Received: 7 April 2023 | Accepted: 3 August 2023

DOI: 10.1002/cap.10264

CASE STUDY

The expanded mesh free gingival graft: A novel approach to increase the width of keratinized mucosa

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Abstract

Background: The importance of an adequate amount of peri-implant keratinized tissue and attached mucosa has recently been emphasized. This manuscript presents preliminary findings of a novel approach for increasing the width of keratinized mucosa (KM) around dental implants using a mesh free gingival graft (mesh-FGG).

Methods: Two healthy adults were treated as part of this study. After implant placement, a large edentulous alveolar ridge with shallow vestibule and minimal amount of KM was treated in both subjects (one in the posterior mandible and the other in the anterior mandible) with the combination of an apically positioned flap and a mesh-FGG. Clinical, esthetic and patient-reported outcomes were observed at approximately 4-month time points.

Results: All sites healed uneventfully after the treatments. In both cases, increased vestibule depth, soft-tissue thickness, and width of peri-implant KM were obtained. The patients did not report any accessory discomfort. Four months following the grafting procedure, good overall esthetic outcome was observed with minimal color disparity and graft demarcation.

Conclusions: Width of KM around dental implants can be increased using a mesh-FGG. Randomized controlled clinical studies comparing mesh-FGG to conventional FGG and other commonly applied techniques are required to assess the long-term efficacy of this novel technique in terms of soft-tissue thickness, width of peri-implant KM, and patient-reported outcomes.

KEYWORDS
autogenous grafts, autografts, periodontal, soft tissue grafting

Key points

Principal Findings:

- Meshed-FGG allowed an expansion of the length of the harvested graft. This results in coverage of large recipient sites, increase in height of KM and good aesthetic integration of the graft.

INTRODUCTION

The clinical significance of the width of peri-implant keratinized mucosa (KM) remains a subject of ongoing debate but is generally accepted. During the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions, experts failed to identify KM as a contributing factor for peri-implantitis but suggested that "the absence, or a reduced width of KM may negatively affect self-performed oral hygiene measures."[1] However, a recent systematic review has indicated that a reduced width of KM (<2 mm) is associated with an increased biofilm

accumulation, soft-tissue inflammation, mucosal recession, marginal bone loss, prevalence of peri-implantitis, and heightened patient discomfort.[2]

Multiple surgical options for increasing width of KM are available and include among others an apically positioned flap (APF) alone or combined with an autogenous graft or a xenogeneic collagen matrix (CM).[3] The free gingival graft (FGG), first described in 1963 by Björn, is considered a well-established technique with a significant history of successful clinical use.[4,5] However, the harvesting autogenous graft from the palatal mucosa is usually associated with significant patient morbidity, mainly when there is a need to graft large mucosal areas. In order to overcome these disadvantages and challenges, a variety of grafting modifications has been proposed to limit the need for an extensive autograft harvest. In the accordion technique proposed by Rateitschak et al. in 1985, the harvested FGG was expanded by performing intermittent incisions at alternate sides of the graft using a scalpel blade.[6] In 1983, Han introduced the strip gingival autograft technique, where thin strips of FGGs were placed parallel to each other and fixed to the most apical extension of the prepared periosteal bed, leaving the exposed connective tissue area between the graft strips to heal by secondary intention.[7] A vertical modification of the strip gingival graft was proposed by Akbari in 2004.[8] Urban et al. combined the strip gingival graft technique with the use of a xenogeneic CM to correct large areas of mucogingival alterations resulting from advanced regenerative procedures.[9]

Modifications of autogenous graft aiming to expand the size of the harvested soft-tissue have been proposed and used in other medical specialties. Expanded mesh grafts have been largely used in plastic surgery and related fields, especially to treat large burn wounds.[10] The purpose of this case report was to apply the conceptualization of the expanded mesh graft, to the field of mucogingival surgery, aiming at increasing the width of KM at large edentulous ridge areas prior to implant therapy.

