THE USE OF THE ERBIUM YTTRIUM ALUMINUM GARNET (2940nm) IN LASER-ASSISTED IMPLANT THERAPY AND GBR TECHNIQUE

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INTRODUCTION

Osseo-integration dental implants have become a routinely recommended procedure in the clinical practice of dentistry[1-4], and have been utilized as a successful treatment modality for over three decades with a reported success rate of greater than 90%[5-7,8]. The predictability and success of dental implants have secured their place as a standard treatment modality.

A clinical case study will demonstrate the use of the Er:YAG laser in the world of implantology. This technique using the Er:YAG laser presents several advantages vs. conventional treatment methods, and there are minimal post-operative complications coupled with a high rate of success.

Er:YAG is one of the most suitable wavelengths for bone applications. The 2940nm wavelength is highly absorbed in the water component of dental tissue, and provides efficient ablation without the risk of significant thermal damage[14]. This article will discuss the utilization of the LiteTouch laser (Syneron Medical Ltd.) for implantology.

The array of available clinical applications for laser assisted dentistry is growing rapidly, with the greater number of applications being for oral surgery. Er:YAG is a laser wavelength which is located in the infrared zone of the electromagnetic spectrum, is considered to be extremely safe, and is the dominant wavelength in dentistry today .

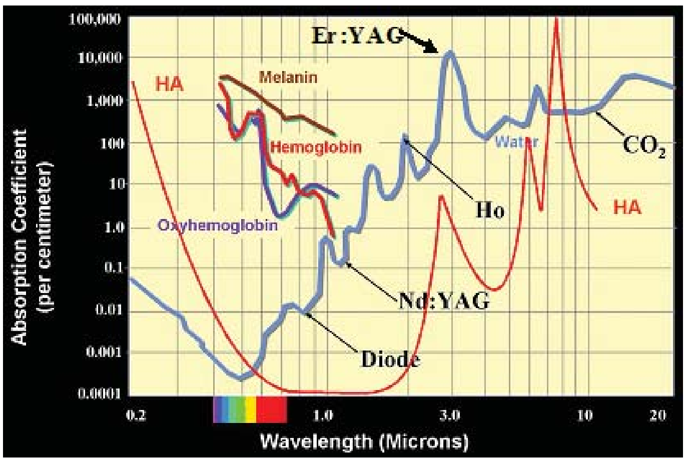
Most of the procedures performed at my practice are in the realm of surgery and they are all performed with the Er:YAG laser:

- Periodontal surgery, without the assistance of rotary equipment, scalpels or other hand tools
- Apicoectomy and bone manipulation - bone smoothing, harvesting and vaporization
- Guided bone regeneration (GBR)

How far can we advance with this technology? Where is the line between reality and fantasy - very clear at times, other times it can barely be seen, and yet at other times the line disappears altogether. What is the stage where I lay down the laser's handpiece and retreat to the conventional system and rotary equipment? Today we can observe an inordinate lack of knowledge and clarity concerning the clinical uses of the laser in the field of implantology, and with many doctors in the field reality does indeed mix with fantasy.

ER:YAG LASERS AND IMPLANTS

- The Er:YAG laser generates a wavelength of 2940nm and emits as a free-running pulsed train of photons in the mid infrared portion of the electromagnetic spectrum (see Absorption Chart). Successive laser pulses are 100-200 microseconds in width. The prime chromophore of this laser wavelength is water, which makes it appropriate for ablating both hard and soft target oral tissue. Incident laser energy is absorbed by the chromophore, converted into thermal energy which results in expansive vaporization. Such action causes a dislocation of the tissue structure and ablation; often this is accompanied by an audible "popping" sound.
- The Er:YAG laser can perform incisions for flap lifting, such as a crestal incision, or an intrasulcular or vertical release incision. The laser produces a wet incision (some bleeding) as opposed to the dry incision (no bleeding) that is produced by the CO_2 laser[9-13].
- Vaporization of granulation tissue[14-15] (if any exists) after raising a flap is efficient with the Er:YAG laser, with a lower risk of overheating the bone[14,16,17] than those posed by the current diode or CO_2 lasers.
- Using the Er:YAG laser in non-contact mode (1.5-2 mm from the target tissue), the future location and angle of the implant is outlined; and the laser is used only on the cortical bone. As an important point of clarification, the laser does not replace the pilot drill; it is used to create a "pilot hole" for the drill. The entire length of the implant should not be lased with the laser.
- Ablating the bone with the Er:YAG laser - remodeling, shaping and ablating necrosis bone[13,18-21].
- Implant exposure
- Implants complications - Peri-implantitis



