Regeneration of Peri-implantitis Infrabony Defects: Report on Three Cases

Shih-Cheng Wen, DDS, MS
Wen-Xia Huang, DDS, PhD
Hom-Lay Wang, DDS, MSD, PhD

This paper presents a surgical treatment protocol known as EP-DDS (etiologic identification, primary wound closure, debridement, decontamination, and stability of wound). The treatment protocol can be achieved in five steps. First, identify etiologic factors associated with peri-implantitis to determine whether or not the defects can be treated with this protocol. Second, in order to achieve primary wound coverage, ensure there is undisturbed wound healing, which may involve using procedures such as removing an existing prosthesis and performing tension-releasing flap design. Third, perform proper debridement of the inflamed granulomatous tissues to ensure the wound is free of any inflamed remnants. Fourth, conduct implant-surface decontamination by using a titanium brush or lasers. And finally, place appropriate space fillers (bone grafts and membrane) for wound stability. The three cases that have been successfully treated with the EP-DDS surgical protocol suggest it is a feasible surgical approach to obtain good infrabony defect bone fill (5.5-mm average) around the defects (buccal, mesial, lingual, and distal). Nonetheless, future randomized clinical trials with larger sample sizes and longer follow-ups are needed to further validate this treatment protocol.


Implant therapy has become a routine clinical procedure, but peri-implant diseases associated with implant therapy have become a challenge for every implantologist. Based upon recent world workshop classification, peri-implantitis has been regarded as a plaque-associated disease that affects both soft and hard peri-implant tissues.1,2 Derks and Tomasi3 demonstrated that peri-implantitis has a prevalence of 21.7% at the patient level. The etiology factors associated with peri-implant diseases remain unknown, which is why the treatment of peri-implantitis is still largely unpredictable. Recent literature has shown nonsurgical treatments have only limited efficacy.4,5 Although surgical protocols achieve better clinical outcomes, they remain unpredictable and limited.6–8 In addition, the long-term success rate of both treatments was lower than 60%.7–9

Successfully regenerating a peri-implantitis infrabony defect requires a thorough understanding of both the etiology causing the peri-implantitis defects and the defect morphology. With this understanding, the main instigating factors can be removed and the proper defect types (eg, circumferential or two- or three-walled infrabony defects)10 can be identified to better assist predictable regeneration.

1Taipei Medical University, Taipei, Taiwan; Private Practice, Taipei County, Taiwan, Republic of China.
2Periodontics Department, Xiamen Stomatological Hospital, Xiamen, China.
3Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, Michigan, USA.

Correspondence to: Dr Hom-Lay Wang, Department of Periodontics and Oral Medicine, University of Michigan School of Dentistry, 1011 North University Avenue, Ann Arbor, MI 48109-1078, USA. Email: homlay@umich.edu

Submitted January 5, 2019; accepted February 12, 2019. ©2019 by Quintessence Publishing Co Inc.
Though plaque is regarded as the primary cause (precipitating factor) for peri-implantitis, there are also contributing predisposing factors—such as wrong implant position (eg, too buccal or lingual, too close or deep); surgical trauma (eg, overheating, high insertion torque); difficult prosthesis cleaning due to improper design (eg, residual cement, over-contoured, etc); lack of keratinized mucosa and inadequate mucosa thickness (≤ 2 mm); patient characteristics (ie, smoking or diabetes); and foreign body reactions from residual titanium particles or the titanium itself—that may predispose a patient to plaque accumulation and lead to the development of peri-implantitis lesions. Although some of these factors remain controversial, it is important to control or remove these factors to ensure predictably of regenerated peri-implantitis defects.

For predictable bone regeneration, as the authors previously published, a PASS (primary wound closure, angiogenesis, space creation and maintenance for regeneration and wound stability) principle must be followed. The same principle also applies when regenerating peri-implantitis defects. The authors recently adopted a similar concept by considering the peri-implantitis etiology and PASS principle to develop the EP-DDS (etiology identification, primary wound closure, debridement, decontamination, and stability of wound) protocol for the regeneration of peri-implantitis defects. The purpose of this case series report is to illustrate this treatment protocol and provide case demonstrations on EP-DDS treatment protocol for successful regeneration of peri-implantitis infrabony defects.

**Materials and Methods**

**Description of EP-DDS Treatment Procedures**

After confirming that the implants have defects associated with peri-implantitis, a clinician must determine first whether or not the defects can be treated with a regeneration procedure. The indications for the proposed treatment protocol include but are not limited to vertical defect with surrounding bony walls, Schwarz et al Class I defect infrabony classification, and defects located within the bony housing either with or without buccal or lingual bony walls. Defects that are outside of bony housing, such as Schwarz et al Class II suprabony defect, and defects beyond the line drawn between two adjacent bone contours are not suitable for this approach. In these situations, clinicians may need to decide if they will perform implantoloplasty or remove the diseased implant.

