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CASE STUDY

Operating microscope-assisted reconstructive strategy for peri-implantitis: A case series report

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Abstract

Background: Treating peri-implantitis with reconstructive means has been largely unpredictable due to access limitations for surface decontamination, unfavorable bony topography, difficulty in achieving wound stability, and inferior soft tissue qualities. A microsurgical approach with the use of the operating microscope (OM) that provides adjustable higher magnification (~5–30 times) and coaxial illumination, coupled with the use of microsurgical instruments, may overcome, or alleviate some of the abovementioned obstacles, resulting in more predictable outcomes.

Methods: Three patients received reconstructive therapy for correcting peri-implant defects under OM in private practice settings. After precise incisions to preserve soft tissue volume, the flaps were dissected prudently from underlying granulomatous tissues, which were subsequently removed, followed by controlled flap releasing under ~10–15x magnification. Surface decontamination was performed using a piezoelectric ultrasonic device, air polishing, and hand instruments at ~30x magnification. The biomaterial selections were dehydrated human de-epithelialized amnion-chorion membrane with mineralized allograft particulates in two cases and xenografts in one case, based on the surgeons' preference. Wound closure followed the non-submerged approach.

Results: These cases demonstrated uneventful soft tissue healing, favorable radiographic bone fill, and disease resolution with follow-ups ranging from 2 to 4 years.

Conclusions: Preliminary data suggest encouraging outcomes after the microsurgical approach following biological as well as biomechanical principles for peri-implant defect reconstruction.

KEYWORDS
bone regeneration, microsurgery, minimally invasive surgical procedures, peri-implantitis, wound healing

INTRODUCTION

Peri-implantitis is a pathological condition characterized by peri-implant tissue inflammation and loss of supporting bone around implants. The prevalence of peri-implantitis varies in the literature. At the patient level, studies reported that peri-implantitis affects approximately one-fifth of the patients with dental implants.[1,2] A recent study by Shimchuk et al. in 2021 also showed a prevalence of 15.2% patients having peri-implantitis.[3] According to the 2017 World Workshop, the current etiologic factors for peri-implantitis with strong evidence are a history of periodontitis, poor plaque control, and lack of regular maintenance.[4] Besides reducing bleeding on probing (BOP) in some cases, non-surgical treatment methods for peri-implantitis have been shown to be inefficient in resolving peri-implantitis.[5] As for surgical options, resective as well as reconstructive procedures have been applied with different goals.[6]

While the purpose of resective means is to reduce the probing depths (PDs) around an infected implant and to gain access for home care by apical positioning of the mucoperiosteal flap commonly accompanied with bone recontouring, the reconstructive approach aims to regain bone, achieve reosseointegration, and limit peri-implant soft tissue implant recession that was lost due to the disease.[6] The current reconstructive protocol is framed in five steps: identify and remove etiology, achieve primary wound coverage, proper inflamed granulomatous tissue debridement, implant surface decontamination, and space maintenance for wound stability.[7] While obtaining primary wound coverage is a crucial factor in achieving predictable bone reconstruction,[8] in certain scenarios, such as when the patient's preference is to keep the implant crowns, a non-submerged approach may be implemented. While yielding better treatment outcomes than non-surgical methods, these surgical procedures are still considered unpredictable, especially the reconstructive methods.[6,9]

One of the most commonly seen challenges for effective peri-implant reconstruction is surface decontamination. Modern implants have a thread design with a pitch distance ranging from approximately 0.5–1 mm, depending on the implant brand and product line.[10] Along with this design is the presence of peaks and valleys of 0.2–0.5 mm depth. Microscopically, commonly use implants have a moderately rough surface with an average roughness of 1–2 μm.[11] These anatomical structures handicap efficient implant surface debridement with the currently available armamentarium. Additionally, peri-implant bone defect topography is most of the time not favorable for reconstruction.[12,13] These defects tend to miss part of the facial and/or palatal/lingual bone plate, making bone particulates unstable. Inadequate quality and quantity of soft tissues pose another challenge for a reconstructive attempt. Compared to natural dentition, the mucosa is less cellular and vascular.[14] The width of keratinized mucosa is decreased and sometimes lacking, coupled with shallow vestibule, making primary wound closure very difficult. The blood supply in peri-implant architecture is compromised, due to the absence of a periodontal ligament vascular network, smaller-sized arterioles, decreased density of supraperiosteal plexus, and the avascular implant surface.[14–16] Reduced tissue perfusion may lead to a higher chance of wound opening.

