Peri-Implant Plastic Surgical Approaches to Increasing Keratinized Mucosa Width: Which to Use and When?

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The long-term efficacy of adequate keratinized mucosa (>2 mm) in dental implants is controversial. Peri-implant plastic surgeries are currently used because they increase keratinized mucosa width (KMW), helping to regain peri-implant health and maintaining it over the long-term. We present the clinical findings using free-gingival-graft (FGG) and free-periosteal-graft (FPG) techniques in peri-implant plastic surgery for implant rehabilitation patients. We included 20 patients with implant indications of inadequate KMW (KMW < 2 mm for postimplantation) in the maxilla and mandible. All underwent clinical and radiographic measurements and a treatment protocol was prepared for implant rehabilitation and subsequent peri-implant plastic surgery. A decision as to whether and when FGG or FPG techniques would be used was made. FGG/FPG was performed pre-implantation (before monocortical block-bone augmentation) or postimplantation (before/during/after stage 2 surgery). KMW was ≥ 2 mm after application of FGG/FPG pre- or post-implantation. Moreover, peri-implant tissue health was regained/maintained in all cases from 6 months to 4 years. Peri-implant plastic surgery techniques can prevent hard- and soft-tissue problems after implant rehabilitation and during treatment of developing problems. However, surgical design and timing, and an interdisciplinary perspective determine the success of peri-implant plastic surgery.

Key Words: clinical study, implant, peri-implant plastic surgery techniques, keratinized mucosa width, soft tissue augmentation

INTRODUCTION

Scientific developments in dental implantology have gradually improved both the success rate and the ability to meet patient expectations. Dental implant rehabilitation is no longer confined to restoration of mastication and phonetic function. The attainment of "ideal" treatment results with structural and aesthetic "regeneration" of edentulous areas is an important goal in modern implant dentistry.[1,2] The long-term functional and aesthetic success of dental implants depends on a balance between hard structures and soft tissues. Thus, peri-implant health should be considered important in resistance against mechanical forces, and bacterial plaque and also mucosal stress must be eliminated.[1–4]

For ideal dental implant rehabilitation, an adequate bone volume, optimal implant position, aesthetic soft tissue contours, and stable and healthy soft tissue are required.[1,5] In particular, soft-tissue defects, such as gingival and connective tissue, play crucial roles in long-term implant success.[2–4] Periodontal plastic surgery techniques are now routine treatments for various soft-tissue defects. The peri-implant plastic surgery concept has been proposed due to the adaptation of these techniques to dental implantology; this is also known as peri-implant soft tissue management/augmentation."[1–3,6]

Peri-implant plastic surgery approaches facilitate the development of healthy peri-implant structures that are able to withstand occlusal forces and mucogingival stress, while providing satisfactory aesthetic results in both soft and hard tissues.[1,2] The treatment of hard structure and soft-tissue problems that arise post-implantation is another important goal of peri-implant plastic surgery.[1–3] Peri-implant plastic surgery enables the creation of the peri-implant keratinized mucosa (KM).[2] KM comprises of dense, collagen-rich connective tissue, lined by a keratinising epithelium. No free elastic fibers are found in the connective tissue, and the lamina propria is firmly and directly attached to the bone periosteum.[4]

Whether the presence of a KM zone around dental implants is required for peri-implant health is controversial.[4,7,8] While significantly higher plaque[9–13] and bleeding scores [10–15] and more soft-tissue recession in the early phase (6–12 months after prosthesis)[12,16] have been reported in regions with inadequate KM width (KMW, <2 mm), other researchers reported the opposite.[4,7] Moreover, although interproximal bone level[12] and implant loss[17] were not detected in such cases, these evaluations could not be completely assessed due to methodological limitations. Therefore, even though no significant

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association was found between KM existence/nonexistence and peri-implant health, the establishment or maintenance of an adequate zone of peri-implant KM is thought to be necessary.[4,7–15]

The evidence that grafting procedures aimed at increasing the amount of KM improve implant therapy outcomes is lacking.[3,4,6,18,19] Techniques to maintain adequate KM around 2-stage implants have been suggested.[3] During implant exposure, apically positioned flaps (APF) or laterally postioned flaps (LPF) and free gingival grafts (FGG) are commonly used to increase KM.[3,20,21] The surgical approach used most frequently is APF plus autogenous graft application (APF–AG), harvested from the palatal mucosa.[3,19,22,23] Performance of these techniques to prevent or treat peri-implant health issues have been suggested, but whether they should be performed pre- or postimplantation remains unknown.[1,3,6,19]

In this study, we present long-term clinical findings of increasing KMW in a case series of patients undergoing dental implant rehabilitation using the FGG and free periosteal graft (FPG).

Materials and Methods

Study groups

We included 20 patients (6 males, 14 females, aged 23–65) undergoing 2-stage implantation at Karadeniz Technical University, Faculty of Dentistry, Periodontology Department, between January 2008 and January 2012. All patients had ≥ 1 tooth loss in the maxilla or mandible, due to root fractures, caries, endodontic lesions, or periodontal disease. Peri-implant plastic surgical approaches were applied as follows: pre-implant (based on fixed prosthesis planning, before monocortical block bone augmentation), postimplant (based on fixed prosthesis or over-denture prosthesis planning, before/during/after stage 2 surgery).

