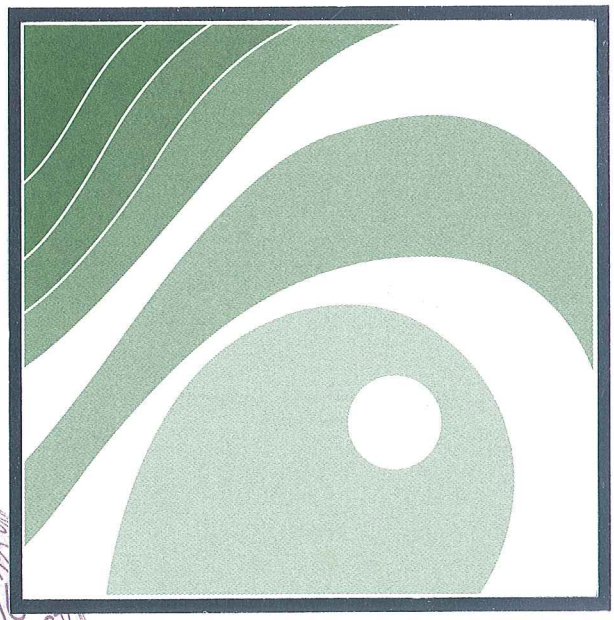
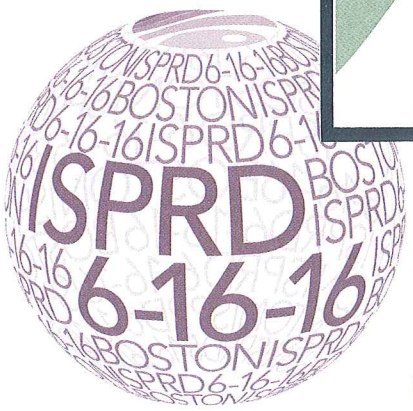
The International Journal of