The operating microscope (OM) has been used for periodontal regeneration procedures to assist in a minimally invasive approach aiming to debride the etiology thoroughly, reduce tissue trauma, and enhance early wound healing.[17] Higher magnification and illumination offered by OM are key elements to detect the etiology of peri-implant bone loss, for example, pathogens, residual cement, and infected tissues, assist in the elimination of the etiologic factors and facilitate site preparation, that is, osseous decortication, for reconstructive procedures. The maximal magnification for the OM is ∼30 times, compared to ∼3.5 for average dental loupes. This high magnification can benefit implant surface decontamination, allowing for direct visualization and removal of microscale bacteria and calcified deposits residing between the implant threads. An additional benefit of higher magnification is that it allows for the implementation of fine motor skills along with microinstruments to perform precise incisions, gentle tissue manipulation, and accurate wound closure to maximize blood clot stability.[18] Therefore, this study aims to provide preliminary data on treating three cases of peri-implantitis with reconstructive means assisted by the OM.

MATERIALS/METHODS

Three patients were included in this case report to demonstrate the use of the OM for treating peri-implantitis. All patients signed a consent form for their recommended treatment option. All three cases were treated in private practice. The patient/treatment site information as well as the treatment sequences were narratively described below.

RESULTS

Case 1

The patient was a 90-year-old male, systematically healthy, presenting on September 10, 2020, initially referred for extraction of #19 implant due to severe bone loss (30% remaining bone) (Figure 1A) and 6–8 mm probing depth with BOP (Figure 1B) (Table 1); however, he expressed a strong desire for keeping this implant. Therefore, a surgical debridement with possible bone reconstruction was planned. Intrasulcular incisions were performed by an ophthalmic knife§, and 15C blades, and full-thickness flaps were elevated. Under the microscope‖ at ∼30x magnification, firm deposits could be seen between the implant threads (Figure 1C). Additionally, a thin layer of biofilm was present on the implant surface. These foreign bodies were removed by the ultrasonic device (US) until the surface became shiny (Figure 1D and see Video S1 in the online *Journal of Periodontology*). Afterward, cortical bone allograft¶ was placed and covered with a dehydrated human deepithelialized amnion-chorion membrane# (Figure 1E). The wound was approximated with 7-0 polypropylene sutures**, aiming for primary closure around the implant crown (Figure 1F). Two external vertical mattress sutures were placed at the implant line angles to reduce the dead space. Additional two interrupted sutures were placed next to the two mattress sutures. Postoperative medications included Amoxicillin 500 mg for 5 days and Ibuprofen 600 mg q6-8 h when needed. The patient returned for 2-week suture removal with uneventful healing (Figure 1G). Periapical radiographs taken at 5-month (Figure 1H) and 26-month (Figure 1I) follow-up visits demonstrated

