Er:YAG Garnet in laser-assisted crown lengthening

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Introduction

This article describes and demonstrates the use of the Erbium:YAG 2,940 nm laser system (Lite-Touch, Syneron Medical Ltd.) as a central tool in the treatment of osseous crown lengthening, and the advantages this wavelength offers versus the use of conventional methods.

Objectives and methods

Crown lengthening is a surgical procedure employed for the removal of periodontal tissue, in order to increase the clinical crown height. It is the most frequently used and valuable periodontal surgical procedure related to restorative treatment.1-4

The objectives of clinical crown lengthening include:

- Removal of subgingival caries
- Preservation and maintenance of restorations
- Cosmetic improvement
- Enabling restorative treatment without impinging on biologic width
- Correction of the occlusal plane
- Facilitation of improved oral hygiene
There are two methods of crown lengthening:
- Orthodontic—coronal extension
- Surgical—apical extension.

**Clinical considerations**
- Importance of the tooth
- Subgingival caries
- Clinical crown/root ratio
- Root length and morphology
- Residual amount of bone support
- Furcation involvement
- Tooth mobility
- Aesthetic demands
- Post-op maintenance and plaque control.

**Biologic width and aesthetic dentistry**

The clinician must create a symmetrical and harmonious relationship between lips, gingival architecture and positions of the natural dentate forms. Spear et al.1 have referred to this diagnostic methodology as facially generated treatment planning, where the maxillary central incisal edges determine where the soft tissue, i.e., gingiva, and bone should be positioned.5

To utilize crown lengthening, it is important for the restorative dentist to understand the concept of biologic width, indications, technique and other principles.2-4 To maintain healthy periodontal tissue, the attached gingival and biologic width must be considered. Biologic width is measured from the bottom of the gingival sulcus to the alveolar crest and is maintained by homeostasis.10,11 This width consists of the epithelial attachment to the tooth surface and its connective tissue. The average width is 2.04 mm. Impinging biologic width may cause periodontal tissue destruction; therefore, in crown lengthening, the position of the margin is important.

**Methods of clinical crown lengthening**

As mentioned above, there are two methods to lengthen a crown: coronal extension and apical extension. Apical extension of the crown is achieved by surgery, with or without osseous resection. In apical extension there are two methods:

- Open technique—patients who exhibit asymmetrical gingival levels, those with greater than 3 to 5 mm of maxillary gingival display, or both may be candidates for surgical gingival and/or alveolar bone repositioning to improve their aesthetics.
- Closed technique—for minor localized biologic width and/or aesthetic gingival zenith corrections. Can be used in lieu of a flap procedure to make the correction and complete the restorative process without the necessary healing time required for open crown lengthening surgeries.12

**Case presentation**

This clinical report describes a situation in which a crown lengthening procedure was successfully performed with the Er:YAG laser (Lite-Touch, Syneron Medical Ltd.) as a principal auxiliary tool, and the advantages of the 2,940 nm wavelength versus conventional methods.
Examination
Clinical examination of a 57-year-old male revealed missing teeth at the locations #17, 36, 44, 45 and 46 with overeruption of teeth #14 and 15 (Fig. 1). Radiographic examination of the area showed overeruption of teeth 14 and 15 with the alveolar bone.

Treatment options
The treatment options available in this case were:

- Insertion of implants and metal-ceramic crowns at the locations of teeth #17, 36, 44, 45 and 46.
- In addition to option one above: crown lengthening for teeth #14 and 15 and covering them with metal-ceramic crowns.

Following discussion with the patient and evaluation of the possibilities for success, it was decided to perform crown lengthening. Treatment would involve the use of the Er:YAG laser to perform the following steps, based upon accepted research:

- Flap incision\textsuperscript{13-15}
- Ablation of soft tissue around the teeth after raising a flap\textsuperscript{16-18}
- Remodelling, shaping and ablating of the bone\textsuperscript{13,15,19,20}

Treatment
All five implants were placed in one sitting (Fig. 2). Crown lengthening was performed three weeks postop (Fig. 3). Laser operating parameters employed for the various surgical stages were as follows:

- Flap Access: Wavelength: 2,940 nm (Er:YAG), 600-micron sapphire tip, contact mode; 200 mJ per pulse at 35 Hz. Total power: 7 Watts.
- Soft Tissue Removal: Wavelength: 2,940 nm (Er:YAG), 1,300-micron sapphire tip, non-contact mode; 400 mJ per pulse at 20 Hz. Total power: 8 Watts.
- Bone Surgery: Wavelength: 2,940 nm (Er:YAG), 1,300-micron sapphire tip, non-contact mode; 300 mJ per pulse at 20 Hz. Total power: 6 Watts.

