A simplified soft tissue management for peri-implant bone augmentation

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ABSTRACT

Purpose: This case series illustrates a simplified soft tissue management, namely, the subperiosteal peri-implant augmented layer (SPAL), to increase hard and soft tissue dimensions at the most coronal portion of an implant. **Materials and Methods:** Twenty-seven implants in 16 patients presenting either a buccal bone dehiscence or a thin (< 1 mm) buccal cortical bone plate (BCBP) were consecutively treated. Briefly, a split-thickness flap (namely, the mucosal layer) was raised on the buccal aspect. Then, the periosteal layer was elevated from the bone crest. A full-thickness flap was elevated on the oral aspect. After implant site preparation, a xenograft was used to fill the space between the periosteal layer and the BCBP and/or exposed implant surface and, if present, to completely correct the bone dehiscence. The periosteal layer was sutured to the oral flap. The mucosal layer was coronally advanced and sutured to submerge both the graft and the implants. At 3 to 6 months, a re-entry procedure for implant exposure was performed. **Results:** Healing was uneventful, with no signs of infection in all cases. A wound dehiscence was observed in three implants in two patients at 2 weeks postsurgery. Out of 15 implants showing an initial bone dehiscence, 12 implants (80%) showed a complete resolution, with a subperiosteal tissue thickness (SPTT) at the time of re-entry of 3.1 ± 1.0 mm. Three implants presented a residual dehiscence of 1 mm (two implants) or 2 mm (one implant), with a SPTT of at least 2 mm. Out of 12 implants showing a thin BCBP at implant placement, 10 implants (90%) revealed a SPTT ≥ 2 at the time of re-entry. Two implants revealed a SPTT of 1 mm. **Conclusion:** The SPAL technique represents a valuable simplified surgical approach associated with a low rate of complications in the treatment of peri-implant bone dehiscence and in the horizontal augmentation of peri-implant tissue thickness. *J Oral Maxillofac Implants 2018. doi: 10.11607/jomi.6959*

INTRODUCTION

Insufficient bone volume with respect to implant dimension may lead to a deficiency of peri-implant tissues, thus calling for hard and/or soft tissues reconstructive procedures. In particular, prosthetically-driven implant placement in a reduced horizontal bone dimension often results in a peri-implant bone dehiscence or fenestration. Even in presence of an intact but thin cortical bone plate, trauma and consequent bone remodeling following surgical procedure for implant placement may result in a vertical bone loss with the exposure of the coronal part of the implant at uncovering (1, 2, 3).

The presence of a buccal bone dehiscence has been shown to be associated with greater mucosal recession on the long-term. Also, a greater risk for the occurrence of mucosal bleeding upon probing was reported for implants with dehiscences deeper than 1 mm compared to implants without dehiscence (4). Therefore, bone dehiscence or fenestration around implants are commonly corrected by bone augmentation, soft tissue augmentation or combination. The most documented procedure consists of the use of a resorbable/non-resorbable membrane combined with a graft according to Guided Bone Regeneration (GBR) principles. Experimental studies revealed a greater augmented bone area for groups treated with GBR compared to non-GBR controls (5). However, data shows that the complete resolution of a bone dehiscence around implants is limited to 33% of GBR treated defects (4). A vertical bone loss 6 months after implant insertion was observed in 20% of implants with a shallow (< 5mm) dehiscence treated with GBR (6). In addition, a substantial incidence of membrane exposure has to be expected for resorbable and non resorbable membranes following GBR to correct peri-implant fenestrations/dehiscences (7), thus leading to substantially less bone regeneration compared to non-exposed sites (8, 9).

GBR principles that support new bone formation by the use of a barrier membrane imply the concept of "cell-exclusion" and "space-making" (10). Although the creation of a well-defined and stable compartment underneath a membrane has been repeatedly shown of biological and clinical relevance to enhance bone formation (11), the need to exclude the innate osteogenic potential of the periosteum from the wound area by a membrane barrier has been questioned (12). In this respect, a possible explanation for the observed insufficient bone augmentation following GBR may relate to the exclusion of the contribution of the periosteum in the bone healing process.

Different techniques for grafting buccal plates without barrier membranes for horizontal augmentation have been reported in the literature (13-17). One of these techniques, esthetic grafting, consists of interposing a graft biomaterial directly between the exposed implant surface and the buccal (thick) mucoperiosteal flap. The procedure has been shown effective to treat peri-implant buccal bone dehiscence occurred at the time of implant placement (13, 18). A novel bone augmentation procedure based on the utilization of the periosteum as a barrier membrane and space-making "device" has been successfully used to enhance the horizontal bone dimension prior to implant placement (19). Consistently, the use of a laparoscopic approach to deliver a growth factor/xenograft combination into a subperiosteal pouch resulted in predictable and consistent bone regeneration (20). The biologic rationale for the use of the "periosteum layer" was recently confirmed by an experimental study where the peri-implant osteogenic potential of the periosteum in determining vertical bone augmentation around implants has been histologically reported (21). Collectively, these findings indicate that pre- and peri-implant tissue augmentation may be enhanced by surgical procedures where the periosteum is left intact although detached from the underlying bone, and a secluded space between the periosteum and the bone or implant is warranted.

The purpose of the present study is to produce proof-of-principle evidence on the effectiveness of a simplified soft tissue management, namely the Sub-periosteal Peri-implant Augmented Layer (SPAL). SPAL technique is proposed to increase (horizontal and/or vertical) hard and soft tissue dimensions at the most coronal portion of an implant. Cases where either a bone dehiscence (with exposed implant threads) or a thin buccal cortical bone plate (BCBP) was present are presented.

MATERIALS AND METHODS

Study population

Sixteen systemically healthy patients (7 men and 9 women; 2 patients both smoking 4 cigarettes/day and 1 former smoker), aged 39 to 72 years (mean 57 ± 10 years), in need for implant supported rehabilitation were consecutively included at the Research Centre for the Study of Periodontal and Peri-implant Diseases, University of Ferrara, Italy, and one private practice in Ferrara, from December 2015 to September 2017. When needed, patients had undergone active periodontal therapy for the treatment of periodontitis and were enrolled in a professional recall program prior to implant placement. Treatment plan was based on 3D radiographic assessment, and a surgical stent was fabricated on diagnostic wax-up when deemed necessary.

Patients were included when: >18 y-o and in good general health; the preliminary clinical and radiographic evaluation suggested the presence of a thin (< 1 mm) BCBP or a bone dehiscence was detected at the time of implant placement; willing to undergo the suggested treatment (informed consent). Implants were included only if they showed primary stability at insertion.

Patient with contraindication to oral surgical procedures, uncontrolled diabetes mellitus or heavy smokers (cigarette consumption > 10 sigarette/day) as well as sites requiring either vertical bone augmentation or lateral bone augmentation with a staged approach were excluded from the study.

Surgical procedure

SPAL technique represents a soft tissue management procedure aimed at increasing the horizontal and vertical dimensions of the sub-periosteal tissues at peri-implant sites where BCBP is missing or thin (Figure 1 and 2, respectively).

At implant placement, patients were administered 2 g of amoxicillin + clavulanic acid (Augmentin, GlaxoSmithKline, Verona, Italy) one hour prior to surgery (22). Local anesthesia was attained using articaine with 1:100,000 epinephrine administered by local infiltration. Attention was paid not to infiltrate the area where the split-thickness flap has to be performed.

A partial thickness mid-crestal incision was made by a 15C blade. For single implants, the incision was extended intra-sulcularly one tooth mesial and one tooth distal to the area of interest, thus outlining an envelope flap. In case of multiple implants, one (mesial) or two (mesial and distal) partial-thickness releasing incisions were made to obtain better visibility and avoid tension on the flap. A split-thickness flap was raised on the buccal aspect by sharp dissection (namely, the mucosal layer) and leaving the periosteal layer on the edentulous ridge intact. After separation between the mucosal and periosteal layer to allow for a tension-free, coronal advancement of the mucosal layer, a second crestal incision reaching the bone crest was performed, and the periosteal layer was elevated from the bone crest. Sharp dissection of the mucosal layer was performed by a 15C blade as well as tunneling knives (KPAX, TKN1X

and TKN2X, Hu Friedy, Chicago, Illinois) with varying angulated sharp edges[v] according to the anatomical location, while the periosteal layer was elevated by a periosteal elevator (PTROM, Hu-Friedy, Chicago, Illinois) thus creating a pocket that could accommodate an adequate extension and volume of the bone graft material. A full-thickness flap was elevated on the oral (lingual/palatal) aspect.

Implant site preparation was made with ceramic burs according to manufacturer's instruction, and tissue-level implants (Thommen Medical, Grenchen, Switzerland) were placed with the polished collar (varying from 0.5 to 1 mm) above the bone crest. In all cases, healing cap were used. A xenograft (Bio-Oss® spongiosa granules, particle size 0.25-1.0 mm; Geistlich Pharma, AG, Wolhusen, Switzerland) was used as a space-making device to fill the surgically-created space between the periosteal layer and the BCBP and/or exposed implant surface and, if present, to completely correct the bone dehiscence up to the implant polished collar. No perforations of the buccal plate were performed.

The periosteal layer was sutured to the oral mucoperiosteal flap by means of internal mattress sutures. The mucosal layer was coronally advanced and sutured tension-free by horizontal internal mattress and interrupted sutures to submerge both the graft and the implants. For both mucosal and periosteal layers, a resorbable 6/0 suture (Vicryl 6/0, Ethicon, Somerville NJ, USA) was used.

Patients were instructed not to wear any removable prostheses to avoid compression onto the surgical site for at least 3-4 weeks, and not to chew or brush in the treated area for approximately 2 weeks. The home use of a 0.12% chlorhexidine solution (Curasept ADS Trattamento Rigenerante®; Curaden Healthcare, Saronno, Italy) was prescribed for chemical

plaque control (1-minute rinse b.i.d. for 3 weeks). Sutures were removed at 2-weeks post-surgery.

At 2-6 months following implant placement, a re-entry procedure for implant exposure was performed. Timing of re-entry was based on the size of the peri-implant bone defect at implant placement, i.e. the larger the defect the later the re-entry. A buccal split-thickness flap was performed to position the healing abutment, attention was paid to leave a substantial thickness of tissue to protect the coronal part of the implant. A hard, newly formed tissue with a bone-like appearance and of different thickness was exposed.

