Treatment of the Contaminated Implant Surface Using the Er,Cr:YSGG Laser

Robert J. Miller, DDS, FACD

With modern oral implantology celebrating the close of its fifth decade, treatment planning using dental implants has become the standard of care. Although the predominant modality is the endosseous root-form implant, a significant number of plate-form and subperiosteal implants continue to be used in appropriate cases. As a result of 2 decades of research involving the tissue–implant interface, using roughened or bioactive surfaces, success rates have risen dramatically. If we accept the published figures for implant success from multicenter studies, we find that success rates now exceed 95%.1,2

It is estimated that the number of endosseous implants that will be placed this year will surpass a half million.3 Using the survival tables from previously published studies, we must therefore accept the reality that, even with this high percentage of success, a significant number of implants will develop soft or hard tissue problems and could go from ailing to failure mode if not treated in a timely and effective fashion. Although the body of knowledge for implant placement has increased geometrically, scant resources have been developed for definitively treating the problem implant.

When faced with the ailing implant, one must first understand the etiology of the problem. The first qualification is to determine if the defect is of infective or biomechanical origin.4 If the implant is occlusally overloaded, the biomechanical parameter must be treated first. If the implant is surgically treated before addressing the occlusal problem, it is highly probable that the defect will not respond to treatment. If the lesion is of infective origin without a biomechanical component, one must determine if the defect is purely a soft tissue problem or if it involves soft and hard tissue components. Ultimately, regardless of the etiology, only definitive treatment of the implant will provide a stable interface for possible long-term survival and function.5

Implant surfaces have gone through an evolutionary change, from machined titanium to macro porous geometry. The first endosseous implants had a relatively smooth texture that was created through the machining process. This machined titanium surface (Fig. 1) allowed direct bone apposition while the relative smoothness of this surface helped to prevent bacterial colonization. With good periodontal care, even those implants with saucerization defects were easily maintained by scaling and chemotherapeutic modalities.6

The second-generation implant surface was a titanium plasma sprayed (TPS) coating (Fig. 2). Research indicated that a roughened surface increased wetability and enhanced bone growth along the surface of the implant resulting in direct apposition of bone to titanium.7 This surface, although enhancing implant stability in bone, created an environment for increased plaque and bacterial colonization often resulting in osseous and soft tissue dehiscence. Early attempts at treatment consisted of apically repositioning flaps and removing the roughened surface. This could result in poor implant/crown ratios and resultant failure from biomechanical overloading.

Treatment of the contaminated implant surface by mechanical and chemotherapeutic means has met with mixed success. Incomplete surface debridement or alteration of the implant surface could compromise attempts at grafting and reintegraction of the implant body. Development of a laser system operating at 2780 nm and using an ablative hydrokinetic process offers the possibility for more efficient decontamination and debridement. The Er,Cr:YSGG laser is evaluated and compared with the most commonly used chemotherapeutic modality for treatment of the implant surface. A scanning electron microscope study is presented comparing YSGG ablation to citric acid treatment of the titanium plasma sprayed and HA-coated implant surface. We can conclude that laser ablation using the YSGG laser is highly efficient at removing potential contaminants on the roughened implant surface while demonstrating no effects on the titanium substrate. (Implant Dent 2004; 13:165–170)

Key Words: laser debridement, hydrokinetic, YSGG laser

1. Miller RJ. Treatment of the contaminated implant surface by mechanical and chemotherapeutic means has met with mixed success. Incomplete surface debridement or alteration of the implant surface could compromise attempts at grafting and reintegraction of the implant body. Development of a laser system operating at 2780 nm and using an ablative hydrokinetic process offers the possibility for more efficient decontamination and debridement. The Er,Cr:YSGG laser is evaluated and compared with the most commonly used chemotherapeutic modality for treatment of the implant surface. A scanning electron microscope study is presented comparing YSGG ablation to citric acid treatment of the titanium plasma sprayed and HA-coated implant surface. We can conclude that laser ablation using the YSGG laser is highly efficient at removing potential contaminants on the roughened implant surface while demonstrating no effects on the titanium substrate. (Implant Dent 2004; 13:165–170)

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A third-generation implant surface consisted of blasting the implant body with an abrasive and then acid etching (SLA) to remove the abrasive contaminant. This etching procedure resulted in a more defined ratio of peaks and valleys to increase wettability even further (Fig. 3). However, this increased definition on the implant surface creates a more ideal surface for bacterial colonization and compromises our ability to maintain the implant when the body of the implant is contaminated or exposed.

One current generation of implant surfaces uses a sintering technique (Fig. 4) to create 3-dimensional ingrowth of bone so that shorter implants can be used. However, this surface becomes the most problematic when it becomes infected because normal maintenance procedures will not completely clean the implant surface. Even surgical treatment using chemical means might not completely debride the sintered surface.

Bioactive coatings (HA) have also been used to decrease healing times and increase percentage of bone to implant contact. Although the roughness of these coatings is similar to that of TPS or SLA, an added problem is the dissolution or fracture of the coatings in the presence of inflammation. This could speed up bacterial colonization and bone loss, making timely treatment of these implants that much more important.

