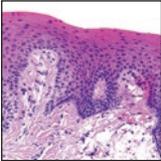


Gain of Keratinized Mucosa Around Implants in the Posterior Mandible by a Modified Apically Positioned Flap and Xenogeneic Collagen Matrix



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This case series demonstrated the regeneration of peri-implant keratinized mucosa (KM) in the posterior mandibles by a modified apically positioned flap and xenogeneic collagen matrix (CM). This modified surgical approach includes a midcrestal incision in the residual KM, partial-thickness flap reflection and apical positioning, removal of submucosal tissue, and CM adaptation. Six patients with 18 implants were recruited. The mean regenerated KM width was 4.81 ± 0.69 mm after 3 months of healing. Histologic analysis of the regenerated KM revealed similar architecture to the native KM. Int J Periodontics Restorative Dent 2019;39:721–727. doi: 10.11607/prd.4176

Keratinized mucosa (KM) around natural teeth is defined as keratinized stratified squamous epithelium between the mucogingival junction and the free gingival margin. If good oral hygiene is maintained, long-term periodontal health can be achieved even without an adequate band of KM.¹ However, dental implants have fundamental structural and anatomical differences from teeth,² and whether an adequate width of KM around the dental implant is needed for maintaining peri-implant health has been long discussed. Some authors believe that KM is not an essential factor for implant maintenance^{3,4}; however, various studies demonstrated positive effects of KM on peri-implant tissue health, implant survival rate, and the esthetic outcomes.^{5–8} Recently, more clinical studies had revealed that a lack of peri-implant KM was associated with higher tendencies of plaque accumulation, bleeding on probing, and pain while brushing.^{9–12} Systematic reviews on this issue also supported the necessity of KM around implant restorations.^{13,14}

Tooth loss can lead to the atrophy of hard and soft tissues and loss of KM. In cases of severe ridge resorption or after advanced bone reconstruction procedures, narrow KM is often combined with a shallow vestibule and prominent muscle attachment.¹⁵ To overcome this problem

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and reconstruct an adequate band of KM, the most frequently used surgical technique is the apically positioned flap combined with autogenous free gingival graft (FGG), which is harvested from the palatal mucosa.¹⁶ However, disadvantages include donor site morbidity, limited graft volume, poor esthetic results, and unpleasant patient experience.

Mucograft (Geistlich Pharma), a xenogeneic collagen matrix (CM), has been investigated for the treatment of augmenting the keratinized tissue around teeth and implants to avoid the drawbacks associated with harvesting autogenous tissue. Clinical evidence has been provided that supports the effectiveness and predictability of using CM instead of FGG for attaining a band of keratinized tissue around implants.¹⁷⁻¹⁹ However, only a few studies focused on this issue, and fewer clinical studies provided histologic outcomes from biopsies of regenerated peri-implant KM.¹⁸ More clinical studies are needed to confirm the validity of CM.

Performing apically positioned flap procedures with vestibuloplasty in the posterior mandible is challenging due to muscle (buccinator) interference, vital structure (mental nerve and its branches) involvement, and limited operation space. Unfortunately, a lack of KM around implants in this area seems to be more adverse than in other oral regions.¹⁰

The primary objectives of the present case series were to evaluate the feasibility of utilizing a modified apically positioned flap and CM instead of FGG in KM regeneration around implants in the posterior mandible. Secondary analysis fo-

cused on the width of regenerated KM after the early healing phase.

Materials and Methods

From February 2017 to March 2018, six consecutive patients were recruited for the study. All patients had missing teeth or teeth pending extraction in the posterior mandible and were evaluated for implant therapy in the Department of Oral Implantology of Peking University School and Hospital of Stomatology. Implant surgery, with or without bone grafting procedures, was performed on all patients, revealing a thin band (≤ 2 mm) of KM at the time of second-stage surgery. No systematic diseases that would interfere with wound healing were identified. Good oral hygiene was maintained.

The study protocol was approved by the local ethical committee (Institutional Review Board of Peking University School and Hospital of Stomatology, approval no.: PKUSSIRB-201623074). An informed consent form was signed by all enrolled patients. All surgical interventions were performed by the same surgeon (X.J.).

