
Fig. 1

Er:YAG laser for peri-implantitis treatment

Author: Dr Fabrice Baudot, France

Fig. 1: Illustration of the photoacoustic and photoablative effects of lasers, "falling stone".

With the increasing popularity of dental implant treatments, the prevalence of peri-implantitis has continued to grow worldwide. In 2008, Esposito et al. admitted that "an optimal treatment protocol with suitable instruments has not yet been established".[1] This observation reflects actual global opinion that peri-implantitis is still a huge problem that the dental community has to deal with now and even more so in the future. In this article, and addressing the biological aspects of peri-implantitis, we would like to emphasise why the microablative and photoacoustic effects of the Er:YAG laser could be of great assistance in the treatment of this disease (Fig. 1).

Peri-implantitis

In 2015, Derks and Tomasi published one of the best meta-analyses to evaluate the prevalence of peri-implant disease.[2] From among 3,840 articles on this topic, they selected 15 articles describing 11 studies. Only longitudinal studies reporting on more than 100 implants were included. In these studies, peri-implant mucositis occurred in 43 % and peri-implantitis in 22 % of all cases. This means that statistically more than 60 % of implants placed could be a problem. It is thus urgent to recognise, as Renvert and Polyzois did in 2015, that "as with every disease, prevention is the best form of treatment, and peri-implantitis is no exception".[3]

While peri-implant mucositis is an inflammation of the peri-implant tissue, peri-implantitis results in bone loss around the implant. Both of those pathologies share similarities with periodontitis. The loss of the integrity of the surrounding peri-implant tissue is the main reason for the development of such problems. The growing incidence of peri-implantitis is a global concept, not just a biological problem.

The most common risk factors for the development of peri-implantitis relate to the following:

- design and quality of the implant surface;
- insertion torque;
- quantity and quality of the bone;
- anatomy and physiology of the peri-implant soft tissue;
- tissular tension: management of peri-implant soft tissue;
- type of prosthetic load and quality of the restoration; and
- peri-implant care.

The biological problem appears mostly as a consequence of these risk factors. When the integrity of the peri-implant tissue is lost, microbial invasion, and the development of a mature and mineralised biofilm in very narrow spaces proceeds rapidly in the oral environment (Figs. 2–5).

Therapeutic strategies

Since Mombelli and Lang published their study on the management of peri-implantitis in 1998,[4] almost nothing has changed in the way this growing problem is treated. Mombelli and Lang established the fundamentals and outlined the prevention of peri-implantitis, including cleaning of the implants and the surrounding tissue. Today, we must recognise that there simply is no definitive solution for the treatment of peri-implantitis yet. We should take into consideration what Renvert and Polyzois wrote in 2015.[3] Concretely, this means that we must take into account all the risk factors in treating implant patients.

As for the biological aspect, we need to explain to our patients the importance of regular recalls to check the implants and set up peri-implant care programmes. The integrity of the peri-implant tissue and the biological stability around the implants are crucial to avoid further problems. When a problem occurs, the ability to clean the implants and the peri-implant tissue, particularly the bone, is fundamental.

There are three steps in the therapeutic strategy corresponding to the level of injury around the implants:

1. As already mentioned, prevention is a key factor to avoid any problem. Therefore, a peri-implant care programme should be set up for every implant immediately after implantation. This programme

Figs. 2–5: Although this case was performed by a French opinion leader in implantology, with a prosthetic reconstruction meeting the current quality criteria, the patient suffered a peri-implantitis at three out of five implants in the mandible ten years after his implant treatment. Causes identified were inadequate follow-up and probably bone heating during implant insertion.

Fig. 2

Fig. 3

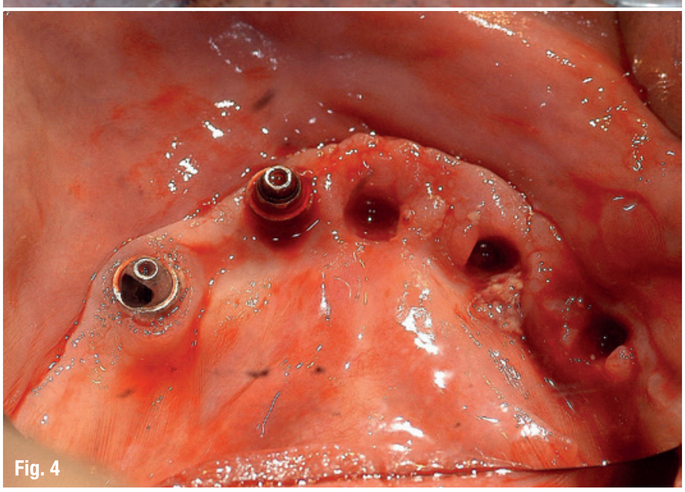


Fig. 4

Fig. 5

Figs. 6 & 7: The Er:YAG laser is a minimally invasive tool that enables practitioners to perform an anti-inflammatory and antiseptic treatment.