Since the buccal soft tissues had been coronally displaced during first stage surgery, at re-entry soft tissues were managed in order to re-establish proper dimensions of the peri-implant mucosal unit. The flap was designed to be either apically positioned or laterally displaced in order to achieve ideal gingival dimensions (height, thickness) at buccal aspect. When necessary (i.e. in absence of an adequate amount of buccal peri-implant mucosa and/or when no keratinized tissue could be obtained from adjacent areas), a gingival graft was positioned at the most coronal portion of the implant.

Clinical measurements

The evaluation of SPAL procedure was focused on its potential to augment the horizontal dimension of the crest, assessed as the change in sub-periosteal tissue thickness (SPTT) at the most coronal portion of the implant (immediately apical to the polished collar) from the time of implant placement to the re-entry procedure. Also, the increase in the vertical dimension of the bone crest was determined as the change in the depth of the buccal bone dehiscence (BBD), when present. All measurements were performed by a single, calibrated examiner using

a periodontal probe (PCPUNC 15, Hu Friedy, Chicago, Illinois) placed perpendicular or parallel to the long axis of the implant (for SPTT and BBD, respectively) at the buccal aspect of each implant.

At the time of implant placement, SPTT was recorded as the thickness of the BCBP measured at the level of the most visible apical portion of the polished collar of the implant. When a buccal bone dehiscence was present, SPTT was recorded as 0. Also, BBD was measured from the most apical portion of the polished collar to the most apical position of the BCBP at the dehiscence. After graft positioning and suturing of the periosteal layer, SPTT was recorded as the buccal thickness of BCBP (if present) plus the graft and the periosteal layer at the most visible apical portion of the polished collar. SPTT and BBD were finally measured following the partial-thickness dissection of the mucosal layer at the time of re-entry. In presence of a residual dehiscence, SPTT was measured in the most coronal portion of the non-exposed buccal implant surface.

Measurements were performed by a periodontal probe • and rounded at the nearest mm. Data are presented as mean ± standard deviation (SD). The implant was the statistical unit.

RESULTS

At implant positioning, SPTT was either <1mm (12 implants) or 0 due to a buccal bone dehiscence (15 implants) (Table 1). BBD was 2.5 ± 1.5 mm. At completion of the grafting of the sub-periosteal space, SPTT and BBD were 3.0 ± 0.9 mm and 0 mm, respectively.

Healing was uneventful, with no signs of infection in all cases. A wound dehiscence was observed in 2 non-smoker patients (3 implants) at 2 weeks post-surgery, with partial implant

exposure in one case (2 implants). Patients were maintained with a 0.2% chlorhexidine mouthrinse regimen for 6 weeks and seen monthly until re-entry.

The re-entry procedure was performed after 3.6 ± 1.0 months. At re-entry, all implants were stable. SPTT at re-entry amounted to 2.6 ± 0.9 mm. 25 implants (92.6%) revealed a SPTT ≥ 2 mm (Table 1). A slight decrease (0.4 ± 1.0 mm) in SPTT was observed from intrasurgery to re-entry.

The postoperative increase in SPTT as measured at most apical visible portion of the polished implant collar in implants either without initial buccal bone dehiscence or with initial buccal bone dehiscence completely corrected is shown in Table 1. Out of 15 implants showing an initial bone dehiscence, 12 implants (80%) in 9 patients showed a complete resolution with a SPTT at the time of re-entry of 3.1 ± 1.0 mm. Three implants in 2 patients presented a residual dehiscence of 1 mm (2 implants) or 2 mm (1 implant) with a SPTT of at least 2 mm (range 2-4 mm). No dehiscence was observed at re-entry on implants where a thin, but present, BCBP was recorded at implant placement. Out of 12 implants showing a thin (<1 mm) BCBP, 10 implants (90%) in 7 patients revealed a SPTT≥ 2 at the time of re-entry (2.2 ± 0.4 mm). Two implants in 2 patients revealed a SPTT of 1 mm.

Out of 27 implants included in this study, 1 implant presented a buccal fenestration of 2 mm, completely resolved at the time of re-entry.

DISCUSSION

SPAL technique originates from the Double Flap incision as originally proposed (23). This design includes a partial-thickness flap elevation leaving the periosteal layer on the edentulous ridge and separation of the mucosal layer of the flap. The periosteal layer is then used to

stabilize the regenerative site using periosteal sutures. Various regenerative devices, such as non-resorbable/resorbable membrane and titanium mesh with different size and locations, were used for both horizontal and vertical implant site development (23). More recently, a similar flap design was reported (19) to perform GBR for horizontal bone augmentation prior to implant placement. A periosteal pocket was created by splitting a mucosal from a periosteal layer, and the created sub-periosteal space was then filled with bone substitute materials and covered by a resorbable membrane. At 6 months, a substantial increase of horizontal bone crest dimensions was recorded.

SPAL technique benefits by the advantages of the two previous techniques, in terms of flap design (23) and creation of a sub-periosteal space aimed at receiving an osteoconductive scaffold (19). However, the present proposal is characterized by two major technical differences that simplify the procedure while leading to predictable results: i) the increase in SPTT is performed at the time of implant placement in presence of either a bone dehiscence or a thin (< 1mm) BCBP; ii) enhanced horizontal dimension and bone dehiscence correction merely relies on the osteogenetic potential inherent to the periosteum without use of membranes. The results indicate that this technique is effective in i) correcting small (≤ 5 mm) bone dehiscence associated with implant placement, and ii) creating at least 2 mm of sub-periosteal tissue thickness in the most coronal portion of the implant, in the great majority (80% and 81%, respectively) of treated implants. Only 2 implants in 1 patient experienced an early wound dehiscence which resulted in a limited (< 2 mm) residual bone dehiscence. Although encouraging, these findings must be considered as preliminary due to the nature of the study design (case series) and the limited sample size and, therefore, need to be corroborated with other trials.

SPAL technique resulted in an overall increase of SPTT from implant placement to re-entry even at implants with bone dehiscence. These findings compare with those recently reported by a study where similar bone dehiscence have been either treated by GBR or left to spontaneously healing (6). The proposed flap approach to horizontal bone augmentation is based on the so-called PASS principle that includes primary wound coverage, angiogenesis, space creation, and wound stability (24).

Space is needed for the osteogenic cells to creep into the wound site, differentiate into osteoblasts, and form woven bone. Stability of the secluded space containing the graft biomaterial acting as scaffold for blood clot formation and maturation has been repeatedly emphasized in GBR, and various devices/techniques aimed at stabilizing the membrane-contained graft have been proposed (25). In the present technique, space provision was warranted by i) creating a sub-periosteal pocket which is open only in its coronal portion, while not detached by underlying bone on the mesial, apical and distal aspects; and ii) the use of slow-resoption xenograft inserted and stabilized with limited dispersion and minimal micromovements.

Deproteinized bovine bone particles may have create a suitable osteoconductive scaffold for new bone formation while mechanically maintaining the periosteal layer elevated from the overlying implant and bone surface. Previous studies have shown that periosteal elevation by means of titanium mesh (26), degradable devices (27), or dental implant (21) resulted in induction of supracortical peri-implant bone formation. Moreover, the application of tensile strain on the periosteum activates the expression of osteogenic and angiogenic factors (28). The periosteum layer may not only represent a source of osteogenetic cells, but also effectively contributes to angiogenesis which is a prerequisite for new bone formation (29). Although the

clinical measurement of SPTT did not qualify the nature of the augmented tissues, human histology derived form a similar procedure where a sub-periosteal pouch was surgically created revealed xenograft particles surrounded by newly formed bone (20).

SPAL technique is characterized by a flap design that allows for soft tissue mobilization leading to tension-free primary closure, a condition which is regarded as essential to achieve undisturbed bone regeneration. Primary closure was facilitated by two factors: i) the amount of horizontal bone resorption is positively correlated with soft tissue thickness (30). In this respect, a substantial (buccal) bone remodeling leads to an increased soft tissue thickness that can be easily manipulated by a split thickness dissection; ii) grafting was limited to the most coronal portion of the implant and rarely exceeded 4 mm in thickness.

Similar to the periosteal pocket flap (PPF) technique (19) and the Double Flap Incision Design (20), SPAL technique determined a complete primary intention healing in 91% of treated implants. In contrast, a recent systematic review showed that soft tissue complications following GBR procedure, including membrane exposure, soft tissue dehiscence, and acute infection/abscess, may reach an incidence of 45% (mean 16.8%) (7) . In GBR, wound dehiscence unavoidably results in membrane exposure which in turn jeopardize the amount of regenerated bone. Previous reports indicating that membrane exposure may lead to 50%-80% less regenerated bone compared to non-exposed sites (31, 32). Notably, in the sole case where a substantial wound failure occurred, a limited residual bone dehiscence associated with SPTT increase was recorded. The limited adverse consequences observed in SPAL technique compared to GBR may be ascribed to a less detrimental effect of bacterial contamination of the surgical area following SPAL technique compared to bacterial contamination of an exposed membrane.

An overall decrease in SPTT was observed from intrasurgery to re-entry. This reduction can be partly explained by post-surgery graft remodeling, with the variability in SPTT change observed among implants being partly explained by differences in the timing for re-entry. The augmented volume obtained with graft during bone reconstructive procedures was shown to undergo a progressive reduction starting from the first postoperative weeks (33). The extent of this shrinkage is dependent on the different physical and chemical characteristics of the graft material, and, for DBBM, amounted to more than 60% of the initial grafted volume at 2 years post-surgery (33). An alternative explanation may involve the horizontal and vertical bone loss associated with implant placement in presence of either a thin BCBP (1) or a bone dehiscence (6), which may have partly counterbalanced the amount of newly formed bone due to the osteogenetic capacity occurred at the sub-periosteal pocket.

In conclusion, SPAL technique represents a valuable simplified surgical approach associated with a low rate of complications in the treatment of peri-implant bone dehiscence and in the horizontal augmentation of peri-implant tissue thickness. Further longitudinal studies are needed to evaluate whether and to what extent this procedure may ensure long-term stability of the buccal mucosal profile and healthy conditions of peri-implant tissues.