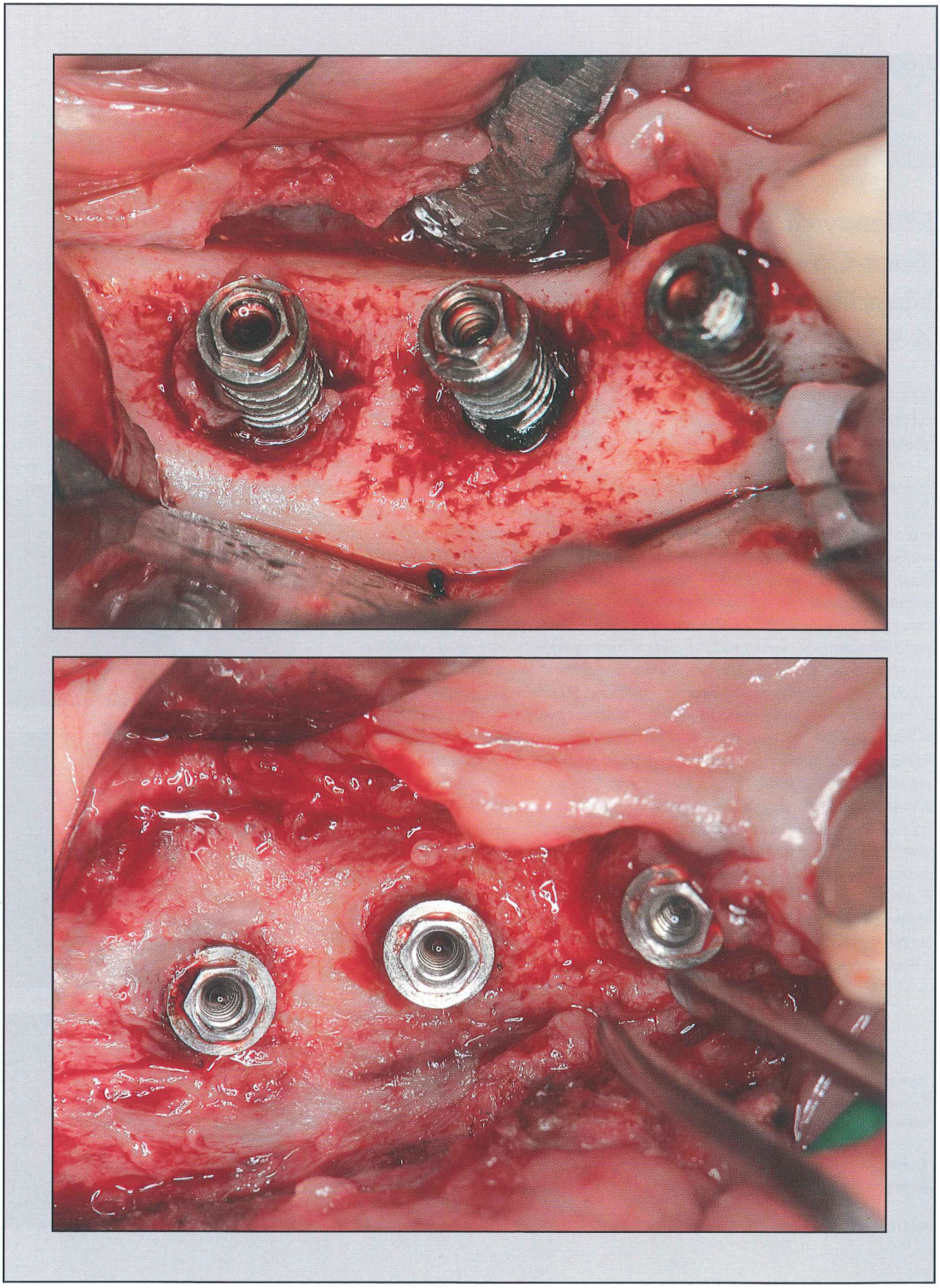
Periodontics & Restorative Dentistry





Volume 35 • Number 1
January/February 2015

QUINTESSENCE PUBLISHING



Innovative Regeneration Technology to Solve Peri-implantitis by Er:YAG Laser Based on the Microbiologic Diagnosis: A Case Series

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Peri-implantitis is an emerging problem, and corrective therapy requires a method for decontaminating the complex surface structure of the implant body and sterilizing the surrounding tissue. The erbium:yttrium-aluminum-garnet (Er:YAG) laser has proven to effectively allow tissue to regenerate when used for peri-implantitis. The power of the Er:YAG laser is absorbed by a water molecule; therefore, its target neither rises in temperature nor carbonizes. An antibacterial remedy based on the bacteriologic diagnosis, followed by debridement and sterilization of the implant surface and peri-implant tissues by Er:YAG laser is efficacious for peri-implantitis treatment. The aim of this report was to present the effectiveness of the Er:YAG laser for peri-implant bone regeneration. This case series of two patients showed that antibiotic therapy reduced the bacterial amount from the peri-implantitis sites significantly and that Er:YAG laser therapy, along with the bone augmentation, enhanced bone regeneration in the peri-implant bony defects.
(Int J Periodontics Restorative Dent 2015;35:67–73. doi: 10.11607/prd.2116)

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Implant therapy has become a routine dental treatment modality and, frequently, the first choice to replace missing teeth. The texture of implant surfaces has been improved to expedite osseointegration, but there is some concern that a rough surface to the collar of the implant may introduce the risk of bacterial infection described as peri-implantitis. Peri-implantitis and periodontitis are inflammatory diseases with a bacterial etiology,[1] but they differ in the fact that the implant has a complex artificial surface placed in alveolar bone. The treatment of any problem requires an appropriate diagnosis and, if possible, an understanding of the etiology before initiating treatment. The debridement of a complex implant surface that has become infected is a significant challenge. The possibility of regenerating lost bone and reestablishing bone-implant contact without a clean surface is unlikely. In this study, the erbium:yttrium-aluminum-garnet (Er:YAG) laser was used to decontaminate the implant surface. This hard tissue laser has the capability of being absorbed by water molecules,[2,3] which prevents a rise in temperature