Fig. 6

should consist of checking the integrity of the implants and peri-implant tissue, and most of all the cleaning of the surfaces exposed to oral biofilm. The instrumentation used for cleaning should be efficient and gentle to avoid any damage to the fragile peri-implant tissue attachment.

2. Early peri-implantitis or peri-implant mucositis could be treated with a non-surgical approach. Cleaning ability seems to be the key point for success in controlling the inflammatory process. In order to prevent any damage and to preserve all the potential of the healing process, particularly vascularisation, we need to use tools that are efficient in very narrow spaces and we should respect the integrity of the tissue.
3. In the case of advanced peri-implantitis, the surgical approach is recommended when the prognosis of the implant has been determined in relation to the bone quality. All granulation tissue and sometimes also calculus around the implants must be removed without damage. Moreover, the nicked bone needs to be deeply cleaned while safeguarding the integrity of the vascularisation, which allows guided osseous regeneration.

Er:YAG laser compared with conventional instrumentation

Concerning peri-implantitis, the main problem is the development of biofilm on the implant surface. Biofilm can be very difficult to remove depending on the type of microstructure and macrostructure of the implant surface, the design of the implant and accessibility to lesions.

Cleaning the implant surface during peri-implantitis treatment is not the only problem that has to be solved. Peri-implantitis is in fact a wound opened to the oral microflora. In order to achieve healing of this wound, it must be cleaned at a histological level. All of the inflammatory tissue surrounding the wound is infiltrated with a large amount of enzymes and microbes responsible for the destruction of the peri-implant tissue. This granulation tissue around the implant must be removed to encourage healing.

The conventional tools for a mechanical approach to cleaning the implant surface, such as ultrasonic devices, polishers and air scalers have a certain proven efficacy. Air abrasion seems to be the best tool for removing plaque from a rough implant surface and can be used to treat peri-implantitis in a non-surgical approach, as shown by Sahm et al. in a randomised controlled clinical study.[5] However, we could also say that it is a dirty tool because it leaves a great deal of powder particles in the peri-implant spaces, and this could induce chronic inflammation.

Renvert et al. showed in a randomised clinical trial that the Er:YAG laser is equal to an air-abrasive device in the treatment of peri-implantitis.[6] We have shown in some videos that not only is the Er:YAG laser able to remove biofilm from the implant surface better than air abrasion can, but it does so without leaving any debris.

The major advantage of the Er:YAG laser compared with conventional instruments in the treatment of peri-implantitis lies not in the ability to clean the implant surface, but in the precise capacity to remove selectively all of the granulation tissue from the peri-implant lesions. By its physical properties, the Er:YAG laser is unique, and to the best of our knowledge, no other instrument is able to remove granulation tissue better than this laser device can (Figs. 6 & 7).

Er:YAG laser wavelength compared with other laser wavelengths

The key point, compared with the other laser wavelengths used in the medical field, is that the Er:YAG laser has peak absorption in water and hydroxyapatite in the energy absorption spectrum curve. This physical property makes the Er:YAG a unique tool and the most versatile laser for use in dentistry.

Briefly, to understand the way this laser works on vital tissue, one could say that the energy delivered by the laser beam is absorbed by the tissue and produces biological effects. Vital tissue, particularly human tissue, is mainly composed of water in the case of soft tissue and a great amount of hydroxyapatite in the case of hard tissue (teeth and bone).

Massively absorbed, the Er:YAG wavelength causes an intense and extremely sudden increase in energy in the targeted tissue. The consequence is micro-explosions of the water and hydroxyapatite molecules that materialise macroscopically (when this phenomenon is repeated) by the microablative effect. Takasaki et al. found this effect to occur within 30 µ/s.[7]

Because of its peak absorption, the Er:YAG laser is a surface laser. As the energy is massively absorbed, the consequent increase in temperature is rapidly dispersed. The thermally affected layer is in the range of 20–50 µ, compared with deep-acting lasers, like the Nd:YAG and diode laser, which is some millimetres deep.