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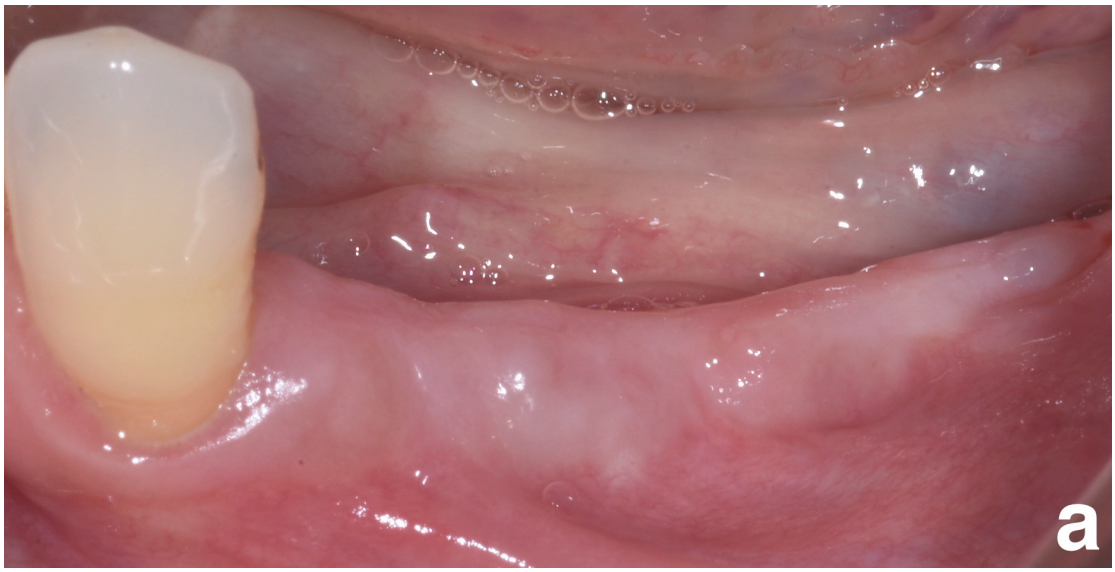
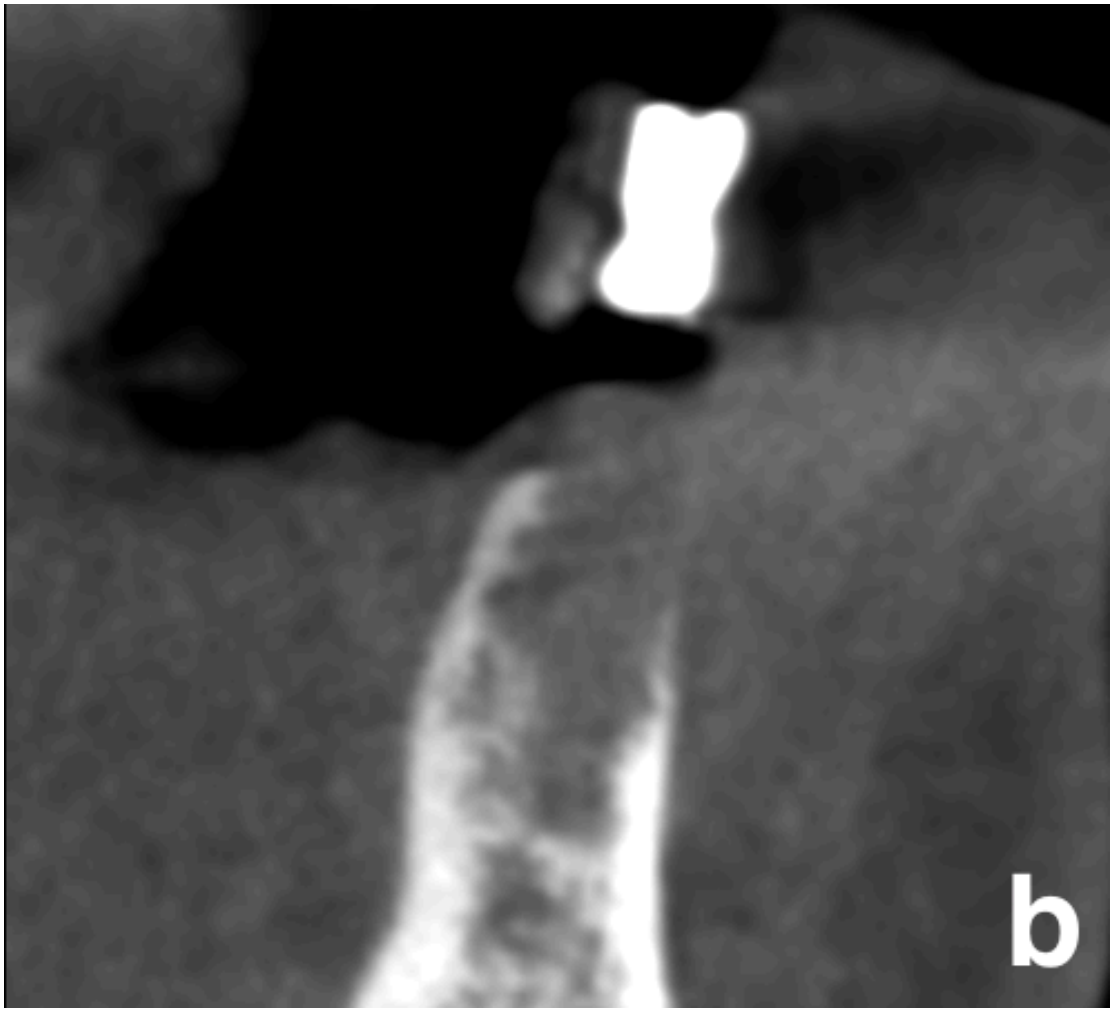
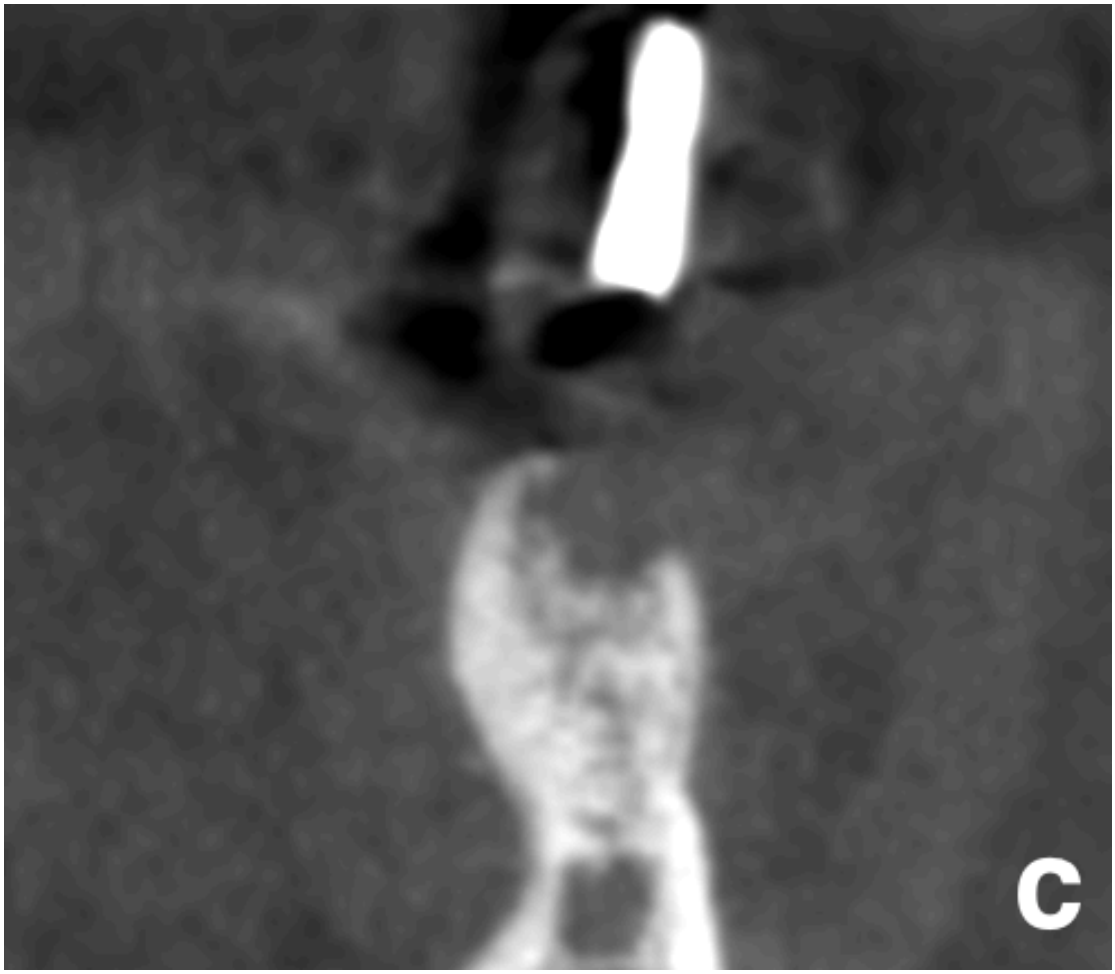
TABLES