Second, once the treatment decision is made, a primary wound closure must be achieved in order to have a predictable treatment outcome as suggested in the PASS principle of guided bone regeneration (GBR). This suggests that clinicians have to remove the existing prosthesis and perform tension-release flap designs so the flap can be closed tension-free to ensure undisturbed wound healing for at least 6 to 9 months.

Third, thorough debridement of the inflamed granulomatous tissues must be performed by using curets or a dental laser, such as the Erbium:YAG (Er:YAG) laser, to ensure the wound is free of any inflamed remnants.

The fourth step is conducting implant surface decontamination by using a titanium brush, an implantoplasty bur (Brasseler) if the implant is above the existing adjacent bone levels, or dental lasers. The authors feel that all three instruments have shown they are capable of removing implant surface contaminants.

Lastly, the appropriate space fillers must be placed and covered with membrane to ensure there is space for bone to grow as well as to achieve wound stability. In the EP-DDS approach, the authors adopted the GBR protocol proposed by Urban et al: A 1:1 mixture of autogenous bone graft and mineralized bone (ie, Cerabone, Botiss; or BioOss, Geistlich) was placed and covered with dense polytetrafluoroethylene (dPTFE) (Osteogenics Biomedical); fixation pins were clinically applied to ensure wound stability and space maintenance.

A proper healing time is required for bone to grow and form. Generally speaking, a healing time of 6 to 9 months is needed. In these three cases, an 8-month healing period was given, and the outcomes were very successful.
Table 1: Comparison Between Pre- and Posttreatment (Reentry) of All Three Patients and Six Peri-implantitis Defects

<table>
<thead>
<tr>
<th>Patient</th>
<th>Implant sites (FDI system)</th>
<th>Buccal (mm)</th>
<th>Lingual (mm)</th>
<th>Mesial (mm)</th>
<th>Distal (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Tx</td>
<td>Post-Tx</td>
<td>Change</td>
<td>Pre-Tx</td>
<td>Post-Tx</td>
</tr>
<tr>
<td>1</td>
<td>46</td>
<td>4.4</td>
<td>1.4</td>
<td>3.0</td>
<td>3.6</td>
</tr>
<tr>
<td>1</td>
<td>47</td>
<td>7.7</td>
<td>0.0</td>
<td>7.7</td>
<td>8.7</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>7.3</td>
<td>0.0</td>
<td>7.3</td>
<td>7.5</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>3.3</td>
<td>0.0</td>
<td>3.3</td>
<td>3.7</td>
</tr>
<tr>
<td>3</td>
<td>46</td>
<td>2.8</td>
<td>0.0</td>
<td>2.8</td>
<td>3.7</td>
</tr>
<tr>
<td>3</td>
<td>47</td>
<td>6.9</td>
<td>0.0</td>
<td>6.9</td>
<td>5.1</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>5.4 ± 2.0</td>
<td>0.1 ± 0.6</td>
<td>5.4 ± 2.0</td>
<td>5.4 ± 2.0</td>
<td>0.3 ± 0.0</td>
</tr>
<tr>
<td>Overall gain</td>
<td>5.5 ± 0.3</td>
<td>0.0 ± 0.0</td>
<td>5.5 ± 0.3</td>
<td>5.5 ± 0.3</td>
<td>0.0 ± 0.0</td>
</tr>
</tbody>
</table>

**Results from Three Treated Cases**

Table 1 summarizes pre- and post-surgery measurements as well as gains in each defect (buccal, lingual, mesial, and distal). In summary, at the time of peri-implantitis, an average of 55.2% ± 3.8% (5.4 ± 0.2 mm) of bone loss was found (buccal: 55.3% ± 20.8%; lingual: 55% ± 17.8%; mesial: 60.5% ± 19.9%; and distal: 49.7% ± 15.9%). However, after EP-DDS treatment, an average bone gain of 96.0% ± 1.3% (5.5 ± 0.3 mm) was achieved (buccal: 94.7% ± 11.9%; lingual: 94.5% ± 12.0%; mesial: 97.3% ± 6.1%; and distal: 97.2% ± 6.2%) based upon reentry measurements. This was further confirmed by three-dimensional cone beam computed tomography (CBCT). In order to focus on presenting clinical data related to bone regeneration, the authors decided not to report all clinical parameters documented in this three-case report, as the sample size is too small to have any meaningful scientific value. Nonetheless, clinical probing pocket depths before and after treatment are presented in Appendix Table 1 (see Appendix in the online version of this article at www.quintpub.com/journals). Most treated sites had 100% bone regeneration, and some had bone growth to the fixture level, which was occupied by a smooth surface; this clearly indicates that the proposed treatment protocol can be very effective in treating these types of peri-implantitis vertical defects.