Inclusion criteria

(1) For peri-implant plastic surgery in patients with pre-implant monocortical block bone augmentation, KMW was $<$ bone defect height $+$ bone defect width.
(2) For those who underwent peri-implant plastic surgery after implantation, KMW was $<$ 2 mm.
(3) No systemic disease that could influence the outcome of implant or peri-implant plastic surgery (eg, uncontrolled diabetes (HbA_{1c} $<$7), osteoporosis, bisphosphonate medication, coagulation disorders).
(4) Nonsmoker or light smoker ($<$5 cigarettes per day).
(5) Treated chronic periodontitis and proper periodontal maintenance care.
(6) Good oral hygiene (plaque index [PI] $<$1).[24]

The protocol was consistent with the Helsinki Declaration. Each patient was given a detailed description of therapies and provided informed consent.

Peri-implant plastic surgery protocols

All patients had clinical and radiographic (periapical and panoramic radiography, dental computerized tomography [CT]) measurements and a treatment protocol was prepared for implant rehabilitation, and subsequent peri-implant plastic surgery. According to the protocol, a decision about which technique (FGG/FPG) and when they would be used was made. In cases with early peri-implant bone resorption/peri-implantitis, KMW was increased; in the meantime, FPG was used to facilitate regeneration, due to its denser cell content. FGG was used only in cases of peri-implant health/peri-implant mucositis with inadequate KMW. Preventive peri-implant plastic surgical approaches were performed averagely 2 months before the stage surgery, during and after the stage 2 surgery. The application period of peri-implant plastic surgeries for treatment was meanly 2 months following stage 2 surgery. Prior to surgeries, if needed, nonsurgical treatment was performed along with antimicrobials. The surgeries were performed after the lesion was resolved.[25] Demographic data of the patients and treatment protocols related to peri-implant plastic surgical approaches are given in Table 1.

KMW and peri-implant clinical measurements

All the clinical parameters are measured for peri-implant plastic surgery regions and for other implant regions on which no peri-implant plastic surgery process will be applied. The KMW was evaluated baseline and 6 months later. Pre-stage 2 surgery KMW was measured from the mucogingival junction (MGJ) to the top of the alveolar crest. Post-stage 2 surgery KMW at the mid-buccal point was measured from MGJ to the free gingival margin.[9] Other peri-implant clinical parameters were measured baseline and 6 months later in post-stage 2 surgery patients, because the implants were not exposed. The measurements in the remaining patients were conducted only at 6 months: (1) probing depth (PD), measured from the mucosal margin to the bottom of the probable pocket; (2) bleeding on probing (BOP);[26] (3) PI;[24] (4) mucosal recession (MR), measured from the implant shoulder/restoration margin to the mucosal margin. PD was recorded at 6 sites (mesiobuccal, midbuccal, distobuccal, mesiolingual/palatal, distolingual/palatal, and midlingual/palatal) using a periodontal probe (Michigan O Color-Coded Probe, Hu-Friedy, Chicago, Ill). PI was measured at 4 sites (midmesial, midbuccal, mid-distal, and midlingual/palatal). MR was reported from mesial, distal, and buccal of each implant. The probe was placed as parallel as possible to the long axis of the implant, without causing damage to the region. Clinical parameters were recorded for each dental implant by the same calibrated periodontist (E.B.). The patients were monitored postoperatively for 6 months to 4-year intervals depending on the case. Table 2 shows implant data and clinical and radiographic measurements appropriate to the peri-implant plastic surgery treatment protocol.

Clinical diagnosis of peri-implant tissue destruction

Peri-implant mucositis was defined as the presence of peri-implant BOP, while peri-implantitis was defined as the presence of PD $\geq$ 5 mm in association with peri-implant BOP and/or pus, and with loss of supporting bone.[27–29] On the other hand, early peri-implant bone resorption not associated with clinical findings of peri-implantitis was also seen in some of our cases. Early peri-implant bone resorption can be caused by remodeling, which may be unrelated to infection and is not

Table 1

Demographic data of all patients and treatment protocols associated with peri-implant plastic surgery approaches