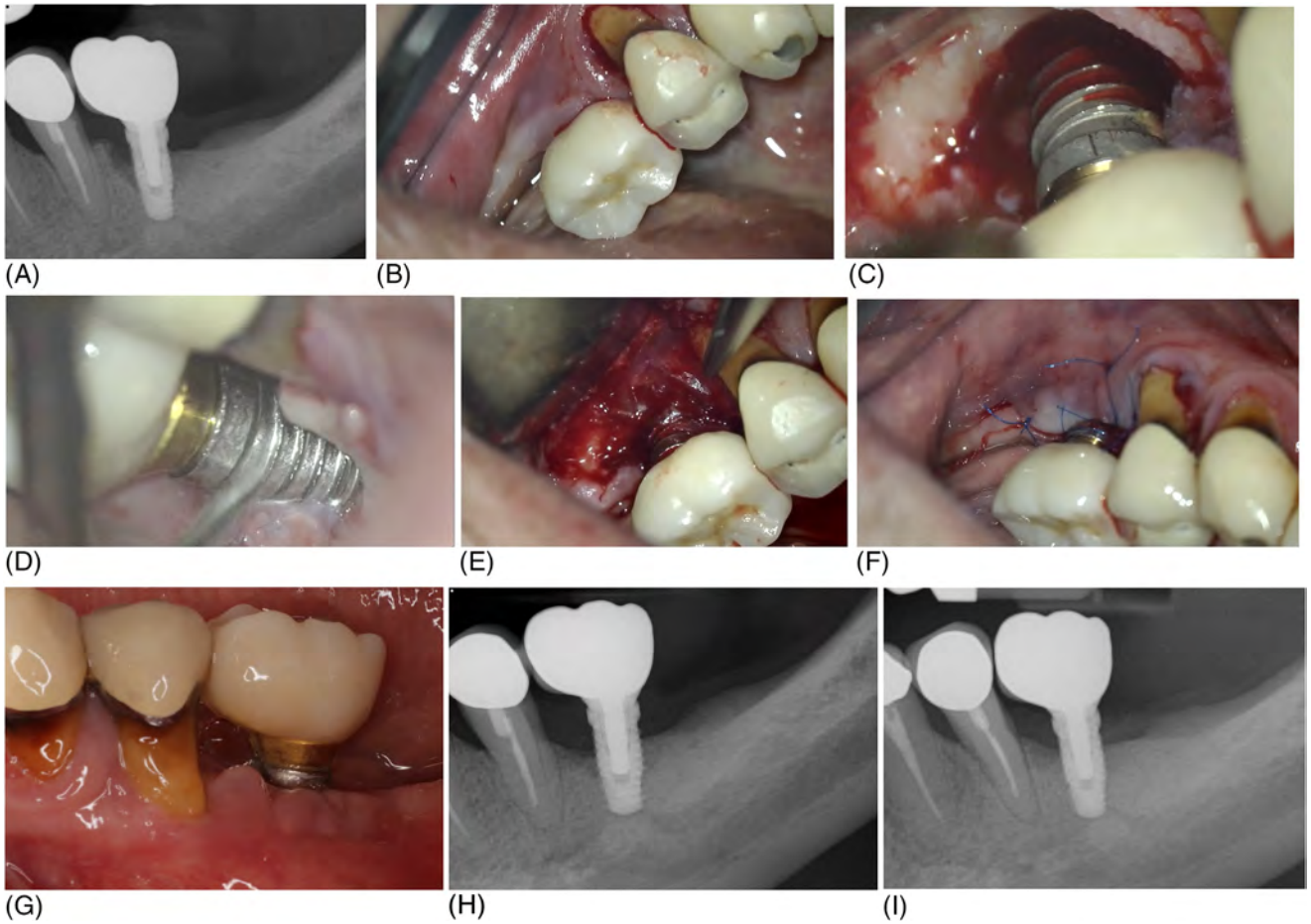

FIGURE 1 **A demonstration of applying a reconstructive approach for treating Case 1**. (A) Severe bone loss with 30% remaining bone around implant #19 was shown in the radiograph. (B) Clinical photo under operating microscope (OM) showing inflamed peri-implant tissues. (C) Firm deposits were seen between the implant threads under OM. (D) After debridement, the implant surface became shiny. (E) Cortical bone allograft was placed and covered with a dehydrated human de-epithelialized amnion-chorion membrane for reconstruction purposes. (F) 7-0 polypropylene sutures were used to approximate the flaps around the implant crown. (G) Initial healing photo at 2 weeks. (H) Periapical radiograph showed bone fill at 5-month follow-up. (I) Periapical radiograph showed stable bone level at 26-month follow-up.

radiographic bone fill. Post-treatment clinical indices recorded in Table 2.

