Received: 15 October 2023 | Accepted: 11 November 2023

DOI: 10.1002/cap.10275

CASE STUDY

Surgical reconstruction of peri-implantitis with adjunctive antimicrobial photodynamic therapy: A case report with 5-year follow-up

Ardavan Etemadi[1] | **Hamoun Sabri**[2,3] | **Mahsa Enssi**[1]

[1]Department of Periodontics, Tehran Islamic Azad University School of Dentistry, Tehran, Iran

[2]Department of Periodontics and Oral Medicine, University of Michigan School of Dentistry, Ann Arbor, Michigan, USA

[3]Center for Clinical Research and Evidence Synthesis in Oral Tissue Regeneration (CRITERION), Ann Arbor, Michigan, USA

Correspondence
Hamoun Sabri, Department of Periodontics and Oral Medicine, University of Michigan School of Dentistry, 1011 N University Ave, Ann Arbor, MI 48109, USA.
Email: Hsabri@umich.edu

Abstract

Background: Peri-implantitis poses a significant challenge in dental implantology due to its potential to result in the loss of supporting tissue around dental implants. Surgical reconstruction is often recommended for intrabony defects, accompanied by various adjunctive therapies, such as antimicrobial photodynamic therapy (aPDT), for bacterial decontamination. However, the long-term efficacy of such treatments remains unclear.

Methods: This clinical report presents a case of peri-implantitis management in a healthy 55-year-old male using guided bone regeneration principles and surface decontamination via aPDT. The patient exhibited peri-implantitis with probing pocket depths (PPD) of 7 mm at buccal sites, 5 mm at palatal sites, and significant bone loss around implant #12. The reconstructive approach involved preservation of the existing implant and following a non-submerged healing protocol. The surgical phase included meticulous debridement, chemical detoxification with hydrogen peroxide, and aPDT using a 670 nm diode laser with methylene blue as the photosensitizer. Xenogenic bone graft and a resorbable collagen membrane were applied and the patient was followed up to through a 5-year period.

Results: Postsurgery the patient exhibited normal healing, and long-term follow-up at 5 years showed reduced PPD (2 mm buccally, 3 mm mid-palatally), complete intrabony defect fill, and stable bone levels, indicating successful treatment.

Conclusions: This case report demonstrates the potential long-term success of a reconstructive approach with adjunctive aPDT in peri-implantitis management. However, it highlights the need for standardized protocols and further clinical trials to establish the clinical benefits of aPDT in surgical reconstruction of peri-implantitis defects, serving as valuable pilot data for future research.

Drs. Ardavan Etemadi and Hamoun Sabri contributed equally to this study.

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2023 The Authors. *Clinical Advances in Periodontics* published by Wiley Periodicals LLC on behalf of American Academy of Periodontology.

KEYWORDS
bone regeneration, dental implants, lasers, peri-implantitis, photochemotherapy

Key points

Why is this case new information?

- Provides a rare 5-year insight into peri-implantitis intrabony defect reconstruction, offering extended success and outcomes not frequently documented.
- Demonstrates the efficacy of aPDT with a 670-nm diode laser in achieving successful long-term outcomes, contributing valuable evidence to existing literature.

Keys to successful management of this case:

- Success involves initial non-surgical debridement followed by a reconstructive strategy, incorporating guided bone regeneration and surface decontamination via aPDT.
- Long-term success hinges on patient compliance with routine oral hygiene, emphasizing the importance of adherence to preventive measures post-reconstruction to minimize recurrence risk.

What are the primary limitations to success in this case?

- Variability in photosensitizer uptake, and potential risks such as tissue damage and bacterial resistance pose challenges to the effectiveness of aPDT.
- The existing literature on aPDT in peri-implantitis treatment lacks standardization in methodology, laser parameters, and follow-up durations, making it challenging to establish a universally accepted protocol.