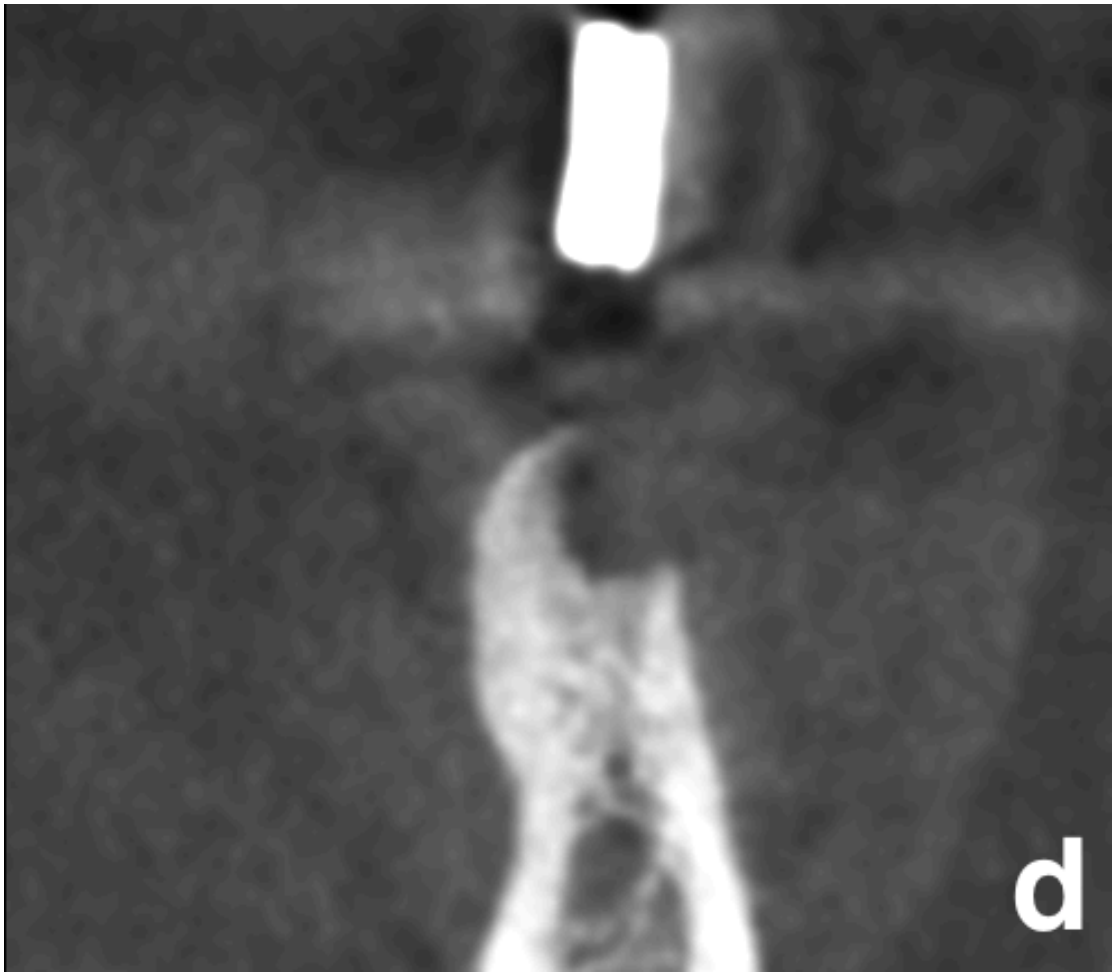
Table 1. Sub-periosteal tissue thickness (SPTT) and depth of the buccal bone dehiscence (BBD) at each observation interval.