Absorption Chart

Implant Complications and Treating Them with the LiteTouch Er:YAG Laser System

There are two groups of most common complications:

1. *Intra-operative complications:* bleeding, nerve injury, mandibular fracture, implant displacement (sinus, mandibular canal nasal fosse), accidental bone perforation and incomplete flap closure. The most prevalent reasons for intra-operative problems are: improper patient selection, an incorrectly performed surgical procedure, improper prosthetic rehabilitation, and inadequate oral hygiene.
2. *Post-operative complications:* peri-implant mucocytis, peri-implantitis, surgical wound dehiscence, lesions to adjacent teeth, and incomplete osteointegration. Lasers can be employed for treatment of both infectious processes to lessen the chance of implant failure.

Mucocytis - is an infection focused on the soft tissue around the implants. Treatment involves improved oral hygiene, mechanical bacterial reduction of the pockets and use of antimicrobial agents such as Chlorhexidine 0.12%. The laser can then disinfect the pockets and vaporize the granulation tissue; if an open flap method is used, the granulation tissue should be ablated with the Er:YAG laser and a water-spray, which creates a minimal zone of thermal necrosis. When working with or near the bone, maximum caution is required[26,31].

Peri-Implantitis - is an inflammatory process that affects the soft and hard tissues around the implant and involves bone loss. Conventional treatment involves a combined application of local and systemic antibiotics, and mechanical & chemical cleaning of the damaged implant's surface with citric acid and tetracycline solution. Alternatively, instead of using chemicals, a flap is lifted with the Er:YAG laser, vaporizes any existing granulation tissue until a new, healthy bone surface is achieved, after which laser energy is applied to the surface of the damaged implant. If necessary, guided bone regeneration may be performed after the bone and implant surfaces are disinfected and clean.

The Advantages of Lasers in Dental Implantology

There are several advantages for using lasers around implants:

- Safe for the surrounding tissue[22-24]
- Surgical site sterilization - the laser is bactericidal[25]
- There is a smaller zone of thermal necrosis compared to that when using a rotary drill[26]
- The Er:YAG laser cuts the periostium better than the diode or CO_2 lasers do because of its wavelength's enhanced level of absorption in water[27].
- The laser's efficiency can save time[26]
- Less bleeding during the procedure[10]
- Post-operative - less swelling and less pain due to the laser's ability to cauterize small blood vessels, lymphatic vessels and exposed nerve endings[28]
- No rotary tool vibrations: reducing patient discomfort and enhancing the surgical site. Less stressful oral therapy with enhanced outcomes[29,15].
- The Er:YAG laser produces no smear layer[14,30]

Case Study

The following clinical case study describes the use of the Er:YAG laser in the insertion of four implants in the upper-left quadrant, GBR technique and the advantages of the Er:YAG laser's wavelength in these processes.

Examination

A 56 year old patient with an unremarkable medical history presented complaining of bridge mobility in the upper left quadrant, requesting gradual restoration on the same side (figures 1&2).

Upon examination - a bridge of five crowns lying on two abutments: teeth # 23 & 27, with mobility grad 3. Panoramic and periapical film showed destruction of the abutments.

Treatment Options

The treatment options available were:

1. Extraction of teeth # 23 & 27 and partial dentures.
2. Extraction of teeth # 23 & 27 and insertion of 4 implants.

Following discussion with the patient and evaluation of the possibilities for success, it was decided upon the second option.

Treatment would involve the use of the LiteTouch Er:YAG laser to perform the following, based upon accepted research:

- The flap incision
- Ablation of granulation tissue, if any exists.
- Remodeling, shaping and ablating of the bone at the location of the extracted tooth #23.
- An associated osteogenic (GBR) procedure to prevent soft tissue in-growth and maintain the form of the alveolus.