INTRODUCTION

Regarded as a biofilm-induced inflammatory condition, peri-implantitis has the potential to cause progressive loss of supporting tissue around affected dental implants.[1–3] Several factors transform this condition into a serious threat to survival of dental implants. Increasing prevalence, hurdles in treatment, and inconclusive research are among these mentioned factors.[1,4–6] Recently, there has been a great effort in dental implantology research, to not only explore the epidemiology and etiology, but also, efficacy of various available treatment strategies.[7] Overall, the literature agrees upon ineffectiveness of nonsurgical therapy alone, thereby, surgical interventions to reconstruct the bygone structure is usually recommended.[3,8,9] The surgical therapy can be either resective or regenerative (reconstructive) for which the decision making takes place based on the defect morphology.[5] More specifically, defects presenting with an intrabony component (angular defect), are candidates of performing reconstructive approaches.[4,5] Barrier membranes, either resorbable or non-resorbable are usually implemented to maximize the defect reconstruction outcomes.[10,11] This also may accompany with other adjunctive such as application of lasers, local or systemic antimicrobials.[12,13]

Within attempts to achieve bacterial decontamination of implants in peri-implantitis, the efficacy of antimicrobial photodynamic therapy (aPDT) has been investigated. This provides a noninvasive and biocompatible approach. Moreover, aPDT comprises a light-induced inactivation and reduction of the virulence factors and effectiveness of microbes. This is achieved with the combined used of light and photosensitizers in a synergistic fashion which lead to sensitized photo-oxidation reactions. The resultant excited state of the photosensitizer subsequently, undergoes several different reactions, which result in the destruction of different pathogens in planktonic and biofilm forms.[14,15] The evidence suggests that application of aPDT mediated by methylene blue dye yields superior outcome compared to that of other agents such as toluidine blue.[16] From the in vitro perspective, a study by Tonin et al.,[17] demonstrated aPDT resulting in significant reduction in cultures of periodontal and peri-implant biofilm. When it comes to the clinical evidence, in a randomized trial on 21 peri-implantitis cases by Ohba et al., a significant difference in reduction of pus discharge was reported when aPDT was applied compared to the irrigation-only group (58.3% vs. 15.4%, $p = 0.04$).[18] Furthermore, a recent meta-analysis[19] on the outcomes of different decontamination strategies found that aPDT resulted in a significant reduction in bleeding on probing (BoP) (7.41%; 95% CI: 0.81–14.00). However, the systematic review emphasized a lack of long-term outcomes and insufficient data. Therefore, the aim of this clinical report was to present 5-year outcomes of treatment of a peri-implantitis intrabony defect with the use of guided bone



FIGURE 1 Baseline clinical photos, **(A)** buccal and **(B)** palatal, as well as the initial radiographic image **(C)** showing the intrabony defect around the implant #12.

regeneration principles and surface decontamination via aPDT.

MATERIALS AND METHODS

Case presentation

A 55-year-old Caucasian male was referred for the management of peri-implantitis around implant #12 (ADA numbering system) (Figure 1A,B). The initial screening, in 2018, revealed no significant past medical history with no medication intake nor smoking habits, therefore, classifying patient as healthy. Similarly, the patient was periodontally healthy/stable and past dental history revealed no history of previous periodontal disease. The implant had been restored 1 year prior to presentation of the patient to the clinic. The patient reported no pain/discomfort at the time of consultation. Intraoral examination confirmed diagnosis of peri-implantitis around #12 implant with presence of probing pocket depths (PPD) of 7 mm at all buccal sites (mesial, mid-buccal and distal) as well as 5 mm at palatal sites. This accompanied with BoP and pus discharge positive at all sites. The implant was non-mobile. Radiographical examination via peri-apical and panoramic radiographs presented 4 mm of marginal bone loss (MBL) at mesial and distal (Figure 1C). This indicated bone loss equal to >25% of the implant length in less than 2 years after implant placement. The evaluation of the cases was consistent with a diagnosis of class IIIa defect according to Monje et al.'s[5] classification of peri-implantitis defects.

Case management

The initial treatment plan comprised a nonsurgical phase of mechanical instrumentation (scaling and debridement via curettes) resulted in no alleviation in BoP and PPD after a follow-up of 2 months. At this stage, the patient was given the possible treatment options of implant removal, guided bone regeneration (GBR) and new implant placement or attempting a reconstructive approach and moving forward with keeping the existing diseased implant in place. As per the patient's final decision the reconstructive approach was chosen. Before initiation of the surgical phase, a written informed consent was obtained from him.