The wavelengths of other lasers are less absorbed, so the energy penetrates deeper into the tissue and produces an increase in temperature in many more layers than the Er:YAG does. This is the main reason that the Er:YAG laser is a very accurate tool, adapted to microsurgery. With it, one is able to sculpt the tissue in the microdimension under visual control when using optical aids and without any thermal effect over 50 µ.

Er:YAG microsurgery around implants

Tissue can be classified by the amount of hydric charge regarding the Er:YAG laser effects. The most hydrated tissue is ablated prior to the less hydrated tissue. Oral surgery and dental procedures are unique in that the whole range of tissue, from the less hydrated tissue of the organism (which is the enamel) to the most hydrated tissue (which is inflammatory tissue), is treated. The particularity of dentistry is that all of this tissue occurs in a very small space: in a few millimetres, the whole range of tissue can be found. Across a gradient of hydric charge, the Er:YAG laser works selectively from the most hydrated tissue to the less. It is crucial in dentistry and specifically around implants to use such a tool that works at the surface of the targeted tissue very precisely, selectively and with limited thermal effects.

The Er:YAG laser is a unique tool compared with conventional instruments. With it, the surgeon is able to remove granulation tissue with equal precision from the soft part of the peri-implant pocket, the cancellous bone and the implant, where it is also possible to remove calculus without contact.

Vascularisation of the remaining tissue is preserved, even stimulated, by the biostimulation effects of the laser, and the implant surface and surrounding bone are not overheated or damaged. In narrow spaces, which is often the case around implants, the Er:YAG laser is able to ablate granulation tissue at a distance.

Antibacterial effects of the Er:YAG laser

Laser irradiation of a targeted tissue produces two major effects: the photoablative effect, which is able to remove material, as explained; and the photoacoustic effect, which is a shock wave resulting from the first effect. In order to better understand these phenomena, one can liken a laser beam on a tissue to a stone falling into water. The impact on the water produces a series of waves that could represent the photoacoustic effect.

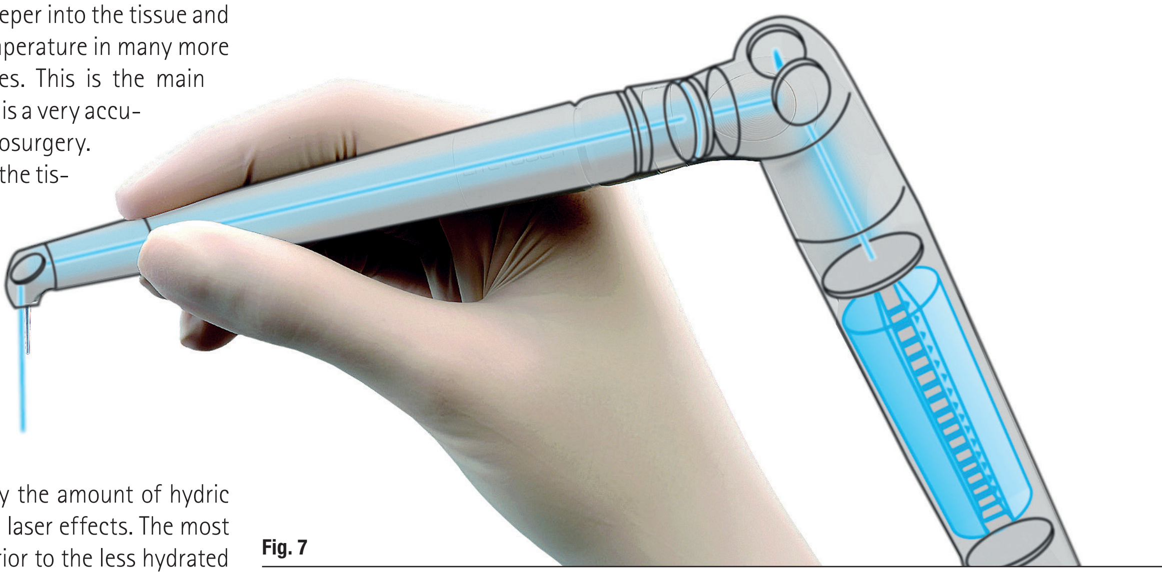
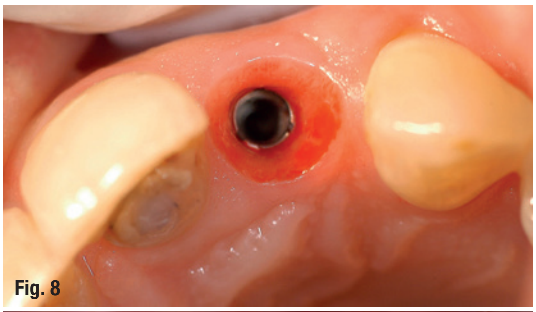


