Biological Reset Protocol for the Regenerative Treatment of Advanced Peri-implantitis Defects: A Proof of Concept

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Abstract

This study presents the Biologic Reset Protocol (BRP), a reproducible workflow that integrates prosthetic and surgical phases to improve the predictability of regenerative treatment in intrabony peri-implantitis lesions. The protocol is designed to re-establish peri-implant conditions favorable to long-term tissue stability and proper implant function. The BRP is structured into three sequential phases: (1) a pre-surgical phase, involving the removal of the existing prosthesis to improve diagnostic accuracy, facilitate non-surgical decontamination, and promote soft tissue healing; (2) a regenerative surgical phase based on principles of guided bone and tissue regeneration, favoring a submerged healing approach. This phase involves meticulous implant surface decontamination using air-polishing to preserve the fixture's original biocompatibility, followed by the placement of particulate bone grafting combined, when necessary, with a stabilized membrane; and (3) a final prosthetic phase which may include prosthetic refinement or replacement to ensure biologically favorable design and prevent disease recurrence. By integrating current evidence with comprehensive biological, surgical, and prosthetic principles, the BRP offers a structured and predictable framework for the treatment of complex peri-implantitis cases, promoting both regenerative success and the long-term preservation of implant health. *Int J Periodontics Restorative Dent 2025. doi: 10.1160/prd.7923*

Keywords: bone regeneration, decontamination, dental implant, implant-supported dental prosthesis, peri-implantitis

Introduction

Peri-implantitis is an inflammatory disease induced by bacterial biofilm, which affects the peri-implant supporting tissues. Clinically, it is characterized by bleeding on probing (BoP), suppuration, increased probing depths, progressive bone loss, and frequently, soft tissue recession.[1] If not treated, peri-implantitis can lead to implant loss.

The treatment of peri-implantitis generally follows a stepwise approach, similar to that employed for periodontitis. After addressing modifiable risk factors, submarginal instrumentation is recommended to reduce inflammation and optimize soft tissue conditions. However, the effectiveness of non-surgical therapy in achieving the clinical endpoint defined by the EFP guidelines (absence of residual pockets >5 mm and BoP) remains limited.1 Surgical therapy is often required to allow access for implant surface decontamination. Techniques include open flap debridement, resective, or regenerative procedures, and the use of adjunctive agents. Regenerative approaches aim to promote bone fill and re-osseointegration through the application of grafts, membranes, or bioactive materials.[2] Nonetheless, treatment outcomes remain inconsistent due to the heterogeneity of implant surfaces, surgical protocols, biomaterials, and defect morphologies. This variability has hindered the development of clear and consistent guidelines regarding the efficacy and optimal indications for each technique.

Despite active treatment, long-term disease control remains unpredictable. A 5-year study reported a 44% rate of recurrence and a 27% rate of implant loss following surgical therapy, with residual pockets ≥6 mm identified as the main predictor of failure.[3] Another prospective clinical study reported complete disease resolution in only 42% of cases at 5 years.[4] Evidence from the 10-year regenerative study shows that even under strict supportive therapy, implant survival was only 67% overall (80% for SLA, 55% for TPS), with treatment success limited to 29-42% and multiple cases requiring retreatment or implant removal.[5]

Given these challenges, there is a clear need to refine and standardize surgical strategies for peri-implantitis management. The present study introduces the Biologic Reset Protocol (BRP), an evidence-based regenerative approach designed to help clinicians achieve more predictable and stable bone regeneration in the treatment of intrabony defects at implants affected by peri-implantitis.

Presentation of the Protocol

The BRP was organized into three sequential steps (Fig 1). The first step is the pre-surgical preparation, which involves removal of the prosthesis, non-surgical biofilm control, and soft tissue closure. The second step is the surgical decontamination and reconstruction, integrating bone graft and guided bone/tissue regeneration principles to re-establish hard and soft tissue support. After healing, a re-entry evaluation is performed to assess the degree of bone fill and, if necessary, to carry out additional regenerative intervention. Finally, the protocol concludes with prosthetic re-establishment, ensuring a design that favors long-term cleansability and biological stability. All clinical cases to illustrate the technique were reported according to the CARE guidelines.[6]

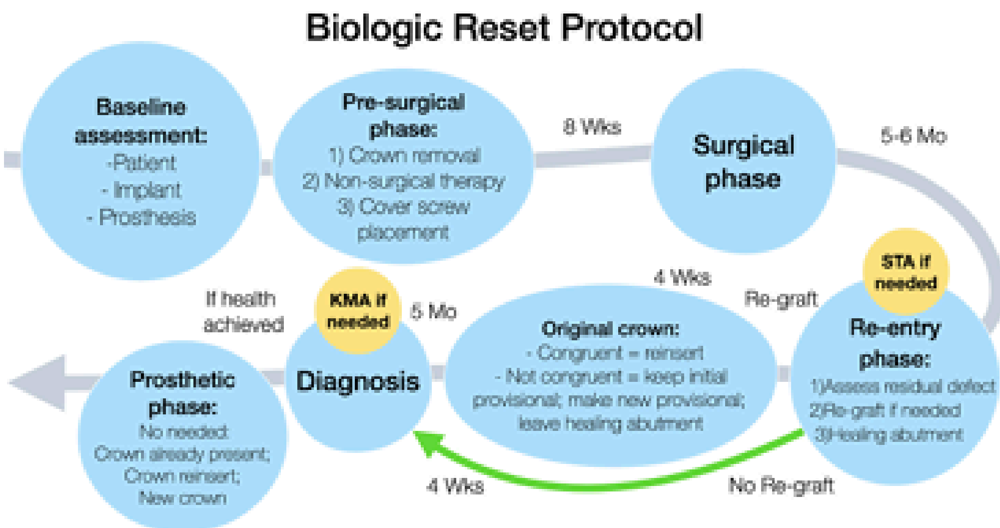

Fig 1 Flowchart of the Biologic Reset Protocol. STA - soft-tissue augmentation (connective tissue graft or soft-tissue substitutes used to increase peri-implant mucosal thickness); KMA = keratinized mucosa augmentation (free gingival graft or soft-tissue substitutes used to increase the width of keratinized mucosa).

