)



Before bleaching

Figure 10

After bleaching

Figure 11

whitening method possible. It is also important to note that for the TouchWhite™ treatments the laser parameters are adjusted so that the laser fluence of every laser pulse is significantly below the ablation threshold for dental tissues. There is therefore no risk of accidentally damaging the hard dental tissue (Gutknecht et al., 2011).

a) Er:YAG whitening, and b) diode whitening. The Er:YAG laser directly heats the gel only, while the diode laser directly heats the whole tooth.(After Guteknecht et al., 2011).

Since the Er:YAG wavelength is fully absorbed in the gel, there is no direct heating of the underlying tooth. On the other hand, the diode wavelength is relatively weakly absorbed in the gel, and the transmitted light directly heats up the whole tooth. For this reason, the Er:YAG laser power is utilized more effectively, and the gel can be heated to higher temperatures, without compromising the safety of the tooth or of the pulp.

TouchWhite™ is the most effective and least invasive laser-assisted whitening method possible tooth. In comparison with diode and Nd:YAG bleaching, the TouchWhite™ Er:YAG whitening method has proven to be more comfortable for patients while achieving the same or better whitening efficacy. Also, because the bleaching agent stays on the tooth less time, patient safety and comfort increase.

Diode laser

Diode is a solid active medium laser, manufactured from semiconductor crystals using some combination of aluminum or indium, gallium, and arsenic. The available wavelengths for dental use range from about 800 nm for the active medium containing aluminium to 980 nm for the active medium composed of indium. All of the diode wavelengths are highly absorbed by pigmented tissue and are deeply penetrating, although hemostasis is not rapid. These lasers are relatively poorly absorbed by tooth structure so that soft tissue surgery can be safely performed in close proximity to enamel dentin and cementum.

The bleaching procedure had the following steps:

1) preoperative photographic record;

2) mechanical plaque removal – pumice, cleansing with alcohol and drying;
3) covering of control half of teeth with wax;
4) mixing the product;
5) immediate application of 1-2 mm layer to uncovered part of labial surface;
6) time measurement of bleaching process;
7) rinsing gel with water.

In this study, the chemical oxidation of hydrogen peroxide was the experiment control and it resulted in 2-3 shade change in one treatment with the minimum time for chemical oxidation was 15 minute. But there is a slight modification on the enamel surface observed.

The blue light laser (970nm) radiation and bleaching agent cause the same effect (2-3 shades) with a shorter time bleaching process which was about 5 minute. But the power that was used for this type of diode laser has a direct influence on the bleaching time. If 1W power were used, bleaching process is about 5 minute, and if 2W power source were used, the bleaching process took about 2.5 minute. The good thing is, there were no morphological changes of the enamel surface. Infrared diode laser, wavelength 790nm with bleaching agent help reached the desired color shades in shorter time which was about 5 min using only 40mW power source.

Other result that was observed using this laser is that the enamel's surface was also smoother with no morphological changes in the enamel tissue and the relief of hydroxyl apatite prism was well formed (Dostalova et al., 2004).

CONCLUSION

Base on the studies that have been made, we can conclude that the use of lasers in tooth whitening is an effective ways to bleach the teeth. Although some studies have shown that there are maybe some side effects to it, but these effects can definitely be avoid by selective radiation which can decrease the exposure time during bleaching hence reduces that intra-pulpal temperature rise. There are 3 dental lasers that have been cleared by Food and Drug Administration (FDA) for tooth whitening: argon laser, CO_2 laser and diode laser. But there are other lasers that have been tested for teeth whitening as Alexandrite and Nd:YAG. However Er:YAG and diode lasers are the most type of lasers used in tooth bleaching specifically the recent types as touchwhite by fotona Er:YAG

Overall, an efficient heating of the bleaching gel and thus an efficient teeth whitening method has been introduced that overcomes the drawbacks of the previous laser-assisted whitening methods. An additional advantage is that the Er:YAG laser is becoming a standard laser tool in dental practices for treating hard and soft dental tissues. Adding another application for use (i.e., teeth whitening) for this laser is beneficial to dentists as they do not have to acquire an additional special laser to be used only for teeth whitening. The use of the Er:YAG laser wavelength, which is strongly absorbed in the major component of the aqueous bleaching gel, i.e., in water, eliminates the need for any additional absorbing particles in the gel. Due to the high absorption in the bleaching gel, the Er:YAG laser beam is fully absorbed in the gel. The Er:YAG light does not penetrate through the gel and consequently does not directly heat the hard dental tissue or the pulp. All the laser energy is thus effectively used for the direct heating of the gel. The TouchWhite™ procedure thus represents the most effective and least invasive laser-assisted tooth whitening method possible.

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