Deployment of a 410 nm Diode Laser Prototype

First experiences with the "blue diode"

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Based on their market launch in 1995 within the scope of the IDS in Cologne, the diode lasers in dentistry experienced a development, which is to be described as "more than turbulent"; with the result that today diode lasers are the most represented laser technology in dental offices and are used with great success primarily for soft tissue cuts and peri-implantitis and periodontitis therapy.

_**Diode lasers currently** available on the market significantly differ technically; a large number of so-called "entry-level lasers", which normally feature a low output power and are operated primarily in cw mode but attract with a lower price, basically represent Development Stage I of the diode lasers since their basic research one and a half decades ago.

In direct contrast is a small number of so-called "high-tech diode lasers", normally more than twice as expensive as entry-level devices but instead equipped with digital or high-power pulse technology instead and definitely higher power ratings, which in the context of dental surgery is reflected in significantly improved cutting results. Between them, there is a small group of medium-class diode lasers pulsed up to 10,000 Hz. In terms of pricing they are exactly positioned between the two "extremes".

The option to apply in dentistry other wavelengths than the 810 and 980 nm used to date, has caused in the past many authors to point out that from a pure technical standpoint it is possible to develop almost any number of hard diode laser wavelengths. The device introduced in this article represents the result of those considerations. Its basic uses in dentistry need further testing and clarification:

This is a hard diode laser device, produced by an Asian manufacturer, which emits monochromatic 410 nm wavelength light ("blue light").

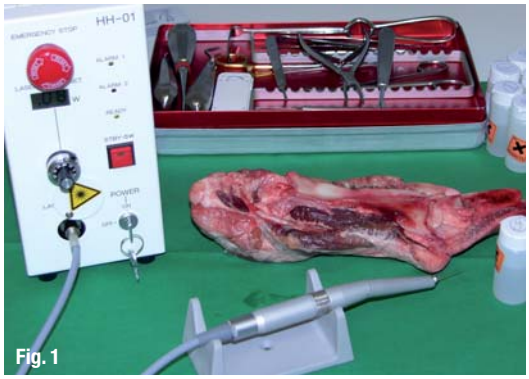


Fig. 1

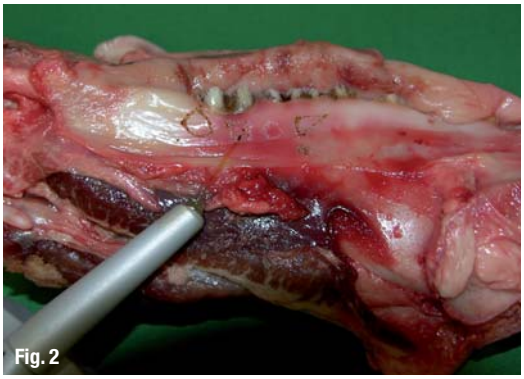

Fig. 2

Fig. 1_410 nm Diode laser prototype.
Fig. 2_Experimental Setup for Soft Tissue Surgery.

_Prototype

Hard Laser

The three components are combined in a very compact cage (10 x 20 x 30—W-H-D).

Those are:

_ the electric control unit,
_ the control module,
_ the laser head.

Monochromatic 410 nm wavelength light is emitted by stimulation, having specific properties.

_ It is monochromatic (also especially pure, it consist of only one wavelength).
_ It is coherent (the waves are aligned in time and space).

Potential Uses

The prototype was tested for the following applications in dentistry

_ in dental surgery (cuts)
_ for decontamination (microbiological test)
_ for hardening of composites (dental filling materials).

_1. Blue Laser Diode in Dental Surgery

Cutting

Most experiences and long-time results are available in the field of dental surgery, the result of which is a comprehensive number of citable bibliographical references and publications with established data. With appropriate laser wavelengths, all cuts commonly applied in dental surgery and periodontology, can be performed. The laser light used in each case should have a good absorption in regards to water or hemoglobin. To a very large degree and with accurate selection of power rating and time parameters, a carbon-free and narrow cut very similar to the established scalpel cut is possible. In the absence of carbon and a good postsurgical approximation of the former wound flaps provide good prerequisites for healing by first intention, which is more comfortable and faster for the patient and occurs with full histological reconstruction of the formerly separated tissues from its continuity. If laser is not suitable for cutting and is absorbed poorly, the power rating and/or the exposure time must be increased in order to even achieve an effect resp. the "desired" cutting effect. This is usually accompanied by a very strong carbonization of the wound edges and an enlargement of the width of the cut.