Treatment

The procedure was started with a vertical incision for release with a 600 micron sapphire tip. The energy used for the incision was 200 mJ per pulse at 35 Hz. Total power: 7 Watts, in contact mode (figures 3&4). The incision was performed on the mesial of tooth # 23, followed by an intrasulcular incision around # 23 and then a crestal incision made on the alveolar ridge, until the tuber (figure 5). Teeth # 23 &27 were extracted and a full-thickness flap was then raised from the buccal and palatal side to allow access and visibility (figure 6). **Very important:** remember that when performing the vertical incision, not to push the end of the sapphire tip into the soft tissue but rather to gently stroke the tissue with the tip.

The soft tissue around the necks of the extracted teeth was ablated with a 1300 micron sapphire tip, in non-contact mode; 400 mJ per pulse at 20 Hz. Total power: 8 Watts (figures 7&11). 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 has been demonstrated in numerous studies[22,32,16].

The locations and the directions of the implants were marked with the laser (figure 9), and only the cortical bone was lased. The tip of choice for this procedure was 1300 microns, power setting of 300 mJ pulse at 20 Hz. Total power: 6 Watts (figures 8&9).

The next step was to drill for the implants with a rotary drill and only then the four implants were inserted into the upper-left quadrant: a 4.2/16 implant at the location of tooth 23, a 3.75/16 implant at the location of tooth 24, a 3.75/13 implant at the location of tooth 25, and a 3.75/10 implant at the location of tooth 26. The implant at the location of tooth #23 was submerged; the other 3 implants were non-submerged (figure 10).

The bone defect around the implant # 23 (figure 12) was filled with Bio-Oss® bone substitute (Geistlich Biomaterials), covered with Bio-Gide® (Geistlich Biomaterials), an absorbent, bi-layer membrane. Sutures were applied and primary closure was achieved (figures 13,14,15&16).

Management of Complications and Follow-Up Care

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 ten days post-op the patient returned for inspection and removal of sutures; the swelling had resolved, there were no signs of fistula and healing was progressing well. At ten weeks post-op the soft tissue was completely healed without complications (figures 17&18). The soft issue had healed over the bone and the implant at the location of tooth # 23, and there were no bony projections observed under the soft tissue; the prognosis was excellent. At three months post-op the submerged implant at # 23 was uncovered. Tip of choice: 1300 microns in non-contact mode; 400 mJ per pulse at 20 Hz. Total power: 8 Watts (figure 19).

The rehabilitation was completed six months post-op (figures 21, 22 & 23).

Golden Rules for Bone Lasing

It is necessary to point out the important issues that require attention when applying the laser to bone tissue:

- Constant hand motion during laser emission - do not apply the laser beam to any one spot longer than necessary. The systems developed for dentistry are thermal lasers, and the interaction between the laser and target tissue raises the temperature of the tissue. Studies have proven that the temperature developed by a laser beam is no higher than that developed by rotary tools.
- As a cooling liquid, use saline solution as opposed to distilled water, to provide the bone tissue with an isotonic environment.
- The laser energy applied to bone tissue should not exceed 300 mJ at 20 Hz.
- The laser application to bone tissue should always be performed in non-contact mode, with a distance of 1-2 mm between the laser tip and the tissue.

Golden Rules for Guided Bone Regeneration

- Sharp incisions far from the membrane's borders
- Stability of the implant
- The bone should be clean; free of soft tissue
- Provide a good blood supply - cortical stimulation
- Space making - creating and maintaining a blood clot mechanical stability
- Membrane fixation and tightening, close adaptation
- Complete/passive soft tissue coverage - primary closure
- No flap tension

Conclusions

The use of the LiteTouch Er:YAG laser (2940nm) as discussed in this article may be considered a safe and comfortable tool when adhering to the recommended operating parameters and tools (energy, tips, handpiece configuration and mode of beam application - contact/non-contact), and it presents many advantages vs. conventional methods. This laser has become an invaluable tool for many procedures by simplifying treatment and offering patients faster, less stressful oral therapy with enhanced outcomes: less bleeding during the operation, providing the practitioner a better field of visibility and reducing patient discomfort during its use. In addition, anecdotal claims have been made that post-operative effects such as pain and swelling are less pronounced.