With the assistance of a diode laser operating at a power setting of 2.4 W in contact mode, the location of the incision was marked (Figs. 4 and 5). An incision was made with the laser (after anaesthesia) at the buccal and palatal side of teeth #14 and 15 (Fig. 6) and a vertical incision was not required. The buccal and palatal flaps were lifted and the area was explored (Fig. 7); there was soft tissue around the neck of the teeth. The soft tissue was ablated using the laser. Vaporization of soft/granulation tissue (if any exists) after raising a flap is efficient with the Er:YAG laser, offering a lower risk of overheating the bone than that posed by the diode or CO\textsubscript{2} lasers\textsuperscript{23} and often obviates the need for hand instruments. Results from both controlled clinical and basic studies have pointed to the high potential of the Er:YAG laser and its excellent ability to effectively ablate soft tissue without producing major thermal side effects to adjacent tissue have been demonstrated in numerous studies.\textsuperscript{16-18}

The Er:YAG laser was aimed at the surface of the exposed bone which was ablated in non-contact mode (Fig. 8). Studies have shown that Er:YAG laser energy effects on bone include bacterial reduction.\textsuperscript{22} Following this, all accessible bone surfaces were exposed to laser energy to ablate necrotic bone and to shape and remodel the surface in accordance with established clinical protocols.\textsuperscript{13,15,20}

The bone level around teeth #14 and 15 fits to the bone level of teeth #13 and 16 (Fig. 9). The mucoperiosteal flap was re-positioned and sutured with silk 3-0, paying particular attention to primary closure of the flap (Fig. 10).

Postoperative instructions
The patient was prescribed antibiotics to avoid infection and painkillers for pain. Instructions were given to rinse with Chlorhexidine 0.2 %, starting the next day for two weeks, three times per day.
Management of complications and follow-up

The following day the patient reported moderate pain and moderate swelling. There was no tissue bleeding and the site was closed. The flap was showing signs of attachment and was healing nicely. At seven days post-op, the patient returned for inspection and removal of sutures. The swelling had resolved and healing was progressing well (Fig. 11). After five months, the soft tissue was healed completely without complications (Fig. 12). The soft issue had healed over the bone and there were no bony projections observed under the soft tissue. The prognosis is excellent. An impression for two metal-ceramic crowns was taken five months post-op (Fig. 10). An aesthetic result was achieved (Figs. 13 & 14).

Conclusion

The Er:YAG laser system (LiteTouch, Syneron Medical, 2,940 nm) can be employed as an auxiliary tool for the purpose of crown lengthening and has been shown to be effective and safe. The use of the LiteTouch wavelength for these procedures presents many advantages as opposed to conventional methods, including enhancement of the surgical site and less bleeding during the operation, providing the surgeon with a better field of visibility and reducing patient discomfort during use. In addition, anecdotal claims have been made that post-operative effects such as pain and swelling are less pronounced. Finally, the laser offers the dental surgeon enhanced ease of use with the hand piece’s 360° swivel capability.

Editorial note: A complete list of references is available from the publisher.
Long-term treatment of peri-implant lesions in geriatric dentistry

Author: Dr Georg Bach, Germany

Introduction

In recent years, photodynamic therapy has gained many new users in laser dentistry, giving it an enormous push forward. This therapy is minimally invasive and long-lasting. A multitude of scientific studies on the therapy have been conducted and it has a uniform nomenclature, established during the last meeting of the DGL (German Association for Laser Dentistry). During this meeting, the difference between “real” photodynamic therapy and one whose sensitiser has its own (antibacterial) properties was established. The following case report describes the minimally invasive use of a photodynamic therapy system with a green sensitiser in geriatric dentistry (treatment of peri-implant lesions).

Real photodynamic therapy: Sensitiser with intrinsic effect

In treatments with real photodynamic therapy, cell death of the pathogenic bacteria is achieved exclusively by the interaction between sensitiser and laser light, which generates oxygen, resulting in destruction of the pathogenic cell. A further differentiation can be made with regard to sensitisers that use blue (usually with antibacterial properties) and those that use green (usually without antibacterial properties) dyes. Systems with green sensitisers are undoubtedly the focal point of current interest. They are generally indocyanine green (ICG) based and activated with an 810 nm (diode) laser (near infrared).