Baseline Assessment

Effective management of peri-implantitis begins with a thorough pre-surgical evaluation to assess implant maintainability and regenerative potential. This evaluation guides whether to retain or remove the implant and the decision on regenerative therapy. Critical parameters must be assessed at patient, implant, and prosthesis level. An unfavorable factor in any category may significantly compromise therapeutic success and must be carefully considered in treatment planning.

Patient-related factors

Evaluation of patient-related factors is essential to determine eligibility for regenerative surgical therapy around dental implants. Absolute contraindications include antiresorptive therapy in oncology patients, recent radiotherapy, severe immunosuppression, recent myocardial infarction or stroke, and recent prosthetic heart valve placement. According to EFP S3 guidelines, surgery should not be performed in non-compliant patients or those unable to maintain plaque control, as this increases the risk of inflammation, graft contamination, and failure.1 Smoking and diabetes are considered relative contraindications; regenerative therapy is discouraged in heavy smokers (>10 cigarettes/day) or poorly controlled diabetes (HbA1c ≥ 7%).[7–10]

Implant-related factors

Implant positioning

Implant position is critical for treatment planning, encompassing its buccolingual, apicocoronal, and mesiodistal aspects. Buccolingually, as described by Zucchelli et al. (2019), implants placed buccal to an imaginary line connecting the gingival margins of adjacent teeth, and with at least one missing or apically positioned papilla (Class IVc), often present with buccal bone dehiscence and soft tissue recession.[11] In such cases, in the presence of peri-implantitis, especially in the esthetic zone, implant removal may be the preferred option. Apicocoronally, implants positioned too shallow may compromise the design and function of the future prosthesis. Mesiodistally, when two adjacent implants affected by peri-implantitis are <3 mm apart, or an implant is excessively close to a tooth with attachment loss, horizontal bone volume may be insufficient for successful regeneration.[12–14]

Defect morphology

Careful assessment of peri-implant defect morphology is essential for treatment planning, and a Cone Beam Computed Tomography (CBCT) is recommended. Schwarz et al.[15] classified peri-implantitis defects as follows:

Class I (intrabony):

- Ia: buccal dehiscence
- Ib: buccal dehiscence + mesial/distal components
- Ic: buccal dehiscence + circumferential components
- Id: buccal and lingual dehiscence + circumferential components
- Ie: circumferential defect

Class II (suprabony): horizontal defects without intrabony component.

The present protocol is most suitable for the treatment of Class Ib, Ic and Ie defects, with or without a subrabony component (Class II). Approximately 25% of peri-implantitis lesions present with a combined intraosseous and suprabony morphology.[16] Class Ia defects, limited to a buccal dehiscence, can generally be managed with simpler regenerative approaches, since surgical access is not a limitation. In contrast, Class Id defects represent the least predictable scenario. When the circumferential component in a Class Id defect is shallow, the present protocol may be attempted; however, in advanced Class Id cases (greater than 50% of the implant length), implant removal or compromised therapy (open flap debridement) is often the most appropriate option[15]

Prosthesis-related factors

When a prosthesis impedes proper cleansability, exhibits misfit at the implant–abutment interface, and/or compromises esthetic outcomes, the possibility of removing and replacing it constitutes an essential component of the BRP, aimed at preventing refractory or recurrent disease. Specifically, an emergence angle greater than 30°, particularly when combined with a convex emergence profile, has been associated with an increased risk of peri-implant disease progression[17] and marginal bone loss,[18] especially when the abutment height is less than 2 mm. Moreover, Koutouzis et al. showed that mismatches at the implant–abutment interface can contribute to marginal bone loss, independently of the mesiodistal interimplant distance.[19] Whenever feasible, such prosthetic discrepancies should be corrected or modified during the post-surgical prosthetic phase, as detailed in Section 3.6.

Presurgical Phase

Crown removal

Removal of the prosthesis, irrespective of its functional adequacy, is the initial step of the BRP. The implant–abutment–prosthesis assembly must be regarded as a unified anatomical unit whose structural and functional characteristics directly affect peri-implant tissue health in the presence of biofilm.[20] To effectively arrest disease progression, all components of this unit require management.

Removing the prosthesis also enables a flap design that better preserves the soft tissues immediately surrounding the implant. When the crown is left in place, intrasulcular incisions constrained by its emergence profile prevents proper scalpel alignment parallel to the long axis of the implant, often resulting in excision of a diamond-shaped portion of soft tissue overlying the defect (Supplementary Fig 1a-i). This tissue is critical to protect the wound, and its loss may compromise the ability to achieve primary closure. Papilla preservation incisions may be similarly compromised, as the bulk of the prosthetic crown on the buccal and or lingual aspect can force the incision into a trajectory that leads to the loss of the soft tissue collar directly above the peri-implant defect (Supplementary Fig 1h,i). Additionally, applying a papilla preserving approach with the prosthesis in place increases the risk of tearing during flap elevation or subsequent necrosis during healing, considering that the area of granulation tissue around an implant is much larger than around teeth (Supplementary Fig 1j-o). In line with this, Cortellini et al. (2021) demonstrated the effectiveness of minimally invasive techniques and papilla preservation strategies for the treatment of peri-implant intrabony defects, and all surgeries were performed after crown removal, underscoring the importance of this step.[21]

Therefore, prosthesis removal offers several clinical advantages across different phases of treatment:

- Diagnostic phase: It improves the accuracy in assessing probing pocket depth and the extent of peri-implant bone defects[22]

- Non-surgical phase: It enhances access for thorough mechanical debridement and effective implant surface decontamination

- Surgical phase: It facilitates more precise flap design, enhances access for effective implant surface decontamination, and allows for predictable primary wound closure

- Postoperative phase: It optimizes plaque control and bone regeneration[23]

In esthetic areas, the use of a provisional restoration with minimal or no contact with the mucosa (eg, Maryland bridge or Essix retainers) is recommended to maintain esthetics during the treatment.