The LiteTouch laser offers the dental surgeon enhanced ease of use with the handpiece's 360° swivel capability.

Figure 1: At presentation

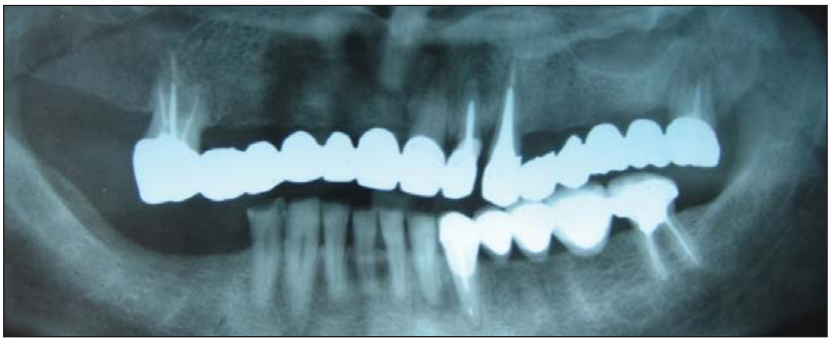


Figure 2: X-ray image at presentation

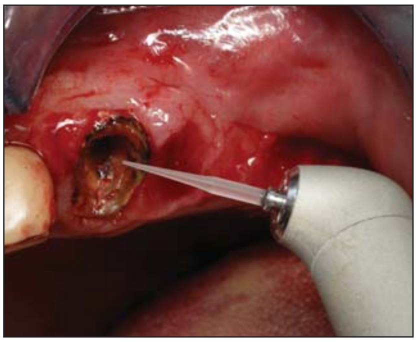


Figure 3: 600 micron tip for incision after removal of the old restoration

Figure 4: Vertical incision

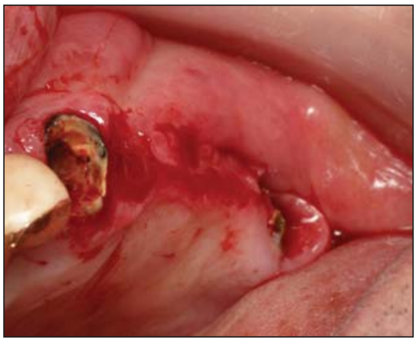


Figure 5: Mid-crestal incision

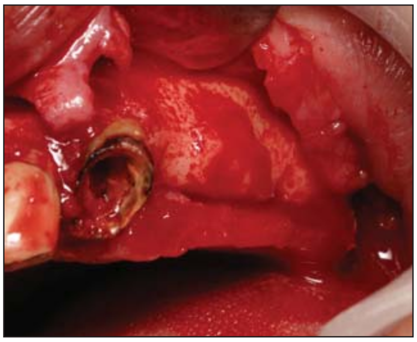


Figure 6: Raising the flap

Figure 7: Extraction tooth # 23 and ablation of granulation tissue. 1300 micron tip in non-contact mode.

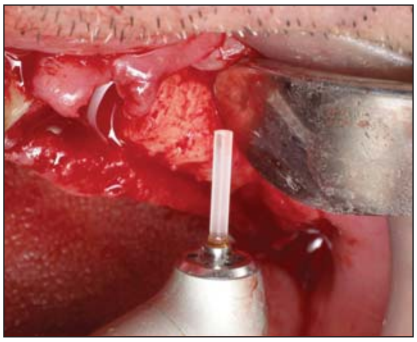


Figure 8: Marking the location and direction of the implant - lasing only the cortical bone in non contact mode