MATERIALS AND METHODS

Technical note

Mesh-expansion of a soft-tissue graft can be obtained by cutting it, either by hand or with a device, in alternating intervals following a symmetrically zipper pattern (Figure 1A).

The first set of cuts consists in aligned but separated vertical marginal incisions along both longitudinal sides, preserving in the middle of the graft an intact intermediate portion of tissue. Thus, the original graft is divided into equal ribbons with a constant and sufficient width. Thereafter, a second set of vertical centered incisions is placed in the middle of each newly formed ribbon. The combination of these staggered incisions on the soft-tissue graft results to a honeycomb pattern when expanding it (Figure 1B). Hence, the ratio of expansion will be determined by the distances among these different incisions. Narrower distances would jeopardize the mechanical stability and handling of the mesh graft. The marginal incisions do not contribute in the overall longitudinal expansion of the graft but are responsible for the preservation of its rectangular geometrical shape, acting as multiple vertical releasors[11] (Figures 1 and 2).

The expansion of meshed graft can be determined mathematically. Considering that the intermediate central cuts are responsible for the expansion of the graft, being reshaped from linear slits to squares, and following the Pythagorean theorem, the longitudinal length gain per slit after full expansion (L') is 0.7 times the original slit length (L)[10] (Figure 1).

Length of the meshed graft after full expansion = Original graft length (ribbon width × total number of ribbons) + longitudinal extension gain (number of intermediate slits × 0.7 × original slit length [L]).

Accordingly, a unidirectional longitudinal gain of up to 70% is theoretically expected.

The adverse effect of the extensive longitudinal expansion of the graft is the associated subsequent vertical reduction of its height. As per the aforementioned mathematical approach, considering that the longitudinal iteration is 0.7 times the original slit length, a height reduction of 0.3 times the original slit length is encountered.

Height of the meshed graft **after full expansion** = Ribbon width × 2 (=number of ribbons present in lateral axis) + lateral height reduction (=0.7 × original slit length [L]).

Accordingly, a maximal lateral reduction of 15% is theoretically expected (Figure 1).

Clinical case presentation

Two patients presenting with insufficient amount of KM at implant sites were treated at a private practice located in Merchtem, Belgium, using a mesh-FGG technique. Treatment was carried out aiming at an increase of the dimensions of KM.

Written informed consents were obtained as a standard of care. Measurements were performed with a manual periodontal probe (PCP15, Hu-Friedy) and rounded to the nearest millimeter mark. Dimension (length and width) of the FGG and width of KM were recorded 1 week prior to surgical therapy and at the 4-month follow-up visit.

Case 1

On October 2022, a 67-year old, nonsmoker, systematically healthy female patient was consulting for replacement of missing lower right second premolar and first molar by