Peri-implantitis infrabony reconstruction: Surgical phase

A non-submerged reconstructive approach, while keeping the crown intact, was decided to be performed.[20] Following administration of local anesthetic agent, a sulcular incision was made extending mesiodistally to the mesiobuccal line angle of #11 and distobuccal line angles of teeth #14 (Figure 2A). Placing vertical incisions were omitted due to esthetic considerations in the area. A full thickness mucoperiosteal flap was then raised, visualizing the osseous defect around implant #12. A thorough debridement of the osseous defect was performed using a surgical curette,[*] and the surrounding granulation tissue was removed (Figure 2B). The defect characteristics and depth were confirmed intraoperatively. This included 4 mm of horizontal bone loss associated with buccal dehiscence (IIIa defect). After mechanical detoxification (curettes) chemical detoxification process was performed via application of hydrogen peroxide 2% for 2–3 min (Figure 2C). Following this step, aPDT was performed by using a low-level 670 nm diode laser device using methylene blue 0.005% as the photosensitizer. This was incorporated around the implant via syringe (Figure 3A,B). Methylene blue is used as a chromophore as it accounts for higher stability in the presence of light, making it a crucial element that helps in generating singlet oxygen molecules. Following retaining the methylene blue at the site for 1 min, the stain was rinsed with sterile water. The diode laser of 670 nm wavelength[†] was then used to irradiate the implant surface for 10 s per site (106.8 J/cm^2 at 660–675 nm) (Figure 3C). The defect then was grafted used a xenogenic (bovine) bone

[*] A. Titan Instruments, Orchard Park, NY, USA
[†] Periowave, Ondine Biopharma, Vancouver, BC, Canada

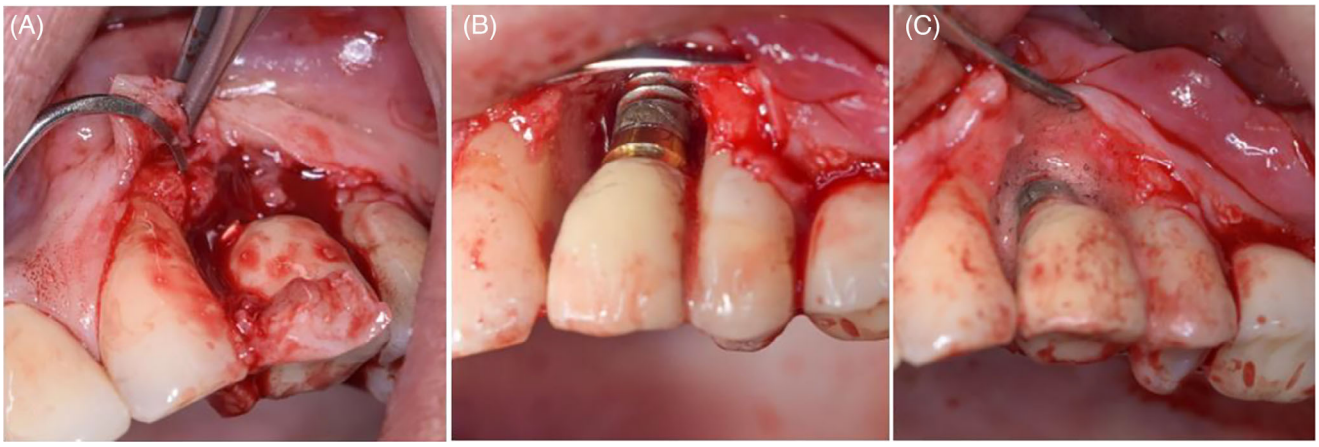


FIGURE 2 **(A)** A mucoperiosteal flap was raised and **(B and C)** debridement, decontamination, and detoxification were performed.