Surgical Procedures

Prophylactic antibiotics (cefuroxime, 0.25 g) were given 1 hour before surgery, and patients were asked to rinse with a 0.2% chlorhexidine solution for 1 minute. The surgery was performed under local anesthesia by infiltration with Primacaine adrenaline (Acteon). The following

surgical procedures are shown in two cases in Figs 1 and 2.

Midcrestal Incision

The incisions began at the midcrest of the residual KM, located about 0.5 to 1.0 mm coronal to the mucogingival junction. This incision design leaves a narrow band of KM in the coronal part of the flap. Two vertical releasing incisions were followed to facilitate apical movement of the soft tissue flap. The incisions should not touch the periosteum.

Reflecting a Partial-Thickness Flap

After the incisions, a partial-thickness square-shaped flap was reflected by sharp dissection. Caution should be taken not to perforate the flap, especially at the mucogingival junction. When the flap is raised beyond the mucogingival line into the oral mucosa, fibers originating from the deep layer of vestibular tissue can be seen intruding into the flap (Fig 1b). These fibers should be separated from the inner side of the flap, which ideally should contain only the epithelium and the superficial layer of lamina propria.

Resecting Submucosal Tissue

After reflecting the flap, frenum, fat, and submucosal tissue, which is movable and contains muscles, were exposed (Fig 2c). This mobile submucosal tissue was removed from the periosteum and disposed. Sharp dissection should not be implemented if the surgery involves the premolar area, as the mental nerve and its branches are encapsulated in the soft tissue (Fig 2d). In this area, complete