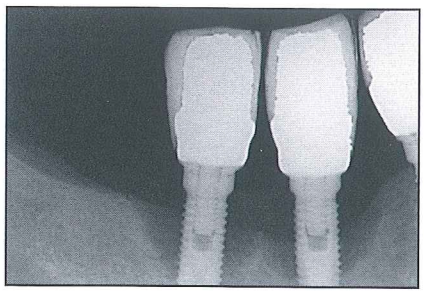


Fig 1 *Severe bone resorption could be observed at the mandibular right second premolar and first molar sites.*

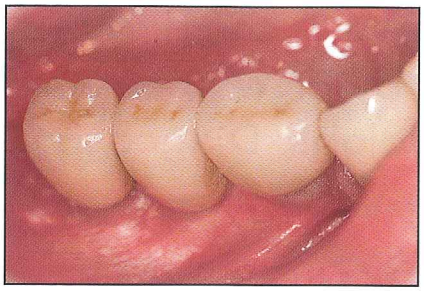


Fig 2 *Before regenerative surgery, a lack of keratinized tissue and a shallow vestibule were observed.*

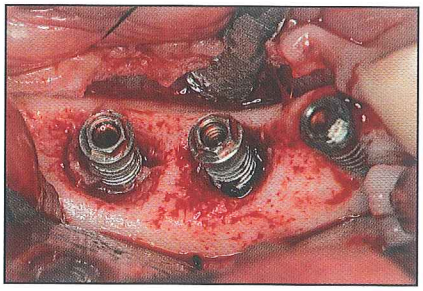


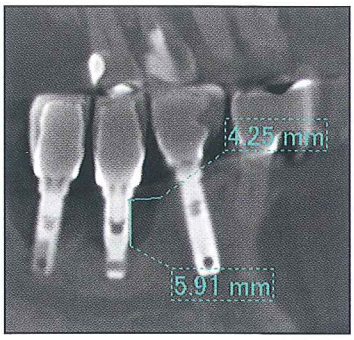
Fig 3 *After flap reflection, severe saucer-like bone resorption and black subgingival calculus were visible on the implants. The implants were irradiated to remove subgingival calculus and to detoxify and sterilize the implant surface without heat or carbonization using an Er:YAG laser.*

that might carbonize or cause thermal degeneration to the surrounding tissues.[4] This device causes the least damage with little or no thermal alteration or melting of the titanium surface at a specific energy band.[3,5] Bacteria on the irradiated surface are eradicated without heat. The device is also reported to be capable of detoxifying lipopolysaccharide (LPS) and improving the healing activity of vital tissues.[6] When treating peri-implantitis, it is effective for debridement of the complex body surface, decortification of bone, sterilization of the soft and hard peri-implant tissues, and detoxification of bacterial metabolites.[7]

This study demonstrated favorable bone regeneration for patients suffering from peri-implantitis by performing antibacterial therapy based on bacteriologic and immunologic testing followed by debridement and sterilization of the implant surface and peri-implant tissues using Er:YAG laser. This laser also is effective for periodontal resective therapy, scaling, and the removal of bone and cementum.[8]

Method and materials

Two patients with prominent loss of alveolar bone due to peri-implantitis were treated by disinfection with the Er:YAG laser and a bone graft regeneration procedure after diagnosis by radiographic examination. A bacteriologic examination with the polymerase chain reaction (PCR)-invader method was performed to measure the total count of bacteria, the number of each bacterial flora, and the partial ratio of each flora. The following bacterial species were examined: *Porphyromonas gingivalis*, *Tannerella forsythia*, *Treponema denticola*, *Aggregatibacter actinomycetemcomitans*, and *Prevotella intermedia*. These factors were measured immediately after the peri-implantitis diagnosis, after antibacterial therapy, and after surgical therapy. Amoxicillin combined with metronidazole was administered for 4 weeks for the first case,[9] and azithromycin, whose effect lasts a week after 3 continuous days of administration, was taken for 3 days as the antibacterial therapy for the second case.[10] Laser irradiation was followed by sterilization. The authors used Er:YAG laser (Erwin AdvErL, J. Morita) with different types of tips, including the straight-irradiation tip (CF400) for bone penetration, the side-irradiation tip (P400T) for debridement of the implant body, and the straight-and-side irradiation tip (PS600T) to remove the inner marginal epithelium of the gingival sulcus. The output levels were selected from the preset panel and were 150 mJ at 10 pulses per second (pps), 40 mJ at 10 pps, and 70 mJ at 25 pps, respectively. Equal amounts of freeze-dried bone allograft (Oragraft Cortical, LifeNet) and autogenous bone were mixed and soaked with recombinant human platelet-derived growth factor BB (Gem 21S, Osteohealth) and were utilized as