Non-surgical therapy

Unlike periodontal therapy where favorable outcomes are generally predictable,[24] the success of non-surgical peri-implant therapy (NSPIT) remains inconsistent and often limited.[25,26] In a randomized multicenter trial of 53 implants, Romandini et al. reported that subgingival therapy yielded minimal or no improvements at 6 weeks, with only 26.9% of implants achieving the composite endpoint of no bone loss > 0.5 mm, absence of bleeding or suppuration on probing, and probing depth ≤ 5 mm.[27] Subsequent studies confirmed these limited outcomes.[1,28,29]

Despite its limitations, NSPIT is essential for reducing supra- and subgingival biofilm and controlling soft tissue inflammation and texture prior to surgical therapy.[30] To accomplish this goal while preserving the implant surface biocompatibility, the present protocol recommends the use of air powder abrasive (APA) with erythritol powder.[31] The APA device equipped with a plastic subgingival nozzle directs the powder jet perpendicularly to the implant surface from the nozzle tip, which is rotated circumferentially (360°) around the implant to ensure complete coverage. Mucosal compression with the fingers and thumb is advised to minimize air penetration into the loose connective tissue, particularly when there is no keratinized gingiva, to reduce the risk of emphysema.

Cover screw placement

Following NSPIT, placement of a cover screw and an 8-week healing phase are recommended to promote tissue maturation and coronal migration of the keratinized mucosa. Before the insertion of the cover screw, the application of 1% chlorhexidine (CHX) gel or 0.2% CHX rinse into the internal cavity of the implant is recommended.[32] The coronal maturation of the peri-implant tissue, along with the potential increase in keratinized mucosa, may lead to partial or complete coverage of the cover screw. This reduces the need for extensive flap release during surgery, preserving keratinized tissue while still enabling primary closure.

Surgical Phase

After an average healing period of 8 weeks following non-surgical therapy, three clinical scenarios may be encountered: (A) the cover screw is completely covered by peri-implant mucosa (Supplementary Fig 2a); (B) a more or less pronounced operculum persists on the mucosa overlying the fixture (Supplementary Fig 2b); or (C) the cover screw remains partially exposed (Supplementary Fig 2c). Complete coverage of the cover screw is generally associated with a thick gingival phenotype, whereas partial exposure is more frequently observed in the presence of a thin gingival phenotype.

Regardless of the clinical scenario, in mandibular sites the incision is performed at the mid-crestal level (Supplementary fig 1p-r). In maxillary sites, however, when the mucosa has completely covered the cover screw (scenario A), creating a continuous tissue bridge between the buccal and palatal flaps, the incision may be shifted 2 mm buccally. As described by De Stavola et al. (2021), shifting the incision buccally according to the defect morphology enhances the adaptation of the inner aspects of the palatal and buccal flaps and reduces the risk of non-primary wound healing.[33] In contrast, in the presence of scenario B or C at a maxillary site, the incision is also made at the mid-crestal level, passing through or tangential to the soft tissue fenestration.

The buccal incision is extended intrasulcularly to one or more adjacent teeth, both mesial and distal to the defect, depending on its corono-apical extension. If needed, a "hockey stick"-shaped vertical releasing incision is performed at the mesio-buccal line angle of the flap and extended 2–3 mm past the mucogingival junction. A second vertical releasing incision may be done distally to improve access and visibility, to facilitate membrane handling and stabilization, and to promote coronal advancement of the flap. The lingual incision is performed intrasulcularly, extending to one or two teeth mesial and distal to the defect, at the clinician's discretion, based on the level of access required to adequately approach the site. For instance, the absence of the buccal or lingual bony wall and a defect extending deeply in the apical direction may warrant either a second buccal vertical releasing incision distally or an extended intrasulcular incision involving two teeth both mesially and distally on both buccal and lingual aspects.

Flap elevation begins as a full-thickness flap at the mesio-buccal angle of the incision and progresses distally, with elevation temporarily interrupted at the defect. The distal portion is then reflected from the disto-buccal angle up to the defect area. Granulation tissue from the defect, in continuity with the flap, is carefully separated using a scalpel blade. Subsequently, the flap is further elevated by an additional 2-3 mm in an apical direction, maintaining a full-thickness design. In Class Ie intraosseous defects,[15] where both buccal and lingual bone walls are preserved, the entire flap elevation remains full thickness. The lingual flap is elevated in the same manner after completing the buccal approach.

Granulation tissue is removed circumferentially (360°) using a surgical stainless-steel curette with vertical and horizontal strokes. In the horizontal approach, the curette tip is directed apically while maintaining contact with the bone, and the cutting edge is oriented toward the implant surface but kept away from it, avoiding any direct instrumentation of the implant threads.

To prevent excessive bleeding during suturing and reduce the risk of postoperative hematoma, periosteal releasing incisions are performed at this stage of the surgical procedure to achieve tension-free advancement of the buccal flap. In defects where the use of a membrane is recommended (Class Ib, Ic, and Id defects), the buccal flap release may be performed in two different ways, depending on the membrane stabilization technique selected. If the membrane is to be stabilized using titanium or stainless-steel pins, the entire elevation of the buccal flap can be accomplished as a full-thickness flap. To release it, a 0.5 mm deep incision is performed at the base of the buccal flap on the periosteal side, thereby creating a coronal and an apical segment. Lateral extension of the coronal portion is attained by applying sweeping pressure with a blunt instrument (such as a Buser periosteal elevator) while simultaneously applying lateral traction to the flap.[34] This approach allows controlled stretching within the submucosal plane, increasing flap mobility and facilitating passive advancement of the flap to the desired coronal position. Alternatively, if membrane stabilization will be achieved using sutures, as in the LASSO technique, once the defect is fully exposed and the flap has been elevated as a full-thickness flap extending 2-3 mm apical to the defect, a partial-thickness dissection is subsequently performed.[35] This is accomplished by keeping the scalpel blade parallel to the underlying bone surface, allowing for controlled separation of the overlying mucosa from the deeper periosteum. The retained periosteal layer, still adherent to the bone, can then serve as an anchorage site for the resorbable internal sutures.