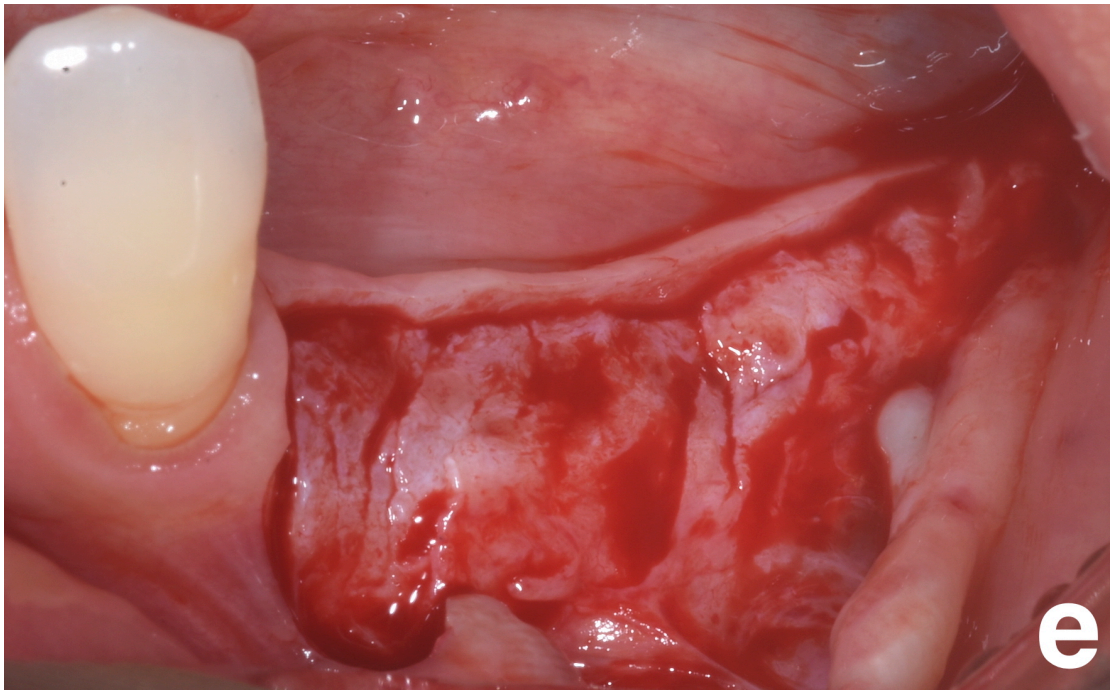
FIGURE LEGEND

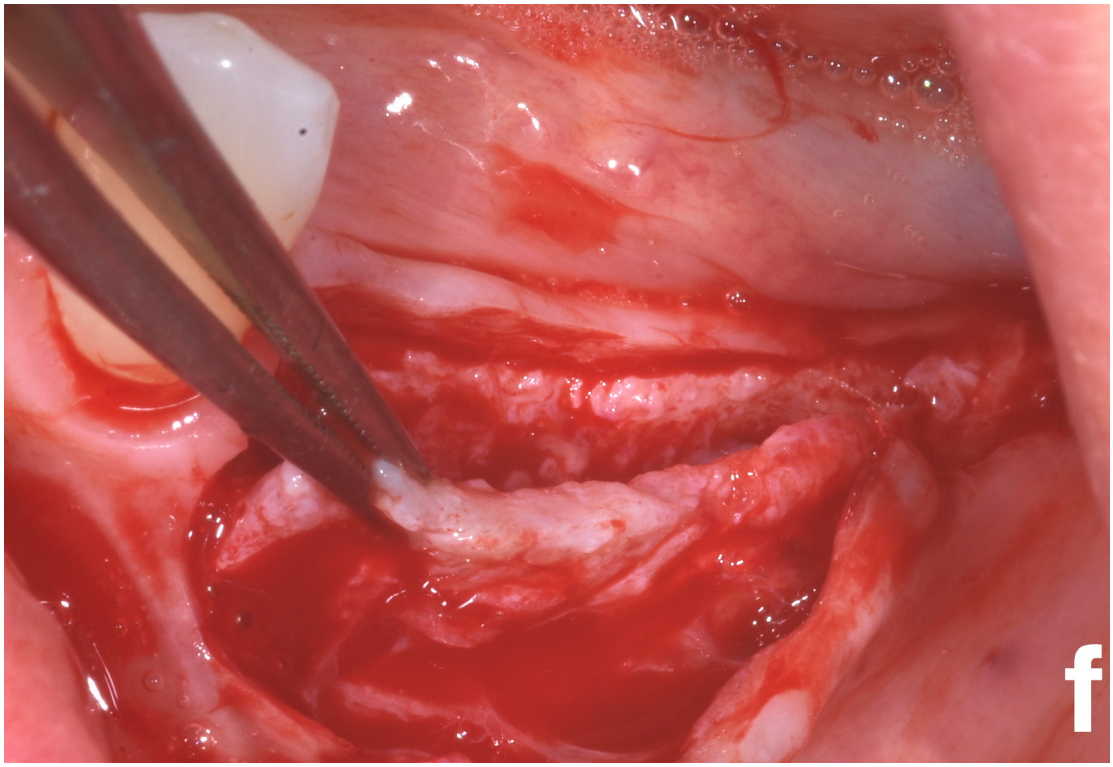


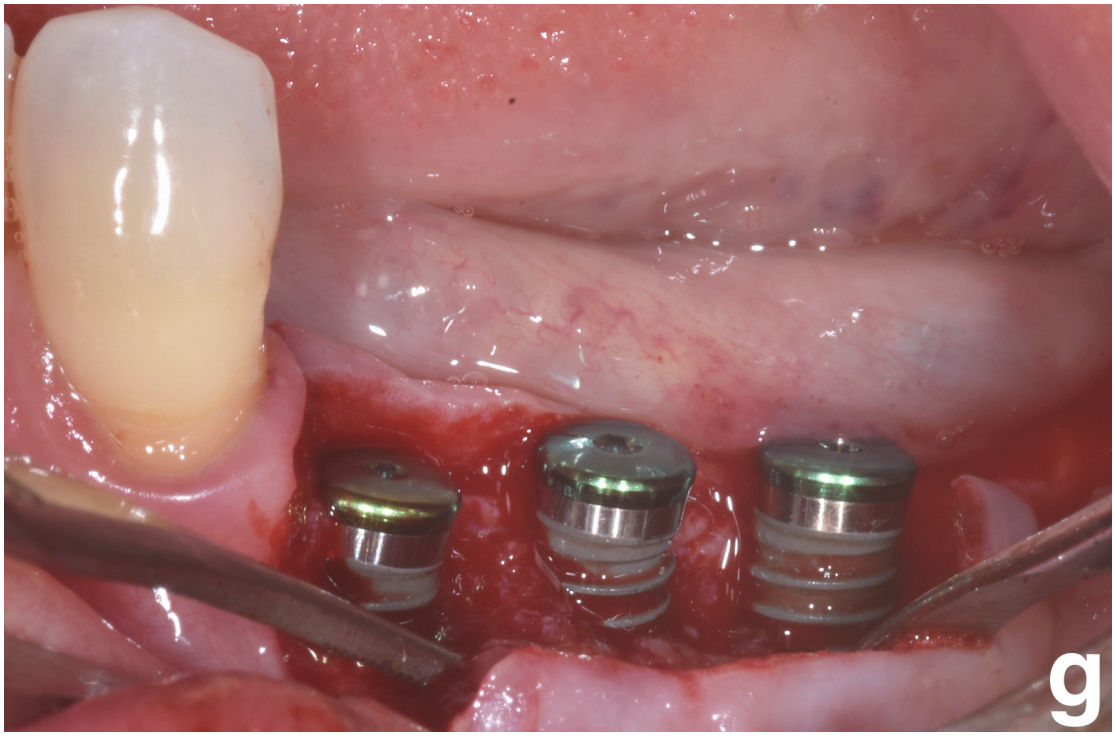


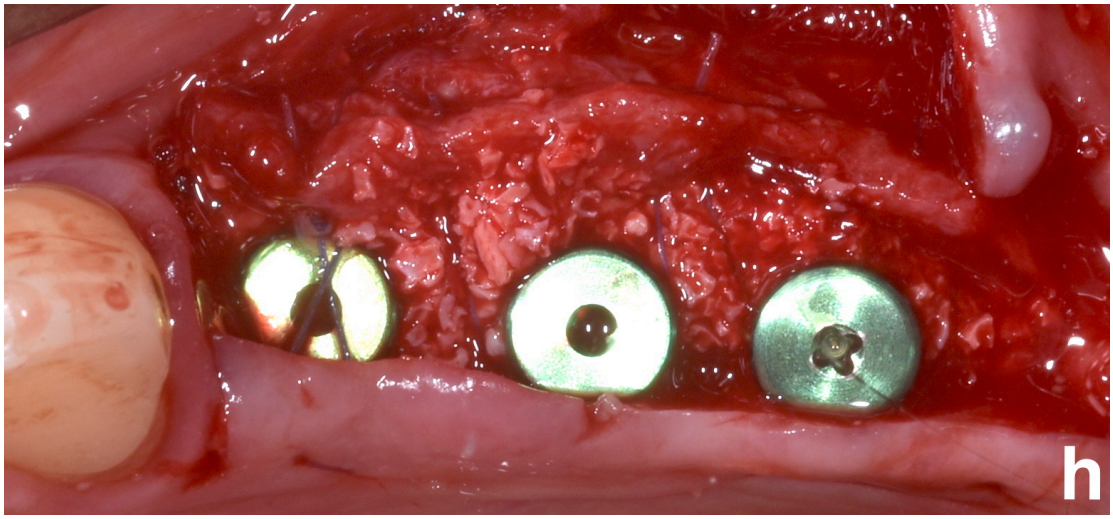


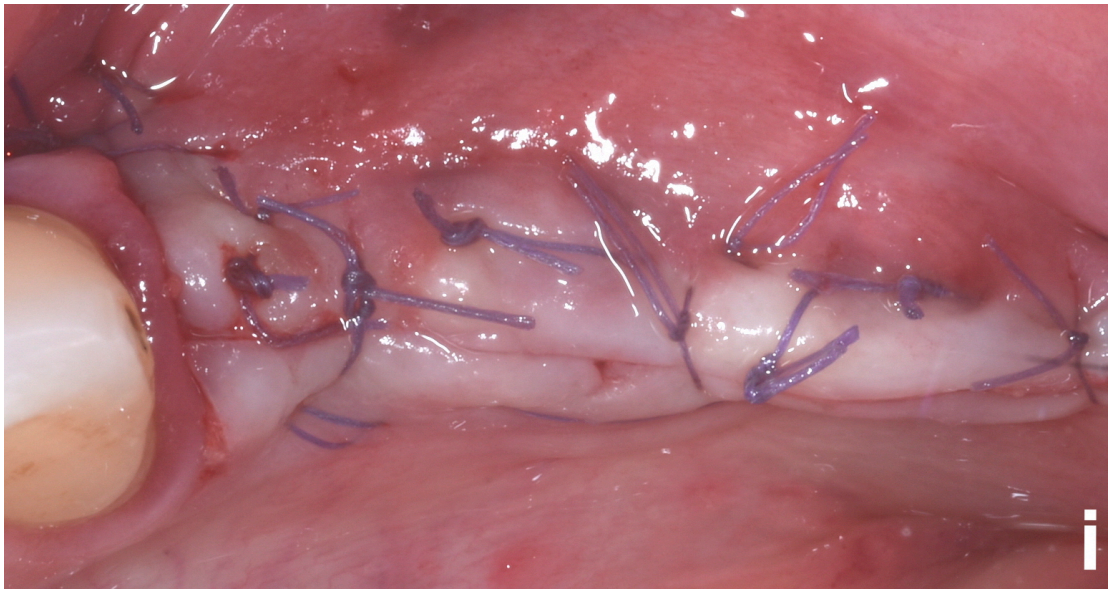


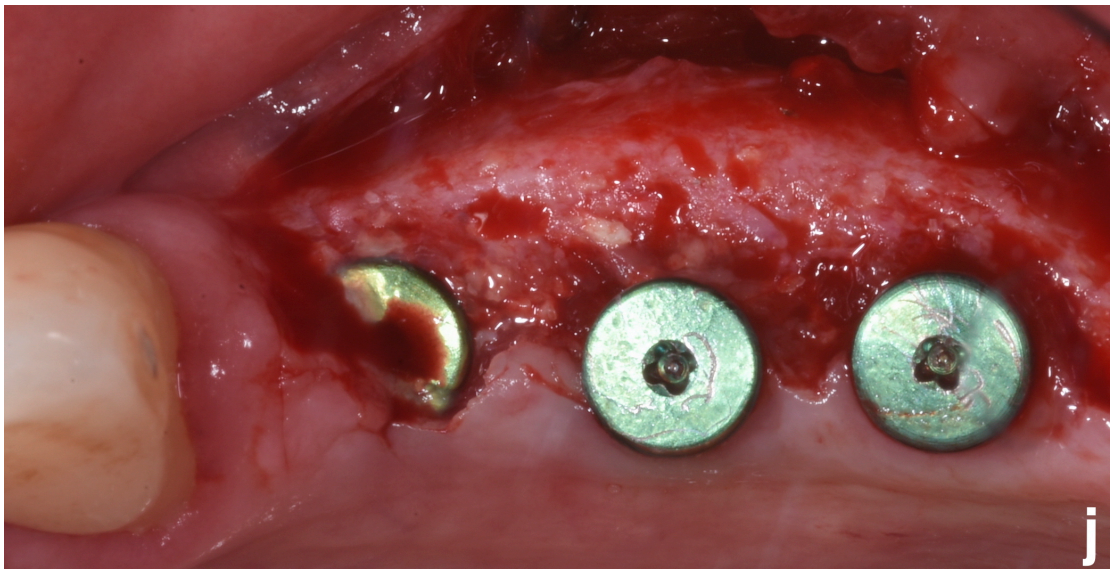


