Cosmetic dentistry has become a very important part of restorative dental practice. The appearance and color of teeth are important to many individuals seeking dental treatment. Studies in the 1980s and 1990s already demonstrated that at least one-third of the population is not satisfied with the color and form of their natural teeth. It has been estimated that among patients presenting for cosmetic treatments, up to 15% suffer from a psychiatric condition termed Body Dysmorphic Disorder (BDD) also known as dysmorphophobia, literally meaning “fear of ugliness.” BDD has an estimated prevalence of 1% to 2% in the general population and is characterized by a preoccupation with a slight or imagined defect of some aspect of physical appearance. Patients with such preoccupation were nine times more likely to consider tooth whitening. With the increasing demand for esthetic dental care, it is clear that bleaching can present a minimally invasive cosmetic approach.

The effect of external bleaching agents on dental hard tissues has been extensively investigated. Systematic reviews demonstrated that bleaching treatments might have a deleterious impact on restorative materials and restorations, and that external bleaching with heat must be done with caution due to unknown effects on the pulpal tissue. It was also shown that bleaching agents might have a negative influence on the integrity of organic enamel structures; in addition, mineral loss, loss of fluoride, increased susceptibility to erosion or caries, increased surface roughness, reduced enamel microtensile strength, reduced fracture stability, and a decrease in abrasion resistance of bleached dental hard tissues were also seen. On the other hand, at present no clinical studies or case reports in the literature have documented macroscopically or clinically visible damage due to vital bleaching or clinically relevant tissue destruction.

Vital tooth bleaching is a popular treatment modality in dentistry. In order to enhance or to accelerate the whitening process, heat activation of the bleaching agent by light, heat, or laser has been introduced. Some proponents of “power bleaching” with light also claim that there is an improved light absorption, a reduced tooth

Laser-assisted Bleaching with the KTP Laser

Katrien Vanderstrichta, Roeland J. G. De Moorb

a Clinical Resident, Department of Operative Dentistry and Endodontology, Ghent University, Ghent University Dental School, Gent, Belgium.
b Professor, Department of Operative Dentistry and Endodontology, Ghent University, Ghent University Dental School, Gent, Belgium.

Abstract: At present, the only system providing laser bleaching (of stains on and in tooth substance) with photothermal, photochemical, and photocatalytic activation of the bleaching gel is the combined use of the KTP laser (λ = 532 nm) with the Smart Bleach gel (SBI). Moreover, this system offers the advantage of performing true photobleaching, meaning that the problem of persisting intense discoloration resistant to the action of the oxygen free radicals – such as results from tetracyclines – can be solved.

Keywords: laser bleaching, KTP laser, photobleaching, power bleaching, tetracyclines.

heating, and even a photochemical activation of the bleaching gel thanks to the addition of an activator or colorant.\textsuperscript{13} In a systematic review, Buchalla and Attin\textsuperscript{10} concluded (1) that available studies on power bleaching did not allow for a final judgement on whether tooth whitening could be increased or accelerated by additional activation; (2) that activation of bleaching agents by heat, light, or laser may have an adverse effect on pulp tissue due to an increase of intrapulpal temperature exceeding the critical value of 5.5°C; (3) that there is no real evidence of photochemical bleaching, and power bleaching is the result of photothermal activation.

**KTP LASER BLEACHING**

The review by Buchalla and Attin\textsuperscript{10} was performed before the availability of studies in A1 journals using KTP laser ($\lambda = 532$ nm) (green light) for dental bleaching. A number of recent studies have demonstrated that KTP laser bleaching (1) did not result in changes or resulted in significantly less change in microhardness of the bleached enamel,\textsuperscript{14,15} (2) did not result in damaging temperature elevation,\textsuperscript{16,17} (3) was effective at providing brighter teeth than with diode laser and LED,\textsuperscript{15} and (4) was particularly helpful for whitening of tetracycline stains.\textsuperscript{18-20}