Patient No	Age	Period		PIPS Region	mVBL (PIPS Region) (mm)	HMA (+/−)	Clinical Follow-Up Time	Peri-Implant Tissue Destruction	Technic	Prosthetic Planning
1	61	Pre – Implant	Before – Augm	Max – Ant	11	–	4 years	-	FGG	Fixed Prosthesis
2	45			Max – Ant	10	–	4years	-	FGG	
3	64	Post – Implant	Before – Stg 2	Max – Pm-M	10	+	30 month	-	FGG	Fixed Prosthesis
4	45		Surg	Mand –Pm-M	10	+	24 month	-	FGG	
5	52			Mand – Pm-M	7.3	+	26 month	-	FGG	
6	54	Post – Implant	During – Stg 2	Mand – Pm-M	8.6	+	18 month	-	FGG	Fixed Prosthesis
7	44		Surg	Mand – M	9	+	16 month	-	FGG	
8	40	Post – Implant	After – Stg 2	Mand – M	11.5	+	12 month	-	FGG	Fixed Prosthesis
9	43		Surg	Mand – M	9.5	–	6 month	PI–M	FGG	
10:1	56			Mand – M	12	–	8 month	PI–M	FGG	
10:2	56			Mand – M	11	–	6 month	PI–M	FGG	
11	48			Mand – M	10	–	42 month	PI–M	FGG	
12	23			Mand – M	12	–	12 month	PI–M	FGG	
13	55			Max – Ant	10	+	22 month	PI–M, Early-PIBR	FPG	
14	38			Max – Ant	11	+	12 month	PI–M, Early–PIBR	FPG	
15	49			Mand – M	8	+	6 month	PI–M, Early–PIBR	FPG	
16	44			Mand – M	12.5	+	6 month	PI–M, Early–PIBR	FPG	
17	50			Mand – M	10	+	10 month	Peri–implantitis	FPG	
18	50			Mand – M	10	+	7 month	Peri–implantitis	FPG	
19	53	Post – Implant	After – Stg 2	Mand – Ant	10	+	26 month	Peri–implantitis	FPG	Overdenture
20	65		Surg	Mand – Ant	10	+	24 month	Peri–implantitis	FPG	Prosthesis

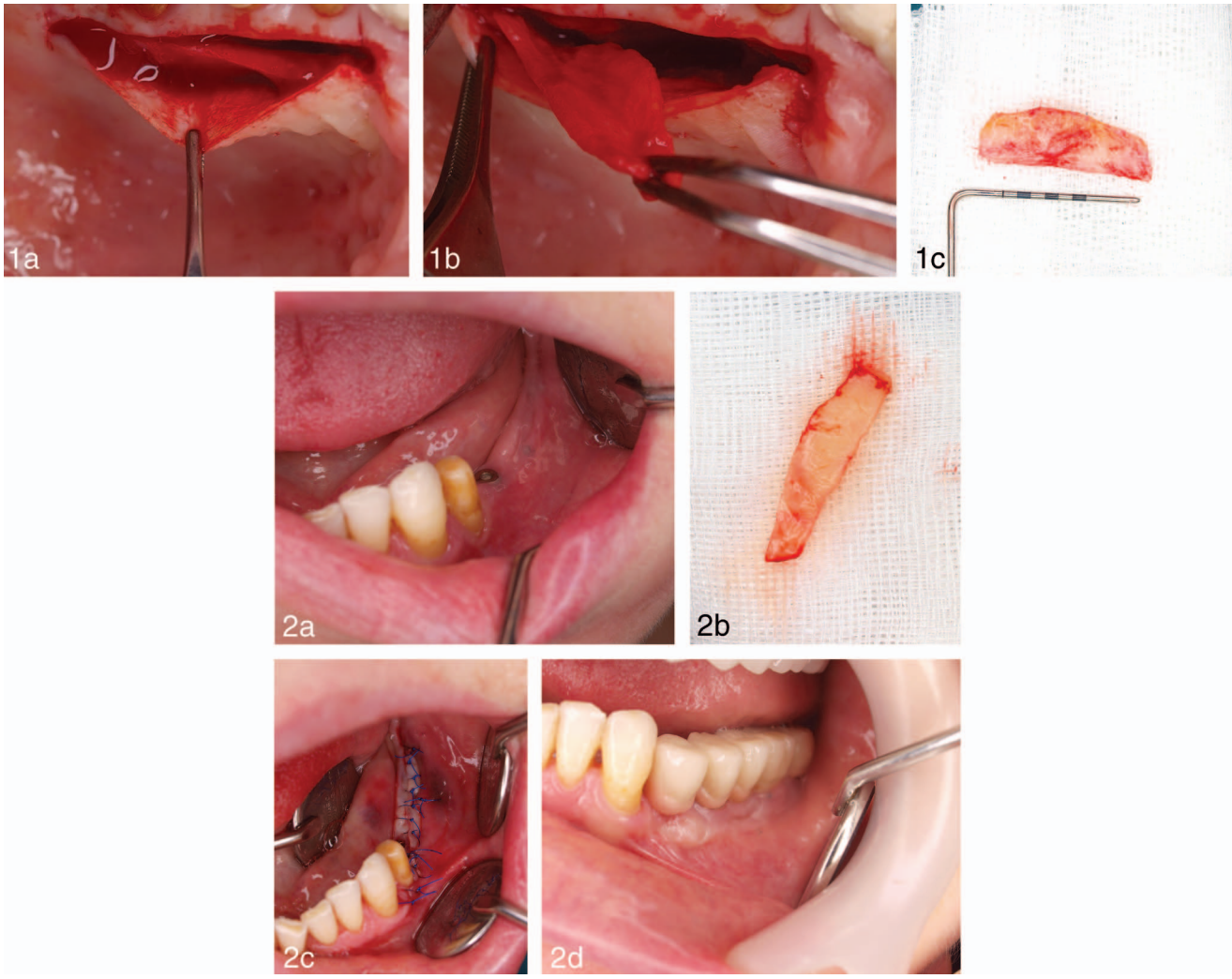
*Ant indicates anterior; Pm, premolar; M, molar; Max, maxillary; Mand, mandibular; Stg 2 Surg, Stage 2 surgery; Augm, augmentation; FGG, free gingival greft; FPG, free periosteal graft; mVBL, mean vertical bone level; HMA, high muscle attachment; PI–M, peri-implant mucositis; Early–PIBR, early peri-implant bone resorption; PIPS, peri-implant plastic surgery.