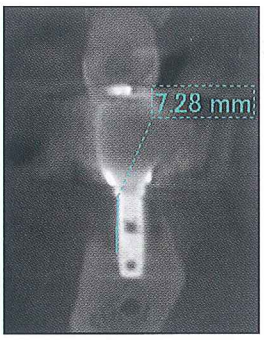
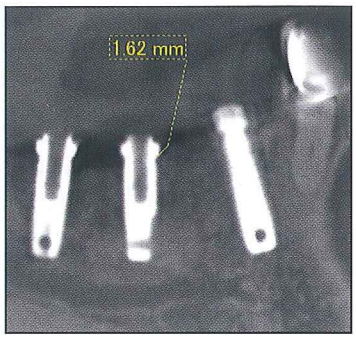


Fig 4 *(left) Preoperative bone resorption around the mandibular right second premolar was 5.91 mm deep and 4.25 mm mesially. (right) The depth of buccal bone resorption on the mandibular right second premolar was 7.28 mm. Measurement of bone resorption around the implants was performed by dental cone beam CT.*



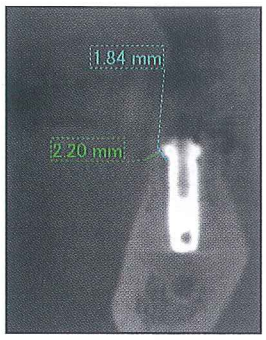


Fig 5 *Measurement of a significant gain in radiopaque tissue surrounding the implants after 10 months. Remarkably increased hard tissue is observed (+7.21 mm vertically and +4.22 mm horizontally). Bone growth over the first thread was observed (1.62 mm mesially, 1.84 mm vertically, and 2.20 mm buccally on mandibular right second premolar.*

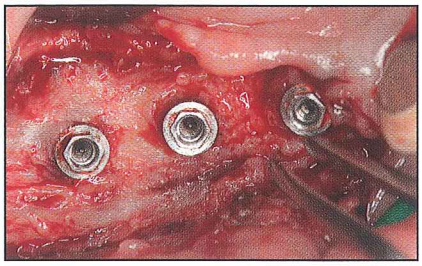


Fig 6 *Clinical findings at reentry at 10 months. Significant bonelike tissue was regenerated.*