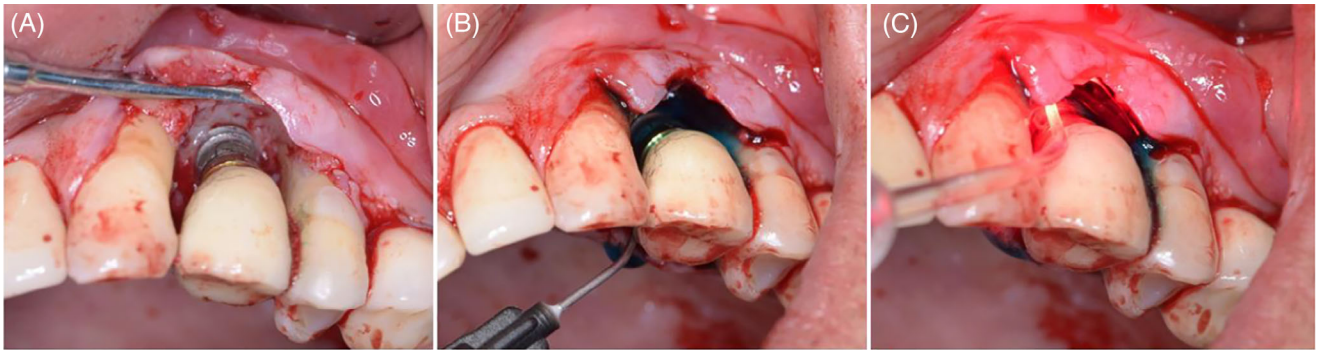


FIGURE 3 **(A)** Defect characteristics after debridement and decontamination. **(B)** For antimicrobial photodynamic therapy (aPDT), firstly a methylene blue dye was applied to the defect, and **(C)** this was followed by application of the diode laser.

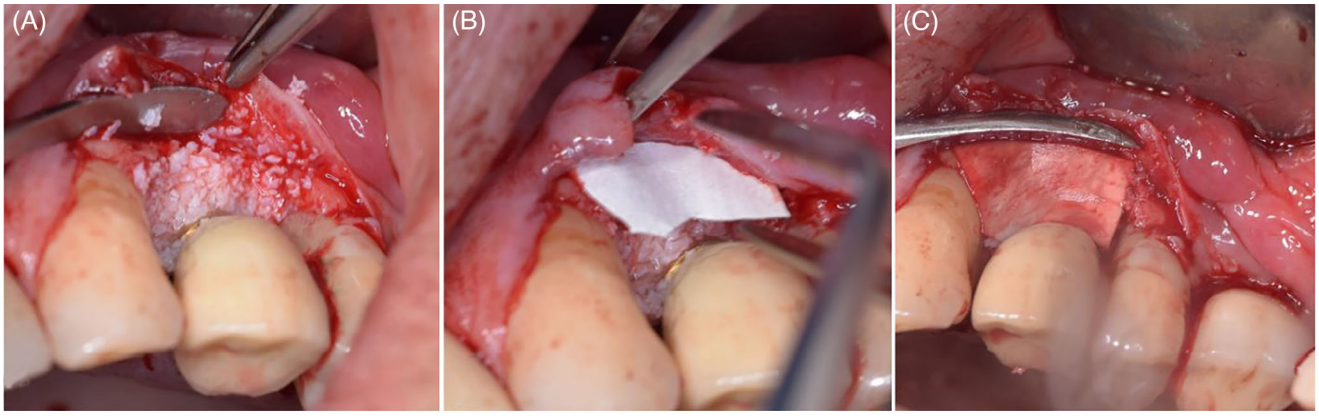


FIGURE 4 **(A)** The defect was filled with the bone graft material, and then **(B and C)** it was covered with a resorbable (collagen) membrane.

graft substitute[‡] and a resorbable collagen membrane[§] was then applied over the grafted site (Figure 4A,C). Lastly, the flap was sutured using single interrupted 4-0 Nylon sutures (Figure 5A,B).

[‡] Cerabone, Botiss Biomaterials GmbH, Zossen, Germany
[§] Jason membrane, Botiss Biomaterials GmbH, Zossen, Germany

RESULTS

The patient was followed up routinely and at the 2-week post-op visit, the healing was within normal limits and a slight loss in mesial papillae was noted (Figure 6). Nonetheless, the decision was made to follow up the case with this regard without any further interventions. The patient was instructed to re-start routine oral hygiene care (brushing and flossing) after the 4 weeks follow-up. After confirming