KTP laser (High Tech Laser; Herzele, Belgium) bleaching with the Smart Bleach gel (SBI; Herzele, Belgium) differs from other light activated systems: of particular interest is the red color of the bleaching gel (red and green are complementary colors) and the specific wavelength of 532 nm which can break tetracycline molecules and greyish discolorations into colorless molecules. This system is rather new and was patented in 2000.\textsuperscript{21} The hydrogen peroxide based bleaching gel (50% H$_2$O$_2$) is mixed with a photosensitizer, rhodamine B dye, resulting in an aqueous gel of high pH ($\text{pH}$ 9.5). The activation of the alkaline gel results in the release of hydroxyl and other oxygen free radicals, which can break down various colored organic molecules. Under these conditions (intense light and alkaline $\text{pH}$), hydroxyl radicals are produced by decomposition of the hydrogen peroxide. These radicals are more reactive than superoxide and other oxygen reactive species.\textsuperscript{22} Thus, the activation of the red bleaching gel with the KTP laser under alkaline conditions will result in a photocatalytic effect (limited photothermal activation of the gel and more pronounced photochemical activation). This process is an example of a photodynamic process employing intense light from a noncoherent light source of a laser to drive a sequence of molecular changes in light-sensitive compounds, which results in the generation of reactive oxygen species. In the Smart Bleach system, photodynamic reactions are exploited for the purpose of bleaching teeth. Activation of the gel results in the release of hydroxyl and other oxygen free radicals. In an alkaline environment (here, ionization of buffered hydrogen peroxide) more perhydroxyl ions are released, of which is known that they are 50% more reactive than other oxygen molecules.

Next to the photocatalytic effect, there is also the feasibility of photobleaching thanks to the specific wavelength. The KTP laser is capable of photo-oxidizing the chelate formed between tetracyclines and hydroxyapatite or calcium orthophosphate, and not responding to the chemical bleaching agents, eg, the produced free radicals. Most grey discolorations form the same chelate as tetracyclines with hydroxyapatite or calcium orthophosphate. These complexes are also photo-oxidizable by the 532 nm of a KTP laser. The combination of all these characteristics enables a more profound bleaching of teeth as compared to other bleaching systems.

**THE SMART BLEACH PROCEDURE**

The appointment for laser bleaching is approximately 90 min in duration, including the initial preparation and photographs. Before the start of the bleaching appointment, all patients had an initial appointment where the oral health status was screened. Contraindications for bleaching are leaking restorations, periodontal problems, caries, too many sensitive root necks, and enamel fractures or cracks. Patients are also informed that they have to stop smoking. Bleaching is not performed in mouths without sufficient oral hygiene, with periodontal problems and untreated carious lesions. Before the start of the bleaching procedure, patients at the GDLC (Ghent Dental Laser Centre) also sign an informed consent form, which informs them about the following: what hydrogen peroxide is and its possible side effects, the bleaching procedure, the fact that in a number of cases more than one session will be needed to achieve a good result and that it is difficult to predict results in advance, the impact of pigments on tooth discoloration and the impact of these colorants on the result and the maintenance of the bleaching result, the fact that filling materials and porcelain cannot be bleached, that a relapse as a function of time due to aging is possible, and that photographs and the patients’ background can be used anonymously for research purposes.

At first, extrinsic stains, plaque, debris, and/or deposits of pellicle are removed with pumice in order to
obtain optimal results (Fig 1). Any remaining organic proteinaceous material on the tooth surface will interact with the bleaching agent, and also reduce its penetration into the enamel, reducing its effectiveness. Conventional polishing and prophylaxis pastes may not be used, because they contain oils and coat the tooth surface, thus inhibiting the redox reaction and impairing the generation of free radicals.

A cheek retractor is then placed and teeth are gently dried, followed by taking photographs. When using the OptraGate Lip and Cheek Retractor (Ivoclar Vivadent; Schaan, Liechtenstein), the retractor is placed at the beginning of the procedure (Fig 2). Both extremes in the shade guide (VITA B1 and C4) are included in the first image (Fig 3). A second photograph is taken with the shade guides reproducing the color of the teeth (Fig 4).

At present we prefer to use the OptraGate Lip and Cheek Retractor. Lips and cheeks are more gently and evenly retracted than with conventional retractors. The system is also more comfortable for the patient and protects the lips better against contact with the bleaching gel. This is also important because the patient must remain still for a good part of the procedure. A combination bite block and saliva aspirator (the “expanded duty cotton mouth dry field system”, HighTech Laser) is also used (Figs 5 and 6). This block protects the tongue from contact with the bleaching materials. Being able to bite on this block also helps the patient relax and enables positioning of the mandible and maxilla, facilitating the bleaching procedure. The isolation devices must remain in position and the patient is not permitted to rinse.

After drying teeth and gums using compressed air, a gingival protection is applied. Exposed cervical root surfaces and the cervical gingival tissues are protected from the hydrogen peroxide gel and from dehydration, using a flowable resin material (Smartblock). Soft tissues need
to be protected, as they would absorb the visible green light of the KTP laser, resulting in thermal damage. The Smartblock is applied using a syringe with a blunt tip which is placed directly into the opening of the gingival crevice (Fig 7). The flowable resin is applied in layers, with the first layer covering the cervical aspects of the teeth for approximately 1 mm. After placement of a border 2 cm long (the width of 2 teeth), the resin is photopolymerized (Figs 8 and 9). The flowable composite can also be used for the protection of areas of exposed dentin on the root surface or the crown.

