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Laser and Ultrasound Osteotomy in Implant Surgery

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Background

In the wake of revolutionary and continuous developments in the field of laser technology, various types of laser are now increasingly used in dental medicine with great success. While the soft-tissue treatment of the intraoral mucous membranes has almost become a routine treatment in modern practices, the treatment of bones still continues to present a problem in many cases. Through an individual modification of laser parameters, the multidisciplinary co-operation of surgeons, physicists and engineers now makes it possible to perform highly precise bone incisions with a suitable laser system without causing associated complications such as thermal damage or wound healing problems. In addition to this groundbreaking innovation, modern ultrasound technology also plays an increasingly important role in bone preparation and implant surgery because of its ability to perform selective incisions, which, as a result of further development, can now also be used beside lasers in the preparation of implant sites.

Clinical and experimental studies

A recent experimental study sponsored by the camlog foundation tested the suitability of Er:YAG laser (erbium-doped yttrium aluminium garnet) osteotomy for the implant site preparation on sheep. The study compared the surgical technique of laser osteotomy together with the subsequent osseointegration process of CAMLOG® SCREW-LINE implants with conventional drilling techniques and the new ultrasound-based implant site preparation (piezo surgery). The individual parameters of the Er:YAG laser osteotomy as well as those of the piezo osteotomy had been comprehensively tested in an earlier animal experiment in order to achieve the optimum conditions for an undisturbed and faster wound healing process compared to mechanical instruments. For that reason, the main focus of the current project is on the early stage of wound healing and the osseointegration process.

First results from animal experiments show a simple and safe preparation of the implant site using the new ultrasound tips. There were no intraoperative complications and all implants could be placed with primary stability. The internal cooling of the implant tips ensured that thermal damage could be safely prevented even at depth. The corresponding histological analyses and torque tests on the stability and the osseointegration of the CAMLOG implants after the respective use of laser, piezo and traditional drills will follow at a later date.

In addition to the experimental application, a second clinical pilot study, also sponsored by the camlog foundation, tests the Er:YAG laser in prepro-

Editorial

Dear Reader,

In the near future, the **camlog foundation** website is going to be revised. The overall structure – public section and closed section reserved to specially registered users – will remain as before. In the closed section, there are several **new services** to be discovered.

The most important new issue is the **Bibliography** showing the titles (and links) of the most important recent publications concerning topics interesting for you as a friend of the **camlog foundation** or a user of CAMLOG products. The Bibliography will be updated twice a year.

The second service is a **Poster Collection** where we stock all the posters submitted at the CAMLOG Congresses and published on other occasions. Here too, the only condition – besides quality – is, that every single piece has to be of potential interest for the friends of the **camlog foundation.**

Two other items, the Research Support and the **camlog foundatio**n Research Award, have to be understood as simple information. These offers will be outlined, later.

Walter Gehrig

sthetic surgery for harvesting of autologous block grafts from the mandible for preimplant ridge augmentation. In the course of the later insertion of CAMLOG® SCREW-LINE implants, a histological sample will be taken after 3 months to verify the undisturbed and safe osseointegration of the grafts. In addition, the augmentation site will be clinically assessed in order to document any possible resorption processes. The CAMLOG® SCREW-LINE implants will be monitored over a three-year period. First clinical results of treatment with the Er:YAG laser show a gentle and efficient bone ablation within a reasonable period of time. Because of consistently applied water cooling, neither the bone nor the adjacent tissue structures suffered visible thermal damage. In this context, compared with rotating instruments, the selected fast pulsing laser parameters were shown to be significantly less traumatic even during accidental injuries to adjacent soft tissue structures. In all cases, the postoperative healing process happened without complications and with no delays compared to conventional methods. Apart from the typical ablation sound and the strong smell of the laser ablation, which occurred during insufficient suction, patients did not experience the laser-assisted procedure as unpleasant.

Basic principles of laser and ultrasound osteotomy

Because of its wave length of 2.94 µm, which coincides with the absorption peak of water, the Er:YAG laser has emerged as a possible alternative to conventional methods of bone ablation. The optical energy of the erbium laser is directly absorbed at the irradiated surface resulting in only minimum penetration depths for water-containing substances. As a result of the thermo-mechanic ablation process, which leads to the almost explosive removal of the apatite crystals due to the fast vaporization of the interstitial water molecules, the bone surface is ablated gently and layer by layer (HIBST 1992). Despite the sometimes very promising results produced by the Er:YAG laser in the ablation of hard bony substances, it has not yet been able to establish itself as an unrestricted and successful method for performing osteotomies in intraoral bone surgery (LEWANDROWSKI et al. 1996). Apart from technical limitations – characterised by the set parameters of laser physics combined with the limited flexibility of the various optical fibre systems – the biological effect of the laser beams on both mineralized target tissue and adjacent regions (SASAKI et al. 2002) remains a problem in clinical practice. Without an optimum selection of the laser parameters (pulse energy, pulse frequency, focus size) and with insufficient water cooling, thermal damage to the wound margins of the osteotomy gap cannot always be ruled out (el MONTASER et al. 1997). Compared to conventional methods, in some instances, this results in an insufficient ablation of bone substance, an increased time requirement for the osteotomy as well as impaired wound healing with at times severe postoperative complications due to carbonization products.