Decontamination of the implant surface represents a critical phase in the resolution of peri-implantitis lesions and in achieving implant re-osseointegration. An 2025 AAP/AO systematic review emphasized that an ideal protocol should aim to completely eliminate the biofilm from implant surfaces, while preventing titanium particle release, preserving the macro- and microstructure of the implant, and minimizing any residues left by the decontamination tools.31 Electrolytic cleaning and APA have shown the most consistent effectiveness, with robust evidence for promoting re-osseointegration in animal studies.[36–38] APA represents one of the most promising approaches for the effective removal of biofilm, including in difficult-to-reach areas such as the valleys of implant microthreads and the apical sides of the threads, where ultrasonic tips often fail due to their size.[39,40] Effective cleaning is achieved by directing the powder jet at 60–90° until the surface appears macroscopically clean.[41] However, when calculus deposits are visible, APA should be combined with mechanical instrumentation, such as a fine ultrasonic scaler to ensure complete decontamination.

Once adequate decontamination of the implant surface is achieved, the angular component of the defect is filled with either a xenograft or allograft. Several randomized controlled trials and systematic reviews demonstrated that grafting provides superior radiographic bone fill and improvement in marginal bone levels compared to open flap debridement alone.[42–45] The 2021 EAO Consensus Report also reported less soft tissue recession with reconstructive approaches.[46] Although the ideal graft material remains uncertain, evidence favors slowly resorbing grafts.4[7–49]

Regarding the use of barrier membranes, the evidence remains heterogeneous. Some studies have shown no additional clinical benefit from covering the graft in peri-implant defects treated with reconstructive procedures.[50,51] However, while membranes may not be necessary for contained four-wall (Class Ie) defects, in two- (Class Id) or three-wall defects (Class Ib and Ic), membrane use is recommended by the authors to improve defect containment and stabilize the graft material.[52] The membrane should then be secured using one of the techniques previously described, which will also influence the flap release and coronal advancement strategy.

Once the membrane has been stabilized, the previously released flap can be coronally advanced to achieve tension-free primary closure, thereby facilitating submerged healing in accordance with the principles of guided bone regeneration (GBR).[53] Non–plaque-retentive and non- or slowly resorbable sutures (e.g., nylon, polypropylene, or PTFE) are recommended.

Horizontal or vertical internal mattress sutures should be placed in the intermediate portion of the flap to ensure optimal adaptation and stability, followed by single interrupted sutures for final closure. Vertical releasing incisions should also be closed with interrupted sutures, preferably angled, with the entry point positioned more apically on the flap and the exit point more coronally on the adjacent, non-reflected gingival tissue. This technique helps promote coronal traction and stabilization of the flap margins at these sites as well.[54]

Suture removal is scheduled at 3 weeks. However, at the surgeon's discretion, based on the quality of healing observed at the treated site, removal may reasonably be performed anytime within a 2- to 3-week interval. The absence of infection or suppuration is key for the success of the technique. Additionally, achieving and maintaining full soft-tissue closure is considered ideal; however, minor dehiscence or small membrane/graft exposure at this stage may still be compatible with favorable outcomes, provided the area remains clean and free of inflammation. Following suture removal, the patient undergoes professional mechanical plaque control, with maintenance visits scheduled every three months.

Radiographic evaluation and the re-entry procedure are carried out at 5-6 months postoperatively according to the defect size.

Postoperative Care

Patients are instructed to avoid brushing the treated area and the immediately adjacent teeth for a period of 15 days. A systemic antibiotic regimen of amoxicillin 500 mg (3 times daily for 7 days) is prescribed. Analgesic and anti-inflammatory therapy with ibuprofen 600 mg (1 tablet every 4-6 hours) is recommended as needed. Home oral hygiene around the surgical area is resumed 4 weeks postoperatively.

Re-entry Phase

One of the advantages of the presented protocol is that, by employing a submerged protocol, a second intervention is required to uncover the implant and place the healing abutment. This step allows for direct clinical evaluation of the extent of bone fill. In addition, complete submergence of the surgical site may facilitate bacterial isolation during the early healing phase. A recent study by Ichioka et al. (2024) highlighted that effective early plaque control is a critical determinant of favorable outcomes in peri-implantitis surgery. The presence of plaque 6 weeks after surgery was shown to adversely affect peri-implant healing, being associated with increased BoP and deeper residual PPD.23

Reconstructive therapy for peri-implantitis achieves clinical success in a variable proportion of cases, ranging from approximately 15-60%, with defect fill between 24-57% of the intrabony component.[45,55,56] While the primary therapeutic endpoint remains the resolution of peri-implant disease, one of the key aims of the present protocol is to achieve complete bone fill of the intrabony defect, as this may reduce the risk of recurrence by avoiding residual exposed implant threads within the infraosseous portion. Evidence from healthy sites suggests that visible interproximal implant threads after physiological bone remodeling could predispose to peri-implantitis57, supporting the rationale for seeking complete defect fill.

After an average healing period of 5-6 months, three scenarios may be encountered at the re-entry procedure:

1. Complete fill of the intrabony component or residual intrabony component <3 mm: the uncovery procedure consists solely of replacing the cover screw with the healing abutment. Diagnostic reassessment and evaluation of endpoint achievement defined by the EFP S3 clinical

guidelines (probing depth <5 mm, absence of BoP and/or suppuration, and <0.5 mm additional marginal bone loss) can be performed 6-8 weeks after soft tissue closure.

2. Partial bone fill with persistence of an intrabony component ≥ 3 mm: both buccal and lingual full-thickness flaps are reflected using an envelope design without vertical releasing incisions on the buccal aspect if defect morphology allows. Implant surface decontamination is repeated, and the defect is grafted with or without a collagen membrane. If a membrane is used, it may be perforated with a sterile punch and stabilized over the defect by means of a healing abutment, using the so-called "poncho-like" technique. Although a non-submerged healing protocol is chosen in this scenario, limited flap release may be accomplished to enhance soft tissue adaptation. According to the authors' experience, the second surgical intervention substantially increases the likelihood of complete bone fill within the defect, thereby enhancing the chances of achieving the 2023 EFP composite therapeutic endpoint, which can then be assessed 5-6 months after regrafting.[1]

Refractory peri-implantitis: implant removal may be the most predictable option.