Previous surgical treatment modalities involved both mechanical debridement (hand scaling, ultrasonics) and chemical surface treatment (tetracycline hydrochloride paste, 40% citric acid pH1, EDTA). These modalities have significant shortcomings. With regard to mechanical treatment of the implant body, alteration of the implant surface could occur. Damage to the surface of the implant could delay or prevent bone regrowth. Incomplete debridement of bacterial colonization and endotoxins could result in failure of grafted sites and a return of the defect. If chemical surface treatment is used, tetracycline paste should be used only on titanium surfaces (CP or titanium alloy). If it is used on HA surfaces, it will interfere with the Ca-P bond of bone and could delay healing. Tetracycline is used to decontaminate the implant but is not effective in removing bacterial endotoxin from the implant surface. The use of citric acid could result in a chemical burn of hard and soft tissue and an organic smear layer, also delaying healing. Citric acid is used to basically freshen the HA surface. It could, however, alter the crystalline surface making it more prone to breakdown after grafting. Ethylenediaminetetraacetic acid (EDTA) has been used to remove the organic smear layer on the implant body after treatment to eliminate granulation tissue in the osseous defect.

A new paradigm for the treatment of the implant surface has been developed after the introduction of the Erbium, Chromium:Yttrium, Scandium, Gallium, Garnet (Er,Cr:YSGG) laser. Previous lasers tested for potential use in oral implantology include Nd:YAG, Ho:YAG, GaAlAS, CO2, and Er:YAG. Most of these lasers, however, function in vaporization mode. High temperatures could alter or damage the implant surface making them inappropriate for use in treating the implant defect. They could also result in charring or coagulation of tissue, delaying the reparative cascade. The Er,Cr:YSGG laser, operating at 2780 nm, ablates tissue by a hydrokinetic process that prevents temperature rise. The following research protocol evaluated the YSGG laser for potential use in debridement of the contaminated implant surface before osseous grafting.

**MATERIALS AND METHODS**

The evaluation of the efficacy of YSGG laser treatment of the implant body consisted of 2 parts. First was a study of the potential effects of the YSGG laser on the titanium surface under available power settings. Current dental implants come in a range of titanium grades, from commercially pure (CP 1–4) to Ti-6Al-4Va alloys. A soft grade (CP-2) implant was chosen because this would be the most easily deformed or damaged as compared with titanium alloy. Second was a study of the ability to remove the hardest material that one could encounter on the implant surface. This material was determined to be an appositional crystalline HA coating. A comparison was also made using the most common protocol for debridement of the implant body (citric acid). The im-
The implant system chosen for the study was Interpore IMZ press-fit cylinders (Interpore International, Irvine, CA).

The implants were divided into 2 groups: a TPS group that included a control (Fig. 5), citric acid-washed, and laser-treated implant, and an HA group that contained a control (Fig. 6), citric acid-washed, and laser-treated implant. The implants remained in their sterile containers until the testing began to avoid inadvertent contamination. The control implants remained sealed until the scanning electron microscope (SEM) evaluation. SEM magnification was set at 25× and 2500× at the junction of the polished collar and roughened surface. The Er,Cr:YSGG laser (Biolase Technology, Inc., San Clemente, CA) was used with a 600-µm tip and at a power setting of 6.00 W (maximum power). Additional parameters used were air pressure setting at 100 and water spray at 32. The combination of highest power and relatively low water setting would maximize any potential thermal effects and act as a threshold for comparison of any additional power settings.

The TPS implant group was evaluated by citric acid wash (40%, ph1) and laser application. The citric acid wash was applied for 3 minutes and was followed by a 1-minute sterile saline rinse (Fig. 7). The laser-treated implant was also treated for 3 minutes followed by a 1-minute sterile saline rinse (Fig. 8). The HA group (Figs. 9 and 10) was treated by the identical protocol. The implants were immediately placed back into their containers and sent to the University of Miami SEM Laboratory for analysis.

**RESULTS**

The SEM study of the TPS and HA-coated implants revealed the following. The YSGG-treated TPS implant revealed no measurable change in surface morphology at the highest power setting (6 W) and at a relatively low water setting. There was no organic smear layer and the surface remained identical to the control implant. The citric acid-washed TPS implant revealed no measurable change to surface morphology but an organic smear layer remained after a sterile saline rinse.

The YSGG-treated HA implant revealed grossly incomplete coating removal, an organic smear layer, and a loss of crystallinity of the remaining bioactive coating.