Indocyanine green-based sensitisers for photodynamic therapy

ICG is a recognised active substance that has been standard in ophthalmology, as well as in oncology, dermatology and veterinary medicine, for years. If irradiated with a low-energy laser of a wavelength of 810 nm, it promises a successful therapy for periodontitis and peri-implantitis.

Case report

Eleven years ago, the now 79-year-old female patient had received implants in the mandible. After several years of total satisfaction with the implant provision, she experienced the first complications. While initially limited to the superstructure (small chips on the ceramic and loosening of the superstructure), problems with the actual implants had increased in the past three years and recurring infections, sometimes painful, and bleeding when brushing her teeth, etc. arose. Local and systemic antibiotics only yielded short-lived improvement, and she was then referred to our practice.

The first superficial intra-oral examination revealed clinical findings clearly indicative of a diagnosis of peri-implantitis:

- massive peri-implant bone loss;
- bowl-shaped defect; and
- pain on probing the soft-tissue sleeve.
Within the scope of a full-mouth disinfection, both of the implants affected by peri-implantitis and the remaining teeth of the mandible were treated with ICG-based photodynamic therapy.
Fig. 2. Mixing of sensitiser: the kit contains all the components required for preparing the sensitiser solution by dissolving the dye tablet in the liquid provided, which can then be used for approximately 30 minutes and is applied intra-orally.
The X-ray confirmed the initial clinical diagnosis: it was a case of full peri-implantitis. One implant in the left half of the mandible had loosened from the bone to the extent that no more than half of the titanium surface that had originally been covered by the implant was still osseointegrated. An explantation with subsequent augmentation and re-implantation later could have been considered for this artificial abutment tooth.

Already at this early stage of decision-making, the family doctor and internal medicine specialist vetoed any procedures with increased risk of bleeding, increased risk of bacteraemia and a high degree of invasiveness owing to the patient’s highly compromised physical condition. With these justified restrictions, photodynamic therapy was the obvious choice for treatment.

An ICG-based sensitiser (Perio Green, elexxion) in combination with an 810 nm diode laser (100 mW, pulsed) was used (Fig. 1). This is a photodynamic therapy system with matched components. The sensitiser is made up immediately prior to treatment by dissolving a dye tablet in the liquid included in the kit and then applied intra-orally (Fig. 2). The application of a low-viscosity light-green sensitiser, which requires a directed droplet-flow technique, is quite demanding compared with high-viscosity blue sensitisers. After application and a period of exposure, the laser fibre is inserted into the target area and the tissue is then irradiated with a low-energy diode laser (810 nm). The persistent colouring of the gingiva that is often observed when using other sensitisers does not occur after completion of treatment. No residue of the dye is visible intra-orally after rinsing several times.

An intra-oral follow-up examination was carried out at one and four weeks. The patient was, and is to date, without any symptoms. To maintain this situation, she is scheduled for recalls every three months, with every recall entailing a professional cleaning and photodynamic therapy for every second recall (Fig. 3).

Since, the patient is now almost completely without symptoms for the first time in years, but no improvement is to be expected with regard to her general health, we decided on this minimally invasive maintenance therapy. Regarding the commitments associated with it, the patient concluded very matter-of-factly, “To me, it is worth it”.

Conclusion

In my opinion, photodynamic therapy is a minimally invasive option compared with conventional methods. It is ideally and most effectively used with a verified treatment protocol and a sensitiser without an intrinsic effect. Photodynamic therapy has become my treatment of choice for patients with compromised health, for whom more invasive therapy options would be more difficult or impossible to implement, and for patients with a risk of bacteraemia._

Fig. 3. Treatment regimen of ICG-based photodynamic therapy using Perio Green.

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Introduction

The notion of utilising laser technology in conservative dentistry was proposed in 1990 by Hibst and Keller, who introduced the possibility of using an Er:YAG laser as alternative to conventional instruments such as the turbine and micro-motor.\(^1,2\) Wide-spread interest in employing this new technology stems from a number of significant advantages, as described in several scientific studies. Thanks to the affinity of the Er:YAG laser wavelength to water and hydroxyapatite, laser technology allows for efficient ablation of hard dental tissues without the risk of micro- and macro-fractures, as have been observed with the use of conventional rotating instruments.\(^3-6\) The dentin surface treated by laser appears clean, without a smear-layer, and with the tubules open and clear.\(^6\)