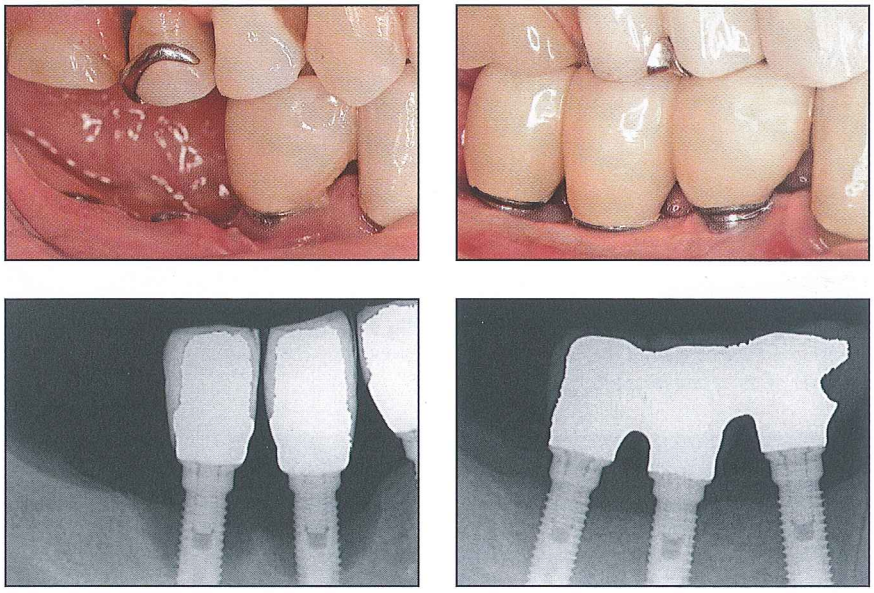


Fig 7 *Additional vestibuloplasty and a free gingival graft were performed, as evident in the (left) before and (right) after images (clinical and radiographs).*

the bone graft material. A polylactate membrane (GC) was fixed by the cover screw. To evaluate the hard tissue, dental cone beam computed tomography (CBCT; Veraviewepocs 3D, J. Morita) was used. Horizontal and vertical bone defects in the mesiodistal sections were evaluated before regenerative therapy and 9 months and 1.5 years after.

Results

Case 1 (Figs 1 to 7)

A 62-year-old woman received implants in the mandibular right posterior area, then presented after 6 years complaining of an unpleasant sensation at that site. The radiographic diagnosis was peri-implantitis. The implant (Steri-Oss, Nobel Biocare) had a titanium plasma-sprayed surface. The results of the bacterial testing are listed in Table 1. There was an excessive ratio of periodontopathic bacterial flora detected; therefore, amoxicillin and metronidazole were administered orally. A panoramic radiograph and CBCT after antibacterial therapy,

Table 1 **Case 1 bacterial analysis of mandibular right first molar site before and after oral antibiotics treatment**

Bacteria	Count		Ratio to total (%)		
	Before treatment	After treatment	Before treatment	After treatment	Normal
Total	100,000	3,700	–	–	–
A actinomycetemcomitans	0	0	0.00	0.00	< 0.01
P gingivalis	49,000	0	49.00	0.00	< 0.5
T forsythia	2,800	0	2.80	0.00	< 0.5
T denticola	15,000	110	15.00	2.97	< 5.0
P intermedia	390	0	0.39	0.00	< 2.5

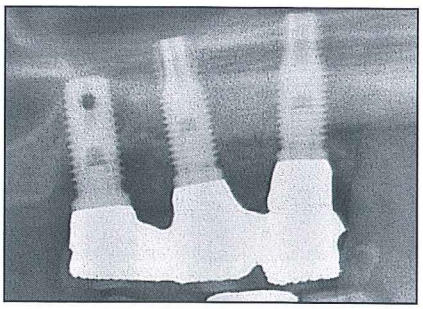


Fig 8 *Preoperative radiograph. Bone resorption is evident on the mesial and distal surfaces of the distal implant.*

Fig 9 *There is a paucity of keratinized gingiva for the distal implant.*

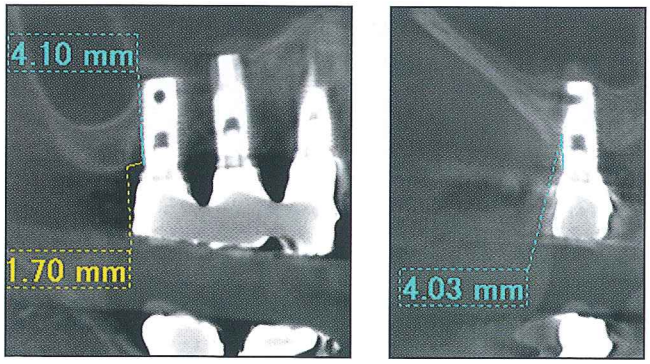


Fig 10 *Preoperative measurement by cone beam CT. (left) Bone resorption (4.1 mm vertically and 1.7 mm horizontally) is evident. (right) The depth of buccal bone resorption was 4.03 mm.*