Post surgically wound carbonization must be reabsorbed and the wide gap in tissue continuity must be bridged. The only way this can be achieved is by second intention healing or, in other words, per granulationem. Wound healing by granulation is tedious and often painful for the patient. Normally the esthetic result is poor, and the (special) tissue originally available is replaced by simple repair tissue. In a current up-to-date study (2001) McDavid, Vobb and colleagues point out that bone damage can be avoided by an accurate selection of parameters. They used a CO_2 and Nd:YAG laser. Chebotareva and Zubov arrived at the same conclusions, and, in addition, could also report positive characteristics for faster healing of soft tissue. This was confirmed in total by Luomanen and Virtanen from Helsinki, who histologically backed up their assessment by means of fluorochrome coupled lectins.

Device Settings

Cuts were made on the anthropomorphic phantom using the diode laser prototype.

The following parameters were applied:

Power:	Mode:
0.45 watts	cw
0.65 watts	cw
0.70 watts	cw
0.86 watts	cw
0.99 watts	cw

Clinical Effects

With settings from 0.45 watts and less, no realizable effects of laser light application in terms of a continuity dissection could be determined. The 0.65 watts setting indeed showed almost carbon-free soft tissue edges but at the same time poor efficiency as compared to diode laser devices with high-power pulse technology. With 0.70 watts, an improved efficiency could be achieved with lower carbonization of soft tissue edges at the same time. With the selection of