Case 2

The patient was a 56-year-old female, systematically healthy, presenting on April 4, 2019, with peri-implantitis of implant #19 due to PD of 5–7 mm (Figure 2A) (Table 1) with bone loss of ~4 mm on the radiograph (Figure 2B). To gain access the crown was removed right before flap reflection; however, the abutment screw stripped and had to leave in-situ. After debridement, a circumferential bone defect with missing part of the buccal plate and a necrotic bone piece attaching to the implant surface was identified (Figure 2C). The implant surface was detoxified along with the removal of the necrotic bone by the US under the microscope. Extraction of #20 was also performed during the surgery due to an unrestorable condition. Cortical allograft particulates†† were placed at #19 and #20 sites, which were covered with a dehydrated human deepithelialized amnion-chorion membrane# (Figure 2D). The flaps at #19 were approximated with 6-0 polypropylene sutures** around the implant abutment (Figure 2E). Postoperative medications included Amoxicillin and Ibuprofen. In June 2020, a free gingival graft procedure was performed in response to patient's discomfort when brushing around the #19 implant and #20 sites (Figure 2F). Two new crowns for implants #19 and #20 were placed around clinically healthy peri-implant mucosa (Figure 2G). A periapical radiograph was taken on December 15, 2022, showing radiographic bone fill and increased bone density (Figure 2H). Post-treatment clinical indices recorded in Table 2.

Case 3

The patient was a 52-year-old female, systematically healthy, presenting with peri-implantitis of implant #30

TABLE 1 Initial presentation of the three cases.

Case	1			2			3		
Implant number	#19i			#19i			#19i		
Site	Buccal								
	M	Mid	D	M	Mid	D	M	Mid	D
PD (mm)	8	6	7	7	5	7	10	9	9
BOP	+	+	+	+	+	+	+	+	+
Plaque	+	+	+	–	–	+	+	+	+
Pus	+	–	+	–	–	+	+	+	+
KMW (mm)	2			1			4		
Site	Lingual								
	M	Mid	D	M	Mid	D	M	Mid	D
PD (mm)	7	4	8	6	5	6	6	7	10
BOP	+	+	+	+	+	+	+	+	+
Plaque	+	+	+	–	–	+	+	+	+
Pus	–	–	–	–	–	+	+	+	+
KMW (mm)	0			2			4		

Probing depth (PD), bleeding on probing (BOP), plaque, pus, and keratinized mucosa width (KMW) at six sites (M = mesial, Mid = middle, and D = distal) of the implant. + = positive; — = negative.

TABLE 2 Clinical presentation of the most recent follow-up visit after the treatment.

Case	1			2			3		
Implant number	#19i			#19i			#19i		
Site	Buccal								
	M	Mid	D	M	Mid	D	M	Mid	D
PD (mm)	4	4	4	3	3	4	4	3	3
BOP	–	–	–	–	–	–	–	–	–
Plaque	–	–	–	–	–	–	–	–	–
Pus	–	–	–	–	–	–	–	–	–
KMW (mm)	2			2			4		
Site	Lingual								
	M	Mid	D	M	Mid	D	M	Mid	D
PD (mm)	4	5	4	4	3	4	4	3	4
BOP	+	+	+	–	–	–	–	–	–
Plaque	+	+	+	–	–	–	–	–	–
Pus	–	–	–	–	–	–	–	–	–
KMW (mm)	1			2			4		

Probing depth (PD), bleeding on probing (BOP), plaque, pus, and keratinized mucosa width (KMW) at six sites (M = mesial, Mid = middle, and D = distal) of the implant. + = positive; — = negative.

on Oct 10, 2018. This implant exhibited increased probing depths ranging from 5 to 10 mm (Figure 3A) (Table 1) with bone loss of ~4-5 mm on the radiograph (Figure 3B). Access was gained with the crown in place (Figure 3C). After debridement, a well confined circumferential bone defect was observed (Figure 3D). The implant surface was detoxified utilizing US and titanium brushes[§§] (Figure 3E) and air abraded with glycine powder[|||] (Figure 3F) under the microscope[‖]. A collagen bound xenograft[¶¶] was placed (Figure 3G). Tissues were approximated with 6-0 PTFE sutures[**] around the implant (Figure 3H). Postoperative medications included Amoxicillin and Ibuprofen. A periapical radiograph was taken 7 months later, and it shows radiographic bone fill and increased bone density (Figure 3I). Probing depths have also been reduced to 3–4 mm (Table 2). This patient has successfully maintained the achieved results for 4 years (Table 2). (See Video S2 in the online *Journal of Periodontology*).[§‖¶#**††§§|||¶¶]