Fig. 7



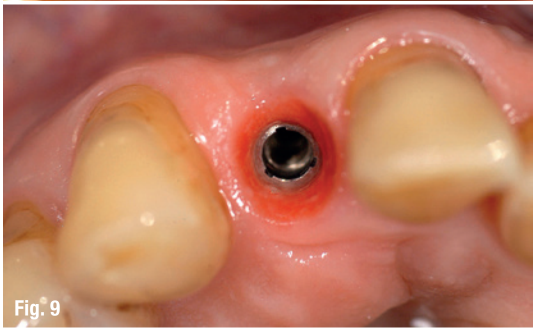


Fig. 8: This clinical situation reflects a good tissue integration of the prosthesis.
Fig. 9: Er:YAG laser for the subgingival part of the implant restoration is an adapted complement, particularly, when there is a pocket around the implant when ceramic or gold fused to metal has been used in UCLA-type restorations (Pilier UCLA).
Fig. 10: Laser application at the entrance of the sulcus irradiation in sweeping motion.

The antibacterial properties of the laser come from those two effects. While the microablative effect is able to eliminate selectively granulation tissue and biofilm (very hydrated structure), the photoacoustic effect shakes the debris and isolated microorganisms to clean the treated spaces.

Biofilm is a protective niche for bacteria. The immune system is basically acting against the biofilm, to no effect, because immune cells are not able to reach the bacteria and other microorganisms inside this structure, which develops on the surface of the implant and the surrounding tissue. Laser irradiation is able to destroy biofilm and isolate microorganisms. In this way, the microorganisms can be reached by the immune system. We are virtually "assembling the players", as Page and Kornman explained in their famous article, in which they described the mechanisms of the immune response in periodontal infections.[8] The equilibrium for a healthy periodontal and peri-implant environment can be recovered.

Er:YAG laser irradiation on implant surfaces

As mentioned in a study by Galli et al., the Er:YAG laser produces no or minimal alteration of the microstructure of machined or sandblasted implants.[9] This laser works in the real dimension to clean the microroughness on a new implant's surface. The shock waves and microablative effect are efficient to clean very deeply the microanfractuousities of the implant surface. When used in the correct way, the Er:YAG laser does not generate a thermal effect and does not damage the titanium implant surface.

It has been found to have an antibacterial effect on titanium and many other materials because it has been observed that living cells like osteoblasts and fibroblasts grow on an implant surface irradiated with an Er:YAG laser, according to Schwarz et al.[10] Kreisler et al. showed that, on implant surfaces conditioned with an Er:YAG laser, the proliferation of the fibroblasts is better than when an air-abrasive device is used.[11] Friedman et al. observed a new attachment of osteoblasts after Er:YAG irradiation on sandblasted and acid-etched implant surfaces.[12]

Takasaki et al. observed better bone–implant contact on sandblasted and acid-etched implant surfaces after Er:YAG irradiation compared with curettage in open-flap surgery.[7] This finding confirms the observations of Schwarz et al., who found better results regarding re-osseointegration on contaminated titanium surfaces irradiated with an Er:YAG laser compared with conventional mechanical and chemical treatments.[10]

With regard to these studies, it could be said that the Er:YAG laser is safe when used to irradiate titanium surfaces. There is some antibacterial effect by its capacity to remove biofilm and a bactericidal effect. Moreover, it seems to stimulate the growth of cells for better healing around implants.

Clinical protocols

As mentioned, the Er:YAG laser has several properties that make it a key tool for treating peri-implantitis. The main goal in the treatment is to control the inflammatory and infectious processes around the implants in order to induce wound healing of the soft tissue and to stop bone resorption. In some particular situations, such as in cases of angular lesions or crater-like lesions, bone regeneration is possible if the implant surface is cleaned very deeply.