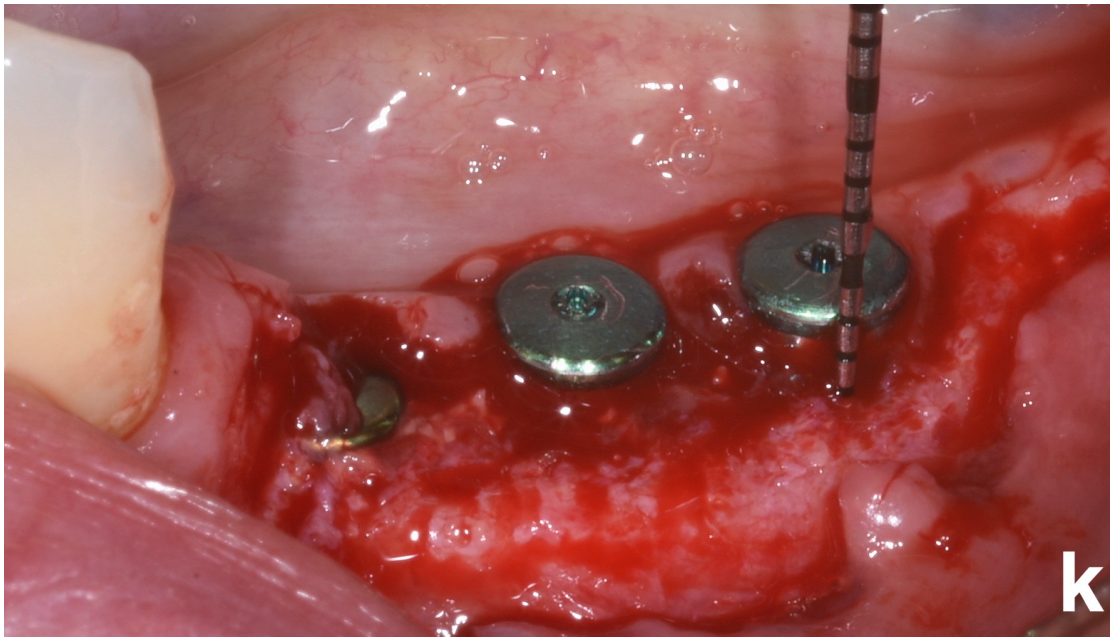


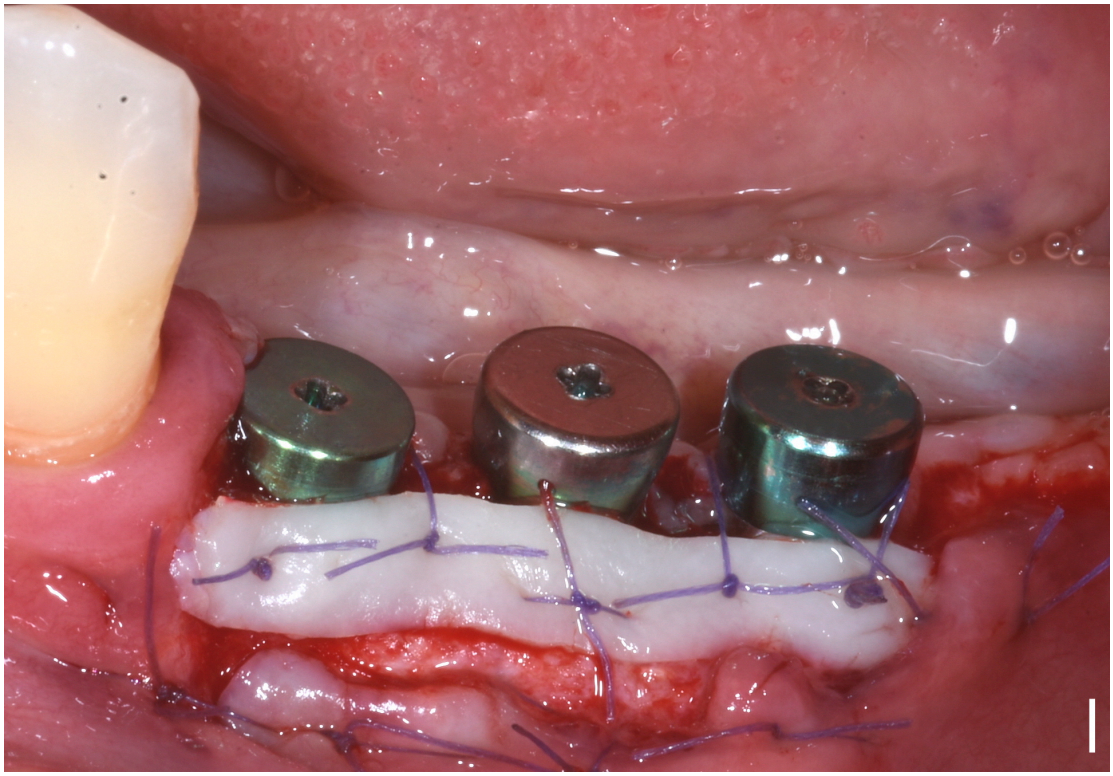












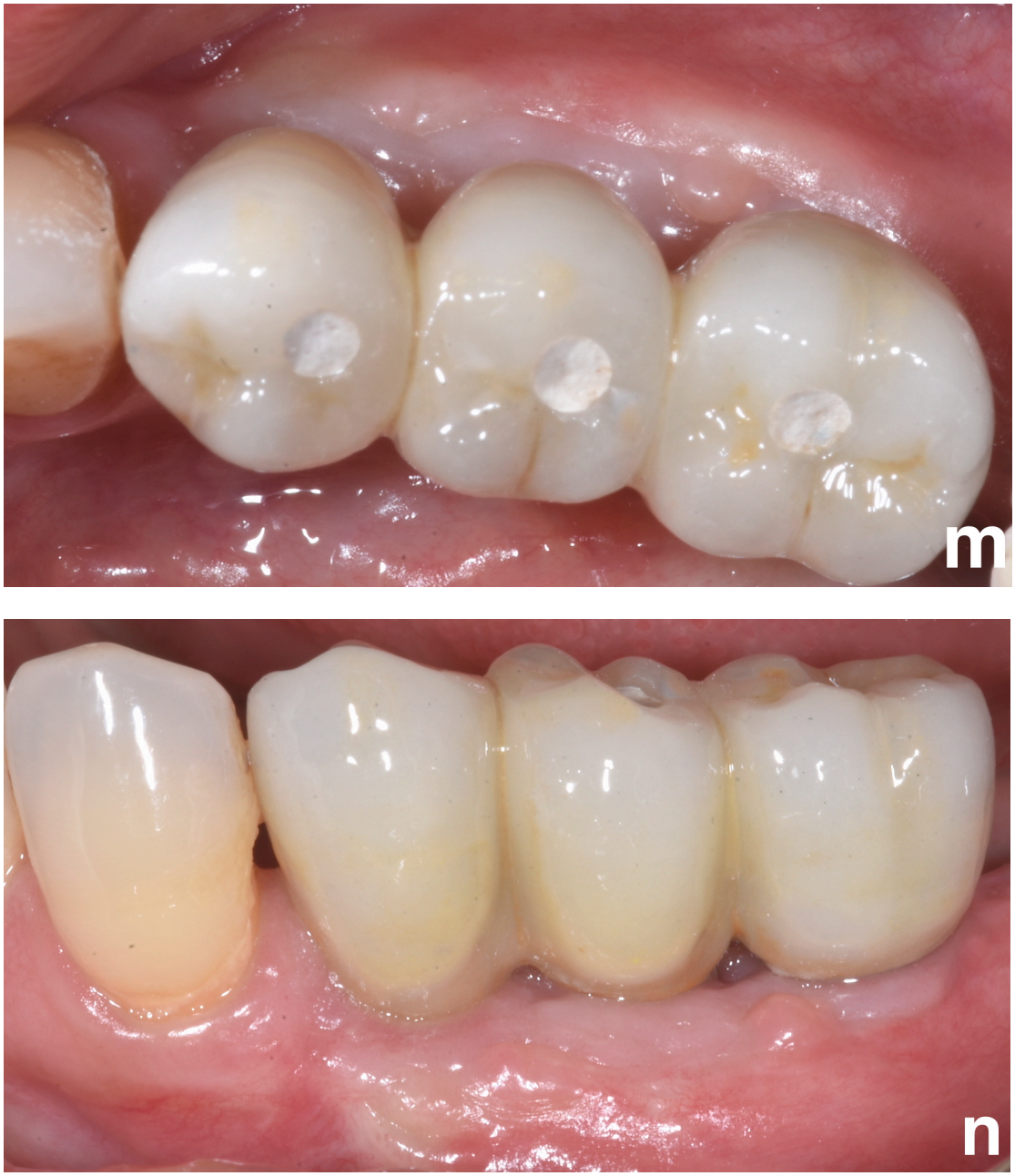
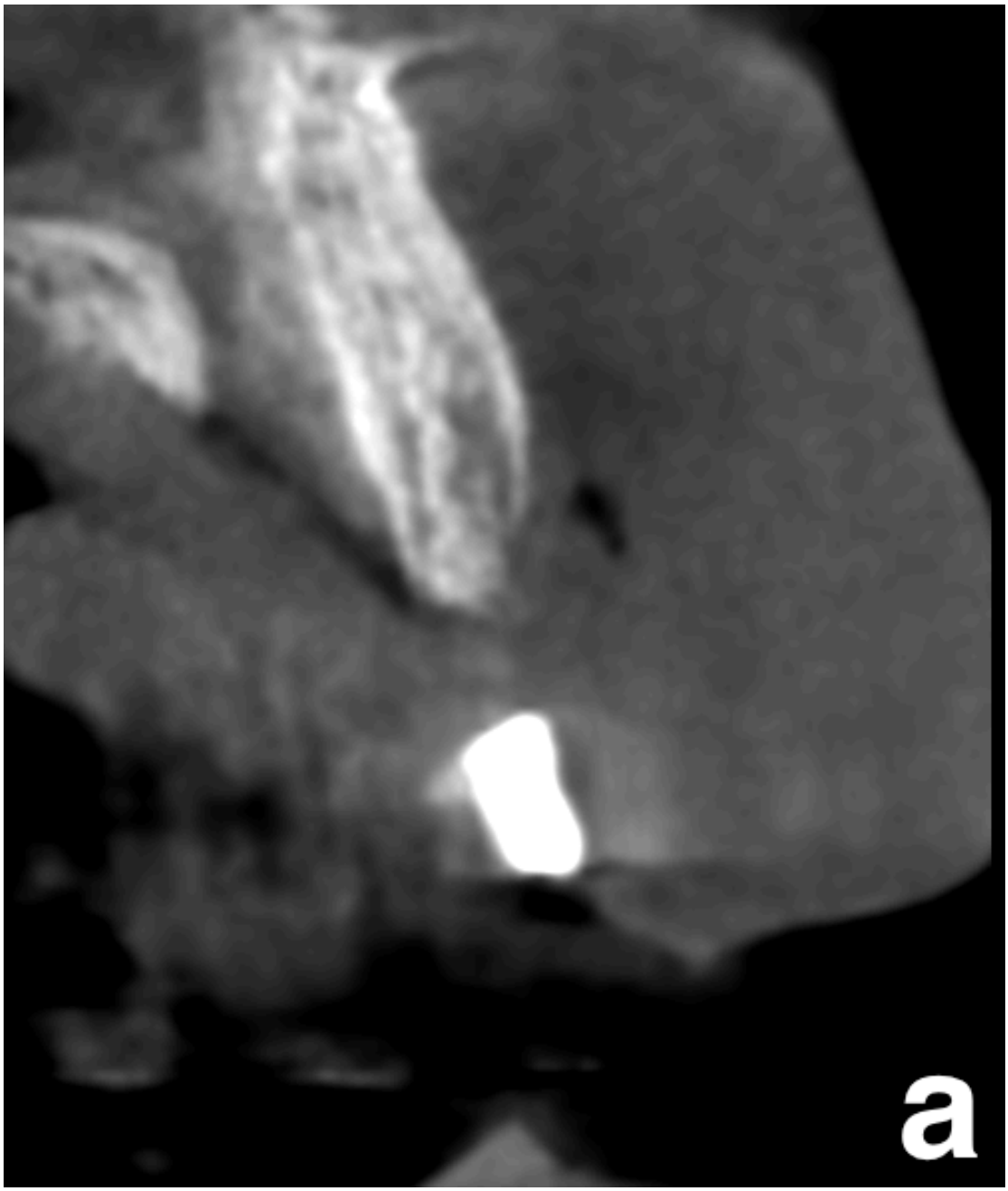
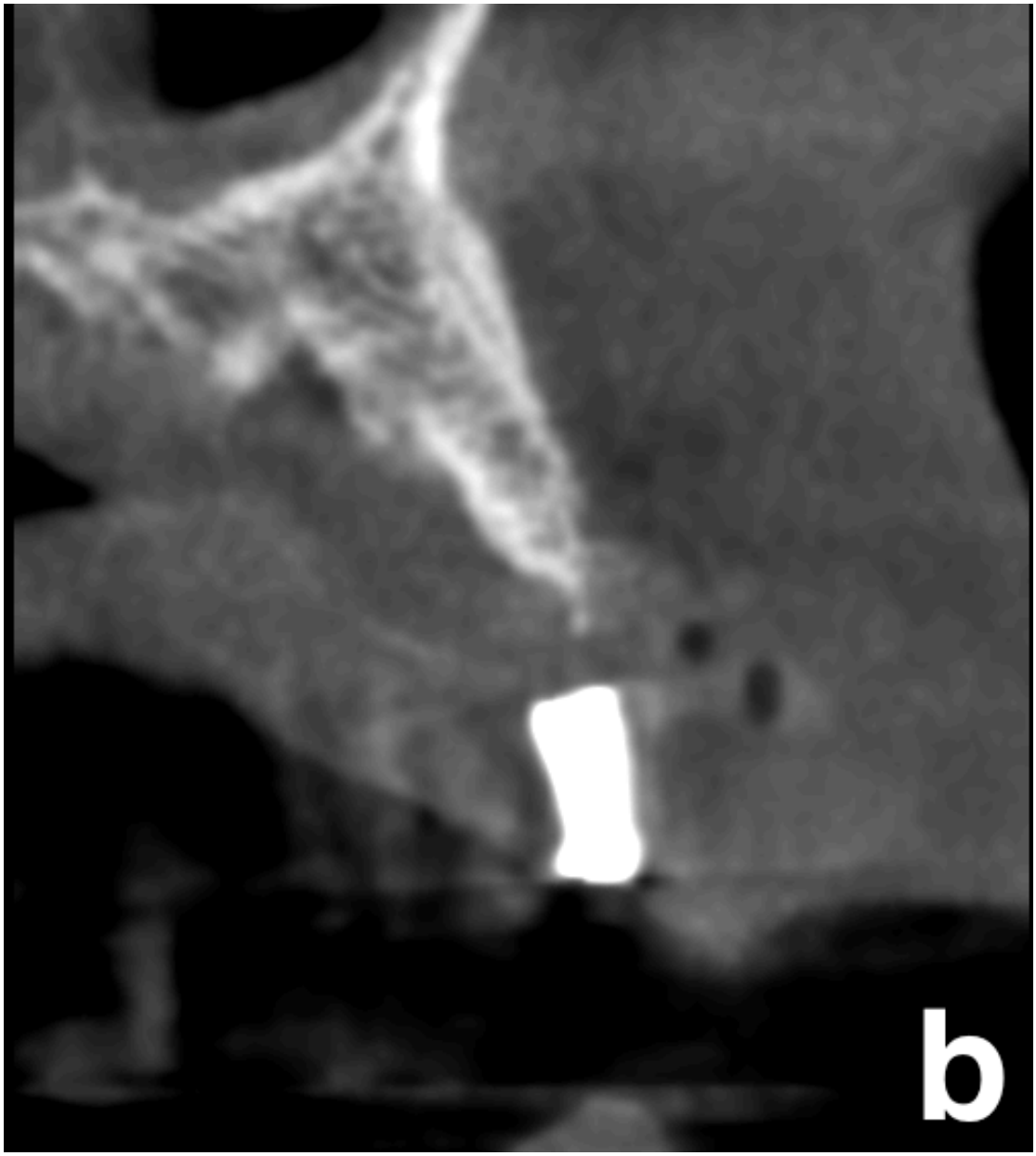
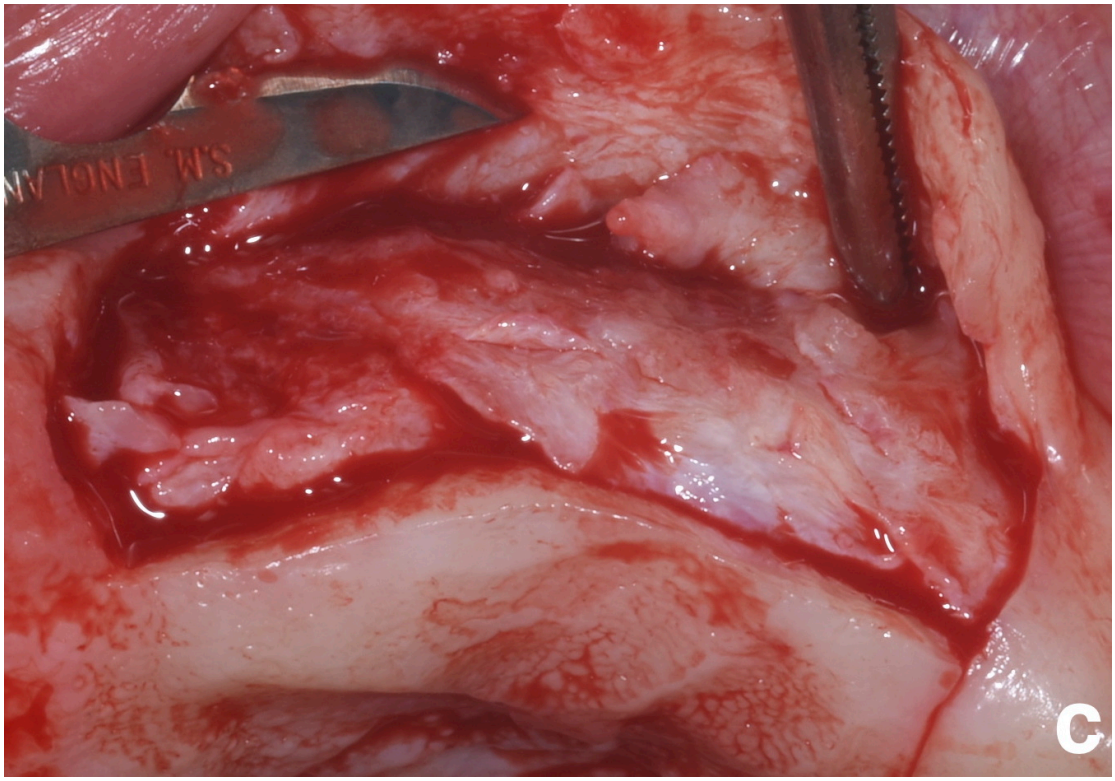
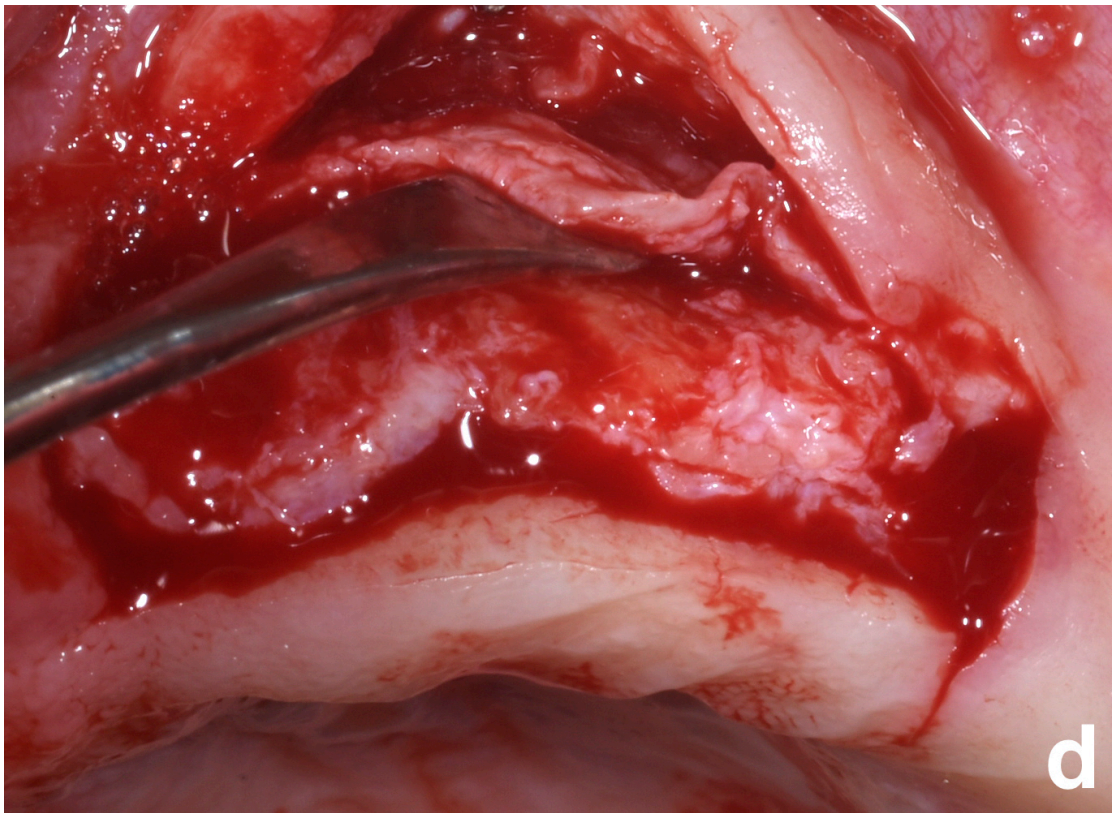