Table 2

Comparison of clinical and radiographic measurements and implant data of all patients

	Number of Implant		Clinical Peri-Implant Parameters (PIPS Region)										Clinical Peri-Implant Parameters (Non-PIPS Region)									
			Baseline					6 Month (After PIPS)					Baseline					6 Month (After PIPS)				
Patient No	Full Mouth	PIPS Region	mPD* (mm)	mMR (mm)	mBOP (%)	mPI	mKMW (mm)	mPD (mm)	mMR (mm)	mBOP (%)	mPI	mKMW (mm)	mPD (mm)	mMR (mm)	mBOP (%)	mPI	mKMW (mm)	mPD (mm)	mMR (mm)	mBOP (%)	mPI	
1	2	2	No parameters				2.5	1.24	0	0	0.25	6	No parameters				No implant rehabilitation					
2	4	2					3	0.5	0	0	0	8					3.5	0	0	0	0	
3	7	2					1.5	0.9	0	0	0.25	3					2	1	0	25	0.50	
4	6	3					1.33	1.24	0	0	0.08	4					2.33	1.66	0.33	25	0.25	
5	7	3					1.66	1.27	0.77	0	0.50	2.66					2.25	1.5	0	0	0.25	
6	4	3					1	1.33	0.44	0	0.41	2.33					2	1.33	0	0	0.50	
7	6	2					1.5	1.08	0.33	0	0.25	2.5					3	1	0.25	0	0.25	
8	1	1	1.33	0.33	0	0.75	1	0.83	0.33	0	0.25	4					No implant rehabilitation					
9	2	2	1.25	0.17	50	0.38	0.5	1.16	0.50	0	0.63	3.5										
10:1	14	4	1.37	0.25	25	0.87	0.5	0.65	0	0	0.187	4.25	1.33	0.25	0.25	0.87	2	1.66	0.25	0.50	0.50	
10:2	14	3	1.50	0.33	33	0.83	0.66	0.94	0.22	0	0.25	4	1.33	0.25	0.25	0.87	2	1.33	0.25	0.66	0.50	
11	7	2	1.42	0.83	100	1	0.5	1.08	0.50	0	0.25	5	1.2	0	0	0.25	2.4	1	0	0	0.25	
12	1	1	1.83	0.66	100	0.5	1	1.5	0.33	0	0.25	5					No implant rehabilitation					
13	5	1	2.16	0.66	100	1	1	1.16	0.33	0	0.25	3	1	0	0	0.25	2.5	1	0	0	0.25	
14	4	1	2.33	0.33	100	1	1	1.66	0	0	0.5	3	1.66	0	0.25	0.50	2.66	1	0	0	0.33	
15	4	2	2.33	0	50	0.63	0.5	1.25	0	0	0.5	3	1.5	0	0.25	0.75	2	1.25	0	0.50	1	
16	4	2	2	0.5	50	0.75	0.5	1.25	0.17	0	0.13	2.5	1	0.5	0	0.25	2	1	0.5	0	0.13	
17	2	1	4	0	100	1.25	0	2.33	0	0	0.5	3	1	0	0	0	2.5	0.33	0	0	0	
18	2	2	4.16	0.66	100	1.13	1	1.42	0.5	0	0.5	2.5					No implant rehabilitation					
19	2	1	4	0	100	0.5	0	1.33	0	0	0.25	2	1	0	0.25	0.25	2	1	0	0	0	
20	2	1	4	0	100	1.25	0	0.83	0	0	0	3	1	0	0	0.25	2	0.83	0	0	0	

*mPD indicates mean probing depth; mMR, mean mucosal recession; mBOP, mean bleeding on probing; mPI, mean plaque index; mKMW, mean keratinized mucosa width; PIPS, peri-implant plastic surgery.



Figures 1 and 2. Figure 1. (a, b, c) Obtaining a free periosteal graft in the palatal area. **Figure 2.** FGG application to the left posterior mandibular area prior to stage 2 surgery. (a) Clinical view prior to FGG. (b,c) FGG and FGG operation. (d) 12 months after FGG.

necessarily periimplantitis.[30] In those cases, diagnosis was made during radiographic investigations or plastic surgical procedures.

Peri-implant procedures

In both techniques, for donor site preparation, horizontal incisions were made in the implant area and the area was made visible. Vertical bone height (VBH) in the area was crucial for vertical incisions. Flaps were positioned apically following vertical incisions in areas with adequate VBH; a vestibuloplasty was performed in atrophic areas. Grafts were obtained from the hard palate. While FGG consists of keratinized epithelium in the palatal region, FPG includes periosteum and some connective tissue in that area.