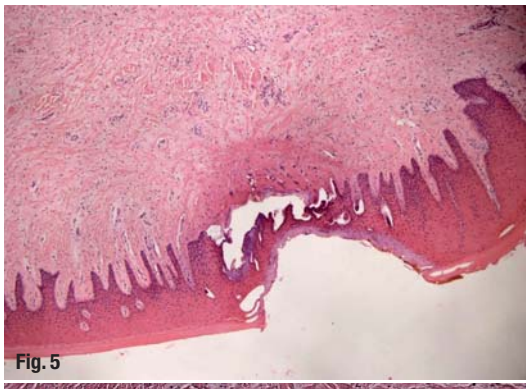

Fig. 3

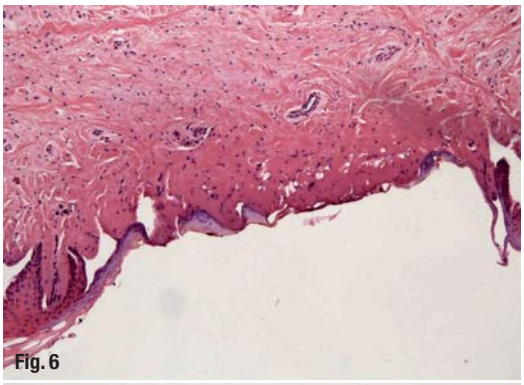


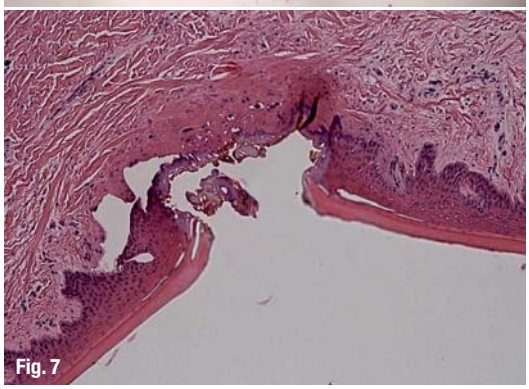
Fig. 4

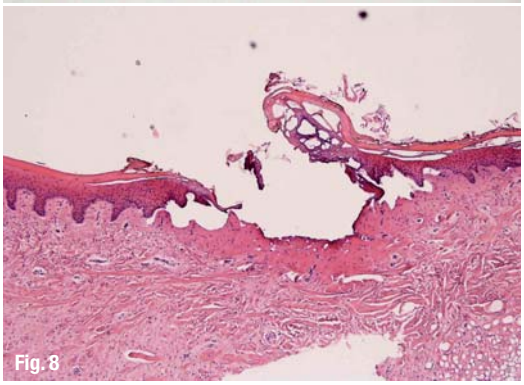
Fig. 3_Achieved Results After a Diode Laser Cut.
Fig. 4_Tissue samples prior to processing.

Figs. 5 – 8_Histological Results.


Fig. 5


Fig. 6


Fig. 7


Fig. 8

higher power settings, an improvement of the cutting efficiency could indeed be achieved however at the cost of an increased laser cut induced carbonization.

Histological Findings

The cuts, which were performed by laser, were preserved in formaldehyde after they were removed from the pig's jaw-bone and sent for histological examination.

Bottom Line

A power setting of 0.70 watts in cw mode allows for the best possible achieved compromise in terms of efficiency and avoidance of a wide carbon layer. What can be said, though, is that the achievable results with the introduced device are inferior to the ones obtained by diode laser (with digital pulse technology) and other wavelengths. In terms of a cut within the scope of a dental procedure and in soft tissue surgery, the 415 nm diode is recommended within with very strong limitations only.

_2. Soft Tissue Management

After completion of the invasive-resective phase of a surgical periodontal therapy but within the scope of implantology, mucous gingival corrections are often required. In this context, free or connective tissue transplants as well as vestibuloplasty are often considered, also including singularly performed gingivectomies and the removal of pseudo-pockets as they are quite common during non-invasively performed conventional-conservative periodontal therapy. Those minimally invasive mucogingival procedures are performed elegantly and quickly to date with the available diode laser systems. In this context, many authors point out the high absence of bleeding, significant pain reduction during surgery and the short time to heal associated with cuts performed by laser. Kreisler and colleagues (2001) report positive effects on a new attachment creation of ligamentary structures after diode laser application and confirm the decontaminating effect of injection laser.

Device Settings

Gingivoplasty was performed on the anthropomorphic phantom with the diode laser prototype. The following parameters were used:

Power:	Mode:
0.45 watts	cw
0.65 watts	cw
0.70 watts	cw
0.86 watts	cw
0.99 watts	cw

Clinical Effects

With settings from 0.45 watts and less, no realizable effects of laser light application in terms of a continuity transection could be determined. The 0.65 watts setting indeed showed almost carbon-free soft tissue edges but at the same time poor efficiency in comparison to the diode laser devices with high-power pulse technology. With 0.70 watts, an improved efficiency could be achieved with lower carbonization of the soft tissue edges at the same time. With the selection of higher power settings, an improvement of the cutting efficiency could indeed be achieved at the cost of increased carbonization by laser cut.

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today SHOW PREVIEW

Interview
Over 1,700 exhibitors from all around the world have announced their participation to say the IDS an undisputed marketplace for the whole range of dental equipment and service. We spoke with Executive Vice Director Oliver P. Kuhrt from Koelnmesse about the current state of preparations and what visitors can look forward to.
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Business
The International Dental Show in Cologne will be an excellent opportunity to find out about up-to-date technologies in the field of dental medicine. Focus on highlights in our industry section and explore what the world's most innovative companies have to offer.
›page 18

Travel
Cologne is one of the destinations in Germany for domestic as well as international visitors. Here we tell you where to eat, where to have a drink and what to do in your time off.
›page 50

Aerospace meets implantology

AFFINIS PRECIOUS

International dental expertise meets at IDS Cologne

World leading trade fair expected to growth further—Organiser introduces new service tools

At a European press conference last December in Cologne, the organisers of IDS 2007 have announced that they expect higher participation numbers than in 2005. More than 1,600 exhibitors have registered for the event with more than 41 percent coming from outside Germany, they said. Although the biggest number of registered exhibitors will be still from the fair's home country, large numbers are anticipated from the USA, France, Italy, Switzerland, France and the UK. In addition, a growing number of suppliers will be attending from countries in the European Union, Middle East, Asia, Australia as well as North America. "With over three months to go before the fair opens, the number of registrations we have received already exceeds the number of companies that exhibited at the event in 2005", said Oliver P. Kuhrt, Executive Vice President of Koelnmesse GmbH. "This increase will be similar to the climb of 12 percent we achieved last time". In 2005, the show had set more than 1,500 exhibitors and 70,000 professional visitors.