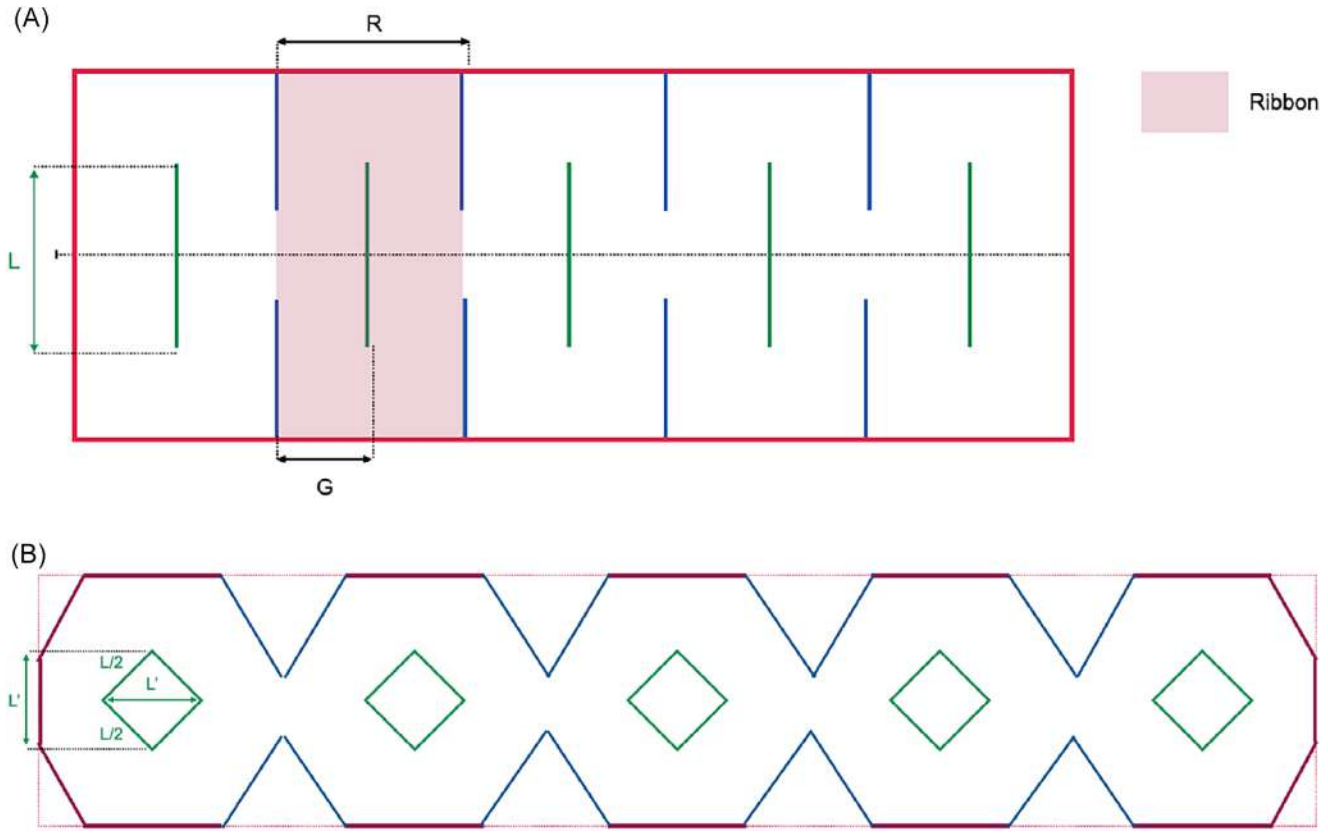

FIGURE 1 (A) A simplified schematical drawing illustrating the general pattern of the offset staggered incisions before mesh-expansion. The first set of aligned but separated vertical marginal incisions along both longitudinal sides (in *blue*) divides the original graft into equal ribbons (*R*) with a constant and sufficient width of at least 4 mm and an intermediate gap (*G*) of at least 2 mm. The second set of vertical centered incision (in *green)* is placed in the middle of each newly formed ribbon, resulting in a controlled pattern composed of multiple 2 mm parallel-interconnected strips. (B) A simplified schematical drawing illustrating the honeycomb pattern of the graft after mesh-expansion. *L*: length of the vertical centered incision. *L'*: longitudinal length gain per slit after full expansion.

implants. The patient presented with a shallow vestibule with a total lack of KM (Figure 3A).

Case 2

On February 2023, a 57-year old, systematically healthy, female patient was referred by her general practitioner for a mandibular implant-supported, bar-retained, overdenture opposing a maxillary complete denture. The patient presented with an anterior shallow vestibule, with a minimal width of KM at lower right and left canine position (3 and 4 mm, respectively) (Figure 4A).

General case management

The implants were placed, following a prior digitally planned cone beam computed tomography exam, according the manufacturer's drilling protocol (Nobel Biocare). Six weeks after implant placement, the mucogingival surgery, consisting of a FGG, was planned. All surgical procedures were performed by one experienced periodontist (ADG).

Following aseptic precautions and under adequate local anesthesia preparation (1.7 mL of lidocaine hydrochloride 1:100.000) of both the recipient and the palatal donor site, the surgical procedure was divided into four main steps.