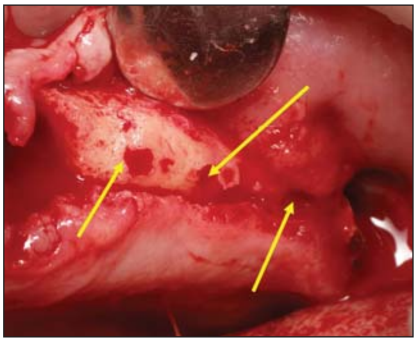


Figure 9: Laser-marked implant locations

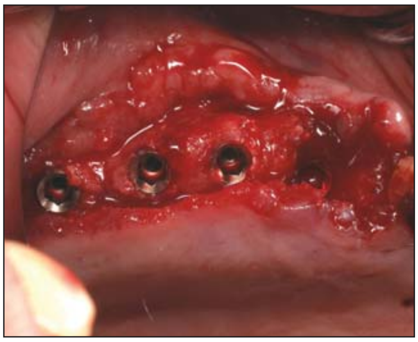


Figure 10: Insertion of four implants

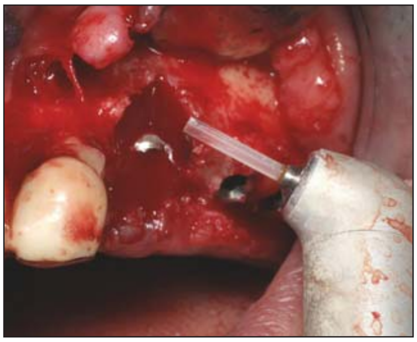


Figure 11: GBR technique - decortication and ablation of granulation tissue. 1300 micron tip in non-contact mode.

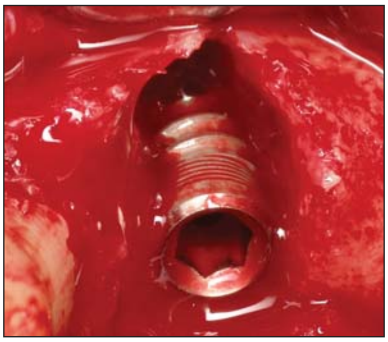


Figure 12: Implant at the location of # 23 after ablating the site

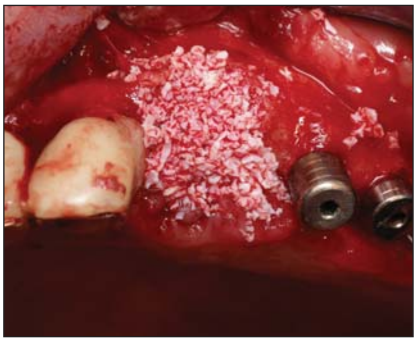


Figure 13: Filling the defect with Bio-Oss® bone substitute

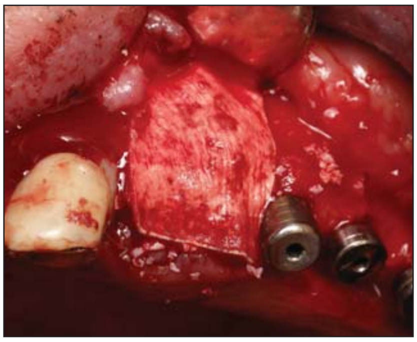


Figure 14: Resorbable bilayer membrane

Figure 15: Final result with primary closure

Figure 16: Panoramic X-ray immediately post-op

Figure 17: Ten weeks post-op

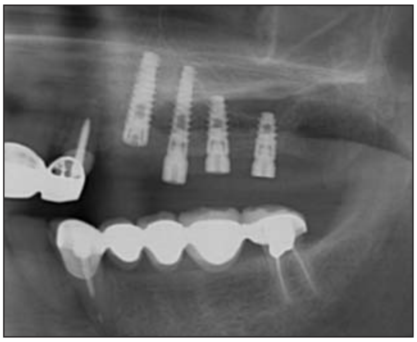


Figure 18: X-ray image three months post-op

Figure 19: Uncovering the submerged implant at the location of tooth # 23.