FGG/FPG procedure

Free gingival graft procedure was performed according to the technique described by Newman and colleagues.[31] During FPG application, granulation tissue in the defect area was removed using an Er, Cr: YSGG Laser (Waterlase MD, Turbo, Calif; Biolase Technology, San Clemente, Calif) and cotton pellets soaked in sterile saline. The FPG was then placed. Briefly, after application of local anesthesia, a linear incision was made 1.5–2 mm from the palatal gingival margin. From this incision, a split-thickness envelope flap was partially raised, creating a ~10-mm-deep pouch in the palatal thickness. Inside the pouch, 4 incisions (mesial, distal, coronal, apical) were made deeper through the bone. Connective tissue with periosteum was obtained using a periosteal elevator (Figure 1). The donor site was closed with 3–0 silk cross-mattress sutures. The FPG were then shaped according to the receiving area and reduced to a 2- to 2.5-mm thickness. The periosteal side of the connective tissue was positioned facing the osseous and implant surface of the receiving area.[32]

Pre-implant peri-implant procedures

KMW Increase via FGG Prior to Monocortical Block-bone Augmentation

The implant site in 2 patients had a shallow vestibule due to inflammation and a horizontal bone defect prior to implanta-

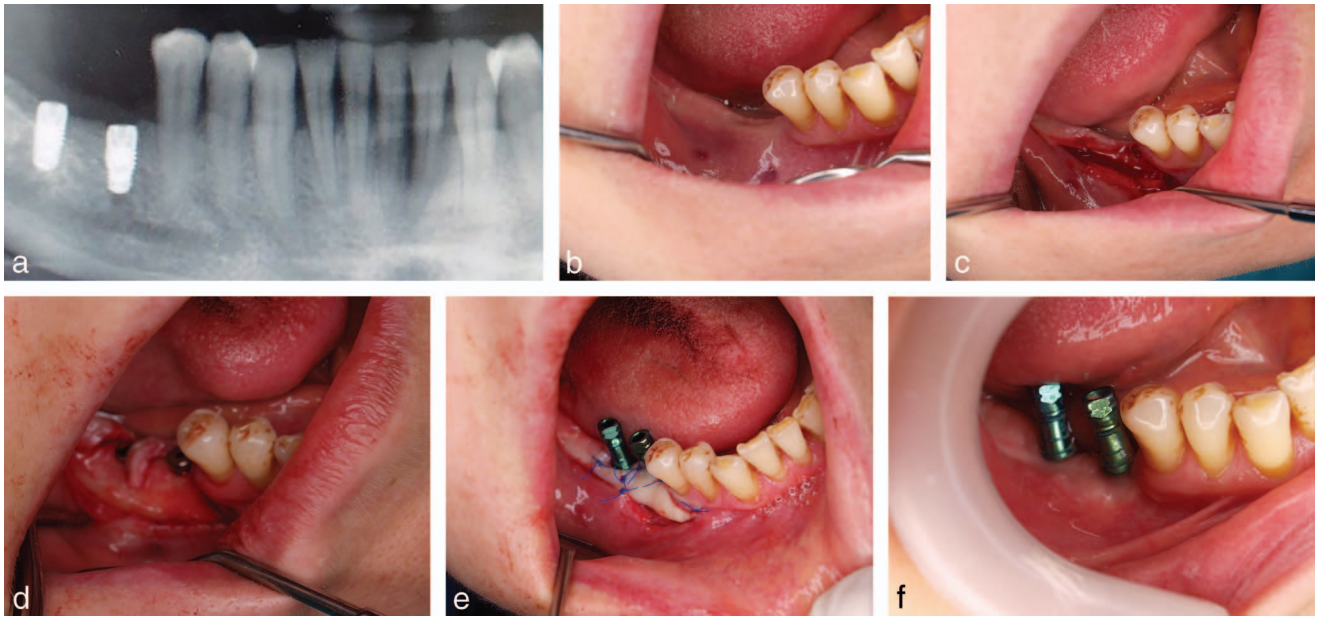


Figure 3. FGG application to the right posterior mandibular area with implant abutment during stage 2 surgery. (a) Radiographic appearance. (b) Clinical view prior to FGG. (c) Incision borderline. (d) Semilunar incision. (e) Immediately after FGG operation. (f) 6 months after FGG.

tion. FGG was suitable, with subsequent monocortical block augmentation. To increase pre-implant KMW, the FGG technique was used. FGG was also used to cover the block bone graft completely and enhance healing. Thus the implant site was prepared for augmentation by applying the FGG graft. The site to which the block bone augmentation would be applied was prepared by making a horizontal incision from the mucogingival junction line. The FGG obtained from the hard palate was placed in this site. Three weeks later, the vestibular depth was adequate. KM, which would completely cover the monocortical block-bone graft, was formed simultaneously.

Postimplant peri-implant procedures

These surgeries were used for KMW increasing/peri-implantitis treatment and were performed before/during/after stage 2 surgery.