Management of the suprabony compartment might also be considered at re-entry. In posterior sites, implantoplasty could be performed to smooth and polish exposed implant threads, thereby reducing surface roughness and plaque retention; however, findings remain contradictory, with concerns about titanium particle release, implant weakening, and uncertain long-term outcomes.[58–60]

Soft Tissue Augmentation Strategies

The presence of > 2 mm of keratinized mucosa width and adequate thickness of the peri-implant mucosa are known to be facilitating factors for the long-term maintenance of peri-implant health.

- Connective tissue graft (CTG): The use of a CTG is indicated at the time of re-entry when keratinized mucosa is sufficient but additional thickness is required, or in esthetically sensitive areas to reduce tissue contraction.

- Free gingival Graft (FGG): The FGG is indicated when keratinized mucosa is inadequate. It should be performed once peri-implant health has been confirmed at the diagnostic evaluation following treatment, and before initiating the prosthetic phase.

Prosthetic Phase

After soft tissue healing, the prosthetic phase is initiated. The steps in this phase are determined by the baseline assessment of the prosthesis and its removability without damage. Establishing a biologically and functionally appropriate prosthetic design is crucial for long-term peri-implant stability, as inadequate contours have been consistently associated with peri-implant inflammation, marginal bone loss, and disease recurrence.[17,18,61] Furthermore, de Tapia et al. demonstrated that modifying prosthetic contours, when combined with biofilm removal, resulted in improved clinical outcomes in comparison to hygiene measures alone on the management of peri-implant mucositis.[62,63]

The prosthetic phase of the BRP requires a tailored approach depending on the healing pattern and whether a second grafting procedure was performed.

- If no re-grafting was needed and a healing abutment has been placed during re-entry, diagnostic assessment may be anticipated at 4-6 weeks. In cases where peri-implant health is confirmed, the clinician may proceed with provisionalization and subsequent delivery of the definitive prosthesis.

When a re-grafting procedure is performed, 4–6 weeks post-grafting the clinician may choose among three options:

1. Maintain the provisional restoration (e.g., Maryland type) fabricated during the pre-surgical phase, particularly in esthetic sites;

2. Reinsert the original prosthetic crown if it was deemed adequate at baseline assessment;

3. Fabricate a new provisional crown to optimize soft tissue conditioning and cleansability.

In all three scenarios, the definitive evaluation of treatment outcomes should be postponed to 6 months after re-entry to allow full tissue maturation. In scenarios 1 and 3, once healthy conditions are confirmed, the final prosthesis can then be fabricated, whereas in scenario 2, the reinserted crown already serves as the definitive prosthesis.

Diagnosis Post Treatment

Following the treatment of peri-implantitis, implants can be classified according to the advanced diagnostic framework proposed by Ravidà et al. (2020), which identifies five potential clinical outcomes64:

- peri-implant health after complete regeneration,
- peri-implant mucositis after complete regeneration,
- peri-implant health with a reduced support,
- peri-implant mucositis with a reduced support,
- recurrent or refractory peri-implantitis

After diagnosis, the patient must be enrolled in a tailored and structured supportive periodontal care program for tertiary prevention of peri-implantitis, ensuring long-term monitoring and maintenance of peri-implant health.

Three representative clinical cases were selected to illustrate the protocol in a step-by-step manner (Figs 2, 3 and Supplementary Fig 3).