Figure 20: Four months post-op

Figure 21: Final results, four months post-op

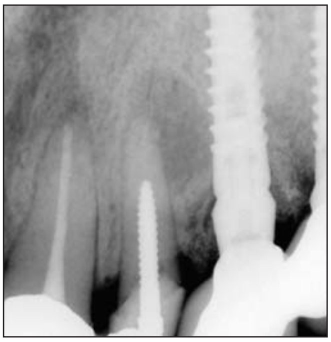


Figure 22: X-ray of the implant at the location of tooth # 23

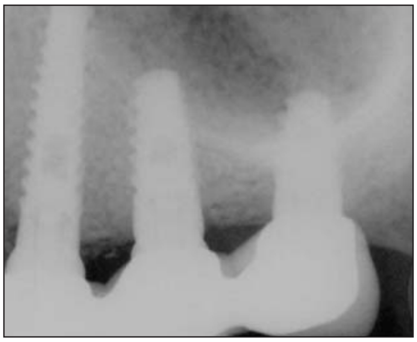


Figure 23: X-ray of the implants at the location of teeth # 24, 25 & 26

References

1. Adell R, Lekholm U, Rockler B, Branemark PI, "A 15-Year Study of Osseointegrated Implants in the Treatment of the Edentulous Jaw". *Int J Oral Surg.* 1981 Dec;10(6):387-416
2. Albrektsson T, "A Multicenter report on Osseointegrated Oral Implants". *J Prosthet Dent.* 1988 Jul;60(1):75-84
3. Buser D, Mericske-Stern R, Dula K, Lang NP., "Clinical Experience with One-Stage, Non-Submerged Dental Implants". *Adv Dent Res.* 1999 Jun;13:153-61
4. Olsson M, Friberg B, Nilson H, Kultje C, "Mkll - a Modified Self-Tapping Branemark Implant: 3-Year Results of a Controlled Prospective Pilot Study". *Int J Oral Maxillofac Implants.* 1995 Mar-Apr;10(2):243
5. Adell R, Lekholm U, Rockler B, et al. "A 15-Year Study of Osseo Integrated Implants in the Treatment of Edentulous Jaw". *Int J Oral Surgery.* 1981;10:387-416
6. Albrektsson T.A. "Multicenter Report on Osseo Integrated Oral Implants". *J Prosthet Dent.* 1988;60:75-84
7. Buser D Mericske-Stern R, Dula K, et al. "Clinical Experience with One-Stage, Non-Submerged Dental Implants". *Adv Dent Res.* 1999;13:153-161
8. Olsson M, Fiberg B, Nilson H, et al. "Mkll - A Modified Self-Tapping Brenemark Implant: 3-Year Results of a Controlled Prospective Pilot Study". *Int J Oral Maxillofac Implants.* 1995;10:15-21
9. Ishikawa L., Takasaki A.A., "Potential Applications of Erbium:YAG Laser in Periodontics", *J Perio Res.* 2004 Aug:39(4):275-85
10. Watanabe H., Ishikawa I., Suzuki M., Hasegawa K., "Clinical Assessments of the Erbium:YAG Laser for Soft Tissue Surgery and Scaling", *J Clin Laser Med Surg.* 1996 Apr,14(2):67-75
11. Ishikawa I., Aoki A., Takasaki A.A., "Potential Applications of Erbium:YAG Laser in Periodontics", *J Periodontal Res.* 2004 Aug;39(4) 275-85
12. Ishikawa I., Sasaki K.M., Aoki A., Watanabe H., "Effects of Er:YAG Laser on Periodontal Therapy", *J Int Acad Periodontol.* 2003 Jan:5(1): 23-8
13. Sasaki K.M., Aoki A., Ichinose S., Yoshino T., Yamada S., Ishikawa L., "Scanning Electron Microscopy and Fourier Transformed Infrared Spectroscopy Analysis of Bone Removal Using Er:YAG and CO_2 Lasers", *J Perio*, 2002 Jun; 73(6):643-52
14. Nelson, JS, et al. "Mid-Infrared Erbium YAG Laser Ablation of Bone: the Effect of Laser Osteotomy on Bone Healing". *Lasers Surg Med.* 1989; 9:362-374
15. Schwarz F., Bieling K, Sculean A, Herten M, Becker J. "Treatment of Peri-Implantitis with Laser or Ultrasound. A Review of the Literature". *Schweiz Monatsschr Zahnmed.* 2004;114:1228-35
16. Kreisler M., Al Haj, H., d'Hoedt, B., "Temperature Changes at the Implant-Bone Interface During Simulated Surface Decontamination with an Er:YAG Laser", *Int J Prosthdont.* Nov-Dec 2002; 15(6):582-7