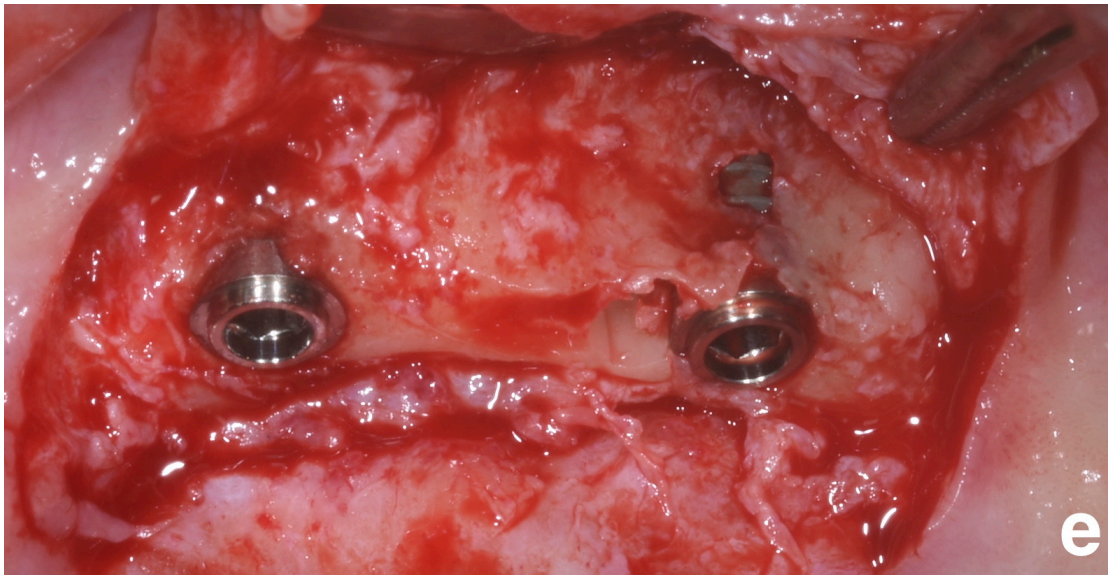
Figure 1. Sub-periosteal Peri-implant Augmented Layer (SPAL) technique at multiple sites with buccal bone dehiscence. a. Preoperative view of an atrophic, edentulous mandibular posterior region**. b-d.** Tomographic scans show insufficient bucco-lingual width of the residual crest at first premolar, second premolar and first molar sites, respectively. **e.** A split-thickness flap with releasing incisions is raised on the buccal aspect by sharp dissection, leaving the periosteal layer on the edentulous ridge intact. **f.** The periosteal layer is elevated from the buccal bone plate**. g.** After placement, all implants show dehiscence defects at the buccal aspect. **h.** A xenograft is positioned into the pocket underneath the periosteal layer. The periosteal layer is sutured to the lingual flap by means of internal mattress sutures**. i.** The mucosal layer is coronally advanced and sutured tension-free by horizontal internal mattress and interrupted sutures to submerge both the graft and the implants. **j,k.** Occlusal and buccal view at re-entry for implant uncovering (4 months). **l.** A free gingival graft is performed to augment the amount of peri-implant keratinized tissue. **m,n.** Occlusal and buccal view at prosthetic rehabilitation.