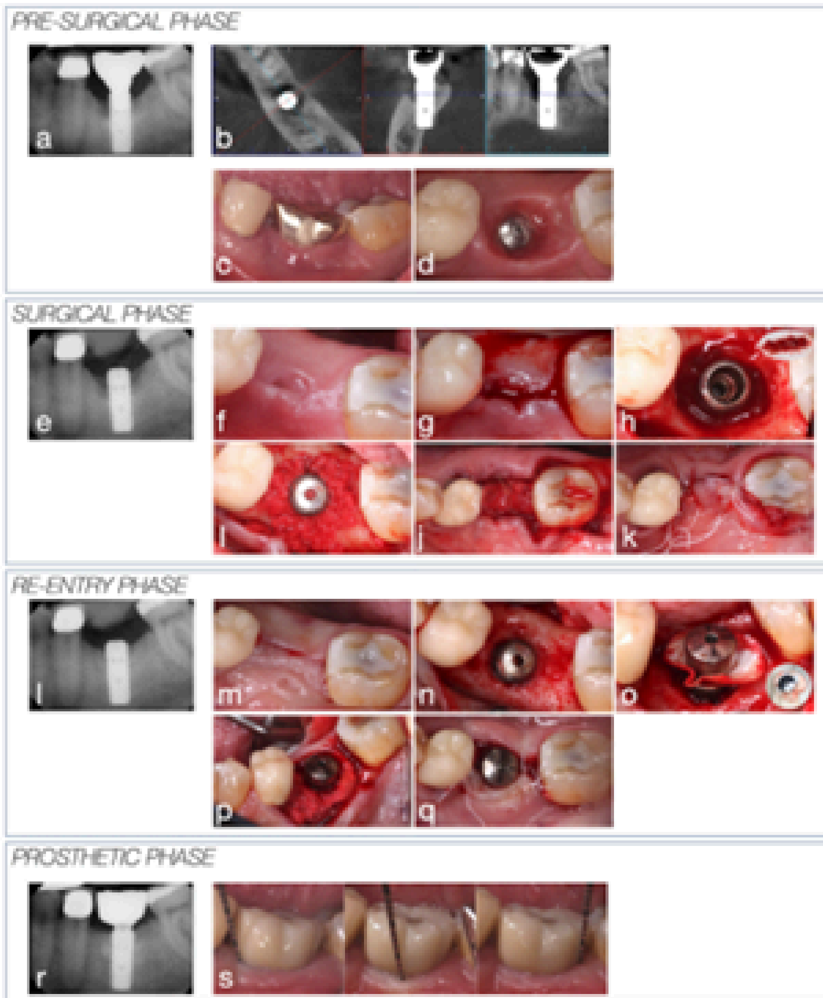

Fig 2 Clinical case – Defect Ie. a) Baseline periapical radiograph, b) CBCT scan, and c) clinical image of an implant affected by peri-implantitis in the position of the left mandibular first molar; d) Removal of the cemented prosthetic crown and placement of the cover screw prior to non-surgical therapy. e) Pre-surgical radiograph of the implant; f) clinical image of the soft tissues showing persistence of a small operculum overlying the cover screw, 8 weeks after non-surgical therapy; g) mid-crestal incision; h) degranulation of the peri-implant defect; i) placement of the bone graft; j) placement of the collagen membrane stabilized with periosteal sutures using the "LASSO" technique; k) flap suturing. l) Radiograph at 6 months after the initial surgical phase; m) Mid-crestal incision; n) re-entry visualization of the degranulated intrabony defect, demonstrating approximately 90% bone fill; o) stabilization of

the collagen membrane with the healing abutment using the "poncho-like" technique; p) placement of the bone graft beneath the membrane; q) flap suturing. r,s) radiographic and clinical images showing the new screw-retained prosthetic crown at 3 years of follow-up. Diagnosis after treatment: peri-implant health after complete regeneration.

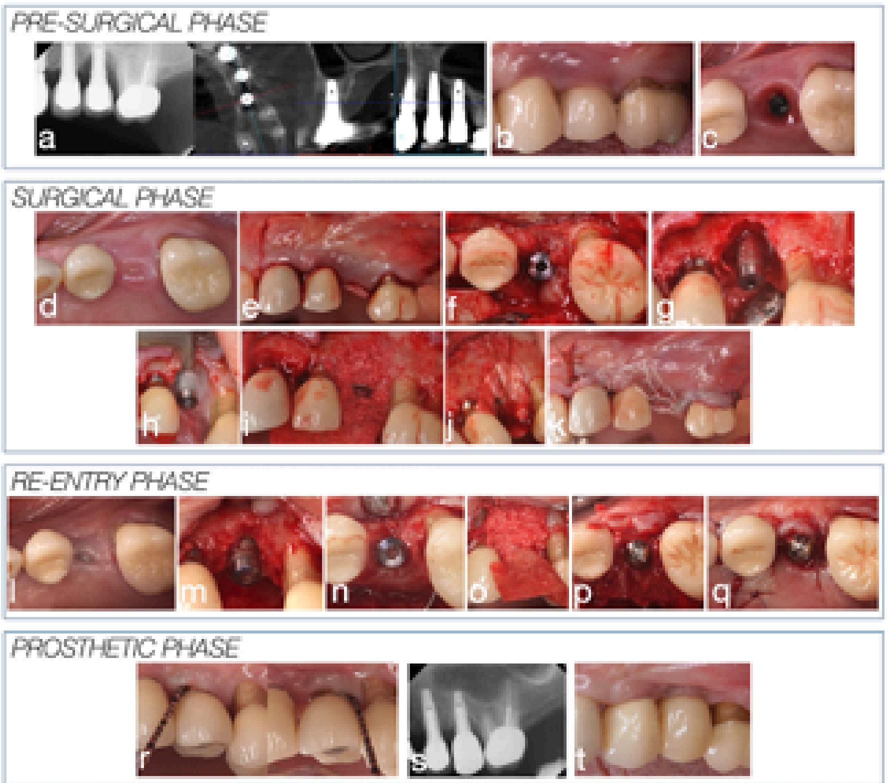

Fig 3 Clinical case – Defect Ic. a) Baseline periapical radiograph, CBCT scan, and b) clinical image of an implant affected by peri-implantitis in the position of the left maxillary second premolar. c) Removal of the prosthetic crown and placement of the cover screw prior to non-surgical therapy. d) Eight-week healing of the soft tissues completely covering the cover screw following non-surgical therapy. e) Mid-crestal incision with mesial and distal vertical releasing incisions; f) flap elevation and occlusal visualization of the non-degranulated peri-implant defect; g) vestibular view of the degranulated defect; h) decontamination of the implant surface using erythritol-based air polishing; i,j) placement of the bone graft and collagen membrane stabilized with periosteal sutures using the "LASSO" technique; k) flap suturing. l) Clinical image at 6 months after the first surgical phase; m,n) vestibular and occlusal visualization of the residual intrabony defect; o,p) placement of the bone graft and collagen membrane fixed with the healing abutment using the "poncho-like" technique; q) flap suturing. r) clinical images with the baseline prosthesis showing probing depths compatible with health; s,t) radiographic and clinical images showing

the new screw-retained prosthetic crown at 2 years of follow-up. Diagnosis after treatment: peri-implant health with a reduced support.

Discussion

The present protocol builds upon the biologic principles of guided tissue regeneration (GTR) and GBR. GTR principles emphasize the importance of understanding the topography of intrabony peri-implant defects, as defect configuration directly influences regenerative predictability. In parallel, GBR principles are applied through meticulous flap management to achieve tension-free primary closure, a prerequisite for submerged healing and stable regeneration. Stabilization of the regenerative space is further ensured by securing the barrier membrane with either pins or sutures, enhancing graft containment and minimizing micromovement.

Another key aspect of the BRP is the removal of the prosthetic crown. In addition to providing improved access during implant surface decontamination, a crucial phase in peri-implantitis therapy, this approach also allows for a flap design that is more respectful and conservative of the soft tissues. Furthermore, the absence of the prosthetic superstructure enables submerged healing of the regenerative site, in accordance with the principles of GBR. A recent reanalysis by Wen et al. (2024) revealed that submerged healing offers significant advantages over non-submerged approaches in terms of both clinical and radiographic outcomes65. In addition, crown removal and site submersion help isolate the treated area from bacterial colonization, which appears to be a fundamental prerequisite, particularly during the first 6 weeks following surgery, for achieving more favorable regenerative outcomes, especially with respect to probing depth reduction.[23]

Lastly, the need for re-entry after the initial surgery, although it represents a second surgical procedure, allows for a direct visual assessment of the infraosseous component that may have resolved. This, in turn, enables the clinician to perform, when necessary, a re-grafting of the residual defect component, thereby enhancing the potential success of the regenerative surgical therapy.