1. Preparation of the recipient bed: After incision following the mucogingival line, a flap was elevated with a split-thickness dissection to deepen the vestibule. The dissected alveolar mucosa was apically positioned and sutured to the fixe periosteal layer using resorbable horizontal mattress sutures (Serafast 6-0, Polyglycolic Acid Caprolactone, Serag Wiessner, Naila, Germany). The resulting recipient site consisted of a periosteal bed, which was for both patients, 8 mm wide and longer than 30 mm (Figures 3B and 4B).
2. Graft harvesting: On the ipsilateral side of the recipient site, an autogenous FGG was harvested from the lateral posterior palate and trimmed to a uniform thickness of approximately 1.00 mm (Figures 2A, 3C, and 4C). After harvesting the FGG, several drops of high-viscosity cyanoacrylate tissue adhesive (Peri-Acryl, GluStitch, Delta, BC, Canada) were applied to the palatal wound before covering it with a porcine derived

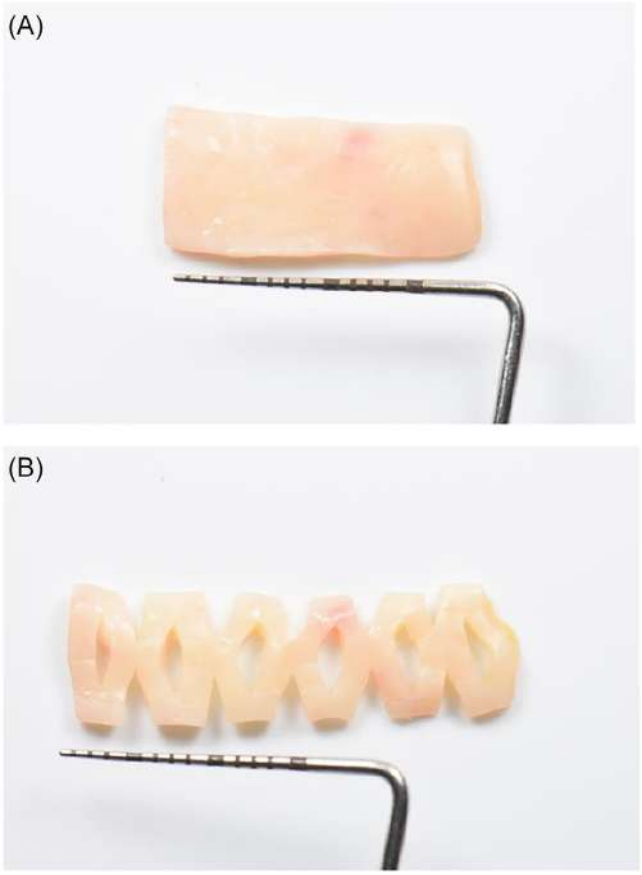

FIGURE 2 Example of harvested palatal free gingival graft (FGG): (A) FGG before mesh-expansion. Length: 18 mm; (B) FGG after mesh-expansion. Length: 27 mm.

collagen sponge (PeriAcryl, GluStitch, Delta, BC, Canada.).[12] The sponge was stabilized by crossed sutures (Seralon 6-0, Polyamid Acid Caprolactone, Serag Wiessner, Naila, Germany).

3. Mesh modification: While holding the graft in position, a standard #15c blade was used to perform two sets of controlled full-thickness and perpendicular incisions on the graft, precisely placed to allow the graft to unfold after expansion. The first set of alternating vertical marginal incisions along both longitudinal sides divided the original graft in equal ribbons of at least 4 mm wide and an intermediate gap of at least 2 mm. Thereafter, a second set of vertical centered incisions was placed strictly in the middle of each newly formed ribbon, resulting in a controlled meshing pattern composed of 2 mm parallel-interconnected strips (Figures 3C,D and 4C,D).