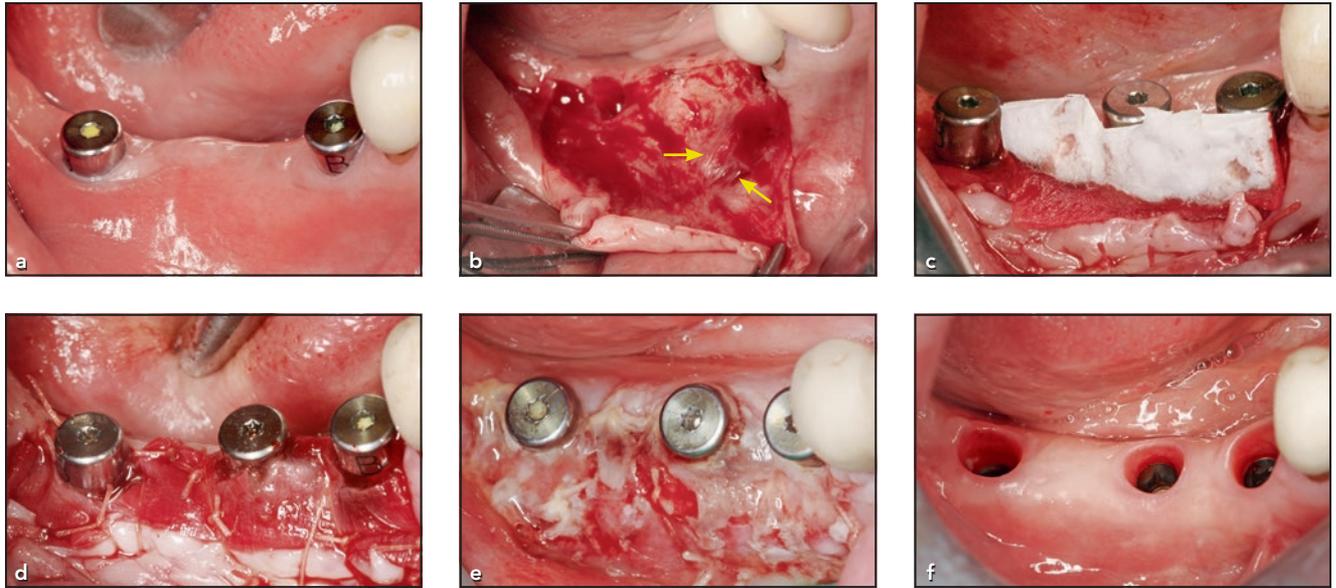


Fig 1 (a) Clinical view of the narrow band of KM on the buccal side and malpositioned mucogingival junction following healing of implant placement and simultaneous guided bone regeneration. (b) A partial-thickness flap was made by a crestal incision and two vertical releasing incisions. The narrow band of KM was reflected with the flap at the coronal aspect. Note the connective tissue fibers originating from the deeper layer and intruding into the flap (yellow arrows), which should be dissected from the flap. (c) The flap was apically positioned, and xenogeneic CM was trimmed and customized to cover the surgical area. (d) Sutures were applied to secure the CM. (e) Three days after healing, remnants of the CM still partially covered the wound. (f) Three months of healing revealed widened KM, an adequate position of the mucogingival line, and complete blending of regenerated KM color and texture with the adjacent soft tissue.

elimination of the redundant sub-mucosal tissue is not possible.

Retaining Intact Periosteum

Remnants of any unattached soft tissue were also removed by sharp dissection. Care should be taken not to cut or perforate the periosteum. Ideally, intact periosteum is retained and firmly attached to the bone, without any movable soft tissue.

Apically Positioning the Flap

The flap was then apically positioned and sutured (Vicryl Rapide, Ethicon) to the underlying periosteum. The implants were uncovered, and healing abutments were connected. Porcine collagen matrix (Mucograft, Geistlich) was shaped, adopted to the recipient bed, and secured by horizontal mattress

sutures (Figs 1c, 1d, and 2e). The wound was left to heal without any tissue-retention devices.

Postoperative instructions included oral medications of antibiotics (250 mg cefuroxime twice daily for 3 days), analgesics (300 mg ibuprofen, taken as needed), and 0.2% chlorhexidine as a gentle mouth rinse (three times daily for 2 weeks). Patients were strictly asked not to brush the surgical area for 2 weeks.

Measurements and Follow-up

Patients were revisited at 3, 14, 30, and 90 days after surgery (Fig 1e). KM widths were evaluated by periodontal probe at 90 days after healing. Measurements were recorded at each implant site starting from

the buccal margin of healing abutment to the surgical repositioned mucogingival line.

Biopsy and Histologic Examination

After 90 days and under local anesthesia, a scalpel was used to harvest one biopsy sample each ($4 \times 2 \times 0.8 \text{ mm}^3$) of the regenerated KM from three of the six patients. The samples were immediately fixed in 10% paraformaldehyde for 48 hours at room temperature. Samples were then embedded in paraffin, fixed in a sledged microtome, sectioned into $4\text{-}\mu\text{m}$ -thick slices, and stained with hematoxylin-eosin. Micromorphologic examinations were performed with an optical microscope.