**Case 1**

A 67-year-old man had implants placed in the mandibular right posterior area (teeth sites 46 and 47, FDI system) in November 2004. After 12 years in function, a peri-implantitis defect was noted in April 2016 and treated with the EP-DDS treatment protocol. Medical history evaluation did not reveal any relevant findings. Dental and periodontal examinations showed the presence of severe gingival inflammation was on the related peri-implantitis defect. After an 8-month healing period, reentry surgery showed an average gain in vertical height of 4.1 mm on the defect at implant site 46, and an 8.4-mm gain was found at implant site 47 (Table 1). This was further confirmed by comparing CBCT scans taken before and after treatment. Representative surgical procedures are shown in Fig 1.

**Case 2**

A 58-year-old male had implants placed in the mandibular left posterior area (teeth sites 35 and 36) in August 2008. After 8 years in function, a peri-implantitis defect was found in March 2015 and was treated with the EP-DDS treatment protocol. Medical history evaluation did not reveal any relevant findings. Dental and periodontal examinations...
showed severe gingival inflammation on the related peri-implantitis defect. After a healing period of 8 months, reentry surgery showed average vertical-height gains of 7.2 mm and 3.4 mm on the defect at sites 35 and 36, respectively (Table 1). This was further confirmed by comparing CBCT scans taken before and after treatment. Representative surgical procedures are shown in Fig 2.

Figs 1a to 1c  (a) Initial periapical radiograph showing vertical bone loss in both implants at tooth sites 46 and 47 (FDI system). The peri-implantitis defects can be seen in the (b) clinical and (c) three-dimensional CBCT images.

Figs 1d to 1k  (d) A flap was reflected, and granulomatous tissues were removed by curets, clearly showing the significant vertical defects on both implants. (e) An implantoplasty bur was used to smooth implant threads above the remaining bone level. After the implant surface was detoxified using a titanium brush (R Brush, Neobiotech) and an Er:YAG laser (AdvErL EVO, J. Morita), it was then irrigated with normal saline prior to bone graft placement. (f) A 1:1 combination of mineralized bovine bone (Cerabone, Botiss) and autogenous bone grafts, obtained from adjacent surgical sites by using a scraper or bone collector, was placed on the defects to the bone level. (g) A titanium-reinforced dPTFE membrane was carefully trimmed to avoid any contact with adjacent teeth and secured with four titanium pins. (h) Primary wound coverage was achieved using a tension-releasing flap design. (i) Reentry was performed 8 months later, showing intact dPTFE membrane that protected the wound uneventfully. (j) After dPTFE membrane removal, bone regeneration up to the fixture level was seen. (k) Posttreatment CBCT confirmed both infected implants (46 and 47) achieved 100% bone regeneration to the fixture level.
Case 3

A 61-year-old man had implants placed in the mandibular right posterior area (teeth sites 46 and 47) in April 2005. After 13 years in function, a peri-implantitis defect was noted in January 2018 and was treated with EP-DDS treatment protocol. Medical history evaluation did not reveal any relevant findings. Dental and periodontal examinations showed severe gingival inflammation on the related peri-implantitis defect. After a healing period of 8 months, reentry surgery showed average vertical-height gains of 4.8 mm and 5.5 mm on the defect at sites 46 and 47, respectively (Table 1). This was further confirmed by comparing CBCT scans taken before and after treatment. Representative surgical procedures are shown in Fig 3.

Discussion

Different types of surgical interventions have been attempted for the treatment of peri-implantitis defects; however, no technique has been reported to predictably regenerate lost bone. The proposed surgical treatment protocol (EP-DDS) presented in this three-case report demonstrates it is a great approach for regenerating vertical defects associated with peri-implantitis. This is because the proposed treatment controls all possible variables and provides a good environment for the bone to grow.

To define treatment success, it is important to identify the etiologic
factors associated with the defects and to remove them prior to initiating treatment. This means the clinician needs to properly select the right indications for this approach. In the three present cases, two of the main contributing factors for peri-implantitis were an over-contoured crown (emergence angles of 60 degrees buccally and 68 degrees lingually) and the lack of keratinized mucosa. As illustrated in Katafuchi et al, an emergence angle ≥ 30 degrees poses a risk of developing peri-implantitis due to inability to clean the implant.18 Furthermore, the authors’ previous study also indicated that a lack of keratinized mucosa increases the risk of having peri-implantitis.19 These precipitating factors have to be controlled in order to achieve long-term stability of bone regeneration. Defects that are within bony housing and can be conducible for regeneration are the ideal defects for the current proposed treatment protocol. Defects that are associated with malpositioned implants, especially buccally placed ones,18 should be treated with other approaches, such as implantoplasty.12 Removing the existing prosthesis and performing tension-free flap-release are key elements for ensuring undisturbed healing in primary wound closure.11 Techniques that are often employed in tension-releasing flap designs have been clearly described in the literature,13,14,20 hence they were not discussed in the current paper. It was previously reported that the amount of bone regenerated was negatively correlated to wound exposure21; thus, it is pivotal for clinicians to achieve primary wound closure to ensure a successful and predictable outcome.