Over the past two years, the organiser has extensively modernised the exhibition centre, and enlarged the exhibition space up to 130,000 square metres. Moreover, the mosaic Masterplan for IDS 2007 has also given, the halls a facelift. While a second entrance area was added in 2005, fair guests can now use three entrances including the new South entrance which is near the Koelnarena/Deutz railway station and links the fair with downtown Cologne and all major airports in the region. The Boulevard, which was completed in January 2007, is supposed to shorten walking distances between the halls and enable visitors to reach the exhibitors' stands more quickly. It will also serve as a promenade for services and deliveries starting at the South entrance. Additionally, the East and West entrance have been rebuilt and renovated. At the piazza, centrally located between Halls 4, 10 and 11, visitors will be able to relax in the open air. Koelnmesse has also announced to provide more space for collegial meetings this year.

New service tools have been developed to ease travel arrangements and the organisation on site. Registrations and ticket can be completed online which also features the possibility to use public transport and avoid waiting lines at the fair's trade box offices. Furthermore, Business Matchmaking will be introduced in 2007 as an Internet-based exchange platform that visitors can use to get in contact with exhibitors before the IDS begins. The tool is supposed to enable visitors to identify products and services they are most interested in. On the other hand, exhibitors may take use of LeadSuccess, a management tool for their show contacts, which will be available on and offline.

With the Speaker's Corner held in Hall 4.1, the IDS will be built on this feature's successful premiere in 2005. There exhibitors will have the chance to demonstrate new products and procedures to an international audience. The popular "Irish Dental Night" held on Friday, March 23, 2007 is supposed to return this year. The proven policy of keeping the first day of the fair open exclusively to the dental trade and importers will be continued. The "Dealers' Day" will offer participants the opportunity to conduct in-depth sales negotiations without distractions. In addition, there will be an 'Importers' and Dealers' Lounge in the Offenbachsaal, especially for dealers from Germany and abroad.

flexibility ›page 4

AD

Periointegration could be key to success

Academy of Periointegration intends to improve the retention of dental implants by new "PERIOTYPE"-design

Dental implants are at the forefront of innovation in dental medicine. Around 500,000 of these artificial teeth are implanted every year. 99 percent of the procedures are successful, but after around 15 years the implant is at risk from periimplantitis. To improve the retention of dental implants, even in the long term, the "Academy of Periointegration" was set up in Berlin in December 2006. This federator of leading representatives of research, teaching practice and industry has the aim of uniting interdisciplinary cooperation to develop criteria for new kinds of implants which replicate real teeth as authentically as possible and, at the same time, provide patients with a prothetory of lifesaver such as diabetes or osteoporosis the possibility of secure realisation.

The "Academy of Periointegration" is utilising interdisciplinary working groups to assess which new technologies can be used for periimplants. For instance, the experts are examining how knowledge transfer, which is already being successfully implemented in other areas of industry and medicine, can be successfully brought into play. Three key technologies with great potential for the future have already been closely looked at. The coating process developed by the Fraunhofer Institute for Surface Technology in Braunschweig using high-performance gas turbines with zirconium oxide is to be used in future to make even traditional titanium implants "tooth white" and, at the same time, tissue friendly. A coating process for implants developed by scientists at the Charité in Berlin for use in accident surgery allows for the release of antibiotics and growth factors. Soon, it will be possible to use this method to significantly improve the security of artificial tooth roots, even in high-risk patients. "For the attainment of long-term bacteria impermeability the research group is looking towards a high-precision process from the watch-making industry which uses a labyrinth seal to significantly reduce the risk of infection", says Rolufuel Gesellmann, Head of Research and Development of Clinical Tissue Europe, a swiss-german medical device manufacturer in Zürich.