**DISCUSSION**

In a comparison of a widely used technique for implant debridement (citric acid) and the new protocol of laser ablation, it is clear that the Er,Cr:YSGG laser is highly efficient and effective in removing contaminants from the implant body. Unlike previous laser systems that operate with a high thermal coefficient, the YSGG laser will not alter the surface characteristics of the roughened titanium surface. The absence of any measurable changes to the titanium surface and the lack of an organic smear layer creates the ideal environment for the regrowth of bone and potential reintegration of the exposed or contaminated area of the implant body. There is no coagulation, charring, or burning of the adjacent tissue. The absence of cell lysis prevents the initiation of an inflammatory process. This allows adjacent bone and soft tissue cells to go directly to a regenerative phase, which significantly shortens the healing process. One must be prepared, after preparation of the implant surface, to graft the osseous defect and to protect the grafted site with a membrane. Like with previous techniques, it might be desirable to take the implant out of function and achieve primary closure to prevent soft tissue invagination and fluid contamination of the graft. If this is not possible, a resorbable membrane should be used to avoid a secondary surgical procedure to remove the membrane after healing.

**CONCLUSION**

Generational changes in implant design and surface technology have dramatically increased implant success rates. The bone-to-implant bond has been enhanced and shorter healing times to loading have become the rule rather than the exception. Although implant dentistry has become highly predictable, treatment of the ailing implant still relies on old methodology. This article has presented a potential new paradigm for the treatment of the...
ailing implant that is periodontally involved. Its application for debridement of the implant body is demonstrably superior to the older mechanical and chemical treatments of the implant surface. The Er,Cr:YSGG laser has the potential for multiple applications in oral implantology, including peri-implant osseous and soft tissue recontouring as well as implant maintenance. Using the hydrokinetic properties of this laser system, we could ultimately replace much of the hand instrumentation currently used in our surgical procedures and do so with less trauma, faster healing, and greater patient comfort.

Disclosure

The author claims to have no financial interest in any company or any of the products mentioned in this article.

REFERENCES


**Abstract Translations [German, Spanish, Portuguese, Japanese]**

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**Behandlung kontaminiert der Implantatoberflächen mittels Er, Cr:YSGG-Laser**


**SCHLÜSSELWÖRTER:** Wundtoilette mittels Laser, hydrokinetisch, YSGG-Laser

**Tratamiento de la superficie contaminada del implante usando el láser Er, Cr:YSGG.**

**Abstracto:** El tratamiento de la superficie contaminada del implante a través de métodos mecánicos y quimioterapéuticos ha logrado resultados inconclusos. Un desbridamiento incompleto de la superficie o alteración de la superficie del implante podría comprometer los intentos del injerto y reintegración del cuerpo del implante. El desarrollo de un sistema láser que funcione a 2780nm y usando un proceso ablativo hidrokinético ofrece la posibilidad de una descontaminación y desbridamiento más eficiente. Se evaluó y comparó el láser Er, Cr:YSGG con la modalidad quimioterapéutica usada más comúnmente para el tratamiento de la superficie del implante. Se presenta un estudio de SEM comparando la ablación YSGG con el tratamiento con ácido cítrico de la superficie recubierta del implante TPS y HA. Podemos concluir que la ablación del láser usando el láser YSGG es altamente eficiente en la eliminación de contaminantes potenciales en la superficie áspera del implante mientras que no demuestra efectos sobre el sustrato de titanio.

**PALABRAS CLAVES:** desbridamiento con láser, hidrokinético, láser YSGG
Tratamento da Superfície de Implante Contaminada Usando o Laser Er,Cr:YSGG

RESUMO: O tratamento da superfície do implante contaminado por meio mecânico e quimioterapêutico teve sucesso variado. O desbridamento incompleto da superfície ou a alteração da superfície do implante pode comprometer tentativas de transplante de tecido e reintegração da matéria do implante. O desenvolvimento de um sistema a laser operando em 2780nm e usando um processo ablativo hidrocinético oferece a possibilidade de descontaminação e desbridamento mais eficientes. O laser Er,Cr:YSGG é avaliado e comparado com a modalidade quimioterapêutica mais comumente usado para o tratamento da superfície do implante. É apresentado um estudo SEM comparando a ablação YSGG ao tratamento com ácido cítico da superfície do implante coberta por TPS e HA. Podemos concluir que a ablação a laser usando o laser YSGG é altamente eficiente na remoção de potenciais contaminantes na superfície de implante tornada áspera, enquanto não demonstra nenhum efeito no substrato de titânio.

PALAVRAS-CHAVE: desbridamento a laser, hidrocinético, laser YSGG

污 染 イ ン プレ ン表面のEr,Cr:YSGGレーザー処置

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要約: 汚染インプラント表面の機械的または化学療法的な処置が成否のいりまざった結果を招くことはよく知られている。不十分な表面デブリードマンやインプラント表面の変化は、implant bodyの移植・再整合の不全を招くことがある。2780nmのレーザー・システムと流体動力学除去処理の開発によって、より効果的な汚染除去・デブリードマンが可能になった。このEr,Cr:YSGGレーザーのインプラント表面処理能力が、もっとも頑用される化学療法的処置のそれと比較する。TPSとHAで被覆されたインプラント表面における、YSGG除去法とくえん酸処理法による処理がSEM検査で比較された。その結果、YSGGレーザーを使ったレーザー除去法は粗面化されたインプラント表面の汚染除去率が高いうえ、チタンsubstrateには何の影響も与えないことがわかった。

キーワード: レーザー除去法、流体動力学、YSGGレーザー

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