The key factor in the management of peri-implantitis is obtaining and maintaining a hermetic seal of the surrounding tissue. Of course, it is a global concept, from the surgical step to the prosthetic procedures, but above all, the prognosis of the implant rehabilitation regarding peri-implantitis depends on the ability to control infection around the implant. By operating the laser correctly, by using the microablative and photoacoustic effects of the Er:YAG laser, we can successfully apply clinical strategies to prevent or treat peri-implantitis.

Prevention of peri-implantitis

The state-of-the-art must be observed in the surgical and implant prosthetic procedures, but it is not enough to guarantee the biological stability of restorations. We need to control the biofilm development around implant restorations without damaging the tissue. Good oral hygiene is a prerequisite, but regular recalls to clean the implant restorations are important as well (Fig. 8).

Air abrasion is efficient for cleaning supragingival parts, but the tissue is too delicate for subgingival use, even with a glycerine powder and adapted tips. It leaves powder in the peri-implant sulcus and could damage the very fragile soft-tissue connection to the implant. Some deep parts may not be accessible to the mechanical effects of the air-abrasive device.

It appears that using the Er:YAG laser for the subgingival part of the implant restoration is an adapted complement. This is particularly the case when there is a pocket around the implant when ceramic or gold fused to metal has been used in UCLA-type restorations (Fig. 9). When titanium and zirconia abutments have been seated at the time of surgery, it seems that no pockets exist around the implant; in those cases, prevention is easier.[13]

In order to prevent the development of biofilm subgingivally around implants, treatment needs to be both delicate and efficient. The Er:YAG laser is able to reach the biofilm structure at a distance and to destroy and emulsify bacteria. It is possible to do this just by placing the laser tip at the entrance of the sulcus. It is not necessary to go deeply around the implant.

A low power is sufficient for efficiency because the energy of the Er:YAG laser is massively absorbed by the biofilm structure. We recommend setting the Er:YAG laser below 1 W, by setting it at 50 mJ and 17 Hz with 70 % water cooling, for example. The application is about one minute per implant, working the tip around in a sweeping motion into the sulcus (Fig. 10). The frequency of application is crucial and must be adapted to the estimated risk factors. An Er:YAG laser prevention protocol should be followed twice a year on average.

Non-surgical approach

When an inflammatory problem such as peri-implant mucositis or early onset peri-implantitis with minimal bone resorption occurs, a minimally invasive approach can be applied. For moderate mucositis, repeated light applications of an Er:YAG laser twice a week using the same settings as for peri-implant maintenance are recommended.

If there is a large amount of granulation tissue, it is removed beforehand by microablation of the internal part of the pocket. The Er:YAG laser settings are as follows: 100–200 mJ, 20 Hz, 50 % water cooling. This first microsurgical intervention is followed by an intense peri-implant maintenance care protocol (as for moderate mucositis) twice a week until resolution of the problem.

In each case, the patient is advised to support this antibacterial protocol by applying curcumin essential oil once a day for several weeks to avoid bacteria of the red complex. If an anatomical problem (tension or thickness of the gingiva) is present, it must be corrected to achieve better stability of the results.[14]

Surgical approach

In the case of advanced lesions, the prognosis must be evaluated and the risk–benefit ratio must be considered to evaluate a conservative approach. Advanced peri-implant lesions are always a problem, have a poor long-term prognosis and are very difficult to maintain in cases in which the conservative approach is compromised. The patient must be informed of the consequences in terms of aesthetics and maintenance difficulties.

A surgical approach is necessary to clean the implant surface deeply, as well as bone lesions around the implant, under visual control. All of the granulation tissue is removed from the bone and implant surface. The recommended settings are 300 mJ, 20 Hz and 70 % water cooling in a defocused mode of 10 mm.

Calculus or foreign debris (cement) is often stuck to the implant surface and easy to remove with the Er:YAG laser's microablative effect without any damage. The bone lesion is deeply cleaned even within the bone trabeculae by the photoacoustic effect. To the best of our knowledge, there is no better instrument to clean such lesions so profoundly and with complete safety.

The intervention is done after raising a full-thickness flap under magnifications. The tissular tension is eliminated by a partial-thickness dissection in order to close the flap after eventual bone filling of the lesions. The surgical approach is followed by a strict peri-implant maintenance care protocol, laser-assisted as mentioned in the case of early onset peri-implantitis.