Thermal elevation in the pulp, recorded during Er:YAG laser irradiation, is lower than that recorded by using a turbine and micro-motor with the same conditions of air/water spray.\(^7,8\) This wavelength also has an antimicrobial decontamination effect on the treated tissue, which destroys both aerobic and anaerobic bacteria.\(^9\) The most interesting aspects of this new technology are related to the goals of modern conservative dentistry, i.e. minimally invasive treatments and adhesive dentistry. Er:YAG lasers can reach spot dimensions smaller than 1 mm, which enables a selective ablation of the affected dentin while preserving the surrounding sound tissue to produce highly efficient restorations.\(^10\) Several in vitro studies have demonstrated that the preparation of enamel and dentine by Er:YAG laser, followed by orthophosphoric acid-etching, enhances the effectiveness in terms of reduced microleakage and increased bond strength.\(^11\)

To understand the role that a scanner can perform in dental treatments, it is useful to take a comparative look at the field of aesthetic medicine. The Er:YAG laser has been used for many years in the field of dermatology, where it is employed for the vaporisation of lesions such as condyloma, naevi, warts, mollusca contagiosa, as well as for the treatment of keloid scars and wrinkles with so-called laser “resurfacing”.\(^12\) For many years, scanners have proven highly effective in dermatological treatments, enabling high-precision surface treatments without overlapping or under-coverage of the laser treatment area.

The aim of our study, which began several years ago, has been to evaluate the possibility of transferring the same type of scanner technology that is widely utilised...
in dermatology to the dental field. The first *in vitro* tests were performed on extracted teeth by using a scanner and a dermatological Er:YAG laser. Because of the fact that this particular dermatological device operates without water, it was necessary to modify it by adding a double external pipeline in order to deliver an air/water spray at the point of the laser’s impact on the tooth.

The results of this first sequence of tests were very promising and convinced the manufacturer Fotona to invest in a major research and development effort to construct a scanner handpiece of reduced size, able to be employed intra-orally. Once developed, the new dental-optimised scanner was given another series of *“in vitro”* tests, and after the safety of its utilisation was demonstrated via K-thermocouple records, optical microscope (Fig. 1) and SEM observation, it was subsequently applied to in vivo tests on human subjects.

**Material and method**

The laser appliance used was a LightWalker (Fotona, Fig. 2). The scanner handpiece is similar to the usual non-contact Er:YAG laser handpiece. The scanning mechanism is integrated inside an ergonomic box that lies on the operator’s hand, with a supplementary electrical cable delivering the digital information from the laser device to the scanning mirrors (Fig. 3). Its application is the same as with the usual non-contact handpiece; the only difference is that it covers a bigger area than the standard handpiece. However, it is useful because it can cover a larger area, or, by pressing the button on the screen, it can be used as a classical one-spot laser handpiece. The scanner handpiece can thus be used for all kinds of treatments by switching from the scanner modality to classic handpiece modality, without swapping handpieces.

The following settings are available for the scanner handpiece on the touch screen (Fig. 4):

- scanning of the area shape (circular, rectangular, hexagonal),
- size of the scanning area (width and length of the rectangle, diameter of circle and hexagon),
- number of scan passages (a function of the requested ablation depth),
- delay between consecutive scans (duration of the pause between scans).

Moreover, all parameters available with the classic handpiece (energy, frequency, mode, spray) are also used with the scanner handpiece. By reducing one of the sides of the rectangular shape, it is possible to obtain a linear cut without moving the handpiece, for instance to cut the root apex during endodontic surgery or to perform an incision in soft tissues surgery.

In this preliminary study, clinical applications are shown below which illustrate this new Er:YAG laser technology.

**Case 1: Enamel laser conditioning for orthodontic bracket bonding**

The employment of an Er:YAG laser to prepare the enamel for improving the strength of adhesion of composite resins has been proposed by several authors in conservative dentistry as well as for bracket bonding in orthodontics. Several studies, based both on traction and microleakage tests, have shown that the best values were obtained with samples irradiated by an Er:YAG beam before acid etching. Additionally, an *“in vitro”* study on extracted human teeth demonstrate...
industry report

strated that preparation by Er:YAG laser alone also gives a stronger adhesion than orthophosphoric acid alone. Moreover, other authors have underscored these results when using lasers to prepare enamel surfaces to make them more resistant to decay. This is possible because of the modification of hydroxypatite crystals, which is important in the prevention of decalcification zones around brackets, particularly in patients with scanty oral hygiene. Another advantage of laser utilisation is the ability to prepare a very small surface area of enamel, exactly of the same dimension of the bracket. We initially proposed a technique based on the use of a plastic template with rectangular windows designed to limit the irradiated area. Now, by using the scanner handpiece, the procedure is faster, easier and more precise.