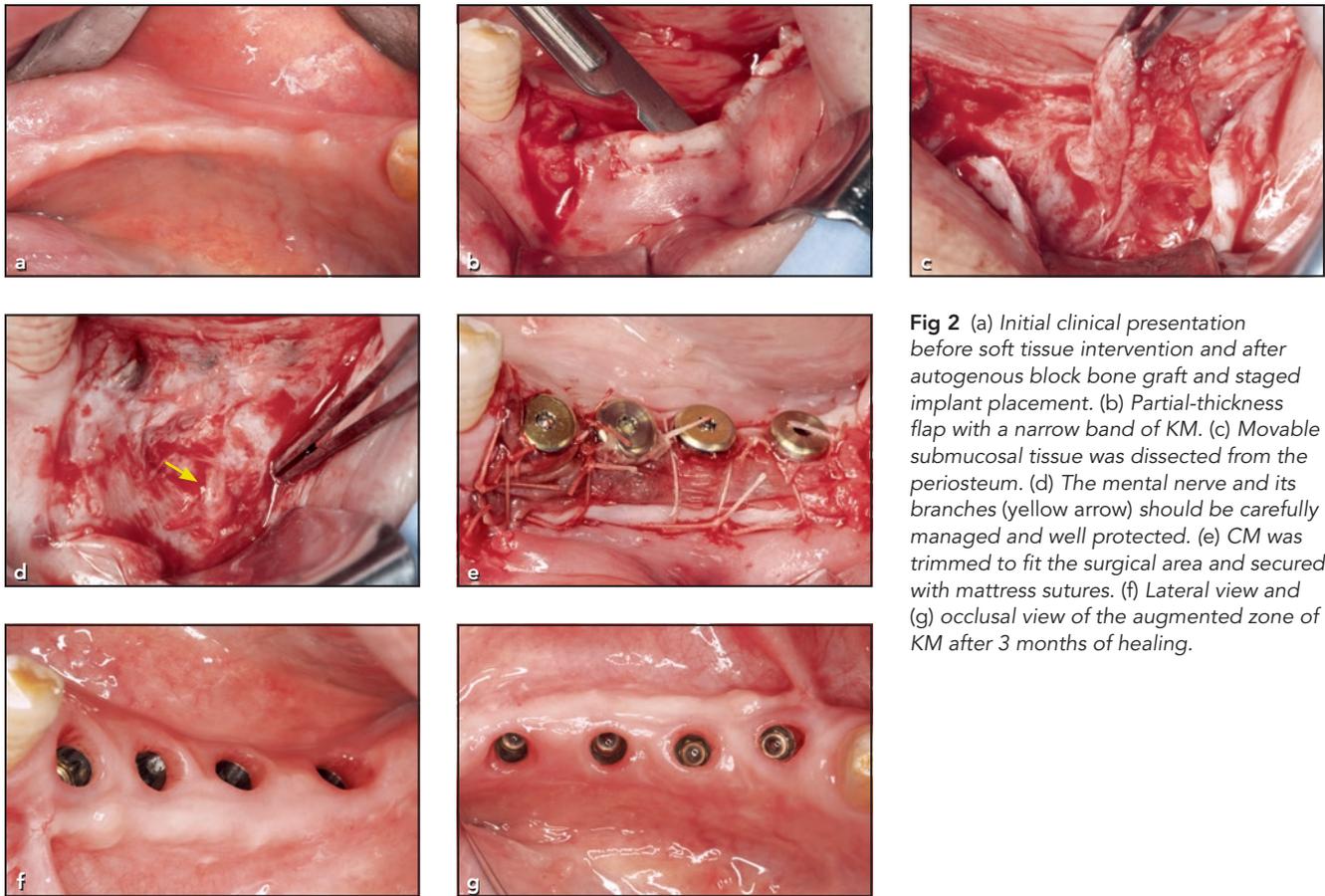


Fig 2 (a) Initial clinical presentation before soft tissue intervention and after autogenous block bone graft and staged implant placement. (b) Partial-thickness flap with a narrow band of KM. (c) Movable submucosal tissue was dissected from the periosteum. (d) The mental nerve and its branches (yellow arrow) should be carefully managed and well protected. (e) CM was trimmed to fit the surgical area and secured with mattress sutures. (f) Lateral view and (g) occlusal view of the augmented zone of KM after 3 months of healing.

Results

Six patients (5 females, 1 male; average age: 56 years) were recruited and participated in this case series. Demographic and characteristic data of the subjects are summarized in Table 1. The modified apically positioned flap was performed, and porcine CM was applied in six surgical areas with 18 implant sites.

All healing processes were uneventful, with clinical signs of early revascularization at the 3-day follow-up and almost complete re-epithelialization by 2 weeks without signs of residual CM biomaterial. Complete soft tissue healing with deepened vestibules and harmoni-

ous KM tissue could be identified at the 90-day follow-up (Figs 1f, 2f, and 2g). No complaint associated with neurosensory disturbances after surgery was reported in any case.

After 3 months of healing, the mean (\pm standard deviation) regenerated KM width was 4.81 ± 0.69 mm, ranging from 3.6 to 6.1 mm.

Biopsy samples, harvested from three of six subjects, all exhibited very consistent histologic results. Typical KM structures, consisting of a continuous lining of stratified squamous epithelium, were identified. From basement membrane to the superficial layer, keratinocytes differentiated with round or cubic cell morphology, altering to a more

flattened shape, and the cells gradually lost their nucleus. A superficial horny layer can be visualized as well as a few pyknotic nuclei, revealing a parakeratinized epithelium (Fig 3).

Discussion

In the present report, a modified surgical technique—apically positioned flap combined with xenogeneic CM (Mucograft)—was used to augment peri-implant KM in the posterior mandible. An adequate width (mean: 4.81 mm; range: 3.6 to 6.1 mm) of regenerated KM was achieved, which was further confirmed by histologic examinations.