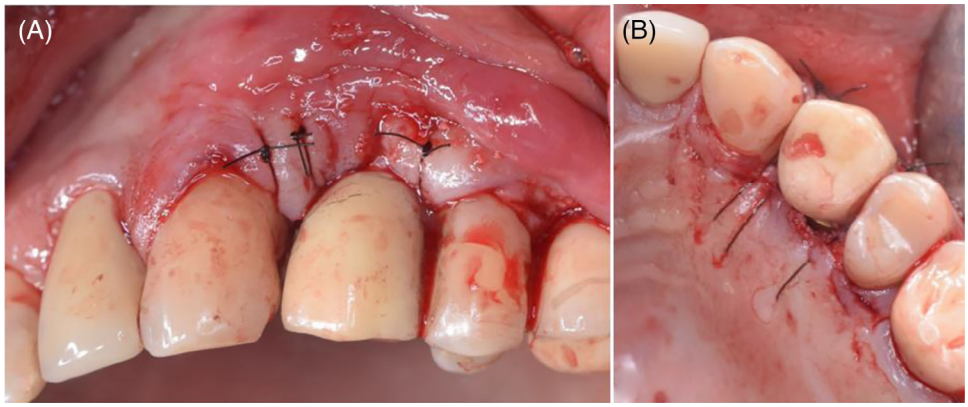


FIGURE 5 The flap was then closed using 4-0 nylon sutures: **(A)** buccal and **(B)** palate-occlusal view.



FIGURE 6 Healing at the 2-week follow-up after the guided bone regeneration surgery.

stable healing status, the patient was put into the regular periodontal maintenance protocol (every 3 months).

The patient's long-term follow-up was extended to a 5-year time-point at which clinical measurements were obtained and a final radiographic image was taken (Figure 7). This revealed healthy soft tissues, reduced PPD was noted with the final PPDs being 2 mm in buccal and 3 mm in mid-palatal areas. The corresponding radiograph indicated complete fill of the intrabony defect (Figure 7D) and bone levels at the first implant thread. Also, an important finding at this stage was creeping of papillary soft tissue to achieve complete fill in this area (compared to the 2-week postop). The corresponding clinical photos show normal gingival tissues with minimal inflammation and only slight changes in gingival margin heights (compared with Figure 1A,B).

DISCUSSION

Recently, there has been an exponential growth in dental implantology research respecting surgical management of peri-implantitis.[7,21] A wide range of therapeutic protocols have been proposed and applied, nevertheless, the long-term outcomes of which are still ambiguous. A recent network meta-analysis[9,22] on GBR around peri-implantitis defects showed Xenogenic bone with or without a barrier membrane associated with improved radiographic bone levels and less soft tissue recession compared to other graft materials. However, only two of the included trials[23,24] presented 5-year outcomes. Moreover, another recent network meta-analysis by Cheng et al., reported superior outcomes of aPDT when added to open flap debridement compared to flap alone. Nonetheless, there was no significant difference in augmentative treatment with or without aPDT.[9] It should be emphasized that the follow-up duration of the included studies pertinent to aPDT were 6–12 months. The treatment and management of the case presented in this report strengthens the evidence that application of aPDT may improve the long-term outcomes of reconstructive treatment of peri-implantitis intrabony defects. Specifically, while adhering to the standard treatment including nonsurgical phase followed by surgical reconstruction via GBR using a xenogenic material covered by a collagen membrane, application of a low-level 670-nm diode laser is thought to be contributing to the successful 5-year outcome. While several original studies and reviews are available in the literature regarding the impact of aPDT via low level lasers in peri-implantitis treatment, the evidence is still inconsistent.

aPDT is an adjunctive modality used for decontamination of dental implant surfaces in peri-implantitis treatment. The mechanism of action consists of absorption of specific wavelength of laser light by photosensitizers in presence of oxygen which in turn leads to production of reactive oxygen species and free radicals. Based on this rationale, antibacterial capability and decontamination of peri-implant environment would be achieved. There has been a body of evidence reporting the outcomes of this strategy. Shahmohammadi et al., meta-analyzed four trials testing mechanical debridement with or without aPDT in nonsurgical therapy. They reported significantly lower PPDs and plaque index in the aPDT group.[25] With regard to surgical therapy, a randomized trial by Albaker et al. indicated a