Using these technologies, the scientists—in collaboration with the industry—intend to develop a new kind of dental implant with the denomination "periotype". The members of the "Academy of Periointegration" include representatives from the Fraunhofer Institute for Surface Technology (IST) in Braunschweig and doctors at the Charité university clinics in Berlin and Münster, as well as dentists in research and practice.

IDS Cologne 2007
Date:
March 20–24, 2007
Opening times:
9 a.m.–7 p.m. (exhibitors)
9 a.m.–6 p.m. (visitors)
Venue:
Koelnmesse exhibition halls 4.1, 5, 10 and 11
Organizer:
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Histological Findings

The cuts, which were achieved with the laser after their removal from the anthropomorphic phantom (pig's jaw-bone) were preserved in formaldehyde and sent for histological examination.

0.45 watts—"Channel-shaped change. Incomplete defect with spongiosis; a small coagulated subepithelial base with a narrow ring-shaped defective zone with a superficially brownish discoloration caused by laser coagulation."

0.65 watts—"A flat bed of the suprabasal and almost completely destroyed epithelium appears showing a narrow underlying coagulation front of the stroma."

0.70 watts—"In the lamellation and embedding of the material, a defect is observed including the epithelium in this area with a slit-shaped increase of the side epithelium from the connective tissue base and a narrow coagulation front in the stroma."

0.86 watts—"The tissue exhibits a clear channel-shaped epithelium defect reaching almost to the stroma with a 30–40 µm wide coagulation front."

0.99 watts—"The material shows stronger dehiscence partly due to the laser coagulation, and in part wedge-shaped defect formation with a 30—100 µm wide coagulation front."

Bottom Line

The power setting of 0.70 watts in cw mode allows for the best possible achieved compromise in terms of efficiency and avoidance of a wide carbon layer. What can be said, though, is that the achievable results with the introduced device are definitely less than the ones obtained by diode laser (with digital pulse technology) and other wavelengths. In terms of an optimization of soft tissue or soft tissue management, for soft tissue surgery the 415 nm diode is recommended only with very strong caveats.

_II. Microbiological Examinations With the Goal of Assessing the Eventual Quality Rating of the Device During Decontamination of Germ-Infested Tooth and Implant Surfaces

The concept of laser decontamination was coined in 1994 by the laser study group of Freiburg University (Krekeler, Bach and Mall) in the context of then newly established diode lasers. In the meantime, the concept of decontamination is used by many other authors in connection with other wavelengths. The decontamination with a laser describes the option to kill germs on teeth and implant surfaces with a laser, which are common during peri-implantitis and the marginal parodontopathy and to disable the endotoxins of those microorganisms. In 1994 Bach, Mall and Krekeler, Moritz in 1996 and Gutknecht in 1997 could demonstrate the diode laser effectively eradicates particularly the gram-negative, anaerobic germ spectrum of the quickly developing parodontopathy and the peri-implantitis, and assigned a higher significance for the efficient combat of those "problem germs" with the laser during the integration of approved treatment procedures for both illnesses. In 2000, for the first time, the aformentioned Freiburg study group presented a 5-year study "(Diode) Lasers in Periodontology".

The authors pointed demonstrated that by the integration of the diode laser decontamination in confirmed periodontitis and peri-implantitis procedures, the prospects for both of these clinical pictures, which formerly often took an unfavorable course can be considerably improved. Bach, Mall and Krekeler found a decrease of the recurrent rate of 33% after 60 months (control group not treated with laser) and of 11% (group treated with the support of a diode laser). After the hard diode laser decontamination had established itself as a factual domain for this wavelength, a further goal of this examination was to test the properties of the 415 nm prototype for this field as well. This potential possibility was first examined within the scope of microbiological growing compounds. A diode laser light in the 415 nm wavelength was applied to microbiological growing plates, which were flooded with the following germs spiked with the three-step smear procedure, in a further examination row:

a) Actinobacillus actinomycetemcomitans (FR68/27-7)
b) Prevotella intermedia (016/16-2)
c) Porphyromonas gingivalis (W381 and FR68/27-2)

Device Settings

The following parameters were applied:

Power:	Mode:
0.45 watts	cw
0.65 watts	cw
0.70 watts	cw
0.86 watts	cw
0.99 watts	cw

Application length: 30 seconds and 1 minute.