The patient, assistant, and dentist performing the laser whitening procedure must wear protective glasses, because the human eye is extremely sensitive to visible green light. Appropriate protective glasses, goggles or face shields must have an attenuating power of log 4 (OD 4). A vitamin E gel is also delivered with the system, and can be used for instant neutralization of tissue irritation or burning due to contact with the bleaching gel. This gel is a very strong anti-oxidant.

The SmartBleach gel needs to be prepared in advance. About 5 ml of peroxide is mixed with the powder to give the desired gel consistency. Once mixed, the gel must be allowed to stand in its closed container for at least 5 min to allow the carbonate buffer system within the gel to elevate the pH to approximately 9.5. The SmartBleach gel is colored using rhodamine B dye, which absorbs visible green laser light and breaks down to release oxygen free radicals.

The gel is applied in thin layers on the teeth with a spatula or a brush and in a predetermined sequence. Because maxillary teeth are bigger and have a thicker layer of enamel, especially in the front area, the gel is applied first on the central incisors 11-21, followed by 12-22, 13-23, 14-24, 15-25, 41-31, 42-32, 43-34, 44-35, 45-35. Every tooth is irradiated for 30 s in the same sequence as the gel application (Fig 10). The laser beam is applied with a spot size of 6 to 8 mm, using continuous wave. The handpiece is moved in a sweeping action across the tooth surface at a power of approximately 1 W. If unfavorable or unacceptable sensitivity occurs, energy density or the average power setting has to be decreased. After irradiation, the gel is left for 10 min on the teeth. Activation and exposure of the gel to the laser beam results in discoloration of the red gel (Fig 11). Therefore, it is also important not to apply the gel too thickly.

After completion of one pass over all teeth, the gel is then removed by aspiration and the teeth are thoroughly rinsed with spray. After inspection of the effect and result, the teeth are gently dried, fresh gel is applied if needed, and the whole procedure is repeated. A maximum of four passes can be performed in one treatment session.

Selective application to restricted areas on a single tooth (eg, tetracycline bands) or teeth is also possible. Instead of the handpiece, a fiber can be used for the activation of the gel for bleaching of localized discolorations.

Fig 6 Protection appliances in situ (cheek retractor – bite block with connected saliva aspirator).
or bands. The fiber is also moved with a sweeping action over the area covered with gel for 30 s at a power of 1 W. At present, investigations have shown that a 10-s pass at 3 W also results in successful whitening and can be of interest for intense discolorations.17

After the last pass is complete and the teeth are cleaned of gel remnants, the gingival protection is removed. After wetting of the teeth with water spray and gentle drying as done in the beginning of the procedure, the final shade can be checked using shade tabs. The two calibrator shades (VITA B1 – C4) (Fig 12) and the original shades (Fig 13) are included in the image to act as reference points.

When the bleaching procedure is completed, a transparent neutral sodium fluoride gel is applied to the teeth. The cheek retractors are removed and the result is discussed with the patient. Patients are also instructed not to consume pigmented foods for 72 h. Coffee, tea, red wine, and smoking should be avoided. An appoint-

ment is always made for a control session after 2 weeks. If more than one bleaching appointment is needed, the interval is one month.
CLINICAL CASES

A guideline to predict a possible outcome of a KTP laser-assisted bleaching is shown in Table 1. Satisfactory results are obtained for mild to moderate yellow discolorations after two to three applications of the bleaching gel; intense discolorations regularly require four passes (Figs 14 to 17). Figures 18 to 20 give an example of a case where the patient was not satisfied with home bleaching using trays. After cleaning with pumice, there was already some change of the color, though with laser bleaching it was possible to eliminate the yellow and orange discoloration. Brown discolorations are more resistant to whitening and generally require at least three passes of bleaching gel and laser energy. Whitening of intense grey discolorations as well as tetracycline staining degrees II and III is hardly possible without the application of laser energy. Here, it is always important to temper the patients expectations and emphasize that at least two sessions are mandatory (Figs 21 and 22).

REFERENCES


Fig 14 Before treatment.

Fig 15 After laser bleaching.

Fig 16 Before KTP laser bleaching.

Fig 17 After KTP laser bleaching.

Fig 18 Patient was not satisfied after a home bleaching with trays.

Fig 19 Cleaning with pumice already reveals a lighter color, though there are still yellowish and orange discolorations present.


Contact address: Professor Dr. Roeland De Moor, Department of Operative Dentistry and Endodontology, Ghent University, Ghent University Hospital, Dental School, Ghent Dental Laser Centre, De Pintelaan 185 - P8, B-9000 Gent, Belgium. Tel: +32-9-332-4000, Fax: +32-9-332-3851. e-mail: roeland.demoor@ugent.be