17. Ishikawa I., Aoki A., Takasaki A.A., "Potential Applications of Erbium:YAG Laser in Periodontics", *J Perio Res.* 2004 Aug;39(4) 275-85
18. Ishikawa I., Sasaki K.M., Aoki A., Watanabe H., "Effects of Er:YAG Laser on Periodontal Therapy", *J Int Acad Perio.* 2003 Jan:5(1): 23-8
19. "Use of the Dental Erbium Laser (2940nm) for Contouring and Resection of Osseous Tissue (Bone) and the Preparation of Endodontic Canals, ©2000 to 2002 Institute for Laser Dentistry", http://www.laserdentistry.ca/erbium.html
20. Rupprecht, S., Tangermann, K., Kessler, P., Neukam, K.W., Wiltfang, J., "Er:YAG Laser Osteotomy Directed by Sensor Controlled Systems", Craniomaxillifac Surg. 2003 Dec;31(6):337-42
21. Kreisler, M., Al Haj, H., d'Hoedt, B., "Temperature Changes at the Implant-Bone Interface During Simulated Surface Decontamination with an Er:YAG Laser", *Int J Prosth,* Nov-Dec 2002; 15(6):582-7
22. Matsuyama, T., Aoki, A., Oda, S., Yoneyama, T., Ishikawa, I., "Effects of the ErYAG Laser Irradiance on Titanium Implant Materials and Contaminated Implant Abutment Surfaces", *J Clin Med Surg,* Feb 2003;21(1):7-17
23. Komori, T., Yokoyama, K., Takato, T., Matsumoto, K., "Clinical Application of the Erbium:YAG Laser for Apicoiectomy", *J Endod.* 1997 Dec, 23(12):748-50
24. Kreisler, M., Kohnen, W., Marinello, C., Götz, H., Duschner, H., Jansen, B., d'Hoedt, B., "Bactericidal Effect of the Er:YAG Laser on Dental Implant Surfaces: An In Vitro Study", *J Perio,* Vol. 73, No. 11, Nov. 2002
25. Lewandrowski, K.U., Lorente, C., Schomacker, K.T., Flotte, T.J., Wilkes, J.W., Deutsch, T.F. "Use of the Er:YAG Laser for Improved Plating in Maxillofacial Surgery: Comparison of Bone Healing in Laser and Drill Osteotomies", Lasers Surg Med. 1996;19(1):40-5
26. Ishikawa, I., Sasaki, K.M., Aoki, A., Watanabi, H. "Effects of Erbium:YAG Laser on Periodontal Therapy", *J Int Acad Periodontal.* 2003 Jan;5(1):23-8
27. Arnabat-Dominguez, J., Espana-Tost, A.J., Berini-Aytes, L., Gay-Escoda, C. "Erbium:YAG Laser Application in the Second Phase of Implant Surgery: A Pilot Study in 20 Patients", *Int J Oral Maxillofac Implants*, Jan-Feb 2003; 18(1):104-112
29. Komori, T., Yokoyama, K., Takato, T., Matsumoto, K., "Clinical Application of the Erbium:YAG Laser for Apicoiectomy", *J Endod. 1997 Dec,* 23(12):748-50

30. Trajtenberg, C.P., Pereira, P.N., Powers, J.M. "Resin Bond Strength and Micromorphology of Human Teeth Prepared with an Erbium:YAG Laser" Am J Dent. 2004 Oct;17(5): 331-6

31. Kesler, G., Koren, R., Kesler, A., Kristt, D., Gal, R. "Differences in Histochemical Characteristics of Gingival Collagen After Er:YAG Laser Periodontal Plastic Surgery", *J Clin Laser Med Surg.* 2000 Aug; 18(4):203-7

32. Schwarz F, Rothamel D, Becker J, "Influence of an Er:YAG Laser on the Surface Structure Of Titanium Implants", *Schweiz Monatsschr Zahnmed.* 2003;113(6):660-71

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