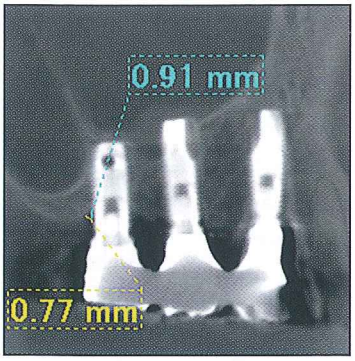
Er:YAG laser irradiation, and bone grafting revealed bone regeneration to be 4.22 mm horizontally and 7.21 mm vertically 9 months after the regenerative therapy (see Figs 4 and 5). The patient has been maintaining good condition for 2 years after treatment, and no periodontopathic bacteria have been detected.

Case 2 (Figs 8 to 12)

A 68-year-old woman received three implants in the posterior region of her right maxilla. A panoramic radiograph 3 years later revealed bone absorption and demonstrated periimplantitis. The result of the bacterial testing is presented in Table 2. A hydroxyapatite-coated implant (Steri-Oss) replaced the first molar because of poor initial fixation. Interestingly, periodontopathic bacterial flora was detected in this site, but not on the machined surface of the hybrid-design implant (Osseotite, Biomet 3i) in the adjacent second premolar site. Regenerative therapy, along with Er:YAG laser irradiation, was performed as described previously following antibacterial therapy. Bony tissue augmentation was identified as 3.19 mm vertically and 0.93 mm horizontally (see Fig 11). The patient was in good condition 2 years after treatment, with no evidence of periodontal bacteria detected during the maintenance phase. The prognosis was considered to be favorable.

Discussion

The history of the diagnostic criteria of implant complications reflects the history of success criteria for implant therapy. The 1978 National Institutes of Health Development Conference at Harvard recognized several criteria that are not applicable for osseointegration, eg, mobility of less than 1 mm and vertical bone resorption up to one-third of the implant length.[11] In 1986,



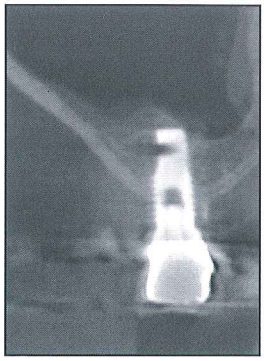


Fig 11 *(left) Measurements of vertical and horizontal ridge augmentation by cone beam CT revealed gains of 3.19 mm vertically and 0.93 mm horizontally 2 years after regenerative surgery around the implant site. (right) Severe buccal bone resorption was observed.*

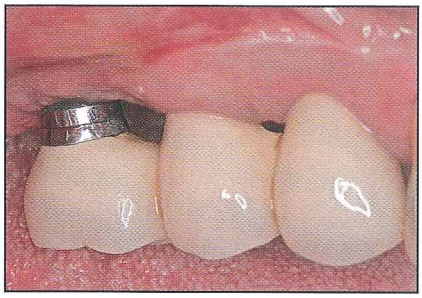


Fig 12 *After the bone grafting was successful, a vestibuloplasty and free gingival graft were performed without any relapse of peri-implantitis.*

Table 2 Case 2 bacterial analysis of maxillary right second premolar (hybrid-design implant) and first molar (HA implant) sites before and after oral antibiotics treatment

	Count				Ratio to total (%)				
	Tooth 16* (HA)		Tooth 15* (hybrid)		Tooth 16* (HA)		Tooth 15* (hybrid)		
Bacteria	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	Normal
Total	17,798,480	2,456,400	98,360	10,680	–	–	–	–	–
A actinomycetemcomitans	0	0	0	0	0.00	0.00	0.00	0.00	< 0.01
P gingivalis	199,680	0	0	0	1.12	0.00	0.00	0.00	< 0.5
T forsythia	75,640	0	0	0	0.42	0.00	0.00	0.00	< 0.5
T denticola	80,320	0	0	0	0.45	0.00	0.00	0.00	< 5.0
P intermedia	663,600	0	0	0	3.73	0.00	0.00	0.00	< 2.5

HA = hydroxyapatite.
*FDI tooth-numbering system.