The case described presents a 14-year-old female receiving orthodontic fixed treatment of the upper arch. The parameters used were determined by SEM observation in order to give the best enamel conditioning coupled with the minimal ablation: 55 mJ, 8 Hz, MSP mode, 4/6 air/water spray. The dimension of the ablation area was 2.5 x 3 mm and the number of passes was 10, once for each tooth.

Case 2: Treatment of amelogenesis imperfecta spots on permanent incisors

The term amelogenesis imperfecta is defined as a diverse group of hereditary disorders that primarily affects the quantity, structure, and composition of enamel. In the hypomature type, the affected teeth exhibit mottled, opaque white-brown or yellowish discoloured enamel, which is softer than normal. The hypocalcified type shows pigmented, softened, and easily detachable enamel, while in the hypoplastic type, the enamel is well mineralised but the amount is reduced.

In our daily practice, we have worked with several young patients exhibiting zones of discoloration in their frontal teeth and who needed treatment to improve the aesthetics of their smile. Due to the impossibility of treating these cases with classical bleaching techniques, it was necessary to ablate the affected zones and to fill the cavities produced with composite resins. We have already described the use of the Er:YAG laser in this type of case as a good example of minimally invasive dentistry but the use of the scanner improves the precision of the ablation even further by programming the extent and depth of the zone in advance.

The case presented concerns an 18-year-old male who had enamel lesions in the right upper lateral incisor, canine, and the first premolar. The treatment was performed without anaesthetics, with a total laser irradiation time of 186 sec. For this case we used the following parameters: 250 mJ, 10 Hz, MSP mode, 4/6 air/water spray. The ablation area was a 3.5 mm diameter circle and the number of passes was 15.

Case 3: Direct composite veneering of permanent incisors

In cases concerning damage to the frontal teeth crowns from a number of possible causes, i.e. traumas or bruxism, and if the patient does not wish to choose a prosthetic option, the solution is to ablate a portion of the enamel and to directly bond a coat of composite resin. The role of the Er:YAG laser in improving the
adhesion of resin to enamel has been well demonstrated and the advantage with the use of a scanner handpiece is the possibility to limit the volume of ablated dental tissue. The case presented regards a 64-year-old male who needed repair of his upper incisors. The treatment was performed without anaesthetics, with a total laser irradiation time of 253 sec. The parameters used were: 300 mJ, 10 Hz, MSP mode, 4/6 air/water spray. The ablation area was a 4.5 mm diameter circle, the number of passes was 15.

_case 4: Aesthetic re-treatment of an aging composite restoration

In some cases, composite restorations may present discolorations and spots after a number of years, particularly in patients who do not observe an adequate level of oral hygiene. The vestibular face of the frontal teeth or the cervical area of the premolars may pose a problem, from an aesthetic point of view, and this is the reason why several patients have come to our offices to regain a pleasant smile. The Er:YAG laser may be very helpful in this situation; in fact, because of its wavelength (2,940 nm) it is well absorbed by Glycidyl methacrylate (GMA) and Silicon Dioxide, two important components of composite. It is very effective in the ablation of old restorations without thermal elevation and can produce a rough surface, very difficult to obtain with orthophosphoric acid, which is able to bond the new coat of resin.

The case presented here involves a 55-year-old female with an aging infiltrated and spotted cervical restoration on tooth 34. The treatment was performed without anaesthetic. The parameters used were: 250 mJ, 10 Hz, MSP mode, 4/6 air/water spray. The ablation area was a 4 mm diameter circle and the number of passes was 15 for two times.

_discussion and conclusion

Laser technology was introduced in dentistry by Goldman in 1967. Since that time, a continuing effort has been made by clinicians, researchers and companies to improve the results of clinical treatments. The introduction of Er:YAG in 1990 provided the option to also treat hard tissues, and this technology was further improved through greater control of pulse duration (VSP—variable square pulse technology).

The recent introduction of a scanner handpiece enabled a higher precision of irradiation and depth of ablation as well as reduced treatment time, allowing laser technology to more fully realise the vision of "minimally invasive“ conservative dentistry.

Editorial note: A list of references is available from the author.