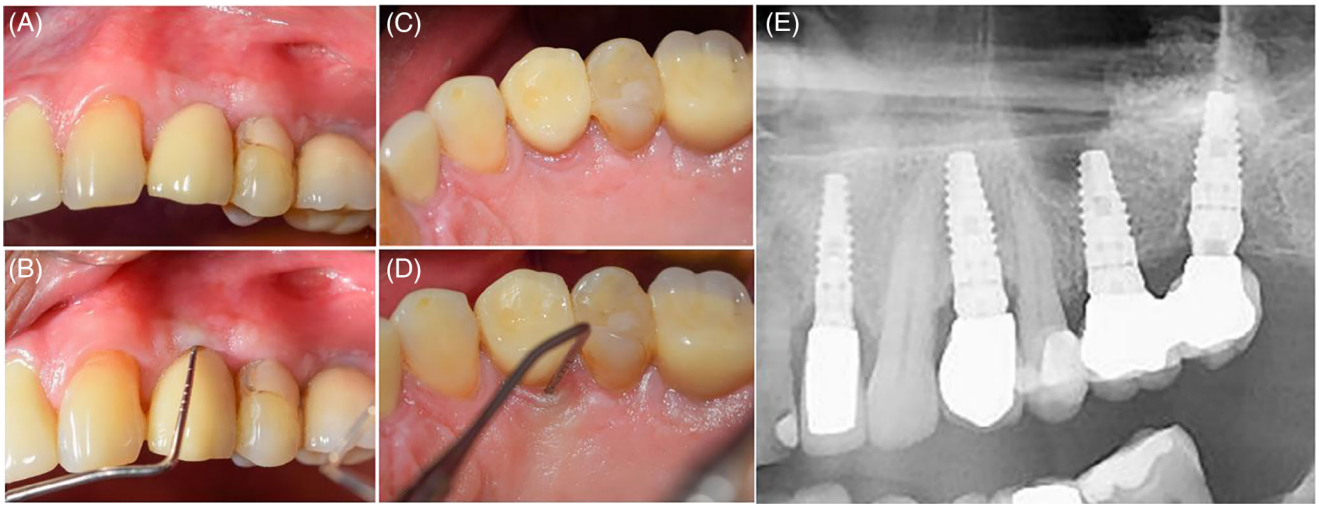


FIGURE 7 Five-year follow-up. **(A and B)** Buccal view and **(C and D)** palato-occlusal view indicating stable probing pocket depths, and **(E)** radiographic image showing stability in bone gain after the longitudinal follow-up. Note the improvement in papillae height and resolution of black triangle in the long-term follow-up compared to immediately after surgery.

significantly higher reduction in plaque index (PI) (from 44.7 ± 8.2 to 16.4 ± 5.1), BoP (from 35.9 ± 10.6% to 17.4 ± 5.5), PPD (from 5.2 ± 1.2 to 3.7 ± 1.1 mm), and MBL (4.1 ± 1.4 to 3.4 ± 1.4 mm) after 12 months follow-up.[14] In a case series by Solakoglu et al., 16 cases received a surgical reconstruction of peri-implantitis bony defects, with a mixture of allogenic and autogenous grafts, collagen barrier membrane and aPDT as adjunctive agent (690-nm wavelength).[26] The study resulted in a mean reduction of 3.18 mm in PPD and a mean bone gain of 3.78 mm at the 3-year time-point. Despite the discussed evidence, the readers should bear in mind that there is still a lack of consensus on clinical benefits of aPDT in surgical reconstruction of peri-implantitis defects and the suggested protocol to apply clinically. Nonetheless, this case report provided a long-term insight into possible long-term success of this adjunctive method and would serve as pilot data for future clinical trials. More specifically, the treatment outcomes of the case revealed a 3–4 mm bone gain as well as 4–5 mm PPD reduction in 5 years post-surgery. Moreover, it should also be emphasized that the long-term success of such cases also depends on patient compliance with routine care and preventive procedures after defect reconstruction phase in order to lower risk of recurrence. This being mentioned, the possible limitations of aPDT in treatment of peri-implant diseases should also be noted. Limited penetration depth in nonsurgical treatment, variability in photosensitizer uptake, risk of tissue damage, and bacterial resistance are among the bio-mechanical and microbiological limitations. Additionally, patient compliance, cost and equipment should also be considered when it comes to the patient and operator related limitations. Likewise, It is crucial to acknowledge several limitations in the existing literature and the presented case report. Firstly, the available studies on the use of aPDT in peri-implantitis treatment vary in terms of methodology, laser parameters, and follow-up durations, making it challenging to establish a standardized protocol. Secondly, the number of long-term studies with extensive follow-up periods beyond 5 years remains scarce, leaving questions about the sustainability of the observed outcomes over an even more extended period. Additionally, the generalizability of findings from single-case reports to a broader patient population should be approached with caution, as individual patient factors and unique clinical circumstances may influence treatment outcomes differently.