Increasing KMW via FGG/FPG With Fixed Prosthesis

In these procedures, criteria such as VBH, number of implants, and muscle hyperactivity (high muscle attachment, HMA) were of high importance in the timing. All surgeries were performed in cases with atrophic/sufficient VBH and (+/−) HMA. The following criteria were important for surgical timing. When the number of implants was $\geq$ 2 and HMA (+), surgical procedures were performed before or during stage 2 in order to avoid any surgical complication that might develop due to insufficient KMW (such as rupture of flap due to stretching) or to prevent development of peri-implant mucositis/peri-implantitis. In FGG applications prior to stage 2 surgery the implant number was $\geq$ 2 and HMA was (+) (Figure 2). In FGG applications during stage 2 surgery, implant number was $\geq$ 2 and HMA was (+). In cases 6 and 7, implants were placed into the posterior atrophic mandible, and FGG was applied with implant abutment. In these cases, while donor area had been prepared, gingiva between the implants was preserved via a semilunar incision (Figure 3). In FGG/FPG applications following stage 2 surgery, surgical procedures were performed for protective purposes or peri-implant mocositis/peri-implantitis treatment. In those applications with a protective purpose, FGG was usually performed. Also in that group, FGG was used when the implant number in the surgical area was $\geq$ 3. Details regarding the timing of cases were shown in Tables 1 and 2.

Increasing KMW via FPG With an Overdenture Prosthesis

Due to the posterior atrophic mandibles in 2 cases in this treatment group, implants were placed into the basal mandible and anterior regions. Despite the KMW $<$1 mm following stage 2 surgery, because the mental foramina was almost at the top of the crest, considering complications, patients were followed for some time and then peri-implantitis plastic surgery was decided on when peri-implantitis began (Figure 4).

All surgical procedures were performed by the same experienced surgeon (E.B.) who was informed of the procedure only at the time of the surgical intervention. Sutures (5.0-trofilen monofilament; polyvinylidene fluoride) were used.

Postoperative care

Systemic antibiotics (amoxicillin + clavulanic acid, 2 $\times$ 1000 mg/d) were administered peri- (1 hour before) and postoperatively for 5 days for transmucosal healing. Postoperative care consisted of rinsing with 0.2% chlorhexidine digluconate twice daily (60 seconds each) for 2 weeks without tooth brushing at the surgical site. Sutures were removed roughly 10–14 days after surgery. To control oral hygiene and wound healing, recall appointments were scheduled every second week during the first 2 months and then monthly during the observation period.

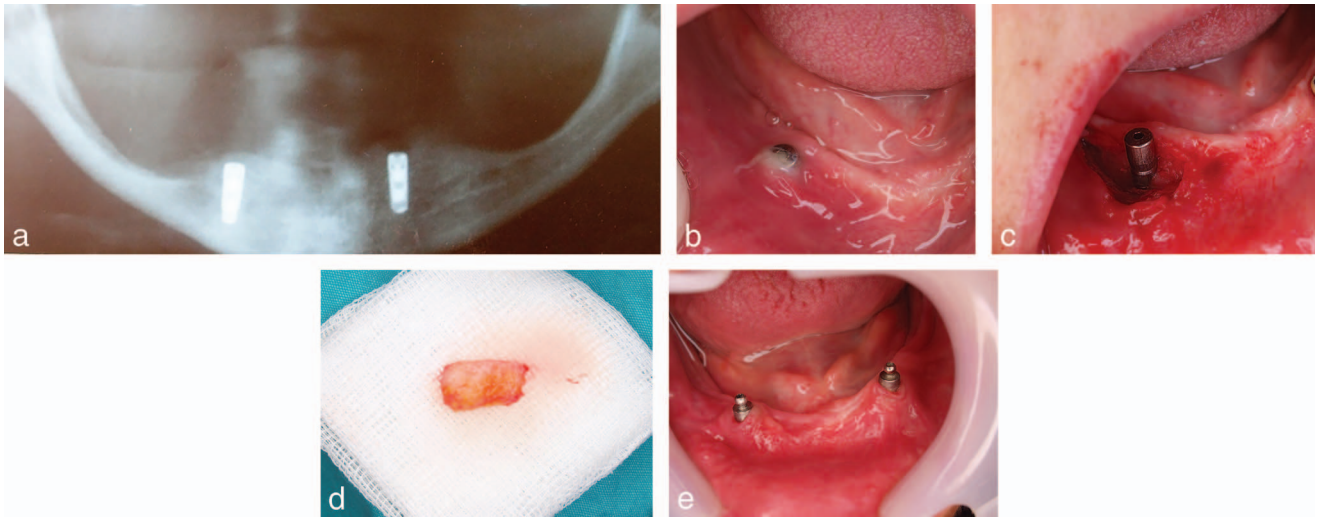


Figure 4. FPG application to the right anterior mandibular area following stage 2 surgery. (a) Radiographic appearance. (b) Clinical view prior to FPG (peri-implantitis and shallow vestibule). (c,d) FGG operation (cleaning of granulation tissues with an Er,Cr:YSGG laser). (e) 6 months after FPG.

Statistical analysis

To evaluate any differences between baseline and sixth month KMW's in peri-implant plastic surgery group, Wilcoxon signed rank test was used. All statistical analyses were performed with SPSS Graduate Package 15.0 (SPSS Inc, Chicago, Ill). A value of $P < 0.05$ was accepted as indicating statistical significance.

Results

In this study, 86 rough-surface implants were used; KMW was increased via pre- and post-implantation FGG/FPG application in 41 implants in 20 patients. The other 45 rough-surface implants on which FGG/FPG was not applied due to sufficient KMW (≥2 mm) were accepted as the control group. The implant numbers used and clinical parameters of the peri-implant hard and soft tissue are given in Table 2.