Albrektsson introduced the criteria of success that are still applicable today.[12] At present, the success criteria resolved at the Toronto Conference on Osseointegration in 1998 are adopted as the standard. Namely, vertical bone resorption of less than 0.2 mm per year after the implant is in function is acceptable. Infection and bone loss at the osseointegrated interface fails to accomplish this criterion. The fact that the bacterial species detected around implant sites are similar to those found around natural teeth[13–15] and that periodontal pathogenic bacterial species are often detected on a failed implant surface suggests that peri-implant infection is similar to periodontitis.[16–18] It is very important to reduce or eliminate periodontal pathogens when treating periodontal disease if a bacterial test reveals an excessive bacterial count. It is rational to suggest that no implant should be placed before completing definitive periodontal treatment.[19] Like periodontal treatment, the treatment of peri-implantitis requires eliminating probing depths, bleeding on probing, and exudate. In the past, probing depth at implants was not

considered an important parameter; however, at present it is considered to be a necessary measure to detect infection or attachment loss. Lang et al accumulated these findings and summarized them in Cumulative Interceptive Supportive Therapy,[20] which is considered to be the current guideline for peri-implantitis treatment. The count of each type of bacterial flora and its ratio to total bacterial count, as well as other physical conditions of the patient, must be considered before antibacterial therapy is initiated. Oral antibacterial medication should be based on the recommendations of the American Academy of Periodontology,[9] and the difficulty of decontaminating the rough microstructure of contemporary implants must be recognized. It is no easy task to expose and clean the surface of a deep infrabony defect on a natural tooth, even with the possibility of the exposed dentinal tubules absorbing topical antibiotics. Once infection has resulted in peri-implant tissue destruction, it never heals spontaneously, and advanced peri-implantitis can lead to the need to remove the implant. At this point in time, the authors consider the Er:YAG laser to be the ideal tool for addressing this situation. The Er:YAG laser has a high energy absorption rate by water molecules with minimum temperature increase, which leads to effective sterilization of the irradiated surface with less carbonization[21] and less damage to the titanium surface.[5] Because of these merits, the authors suggest the Er:YAG laser as the first choice for debridement of the implant surface. The conventional air ablation method may perform effective debridement; however, it scatters microscopic granules that may penetrate and reside in the soft tissue. In addition to avoiding the latter issue, the Er:YAG laser detoxifies LPS[5,6,22] and can accelerate the wound healing mechanism[8,23] compared with the conventional method. Phototherapy, including laser therapy, does not require direct contact with the target, so it can irradiate in various directions, which is very effective in light of the complicated structure of the implant threads.

Conclusions

The recommended composite approach to peri-implantitis should be initiated with bacterial identification leading to antibiotic treatment. When bone-implant contact has been compromised, resulting in bone loss, the complex rough surfaces of implants are difficult to decontaminate. Irradiation by Er:YAG laser is proposed as the appropriate approach to cleansing the implant surface and preparing it for regenerative procedures.

Acknowledgments

The authors are deeply grateful to the J. Morita Corporation for its helpful advice on using the laser device. The authors reported no conflicts of interest related to this study.