The evidence supports that the existence of peri-implant KM shows positive outcomes in maintaining long-term implant health.^{13,14,20} Lack of KM is a common clinical dilemma in severe resorbed edentulous ridges, and reconstructive strategies should include both hard bone tissue and soft peri-implant KM tissue.

To augment the KM around implants, an apically positioned flap combined with FGG is still the most frequently used technique. This surgical intervention can be applied at different time points. Several studies reported the clinical outcomes of augmenting KM around implants that were already restored with a prosthesis. Lorenzo et al reported an average KM gain of 2.75 mm and 2.8 mm (FGG and CM, respectively) at a 6-month follow-up of the restoration's buccal side.¹⁷ Park found a comparable clinical result: a mean KM width of 2.2 mm after 6 months of surgical intervention.²¹ Basegmez et al also reported similar outcomes of 2.36 mm (FGG) in a study with a 1-year follow-up,²² and 2.57 mm and 1.58 mm (FGG and acellular dermal matrix, respectively) in another clinical trial with a 6-month follow-up.²³ However, surgical intervention after the implant has been restored is challenging and considered to have a high risk of complications.^{24,25}

Another treatment strategy is to establish adequate width of KM before restoration delivery, for which second-stage surgery is needed. Schmitt et al's KM-widening procedure was applied by combining an apically positioned flap with FGG or xenogeneic CM during the uncovering surgery, reporting average KM

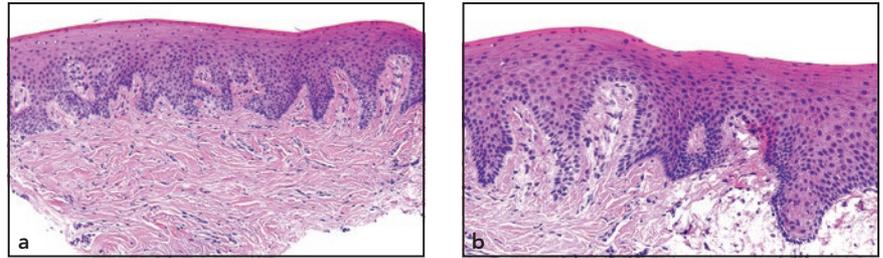


Fig 3 Histologic examination of regenerated KM demonstrated typical KM structure, consisting of a continuous lining of stratified squamous epithelium with parakeratinization. (a) $\times 10$ magnification. (b) $\times 20$ magnification.

Table 1 Demographic Characters of Included Subjects

Patient no.	Age	Sex	Implant position ^a	Intervention ^b
1	72	F	45, 46, 47	Implant + simultaneous GBR
2	35	F	35, 36, 37	Implant + simultaneous GBR
3	70	F	34, 35, 36, 37	Onlay + delayed implant
4	42	F	45, 46, 47	Implant + simultaneous GBR
5	52	M	36, 37	Implant
6	40	F	35, 36, 37	Implant

GBR = guided bone regeneration.

^aFDI system.

^bBefore second-stage surgery.

widths of 9.81 mm and 10.32 mm, respectively, after 90 days of follow-up.¹⁸ In the present study, all KM augmentation procedures were applied at second-stage surgery. The mean KM width at the final follow-up (4.81 mm) was smaller than in the Schmitt group. This discrepancy may be caused by differences in surgical operating areas (posterior only vs posterior and anterior), the flap's range for apical positioning during surgery, and ethnicities of the patients.

From the treatment-strategy standpoint, establishing an adequate band of KM before the prosthetic process is more rational and appropriate. Widening the KM after restoration delivery seems to be a remedial measure, performed when unstable or inflammatory peri-implant soft tissue conditions

are encountered.²² From a biologic standpoint, once the intrasulcular incision is made,^{17,26} the restoration partially blocks the epithelial cell source from the coronal portion, which may compromise the healing and re-epithelialization process.