It is highly difficult to properly clean and disinfect an infected implant surface, and removing existing inflamed granulomatous tissues is crucial in any regenerative procedure. A combination approach of mechanical devices such as curettes, titanium brushes, implantoplasty burs, and Er:YAG16 and CO2 lasers has been used for the EP-DDS protocol. Given the proven effectiveness of lasers, especially the Er:YAG laser, they are often used for decontaminating implant surfaces. The Er:YAG laser has demonstrated a strong ability to reduce uses of bactericides and photobiomodulation, which are used to disinfect contaminated implant surfaces.22,23 No chemical agents (ie, chlorhexidine, hydrogen peroxide, citric acid) were applied to the infected surface except normal saline irrigation after each approach. The authors did not highlight the differences between Er:YAG and CO2 lasers since there is no study currently available comparing the efficacy of the two dental lasers in their ability to disinfect contaminated implant surfaces. Future studies in this area are needed to determine which laser will be more effective in decontaminating an implant surface.

Following the above approach, the defects were then grafted with bone replacement grafts and covered with regenerative membranes. During the vertical GBR procedure, the authors adopted the concept advocated by Urban et al.13,14 One main difference between the two treatment methods is that Urban et al used non-infected defects whereas the present study included infected defects; however, after proper decontamination and disinfection protocols, the defects in the present study should have the same non-infected condition. This is actually supported by the results obtained in these three cases. The grafting material used in this approach was the 1:1 combination of mineralized bovine bone and autogenous bone grafts obtained from adjacent surgical sites using a scraper or bone collector. After the graft is in place, the areas are covered with a titanium-reinforced dPTFE membrane, which is properly trimmed to avoid touching the adjacent teeth. The dPTFE membrane is then secured and fixed with four to six titanium pins to ensure wound stability, which is important for bone regeneration.11 The rationale of selecting dPTFE instead of absorbable collagen membrane is due to its space-making capability as well as its membrane rigidity to properly protect and maintain the space underneath. Nonetheless, the authors also understood there are many different GBR treatment regimens that can be successfully used in regenerating a peri-implantitis infrabony defect. However, it is not the purpose of this case report to discuss which combination of GBR regimen is the best. There are currently controlled clinical trials designed to identify which types of bone graft of GBR membranes will produce the best results.

Furthermore, a healing time of at least 6 to 9 months was advocated.
This is because Urban et al reported that, upon reentry of vertical bone augmentation, it took 9 months for “baby bone” (also called immature bone) to form,\textsuperscript{13,14} and any early opening might be too premature for this combination of bone grafts and vertical bone to form. Hence, an 8-month healing period was adopted in the present protocol, and the reentry surgery confirmed the excellent clinical outcomes.

Conclusions

The results obtained from three cases treated with the EP-DDS surgical protocol showed the importance of identifying and removing associated etiological factors, achieving primary wound coverage during healing, executing good debridement and surface decontamination, performing good space maintenance, and achieving wound stability. These steps are essential to achieve predictable and successful treatment outcomes. However, additional scientific evidence is necessary before promoting further use of this technique.

Acknowledgments

Dr Wang occasionally speaks on behalf of J Morita and Osteogenics Bionedical. The authors declare no conflicts of interest.

References

### Appendix Table 1 Comparison Between Pre- and Posttreatment Probing Pocket Depths (in mm) of All Three Patients

<table>
<thead>
<tr>
<th>Patient</th>
<th>Implant site (FDI)</th>
<th>MB (mm)</th>
<th>Mid-B (mm)</th>
<th>DB (mm)</th>
<th>ML (mm)</th>
<th>Mid-L (mm)</th>
<th>DL (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Tx</td>
<td>Post-Tx</td>
<td>Change</td>
<td>Pre-Tx</td>
<td>Post-Tx</td>
<td>Change</td>
<td>Pre-Tx</td>
</tr>
<tr>
<td>1</td>
<td>46</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>47</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>7</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>46</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>47</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td></td>
<td></td>
<td></td>
<td>2.0 ± 1.3</td>
<td>2.2 ± 1.3</td>
<td>1.8 ± 1.5</td>
<td>2.3 ± 1.1</td>
</tr>
</tbody>
</table>

MB = mesiobuccal; Mid-B = middle-buccal; DB = distobuccal; ML = mesiolingual; Mid-L = middle-lingual; DL = distolingual; Tx = treatment; SD = standard deviation.

Negative numbers indicate increased probing pocket depth.