CONCLUSIONS

In conclusion, this case report demonstrated the long-term success of antimicrobial photodynamic therapy via use of diode laser in surgical reconstructive treatment of peri-implantitis intrabony defect. Significant bone fill and probing pocket depth reduction was achieved and maintained up to 5-year time-point.

AUTHOR CONTRIBUTIONS

Conceptualization; clinical phase, and final approval: Ardavan Etemadi. *Conceptualization; manuscript writing, and final approval*: Hamoun Sabri. *Conceptualization; data collection, and final approval*: Mahsa Enssi.

CONFLICT OF INTEREST STATEMENT

The authors declare no potential conflicts of interest regarding this clinical report.

DATA AVAILABILITY STATEMENT

The data of this study can be provided by the first or corresponding author upon request.

REFERENCES

1. Berglundh T, Armitage G, Araujo MG, et al. Peri-implant diseases and conditions: consensus report of workgroup 4 of the 2017 world workshop on the classification of periodontal and peri-implant diseases and conditions. *J Clin Periodontol*. 2018;45(20):S286-S291.
2. Ganesan SM, Dabdoub SM, Nagaraja HN, Mariotti AJ, Ludden CW, Kumar PS. Biome-microbiome interactions in peri-implantitis: a pilot investigation. *J Periodontol*. 2022;93(6):814-823. doi:10.1002/JPER.21-0423
3. Mancini L. Peri-implant health and diagnostic considerations. *Int J Environ Res Public Health*. 2022;19(19):12008. doi:10.3390/ijerph191912008.
4. Schwarz F, Derks J, Monje A, Wang HL. Peri-implantitis. *J Periodontol*. 2018;89(1):S267-S290. doi:10.1002/JPER.16-0350.
5. Monje A, Pons R, Insua A, Nart J, Wang HL, Schwarz F. Morphology and severity of peri-implantitis bone defects. *Clin Implant Dent Relat Res*. 2019;21(4):635-643. doi:10.1111/cid.12791
6. Rakic M, Galindo-Moreno P, Monje A, et al. How frequent does peri-implantitis occur? A systematic review and meta-analysis. *Clin Oral Investig*. 2018;22(4):1805-1816.
7. Sabri H, Wang HL. Peri-implantitis: a bibliometric network analysis of top 100 most-cited research articles. *Clin Implant Dent Relat Res*. 2023;25(2):284-302. doi:10.1111/cid.13177
8. Schwarz F, Jepsen S, Obreja K, Galarraga-Vinueza ME, Ramanauskaite A. Surgical therapy of peri-implantitis. *Periodontol*. 2000;88(1):145-181.
9. Cheng J, Chen L, Tao X, et al. Efficacy of surgical methods for peri-implantitis: a systematic review and network meta-analysis. *BMC Oral Health*. 2023;23(1):227.
10. Monje A, Pons R, Sculean A, Nart J, Wang HL. Defect angle as prognostic indicator in the reconstructive therapy of peri-implantitis. *Clin Implant Dent Relat Res*. 2023. doi:10.1111/cid.13244
11. Monje A, Pons R, Vilarrasa J, Nart J, Wang HL. Significance of barrier membrane on the reconstructive therapy of peri-implantitis: a randomized controlled trial. *J Periodontol*. 2023;94(3):323-335. doi:10.1002/jper.22-0511
12. Romeo U, Nardi GM, Libotte F, Sabatini S, Palaia G, Grassi FR. The antimicrobial photodynamic therapy in the treatment of peri-implantitis. *Int J Dent*. 2016;2016:7692387. doi:10.1155/2016/7692387
13. Chambrone L, Wang HL, Romanos GE. Antimicrobial photodynamic therapy for the treatment of periodontitis and peri-implantitis: an American Academy of Periodontology best evidence review. *J Periodontol*. 2018;89(7):783-803. doi:10.1902/jop.2017.170172