DISCUSSION

This case series showed that reconstructive therapy with a microsurgical approach resulted in encouraging outcomes with evidence of resolution of clinical signs of inflammation, pocket reduction, and radiographic bone gain. This may be attributed to the precise surgical execution with improved visualization from high magnification (up to ~30x) and coaxial illumination provided by the OM.[19,20] The implant surface was thoroughly inspected under magnification to identify the loosely attached dental plaque, tightly attached calcified deposit, and residual cement, which were subsequently debrided with US and other adjunctive mechanical debridement devices. The focus is on the valleys and the apical surfaces of the implant threads until a shiny surface is achieved. Currently, there are no established methods to detect plaque; florescence lights that can illume plaque may be a promising method. Long-term follow-up with a larger sample size is needed to validate the results.

Different from staged/simultaneous guided bone regeneration (GBR), the flap management in these three cases is resemblant to that for guided tissue regeneration (GTR) in aspects of flap releasing and closure. The flaps were not exuberantly released to achieve flap approximation. Instead, once full-thickness flaps were elevated to the mucogingival junction, a slight sharp periosteal dissection for a couple of millimeters was performed apically, followed by a gentle blunt superficial muscular detachment to alleviate undesirable muscle pull.[21] The microscope is very beneficial for these sensitive tasks for precise soft tissue incisions, releasing, and detachment. Biomaterial stability is primarily offered by the remaining bone walls with no intention to build bone coronal to the infrabony defects.

The "non-submerged approach" was applied for various reasons. In Case 1 the implant prognosis was unfavorable plus the patient's reservation to remove the crown. In Case 2 the abutment screw was stripped and was not able to be removed at the time of the surgery. In Case 3, surgical

[§] Sharpoint, Corza Medical, Westwood, MA, USA
[‖] Zeiss OPMI pico, Carl Zeiss AG, Oberkochen, Germany
[¶] Puros, Zimmer, Warsaw, IN, USA
[#] BioXclude, Snoasis Medical, Golden, CO, USA
[**] Unify, AD Surgical, Sunnyvale, CA, USA
[††] Maxxeus, Community Tissue Services, Dayton, OH, USA
[§§] RotoBrush-Titanium, Salvin Dental, Charlotte, NC, USA
[|||] AirFlow, Hu-Friedy, Chicago, IL, USA
[¶¶] Bio-Oss Collagen, Geistlich Pharma North America, Princeton, NJ, USA