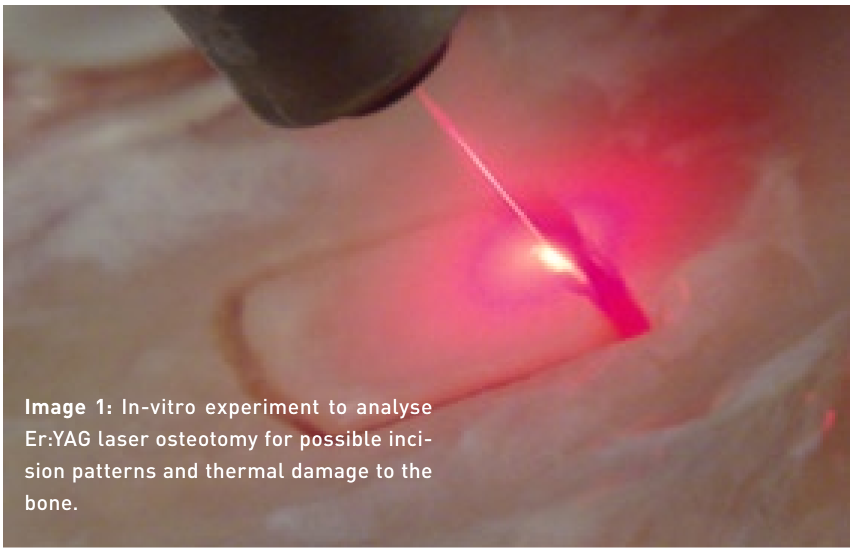

Image 1: In-vitro experiment to analyse Er:YAG laser osteotomy for possible incision patterns and thermal damage to the bone.

Based on our own preliminary experiments using a new Er:YAG laser proving the fast and most importantly carbonization-free osteotomy of a tibia in sheep without wound healing problems, the objective is now two-fold – to use the advantages of laser osteotomy in implant surgery and to compare them with the equally innovative technique of piezo surgery. The main advantages of laser osteotomy are to be seen in the non-contact and thus low-vibration technique with minimal trauma to tissue structures. Furthermore, there is no metallic abrasion in laser cuts with freely selectable incision geometry, and the formation of small bone chips can also be excluded. Through a corresponding coupling with special optical fibre systems or feedback systems (Rupprecht et al. 2004), highly precise and minimally invasive procedures can be performed.

In contrast with the non-contact ablation process using a laser, piezosurgery uses modulated ultrasound for drilling the implant site. A power output of 5 W and a working frequency of 25 to 30 kHz make it possible to selectively cut mineralized hard tissue because a frequency of about 50 kHz would be required to cut soft tissue. The oscillation amplitude of the working tips is based on the superimposition of the horizontal oscillation of 60 to 200 µm and the vertical oscillation of 20 to 60 µm. Using a corresponding slight rotation of the different instruments tips, it is then possible to perform different implant drillings depending on length and diameter.

Conclusion

Current clinical and experimental results lead to the conclusion that in the field of dentoalveolar surgery the Er:YAG laser is currently most suited for osteotomies which require a precise, non-pressure and low-vibration mode of operation. The ablation is performed layer by layer in a controlled manner. However, at present, handling and sometimes difficult guidance of the laser beam within the oral cavity still limit the application to smaller osteotomies with good accessibility, such as the chin or front region. With regard to the advantages of laser osteotomies, such as the non-contact, low-noise and low-vibration method of operation without metallic abrasions or bone chips, corresponding comparative studies verifying their superiority particularly over piezo surgery are still required. This is especially pertinent because the advantages of an ultrasound osteotomy – characterised by exact and selective cuts in the border zone between hard and soft tissue – really come into play only during implant site preparation in difficult indications, such as proximity to the sinus maxillaris or the N. alveolaris inferior.

However, as far as a later coupling with robotics and navigation systems is concerned, laser osteotomy offers significant advantages by virtue of its simple beam control. Corresponding trials are currently under way and will be reported at a later stage.

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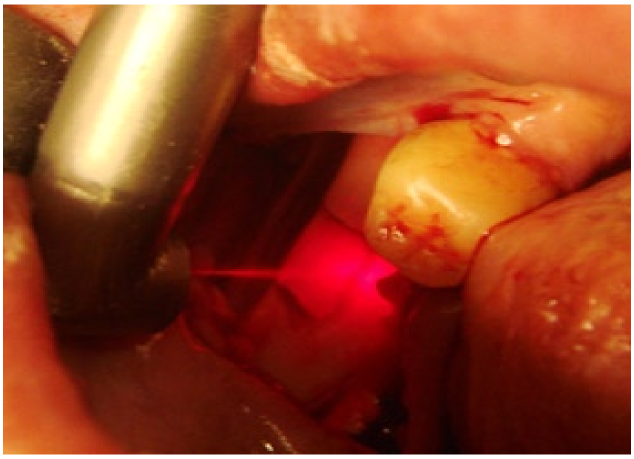

Image 2: Harvesting of a bone graft from the left mandible – ramus region. The red laser beam represents the pilot or target beam. Because of its wave length, the Er:YAG laser beam is invisible to the human eye.

Image 3: Osteotomy site after harvesting of the bone graft. The area of the cut shows no sign of thermal damage or carbonization.

Impressum:

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