The incision in the present study began at the midcrest and was combined with two releasing incisions, facilitating the apical position of the flap. This is different from previous studies,^{18,21–23} in which the incision began at the mucogingival border. A narrow band (0.5 to 1 mm) of KM, which was reflected with the partial-thickness flap and apically secured, is extremely important for wound healing and re-epithelialization of keratinized tissue. This narrow band of KM served as an apical barrier to the nonkeratinized alveolar mucosa,

creating a recipient bed with KM on both the apical and coronal sides. Cells from the surrounding keratinized tissue can migrate into the CM and differentiate into KM.

This presumed biologic mechanism is in accordance with the "strip" FGG technique described by Urban et al,²⁷ the validation of which was further confirmed by a human histologic study.²⁸ Instead of utilizing a midcrestal incision to create a narrow band of KM, 2- to 3-mm-wide autogenous FGG was harvested from the palatal mucosa to cover the apical extension of the recipient bed, coronal but not pedicle to the apically positioned flap. This "strip" FGG also acts as an apical barrier and provides cell sources of keratinized tissue. In case of very limited or complete loss of residual KM, when a midcrestal incision can not guarantee a 0.5- to 1-mm KM width in the flap, the "strip" FGG with CM could be an important alternative to avoid massive autogenous tissue harvesting. In the present study, unlike the "strip" technique requiring a 2- to 3-mm graft width, the authors observed that a 0.5- to 1.0-mm width of residual KM in the coronal portion of the flap was enough to ensure the healing process. This might be explained as better blood supply of the pedicled KM than the FGG strip, which may undergo shrinkage during the revascularization process.

KM gain in the posterior mandible by way of an apically positioned flap is a challenging procedure. In situations of a severely resorbed ridge or after bone augmentation procedures, the muscle attachments are usually prominent, resulting in

a flexible and unattached peri-implant mucosa. Besides, peri-implant soft tissue acts differently with periodontal tissue: even if keratinization is achieved, the peri-implant KM can be mobile and unattached to the underlying periosteum.²⁹ Thus, to re-establish a firmly attached KM, the muscular fiber intrusion and other movable submucosal tissue should be thoroughly detached not only from the inner layer of the partial-thickness flap but also from the periosteum. Then, the apically positioned flap can stably heal in the intended position, blocking the re-intrusion of the muscular fibers, and facilitate the re-epithelialization process over the periosteum without any movable tissue. Finally, regeneration of the attached peri-implant KM can be expected.

Previous studies advised the use of a vestibular retention splint to protect the surgical area and prevent muscle reattachment.^{18,30} However, according to the present authors' experience, if the surgical protocol provided by the present report is followed (that is, a stable apically positioned flap that is free of movable soft tissue and located above the periosteum), the resin retention splint is unnecessary.

Another anatomic concern during the surgery is the mental nerve and its branches. During elimination of muscles and submucosa soft tissue, sharp dissection is strictly forbidden in the area nearing the mental foramen. Blunt dissection and careful management of the nerve and its branches is mandatory. Due to the presence of this vital structure, complete detachment

of the submucosal soft tissue from the periosteum in the premolar area usually cannot be achieved.

Previous clinical studies reported the effectiveness of xenogeneic CM in increasing the width of peri-implant KM. Preliminary clinical results and histologic findings from the present case series also implied that the xenogeneic CM may be a successful alternative to the FGG in certain indications. Compared to autogenous FGG, CM exhibits advantages of better esthetic results, less surgical time, lower morbidity, and unlimited graft volume.^{17-19,21-23,26,31} However, according to a 5-year prospective study, autogenous FGG has better long-term stability than the CM and remains the golden standard of care in highly atrophic cases.¹⁹ When the residual KM is completely missing, FGG is still needed as a cell source for the re-epithelialization process.²⁷

Though no solid conclusion can be drawn due to the nature of this study design (prospective case series), good clinical and histologic results were detected. Limitations of this investigation included lack of a control group, a small number of samples, and short follow-up time. Well-designed clinical trials with appropriate controls and long-term follow-up times are needed to verify this technique.

Conclusions

Within the limitations of this case series, successful outcomes of a modified apically positioned flap combined with CM for KM aug-

mentation in the posterior mandible were reported. Further studies are needed to confirm these outcomes.

Acknowledgments

The authors reported no conflicts of interest related to this study.

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