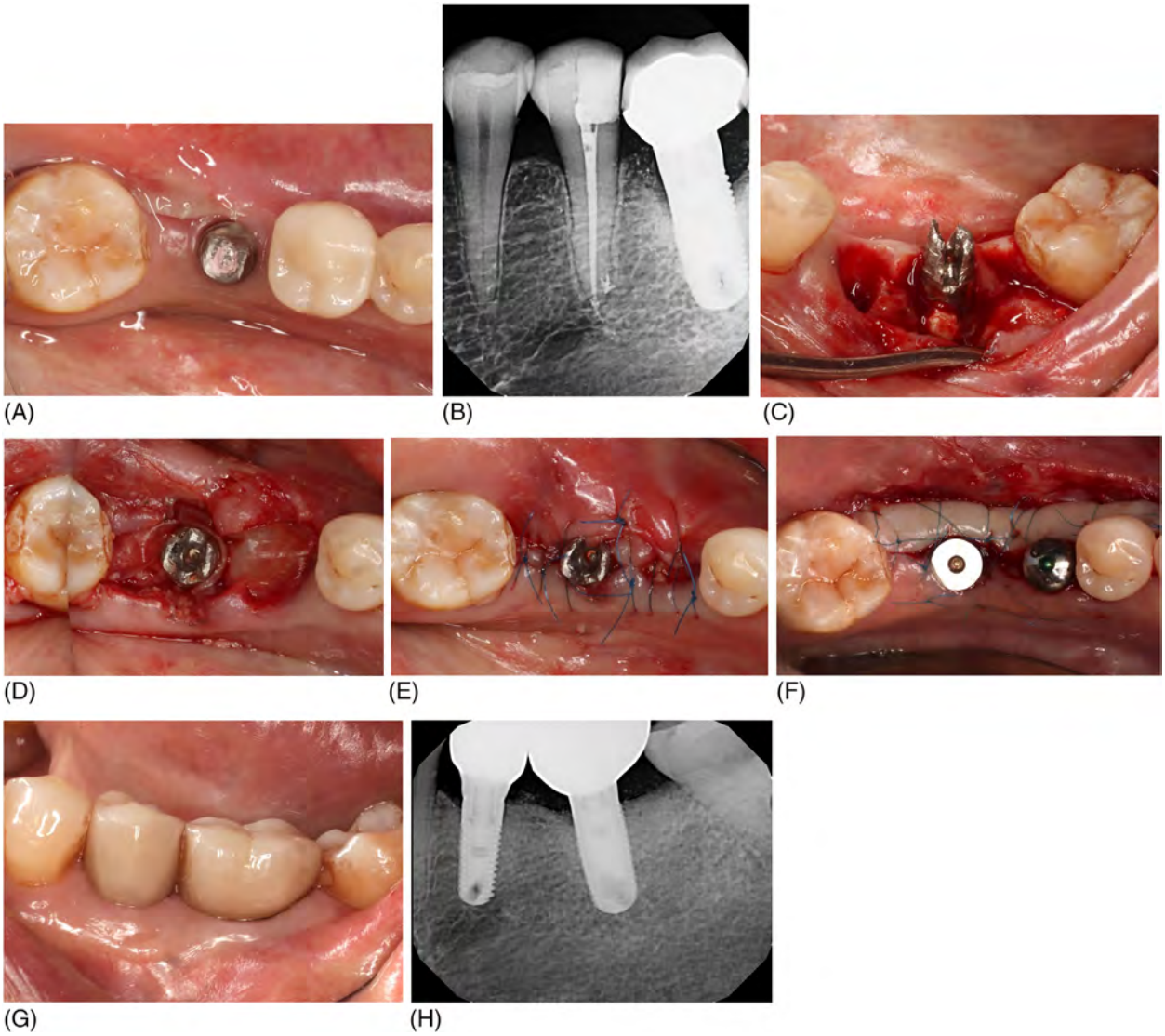

FIGURE 2 **Sequential steps, including free gingival graft (FGG) for treating Case 2**. (A) Clinical occlusal view of implant #19 affected by peri-implantitis. (B) The radiograph showed ~4 mm bone loss. (C) A circumferential bone defect with missing part of the buccal plate and a necrotic bone piece attaching to the implant surface was identified. (D) Cortical allograft particulates were placed at #19 and #20 sites, covered by a dehydrated human deepithelialized amnion-chorion membrane. (E) 6-0 polypropylene sutures were used to close the wound around the implant abutment. (F) FGG was performed due to patient's discomfort when brushing around the #19 implant and #20 sites. (G) Two new crowns for implants #19 and #20 were placed around clinically healthy peri-implant mucosa. (H) Peri-apical radiograph showed bone fill and increased density at 44-month follow-up.

access was achieved without the need for crown removal. Primary submerged closure is still desirable for achieving predictable reconstructive outcomes. It was demonstrated that submerged teeth result in superior periodontal reconstructive healing outcomes.[22] Wound opening is associated with inferior attachment gain in GTR procedures and lesser bone gain in GBR procedures.[23] Although in this case series the term "non-submerged wound approach" was used, in fact, the flaps approximated to the abutment in a fashion similar to regeneration around teeth. There are a few advantages to this approach for treating peri-implantitis. First, the amount of flap release for primary closure is reduced, thus the surgical trauma, disruption to the microvasculature, and patient morbidity are mitigated. Second, currently, no regeneration is expected at the suprabony component of the defect; therefore, a complete coverage attempt may not be needed. It might be even risky to attempt a complete flap coverage because of the creation of a dead space that may encourage infection.[24] Third, the question of whether to pursue a submerged or non-submerged approach for treating peri-implantitis in the literature is a topic of contention.[7,25,26] The non-submerged reconstructive approach results in significant improvements in clinical parameters such as PD and BOP, as well as radiographic defect fill.[26] The submerged approach, by removing implant suprastructure, can also lead to a significant reconstruction of the lost peri-implant supporting bone by obtaining primary closure.[7,25] However, most