Conclusion

As described, the Er:YAG laser produces some clinical effects that are unique compared with conventional tools. Owing to its antibacterial properties, it could be of interest in the control of biofilm development around implants. It is able to reach inaccessible areas by working at a distance around implants. It cleans the implant surfaces and the surrounding tissue very deeply and selectively removes granulation tissue.

The Er:YAG laser is a clean tool that leaves no debris around implants. Furthermore, it is a safe tool when the appropriate settings are used, and it is possible to work efficiently without thermal effects. It is useful as a microsurgical tool in both surgical and non-surgical approaches. Moreover, it is a tool for prevention with repeated applications of laser irradiation around implants very gently, with a frequency in accordance with a global concept to maintain the biological equilibrium and to preserve the integrity of the peri-implant tissue.

The Er:YAG laser deserves to be the object of multicentre double-blind and controlled studies to validate its efficiency in peri-implantitis treatment and to confirm the protocols and settings that we recommend. It should become a key tool in the therapeutic strategy for this growing problem._

contact

Dr Fabrice Baudot
65 impasse des 3 pointes
34980 Saint-Gély-du-Fesc, France
Tel.: +33 4 99060060
dr.baudot34@orange.fr
www.dr-baudot-fabrice-chirurgiens-dentistes.fr

Author details Literature

Kurz & bündig

Mit der zunehmenden Beliebtheit von Zahnimplantatbehandlungen ist die Prävalenz von Periimplantitis weltweit weiter angestiegen. Im Jahr 2008 bekannten Esposito et al., dass „ein optimales Behandlungsprotokoll mit geeigneten Instrumenten noch nicht etabliert wurde“.[1] Diese Beobachtung spiegelt die aktuelle globale Meinung wider, dass Periimplantitis immer noch ein großes Problem ist, mit dem die zahnärztliche Gemeinschaft jetzt und noch mehr in der Zukunft umgehen muss. In Anlehnung an die biologischen Aspekte der Periimplantitis hebt der Autor im Artikel hervor, warum die mikroablativen und photoakustischen Effekte des Er:YAG-Lasers eine große Hilfe bei der Behandlung dieser Krankheit sein können.

Der Er:YAG-Laser erzeugt einige klinische Effekte, die im Vergleich zu herkömmlichen Geräten einzigartig sind. Aufgrund seiner antibakteriellen Eigenschaften könnte er bei der Kontrolle der Biofilmentwicklung um Implantate von Interesse sein. Mittels Laser ist es dem Behandler möglich, unzugängliche Bereiche zu erreichen, Implantatoberflächen und das umgebende Gewebe sehr tief zu reinigen und selektiv Granulationsgewebe zu entfernen ohne Rückstände zu hinterlassen. Als mikrochirurgisches Werkzeug eignet er sich sowohl für chirurgische als auch für nichtchirurgische Verfahren.

Nach Meinung des Autors sollte der Er:YAG-Laser verstärkt Gegenstand von multizentrischen, doppelblinden und kontrollierten Studien werden, um seine Wirksamkeit bei der Periimplantitisbehandlung zu validieren. Er sollte ein Schlüsselinstrument in der therapeutischen Strategie für das wachsende Problem „Periimplantitis“ werden.

Master of Science (M.Sc.) in Laser in Dentistry

Next Start: **15th October 2018** | Aachen, Germany | 4 semesters

Become part of the International Dental Elite

- Create new economic potential for your practice
- Two year career-accompanying postgraduate programme at the University of Excellence RWTH Aachen
- Combination of lectures, skill training sessions, live ops, tutorials, and practical workshops
- Internationally accepted and accredited by the German Govenrent, the European Union, the Washington Accord and the Bologna Process
- Science-based and practice-orientated on highest national and international level
- Increased patient satisfaction: minimal contact reduced vibration and pain

RWTH INTERNATIONAL ACADEMY AACHEN UNIVERSITY

AALZ Aachen Dental Laser Center

ASIIN e.V. accredited degree program

RWTH International Academy
Kackertstraße 10 | 52072 Aachen | Germany
phone +49 241 80 23543 | fax +49 241 80 92525
info@academy.rwth-aachen.de
www.academy rwth-aachen.de

AALZ GmbH
Pauwelsstraße 17 | 52074 Aachen | Germany
phone +49241 47 57 13 10 | fax +49 241 47 57 13 29
info@aalz.de
www.aalz.de

PROFESSIONAL EDUCATION PROGRAMMES

Your contact for more information: Leon Vanweersch • vanweersch@aalz.de - www.aalz.de