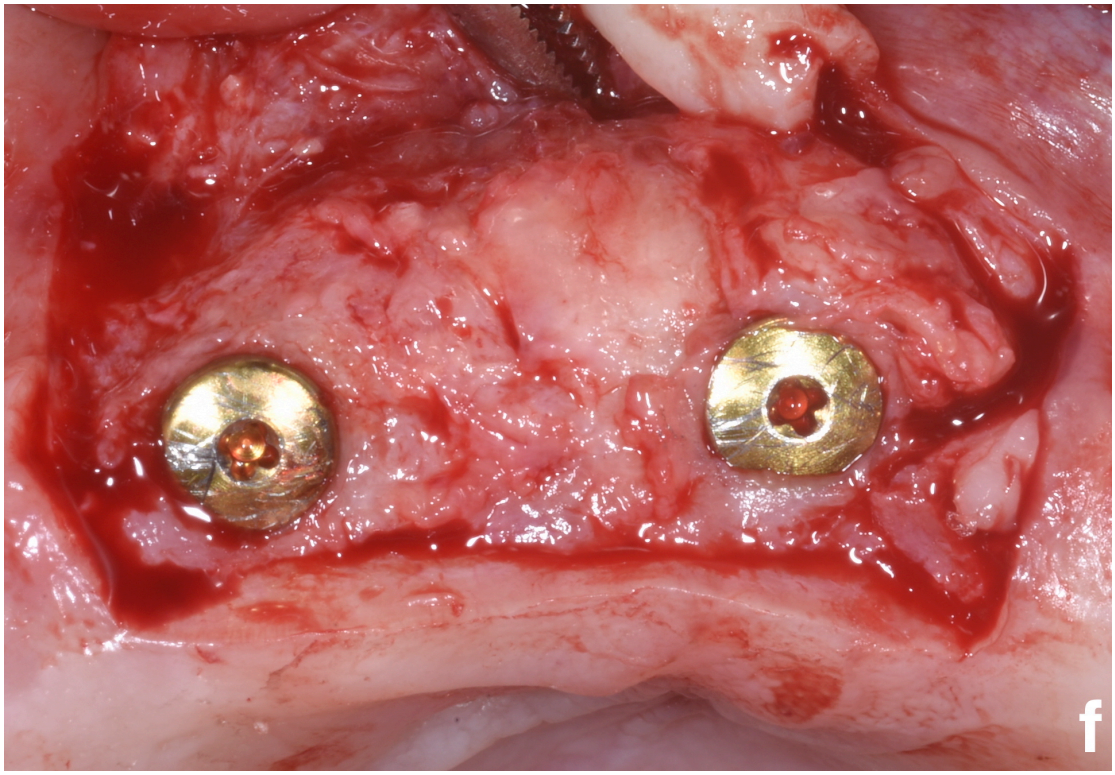












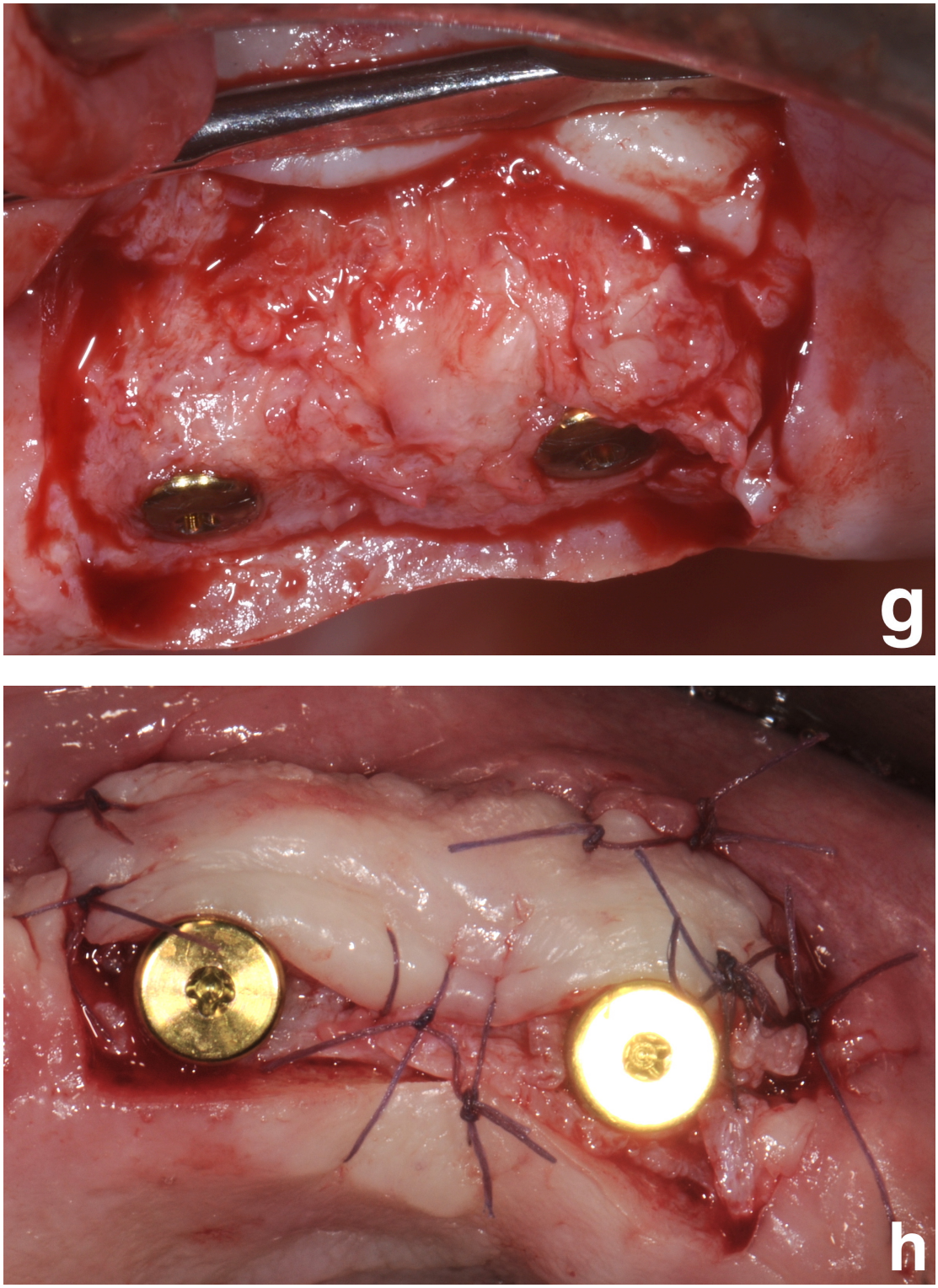


Figure 2. Sub-periosteal Peri-implant Augmented Layer (SPAL) technique at multiple sites with thin buccal cortical bone plate and fenestration. a,b. Tomographic scans show insufficient bucco-lingual width of the residual crest at an edentulous maxillary left central incisor (a) and canine (b) region. **c.** Elevation of a split-thickness flap with releasing incisions on the buccal aspect. **d.** The periosteal layer is elevated from the bone crest. **e.** After placement, both implants show a thin buccal cortical bone plate. A fenestration-type defect is also present on one implant. **f,g.** At 4-month re-entry, a thick band of sub-periosteal tissues is evident at the most coronal portion of both implants. **h.** An apically positioned flap is performed to increase keratinized tissue dimensions.

Table 1. Sub-periosteal tissue thickness (SPTT) and depth of the buccal bone dehiscence (DBD) at each observation interval.

		immediately after implant placement		immediately after graft placement and suturing the periosteal layer		timing for re-entry for implant uncovering	at re-entry for implant uncovering	
Patient number	**Implant position** (tooth number)	**SPTT** * (mm)	**DBD** ♀ (mm)	**at re-entry for implant uncovering**	**DBD** ^ (mm)	(months)	**SPTT** § (mm)	**DBD** ♀ (mm)
1	3.4	0	5	2	0	4	2	2
1	3.5	0	4	2	0	4	3	1
2	4.6	0	2	2	0	3	2	0
3	3.4	0	3	3	0	5	3	0
3	3.5	0	3	4	0	5	5	0
3	3.6	0	4	3	0	5	3	0
4	4.5	0	1	4	0	3	4	0
4	4.6	0	2	3	0	3	3	0
5	2.4	<1	0	2	0	4	2	0
5	2.5	0	4	3	0	4	3	0
6	1.1	<1	0	4	0	4	2	0
6	2.1	<1	0	2	0	4	1	0
6	2.3	<1	0	2	0	4	2	0
7	1.5	0	1	4	0	2	4	0
8	4.5	<1	0	4	0	4	3	0
8	4.6	<1	0	3	0	4	2	0
9	3.6	0	1	2	0	3	3	0
10	4.6	0	2	3	0	2	1	0
10	4.7	<1	0	3	0	2	2	0
11	1.4	<1	0	2	0	6	2	0
12	1.3	<1	0	3	0	4	3	0
13	3.6	0	2	3	0	4	4	1
14	2.2	<1	0	3	0	3	2	0
14	2.3	<1	0	3	0	3	2	0
15	4.6	0	2	3	0	4	3	0
16	2.4	<1	0	6	0	3	3	0
16	2.5	<1	0	4	0	3	2	0

SPPT: sub-periosteal tissue thickness; DBD: depth of the buccal bone dehiscence.

* recorded as the thickness of the buccal cortical bone plate at the level of the most apical visible portion of the polished implant collar. When a buccal bone dehiscence was present, SPTT was recorded as 0.
# recorded as the thickness of buccal cortical bone plate (if present) plus the graft and the periosteal layer at the most apical visible portion of the polished implant collar;
§ recorded following the partial-thickness dissection of the mucosal layer at the time of re-entry. In presence of a residual dehiscence, SPTT was measured in the most coronal portion of the non-exposed buccal implant surface;
♀ measured from the most apical portion of the polished collar to the most apical position of the BCBP at the dehiscence;
^ measured from the most apical portion of the polished implant collar to the most coronal extension of the graft.