In peri-implant plastic surgery group, while FGG was used in 2 areas in case 10, in other patients peri-implant plastic surgery was applied only to the peri-implant area. No complications were evident, and uneventful recoveries occurred within 3 weeks. Pre-implant, in cases in which KMW was increased via FGG, KMW increased by 7 mm on average in both cases. At the third month following FGG, block bone augmentation was performed, and treatment was completed with implant surgery and a fixed prosthesis. KMW was ≥ 2 mm following FGG/FPG techniques applied after implantation. KMW increases in cases with adequate VBH and HMA (–) were higher than those with inadequate VBH and HMA (+). Besides, in the overdenture cases in which FPG technique is used, we obtained KM approximately 2 mm in width, rich with collagen fibers, and healthy. Peri-implant tissue health was regained in patients by year 2. Therefore, peri-implant tissue health was regained/maintained in all cases within 6 months to 4 years. Peri-implant pockets were eliminated. As a result, presurgery (baseline) KMW was < 2 mm and postsurgery (6 months), KMW was ≥ 2 mm ($P < 0.05$; Table 3).

In the control group, peri-implant tissue health was also preserved between 6 months and 4 years.

Table 3

Comparison of baseline and 6 month KMW's in peri-implant plastic surgery region of all patients

mKMW† (mm)			
Baseline		6 Months (After PIPS)	
(Minimum – Maximum)	(Mean ± SD)	(Minimum – Maximum)	(Mean ± SD)
(0 – 3)	0.98 ± 0.76 *	(2 – 8)	3.63 ± 1.43

†mKMW indicates mean keratinized mucosa width; PIPS, peri-implant plastic surgery.

*Significant difference between baseline and 6 months ($P < 0.05$).

Discussion

Although the need for KM remains controversial in the long-term success of dental implants, peri-implant soft tissue management, or peri-implant plastic surgery, is considered essential by clinicians.[3] However, little, if any, data regarding the overall success and longevity of these techniques from well-controlled, long-term studies has been published. Moreover, there is no consensus regarding the timing of application of these techniques.[1] In this case series, peri-implant plastic surgery procedures to increase KMW were discussed with cases; an original perspective was provided in terms of techniques and timing. Adequate KM (>2 mm) was obtained in all cases. Soft and hard tissue defects due to KM insufficiency could be treated using these techniques. In addition, the preservation of peri-implant tissue health in other dental implants, on which FGG/FPG was not applied due to sufficient KMW, emphasized the significance of KMW once again.

Because there is no consensus on peri-implant plastic surgery techniques, the decision about the techniques to be

applied depends on the clinician's choice and the planned surgical and prosthetic treatment.[4,6,19] Although the essential goal of the FGG/FPG techniques was to increase KMW in this study, differences between treatment protocols in implant rehabilitation and clinician choices determine the technique(s) used. The FGG technique was used to increase KMW in pre- and post-implant situations. This is a periodontal plastic surgery procedure used to increase inadequate attached gingival width and to cover exposed root surfaces.[31] Although FGG is among the earliest techniques for increasing peri-implant KMW, the long-term clinical data are limited.[3,4,19] Also, both free and pedicle autogenous periosteal grafts are modern approaches with clinically proven superiority in intra-osseous barrier membrane, or gingival recession defects in regenerative and plastic periodontal surgery.[32] The periosteum is highly vascular and contains fibroblasts, osteoblasts and their progenitor cells, and stem cells.[33] Moreover, FPG may facilitate the stimulation of new bone formation.[32] Because the periosteum has high regenerative potential, contains collagen fibers, and maintains osteoblastic activation, FPG was used following implantation in peri-implantitis cases with adequate KM. Because of these characteristics of FPG, it increased the soft tissue volume more than FGG did.

Although there is no report of clinical findings with FPG, the clinical findings of FGG and free connective tissue graft (FCG) techniques have been investigated.[34–37] FCGs may be preferable due to the less invasive palatal wound, resulting in less donor site morbidity and improved aesthetic results, due to better color matching.[35] Additionally, following FGG 25% shrinkage was seen on average in 4 years, whereas 40% shrinkage was seen with FCG in 1 year.[34,35] We also detected color changes in the cases that underwent FGG. Because the clinical results of FPG in peri-implant plastic surgery are unknown, to decrease the possibility of complications FGG was performed in cases where we planned to increase KMW in a wide area. Also, because FPG quality and quantity in the donor site vary among individuals, obtaining adequate FPG may be difficult. For those reasons, unless absolutely necessary, ie, if peri-implantitis treatment is not required, KMW is best increased by the FGG technique. Moreover, in this study manual periodontal probe was used in clinical peri-implant parameter measurements. These probes were used in similar studies in measuring peri-implant clinical parameters.[14,21]

Based on variability in the cases, peri-implant plastic surgery is appropriate in the pre-implant placement, stage 1 and 2 surgeries and postprosthetic periods.[1–3,6,19] Similarly, while the timing of surgical procedures to increase KMW is unknown, reports show it can be performed mostly during the stage 2 surgery or postprosthetic treatment periods.[3,6] Because the soft and hard tissue dimensions in the implant area are not standardized, and surgical treatment planning varies by case, we formed various treatment groups and surgical timing was determined according to indication. The techniques were investigated pre- and post-implantation. The modified approaches presented here provide a perspective for cases similar to ours.