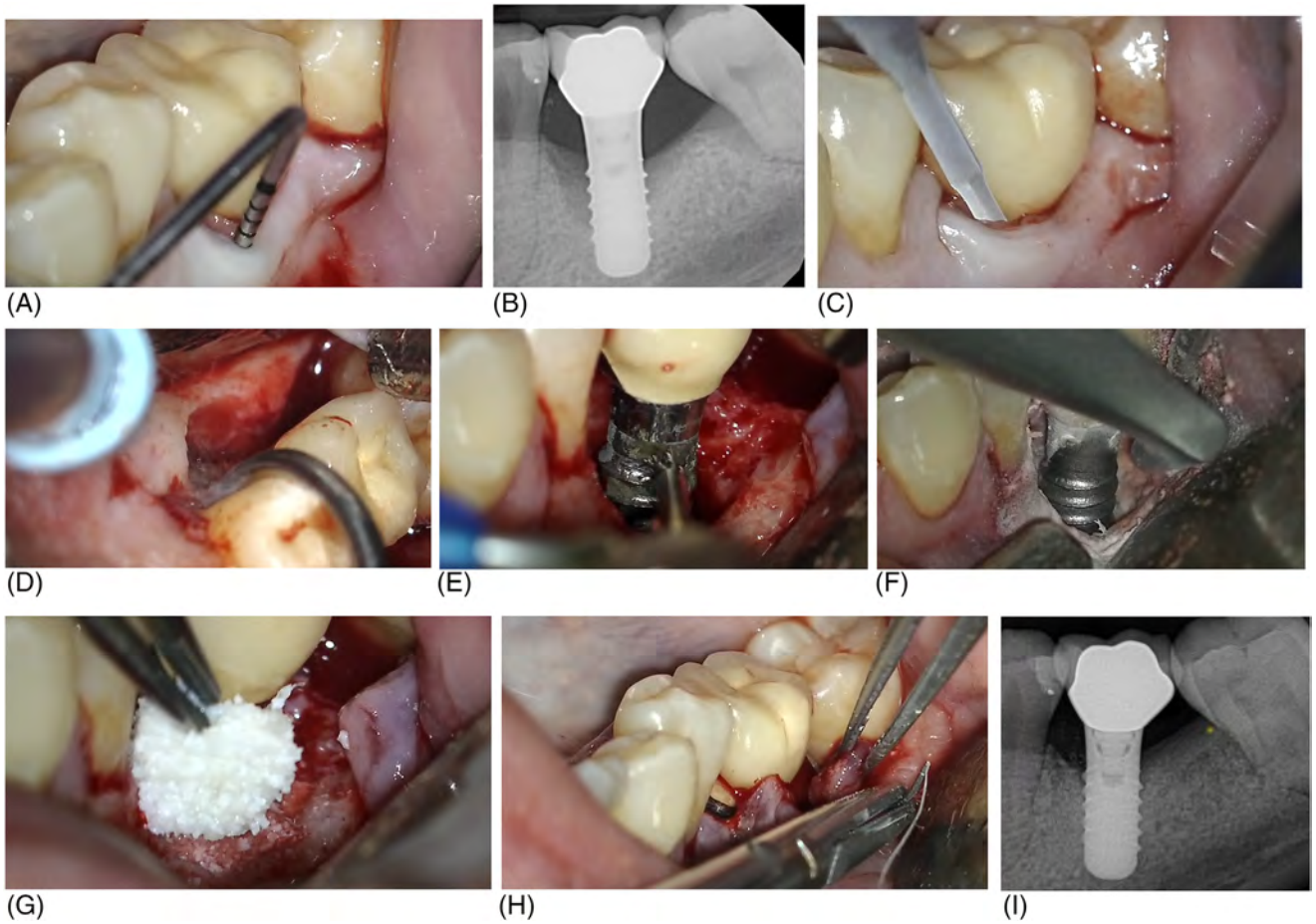

FIGURE 3 **A reconstructive approach for treating peri-implantitis of implant #30**. (A) The clinical photo showed probing depths of 10 mm. (B) The radiograph showed ~4–5 mm bone loss. (C) The surgical access was obtained with the implant crown in place. (D) After debridement, a well confined circumferential bone defect was observed. (E) The implant surface was detoxified utilizing US and titanium brushes under operating microscope (OM). (F) The implant surface was air abraded with glycine powder under OM. (G) A collagen bound xenograft was used to fill the bony defect. (H) 6-0 PTFE sutures were used to close the wound. (I) Peri-apical radiograph showed bone fill and increased bone density at 7-month follow-up.