Microbiological Findings

The growing plates, spiked and irradiated with laser light were stored according to normal microbiological protocol; after 48, and 72 hours respectively, a "reading" was done. It could be determined that following a mere 30-second irradiation of the samples, no significant result in terms of limiting bacteria

growth could be observed in any of the performance models. This is also true for the specimens undergoing one-minute laser light irradiation and settings of less than 0.70 watts. With the 0.86 and 0.9 watts settings, obstruction of germ growth could be observed in the prevotella intermedia. The zones had a radius of approx. 3 mm around the central irradiation area. Minor equivalent effects were observed with the A.a. and the P.g. In comparison to the results, which had already been documented in 1994/1995 using cw mode 810 nm diode lasers, the results are definitely more moderate.

Bottom Line

The power setting of 0.9 watts in cw mode allows for a moderate decontaminating effect in the microbiological test. It is not yet clear if those results can be applied to a clinical environment. What can be said, though, is that the achievable in vitro results with the introduced device do not correspond to the ones established with a diode laser (also with digital pulse technology). For laser light decontamination, the use of a 415 nm wavelength is therefore only possible within limitations.

_Hardening of Composite Samples

For the ("blue") argon laser it is known that its laser light can harden dental composite filling material. Many authors point out that in comparison with lamp hardening, clearly better homogeneous joining of the composite materials is achieved. In support of those observations the "blue diode laser light" was tested in regards to its potential to possibility harden filling materials. 2 mm wide composite pieces (taken from a tube) were irradiated with a hard diode laser using 415 nm wavelength. In terms of a hardening of the respective samples, a clinical significant effect could not be achieved with settings under 0.6 watts and within a time frame of 1.5 minutes (which would be clinical but not relevant and acceptable), therefore the tests were aborted. With the 0.7/0.8 and 0.9 watt settings, hardening effects could be achieved, with 0.8 and 0.9 watts, however, with undesired effects on the composite surface in terms of (heat) bubbles and discolorations. With 0.7 watts, a hardening effect and at the same time undesired manifestations were achieved, which could have been avoided as described with the higher power settings. The hardening effect, however, was of a very superficial nature and was in the area of approx. 0.5 to 0.7 millimeters in the sample piece. Below it, the composite was in the same consistency, as though it was recently removed from the tube. Because of the already clinically evaluated results, a further (raster electronic microscope) analysis of cut samples was not taken into consideration.



Fig. 9_Microbiological Examinations for the Clarification of a Decontamination Effect.

_Discussion

„Not everywhere where the word Diode is written, is also the same diode inside!"—striking but also to the point, one cannot phrase it as the quoted periodontologist and implantologist from Hanover. The diode laser dentistry completely suffers because at the moment three development stages of the injection laser are offered and promoted in the marketplace. For the ingenious, the multitude of offered diode laser devices is confusing indeed where some equipment is offered for the dental market, which because of their physical laser characteristics has very limited use in dentistry! Here, the introduced device and the wavelength of 415 nm (blue diode) fill a vacant position—the only possible use is in decontamination. Because of the experiences and indications with other devices, diode lasers with high power ratings and high-power and digital pulse technology can be mentioned here. In no way blue diodes can be recommended for use in soft tissues; here the bar is raised by the mentioned potent diode lasers and also by the other wavelengths—higher than the device ever can jump. The small size of the device gives some cause for enthusiasm—integration in a dental treatment unit can be realized with no problems—an old dream of laser users in their quest to move away from the (bulky) auxiliary unit. The results achieved with the introduced device, however, do not justify any of those considerations at the present time and the current stage of development of the device._

_contact laser

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