To increase pre-implant KMW, the FGG technique was used. During this period, FGG was also used to cover the block bone graft completely and enhance healing. Thus the implant site was prepared for augmentation by applying the FGG graft. At the third month following FGG, block bone augmentation was performed, and treatment was completed with implant surgery and a fixed prosthesis. During follow-ups for up to 4 years after FGG, peri-implant soft and hard tissue health was maintained and KMW was adequate. This method is an alternative to the controlled tissue expansion technique;[38] peri-implant tissue health benefitted by increasing KMW. Therefore, the ideal indication for pre-implant peri-implant surgical application is an augmentation model similar to our cases.

The FGG technique used prior to postimplant stage 2 surgery may be thought not to be inappropriate because an additional procedure is required. However, because the implants were positioned in the buccal area for prosthetic reasons and HMA (+) and/or implant number was $\geq$ 2, the implants were not exposed and stage 2 surgery was delayed to 2 months after the FGG. Indeed, it has been reported that peri-implant KMW augmentation is affected by implant location, and obtaining a wide keratinized tissue band in the posterior implant region with HMA is problematic, especially with a shallow vestibule.[37]

When FGG was used during postimplant stage 2, to eliminate the possibility of a second surgery, FGG was applied following placement of the implant abutment or cover screw. In these cases, the minimal keratinized tissue present was not excised during implant exposure; it was moved with semilunar incisions and sutured with the FGG. This method represents a modified FGG technique as a combination of the papilla regeneration[2] and FGG techniques. The compliance between implant and soft tissue was better, despite the difficulty of the procedure. The approximate aesthetic was better maintained using semilunar incisions. In these cases with HMA (+) in the posterior region and a shallow vestibule, KMW was adequate following prosthesis placement. Manipulation of soft tissue adjacent to implants enables peri-implant tissue healing.[2]

Although the findings of the effects of the inadequacy of KMW in peri-implant tissue health are controversial, and the association of this condition with peri-implantitis is uncertain, in the presence of insufficient KM, the proposal that increased plaque accumulation and mucosal inflammation cause peri-implantitis is more than just a hypothesis.[4] We also observed early peri-implantitis, characterized with PD and/or pus, in cases 17–20. Moreover, we observed early peri-implant bone resorption in cases 13–16. In these, we both increased KMW and applied a periosteal graft for PD treatment. The clinical findings were encouraging. While PD was eliminated, KMW was adequate at 6 months. Although there was no significant hard-tissue problem, similar clinical success was achieved in cases in which FGG was applied for prevention following stage 2. In case 10, positive results of other procedures encouraged us to go one step further in surgery. Poststage 2 FGG applications were also performed in regions with implant numbers $\geq$3.

Using the FPG technique, the most beneficial results were with an over-denture prosthesis. In severe atrophic mandibles, inadequate KMW emerged as a more important problem in implant regions completely within the mandible. In addition to muscle-related stress, this region could not be cleaned well, and the implant level was almost at the same level as the floor

of the mouth due to severe atrophy, which can make solutions in peri-implant plastic surgery near impossible. FPG may be an option in such cases. We obtained healthy KM approximately 2 mm in width, and rich with collagen fibers. Peri-implant tissue health was regained in patients by year 2. Indeed, ensuring that a keratinized tissue border exists at the implant-soft tissue interface facilitates tight tissue adaptation and a marginal seal at the implant surface and provides a connective tissue circumferential fiber system that resists mechanical stress and facilitates oral hygiene procedures.[1]

We presented our experience of specific cases of peri-implant plastic surgery techniques to increase inadequate KMW. KMW ($\geq$2 mm) was adequate in all cases after FGG/FPG techniques. Peri-implant tissue health was maintained/re-gained. Because the cases were not standardized, the techniques used were modified case by case. Thus, although this was a long-term study, we present it as a case series. Although no general treatment protocol for peri-implant plastic surgery is available, these findings are promising. The techniques performed and their modification, based on purpose or local factors, may facilitate further clinical studies. The FPG technique should be used in peri-implantitis, representing an alternative for peri-implant plastic surgery. However, further studies of FPG are warranted. Our data suggest that the priority for successful peri-implant plastic surgery is successful phase 1 periodontal treatment. While deciding the peri-implant plastic surgery treatment protocol, phase 1 peri-implant treatment should be discussed. Moreover, for successful peri-implant surgery, appropriate techniques, accurate timing, and clinical experience are crucial.

Abbreviations

APF: apically positioned flaps
APF-AG: APF plus autogenous graft application
BOP: bleeding on probing
CT: computerized tomography
FGG: free-gingival-graft
FPG: free-periosteal-graft
HMA: high muscle attachment
KM: keratinized mucosa
KMW: keratinized mucosa width
LPF: laterally positioned flaps
MGJ: mucogingival junction
MR: mucosal recession
PD: probing depth
PI: plaque index
VBH: vertical bone height

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