of the primary wound closure attempts to land at a partial opening due to an avascular implant underneath the flap, making submerged primary closure less effective. As a result, the risks and benefits should be fully evaluated before deciding on a certain manner of flap closure. Clinical research is needed to address this dilemma.

Additionally, in this case series, all three cases were exclusively treated using mechanical methods (primarily piezoelectric ultrasonic device, supplemented by air polishing, titanium brush, and hand instruments if indicated) for surface decontamination. There are other chemical agents available for surface decontamination, such as chlorhexidine,[27] hydrogen peroxide,[28] sterile saline,[28,29] phosphoric acid,[29] citric acid,[28] and antibiotic gel.[28] However, current evidence has shown limited beneficial long-term clinical treatment outcomes.[27–29] For the peri-implant defect, when treating cases in the presence of suprabony defects, since no bone reconstruction is expected, resective therapy such as implantoplasty, may be indicated. The exposed implant threads are mechanically removed and polished, hypothetically leading to less plaque accumulation.[6] Creation of titanium particles, soft tissue recession, and weakening of the implant structure are among the drawbacks of implantoplasty.[30,31]

The use of dehydrated human de-epithelialized amnion-chorion membrane has been shown to promote healing due to its anti-inflammatory, angiogenic, antifibrotic, and antimicrobial properties, allowing for rapid revascularization, re-epithelialization, and bacterial inhibition.[32] In addition, this type of membrane has been shown to contain growth factors such as platelet-derived growth factor AA and vascular endothelial growth factor.[33] Therefore, it has been widely used for accelerating the healing of chronic open wounds in humans such as ulcers in legs,[34] cornea and sclera,[35] oral mucosal defects,[36] extraction sockets,[37] and localized horizontal ridge augmentation.[38] Practically, this membrane is easy to manipulate and is sufficient for small-sized and favorable circumferential bony defects. Trimming of the membrane is not needed; it is pliable and can adapt to the defect well. The thickness is adequate (300 um) when

hydrated, enough for tacking/fixating if needed, and does not interfere with wound closure.

The primary study limitation is related to the retrospective nature with only three cases and a potential case selection bias. Patients' systemic health, compliance, and favorable bony topography are the prerequisites for achieving predictable and successful long-term outcomes. Nevertheless, the use of the OM offers a sound clinical rationale and distinct advantages for treating peri-implantitis that could potentially translate into a more favorable and predictable clinical outcome.

CONCLUSIONS

This case series demonstrates encouraging resolution of inflammation, pocket reduction, and radiographic fill in the short term for the treatment of peri-implantitis with microsurgical reconstruction therapy assisted by the OM. The perceived benefits of using the OM include etiology and bony defect identification, detailed implant surface debridement, and minimally invasive tissue handling and suturing. Given the desperate need for regenerating lost bone due to peri-implantitis, this approach could shed light on achieving predictable outcomes and improving implant prognosis.

AUTHOR CONTRIBUTIONS

Yi-Chen Chiang contributed to data analysis, data interpretation, manuscript preparation, and final approval of the manuscript; Benyapha Sirinirund contributed to data interpretation, manuscript preparation, and final approval of the manuscript; Amanda Rodriguez contributed to data interpretation, manuscript preparation, and final approval of the manuscript; Diego Velasquez contributed to data collection, data interpretation, manuscript preparation, and final approval of the manuscript; Hsun-Liang Chan contributed to the conception of the work, data analysis, manuscript preparation, and final approval of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

PATIENT CONSENT STATEMENT

We received verbal and written consent for treatment provided by all three patients.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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