Importantly, the protocol integrates these regenerative principles with effective, non-destructive implant surface decontamination, allowing biofilm removal while preserving the structural integrity and biocompatibility of the implant.

It should be noted that the overall treatment duration required by the present protocol may, in some cases, result in longer chair time compared to non-submerged regenerative approaches. However, this difference is sometimes clinically negligible. Importantly, a re-grafting procedure is not always necessary, avoiding an additional patient visit and the extra 5-6 months that would otherwise follow a second regenerative surgery, with only a modest increase in chair time for the subsequent uncovering. When re-grafting is indicated and performed, the procedure does not involve a new submergence of the regenerative space. After approximately 4-6 weeks, the time generally needed for soft tissue closure, prosthesis can be placed. Functional loading of the implant can be achieved using the original prosthesis if adequate, avoiding additional costs. When the original prosthesis is inadequate, an intermediate provisional restoration may be fabricated, which could slightly increase chair time and overall costs, though this is generally limited. In any case, regardless of the protocol applied, replacing an inadequate prosthesis is recommended to minimize the risk of disease recurrence and support long-term clinical stability. Therefore, when re-grafting is not required, the total duration of the present protocol is essentially comparable to that of a non-submerged approach. Apart from the healing period required for soft tissue closure after re-entry, the postoperative intervals following non-surgical and regenerative therapy are essentially equivalent, in line with the 2023 EFP clinical guidelines. When re-grafting is indicated, an extension of approximately 5–6 months should be expected; however, this is mitigated by the possibility of re-prosthetizing the implant during the healing phase, maintaining patient function throughout treatment.

Like in all regenerative procedures, the success of this technique is highly conditional to appropriate patient selection and a thorough understanding of defect anatomy. Equally important is the clinician's experience with flap design, release, and tension-free closure, as inadequate soft tissue management may compromise the achievement of primary closure and, consequently, the regenerative outcome.

In Class Ie (circumferential) defects, complete regeneration of the defect may be expected, as shown in Figure 2 and Supplementary Figure 3. On the other hand, two- or three-wall defects may not always achieve complete regeneration but can still provide a stable long-term outcome. Importantly, Figure 3 represents a particularly advanced and unfavorable case, where implant removal would have been considered the most predictable option. In this specific scenario, removal of the implant in a 76-year-old patient would have required extensive regenerative procedures, including GBR and likely a sinus lift, to allow for reimplant placement. By applying the BRP, these additional surgeries were avoided, and it was possible to achieve complete disease resolution and a clinically stable outcome.

For Class Id defects, several authors have reported the use of titanium reinforced non-resorbable membranes such as d-PTFE.66 Based on the authors' clinical experience, gingival phenotype must be carefully considered. In thin phenotypes, d-PTFE should ideally be combined with a CTG to mitigate exposure risk, since the area overlying the implant is poorly vascularized and prone to dehiscence. Membrane exposure in such contexts not only compromises regeneration but may also jeopardize adjacent teeth through contamination and inflammation.

The present protocol has limitations. It should not be applied to all cases, as certain defects, such as predominantly suprabony lesions or deep Class Id defects, are considered unpredictable for regenerative therapy and may be more appropriately managed with open flap resective surgery, compromised therapy (open flap debridement) or implant removal. Another practical limitation is that the protocol requires removal of the existing prosthetic crown, which may not always be feasible in daily practice. Long-term RCTs are required to validate the outcomes of this approach and to refine treatment strategies tailored to specific defect morphologies

Conclusions

The proposed Biologic Reset Protocol provides a comprehensive, biologically driven strategy for managing intrabony peri-implantitis defects. Its stepwise structure not only facilitates bone regeneration and disease resolution but establishes a prosthetically and biologically favorable environment that supports long-term stability, minimizes the risk of recurrence, and provides clinicians with a predictable therapeutic pathway for peri-implantitis cases.

Supplemental Figures

Supplemental figures will be available in the final version of this article.