References

1. Albrektsson T, Isidor F (eds). Consensus report of session IV. In: Lang NP, Karring T (eds). Proceedings of the 1st European Workshop on Periodontology. London: Quintessence, 1994:365–369.
2. Hale GM, Querry MR. Optical constants of water in the 200-nm to 200-microm wavelength region. Appl Opt 1973;12: 555–563.
3. Yamamoto A, Tanabe T. Treatment of peri-implantitis around TiUnite-surface implants using Er:YAG laser microexplosions. Int J Periodontics Restorative Dent 2013;33:21–29.
4. Aoki A, Sasaki KM, Watanabe H, Ishikawa I. Lasers in nonsurgical periodontal therapy. Periodontol 2000 2004;36:59–97.
5. Matsuyama T, Aoki A, Oda S, Yoneyama T, Ishikawa I. Effects of the Er:YAG laser irradiation on titanium implant materials and contaminated implant abutment surfaces. J Clin Laser Med Surg 2003;21: 7–17.
6. Folwaczny M, Aggstaller H, Mehl A, Hickel R. Removal of bacterial endotoxin from root surface with Er:YAG laser. Am J Dent 2003;16:3–5.
7. Aleksic V, Aoki A, Iwasaki K, et al. Low-level Er:YAG laser irradiation enhances osteoblast proliferation through activation of MAPK/ERK. Lasers Med Sci 2010;25:559–569.
8. Folwaczny M, Benner KU, Flasskamp B, Mehl A, Hickel R. Effects of 2.94 microm Er:YAG laser radiation on root surfaces treated in situ: A histological study. J Periodontol 2003;74:360–365.
9. Califano JV; Research, Science and Therapy Committee, American Academy of Periodontology. Position paper: Periodontal diseases of children and adolescents. J Periodontol 2003;74:1696–1704.
10. Gomi K, Yashima A, Nagano T, Kanazashi M, Maeda N, Arai T. Effects of full-mouth scaling and root planing in conjunction with systemically administered azithromycin. J Periodontol 2007;78:422–429.
11. Grunder U, Gracis S, Capelli M. Influence of the 3-D bone-to-implant relationship on esthetics. Int J Periodontics Restorative Dent 2005;25:113–119.
12. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: A review and proposed criteria of success. Int J Oral Maxillofac Implants 1986;1:11–25.

13. Friberg B, Jemt T, Lekholm U. Early failures in 4,641 consecutively placed Brånemark dental implants: A study from stage 1 surgery to the connection of completed prostheses. Int J Oral Maxillofac Implants 1991;6:142–146.
14. Quirynen M, Listgarten MA. Distribution of bacterial morphotypes around natural teeth and titanium implants ad modum Brånemark. Clin Oral Implants Res 1990;1:8–12.
15. Mombelli A, Marxer M, Gaberthüel T, Grunder U, Lang NP. The microbiota of osseointegrated implants in patients with a history of periodontal disease. J Clin Periodontol 1995;22:124–30.
16. Pontoriero R, Tonelli MP, Carnevale G, Mombelli A, Nyman SR, Lang NP. Experimentally induced peri-implant mucositis. A clinical study in humans. Clin Oral Implants Res 1994;5:254–259.
17. Mombelli A, Lang NP. Antimicrobial treatment of peri-implant infections. Clin Oral Implants Res 1992;3:162–168.
18. Rosenberg ES, Torosian JP, Slots J. Microbial differences in 2 clinically distinct types of failures of osseointegrated implants. Clin Oral Implants Res 1991;2: 135–144.
19. Quirynen M, Abarca M, Van Assche N, Nevins M, van Steenberghe D. Impact of supportive periodontal therapy and implant surface roughness on implant outcome in patients with a history of periodontitis. J Clin Periodontol 2007;34: 805–815.
20. Lang NP, Berglundh T, Heitz-Mayfield LJ, Pjetursson BE, Salvi GE, Sanz M. Consensus statements and recommend clinical procedures regarding implants survival and complications. Int Oral Maxillofac Implants 2004;19(suppl):150–154.
21. Yoshino T, Aoki A, Oda S, et al. Long-term histologic analysis of bone tissue alteration and healing following Er:YAG laser irradiation compared to electrosurgery. J Periodontol 2009;80:82–92.
22. Yamaguchi H, Kobayashi K, Osada R, et al. Effects of irradiation of an erbium:YAG laser on root surfaces. J Periodontol 1997;68:1151–1155.
23. Schwarz F, Jepsen S, Herten M, Aoki A, Sculean A, Becker J. Immunohistochemical characterization of periodontal wound healing following nonsurgical treatment with fluorescence controlled Er:YAG laser radiation in dogs. Lasers Surg Med 2007; 39:428–440.