14. Albaker AM, ArRejaie AS, Alrabiah M, et al. Effect of antimicrobial photodynamic therapy in open flap debridement in the treatment of peri-implantitis: a randomized controlled trial. *Photodiagnosis Photodyn Ther*. 2018;23:71-74.
15. Tavares LJ, Pavarina AC, Vergani CE, de Avila ED. The impact of antimicrobial photodynamic therapy on peri-implant disease: what mechanisms are involved in this novel treatment? *Photodiagnosis Photodyn Ther*. 2017;17:236-244. doi:10.1016/j.pdpdt.2016.11.016
16. Marotti J, Tortamano P, Cai S, Ribeiro MS, Franco JE, de Campos TT. Decontamination of dental implant surfaces by means of photodynamic therapy. *Lasers Med Sci*. 2013;28(1):303-309. doi:10.1007/s10103-012-1148-6
17. Tonin MH, Brites FC, Mariano JR, Freitas KMS, Ortiz MAL, Salmeron S. Low-level laser and antimicrobial photodynamic therapy reduce peri-implantitis-related microorganisms grown in vitro. *Eur J Dent*. 2022;16(1):161-166. doi:10.1055/s-0041-1731926
18. Ohba S, Sato M, Noda S, Yamamoto H, Egahira K, Asahina I. Assessment of safety and efficacy of antimicrobial photodynamic therapy for peri-implant disease. *Photodiagnosis Photodyn Ther*. 2020;31:101936. doi:10.1016/j.pdpdt.2020.101936
19. Wilensky A, Shapira L, Limones A, Martin C. The efficacy of implant surface decontamination using chemicals during surgical treatment of peri-implantitis: a systematic review and meta-analysis. *J Clin Periodontol*. 2023;50(26):336-358. doi:10.1111/jcpe.13794.
20. Wen SC, Barootchi S, Wang HL, Huang WX. Non-submerged reconstructive approach for peri-implantitis osseous defect, with removal of implant crowns: one-year outcomes of a prospective case series study. *J Periodontol*. 2022;93(8):1250-1261. doi:10.1002/JPER.21-0502
21. Yin Q, Liang J, Zhang Y, et al. Critical review on quality of methodology and recommendations of clinical practice guidelines for peri-implantitis. *BMC Oral Health*. 2023;23(1):189. doi:10.1186/s12903-023-02904-4
22. Ramanauskaite A, Becker K, Cafferata EA, Schwarz F. Clinical efficacy of guided bone regeneration in peri-implantitis defects. A network meta-analysis. *Periodontol 2000*. 2023. doi:10.1111/prd.12510
23. Aghazadeh A, Persson GR, Stavropoulos A, Renvert S. Reconstructive treatment of peri-implant defects-results after three and five years. *Clin Oral Implants Res*. 2022;33(11):1114-1124. doi:10.1111/clr.13994
24. Roos-Jansåker AM, Persson GR, Lindahl C, Renvert S. Surgical treatment of peri-implantitis using a bone substitute with or without a resorbable membrane: a 5-year follow-up. *J Clin Periodontol*. 2014;41(11):1108-1114. doi:10.1111/jcpe.12308
25. Shahmohammadi R, Younespour S, Paknejad M, Chiniforush N, Heidari M. Efficacy of adjunctive antimicrobial photodynamic therapy to mechanical debridement in the treatment of peri-implantitis or peri-implant mucositis in smokers: a systematic review and meta-analysis. *Photochem Photobiol*. 2022;98(1):232-241.
26. Solakoglu Ö, Filippi A. Regenerative therapy of peri-implantitis: clinical and radiologic documentation of 16 consecutive patients with a mean follow-up of 3 years. *J Oral Implantol*. 2019;45(2):145-153.

How to cite this article: Etemadi A, Sabri H, Enssi M. Surgical reconstruction of peri-implantitis with adjunctive antimicrobial photodynamic therapy: A case report with 5-year follow-up. *Clin Adv Periodontics*. 2024;14:e10275. https://doi.org/10.1002/cap.10275