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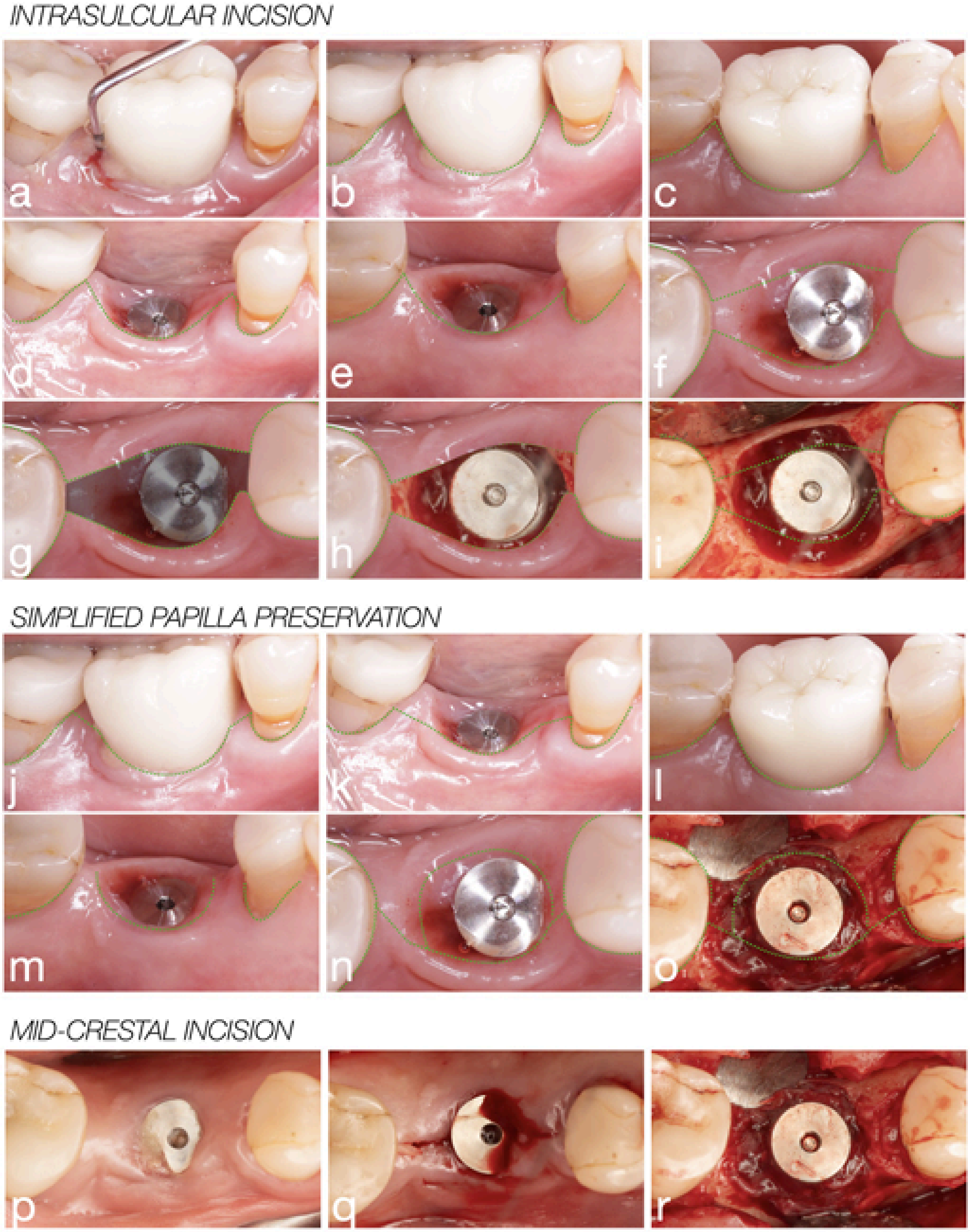
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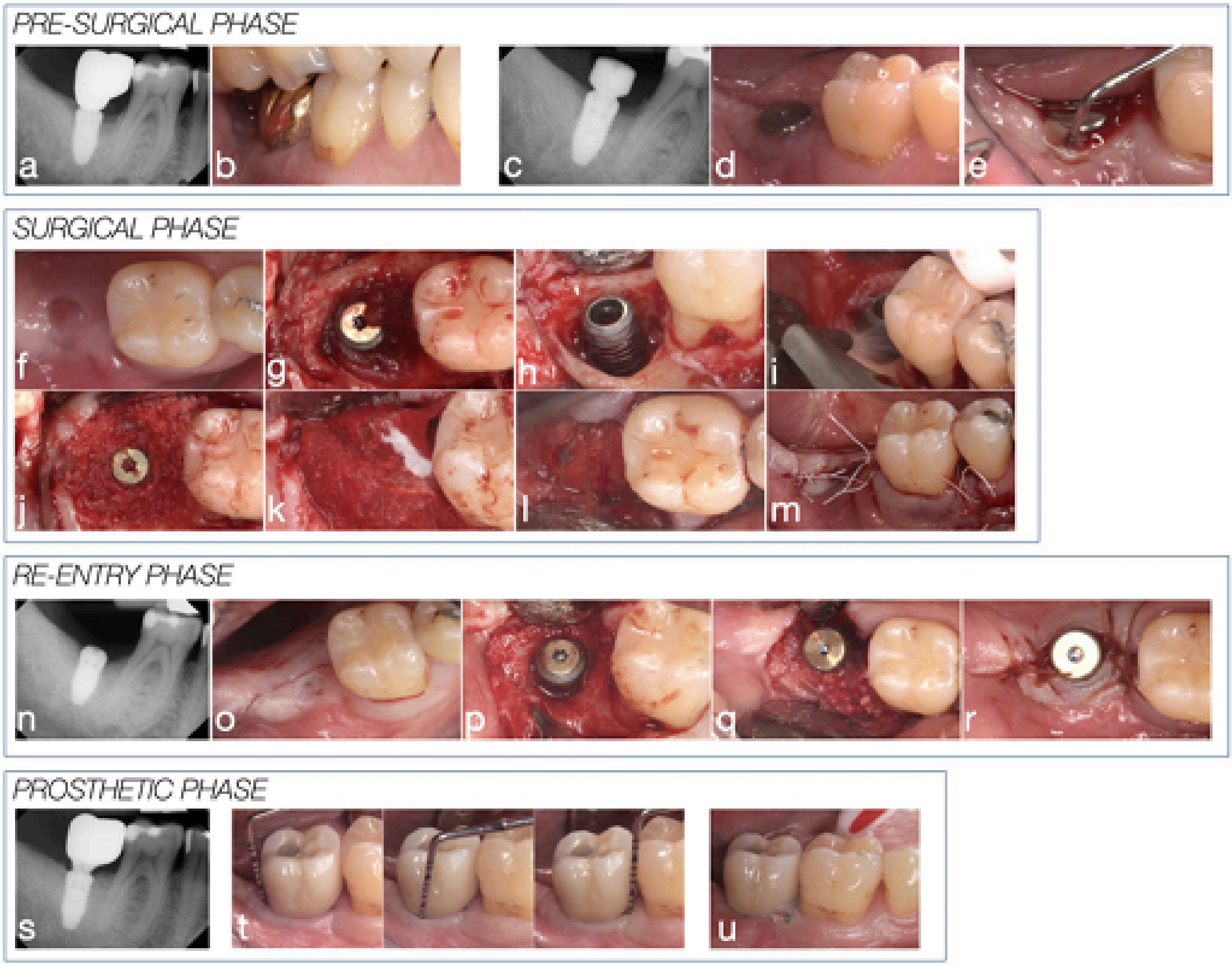
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