   Care was taken to not overextend the incisions, so the appearing juxtaposed strips were strong enough to withstand tension during expansion and retain enough internal rigidity to facilitate graft stabilization during suturing. A minimal strip width of 2 mm was proposed as essential to comply with the previous two parameters. The two longitudinal outer ends stayed unmeshed, providing a platform suitable for primary suturing and stabilization.
4. Graft fixation: The mesh-FGG was unfolded and expanded to adapt to the length of the recipient site and anchored to the periosteum by means of simple interrupted sutures using a 6/0 non-resorbable monofilament (Seralon 6-0, Polyamid Acid Caprolactone, Serag Wiessner, Naila, Germany.). Suturing was continued along the lateral borders of the graft until complete stability of the graft was achieved (Figures 3E and 4E).

Both patients received similar oral and written postoperative instructions and were prescribed Ibuprofen and Paracetamol (600 mg and 1 g, respectively, every 4–6 h for the first 5 days), and a chlorhexidine digluconate mouth rinse (0.12% 3 times daily for 1 min for 14 days).

The sutures were removed 14 days after surgery, and the grafted area was carefully cleaned with a 0.12% chlorhexidine solution. The patients were asked to avoid chewing or brushing the surgical area for the first 4 weeks following the surgery. Thereafter, the subjects were instructed to resume mechanical tooth brushing at the operated area using a roll-stroke brushing technique.

Follow-up was performed 2 weeks and 4 months postoperatively.

RESULTS

After mesh modification of the FGGs, a longitudinal extraoral expansion of 46% (from 24 to 35 mm graft length) and 52% (from 21 to 32 mm) was obtained for cases 1 and 2, respectively (Figures 3C,D and 4C,D). The healing was uneventful, and limited postoperative morbidity was reported by both patients at 2 weeks (Figure 5A) and 4 months (Figures 5B and 6A) postoperatively. During this latter evaluation, both patients exhibited a deepened vestibule and an amount of KM increased by 6 and 5 mm, respectively (Figures 5B and 6A,B). The clinical examination, after prosthetic connection, revealed a good aesthetic integration of the mesh-FGG, with no apparent color or texture disparities in comparison with the surrounding tissue (Figures 5C and 6C).

DISCUSSION

The case report aimed at evaluating the efficacy of a new technique for augmenting peri-implant KM. It was demonstrated that the use of a mesh-FGG is found efficient to overcome the need for an extensive autograft harvest and restore proper width of keratinized tissue (KT) at large edentulous areas. Limited postoperative morbidity was reported by the patients 2 weeks after surgery, and good aesthetic integration of the mesh-FGG was observed at the 4-month reevaluation.

FIGURE 3 The surgical procedure in Patient 1. Initial status with shallow vestibule and the total lack of keratinized mucosa (KM) at lower right second premolar and first molar (A). Preparation of the recipient site (B). Harvested free gingival graft (FGG) before mesh-expansion: 24 mm long, 8 mm wide (C). Harvested FGG after mesh-expansion: 35 mm long, 7 mm wide (D). Fixation of the mesh-FGG by multiple simple sutures (E).

A recent systematic review and meta-analyses evaluated the efficacy of different surgical procedures aiming at reestablishing proper amount of KM at implant sites.[13] Nine studies were identified and reported that the width of KM could be successfully augmented through various techniques and materials. In a randomized controlled trial presented by Tarasenko et al., the use of APF alone or combined with FGG or a xenogeneic CM was compared in 63 patients.[14] At the 12-month reevaluation, the width of KM increased by 42% in the APF group, 152% in the FGG group, and 88% in the CM group, and these intergroup differences were statistically significant. Although all interventions demonstrated significant gain of KM width, it was concluded that FGG was the most effective technique to augment the amount of KT around dental implants. Similar outcomes were reported when allograft was used instead of xenograft.[15]

Although the FGG is considered an efficient technique for the augmentation of KM, the amount of soft-tissue that can be harvested form the palatal mucosa is very often limited. Considering that the harvesting of autogenous graft usually is associated with significant patient morbidity, covering broad mucosal areas can be a real challenge. To limit the need for such extensive harvest, different techniques have been proposed to cover large recipient sites or multiple implants. In the strip gingival autograft technique, Han

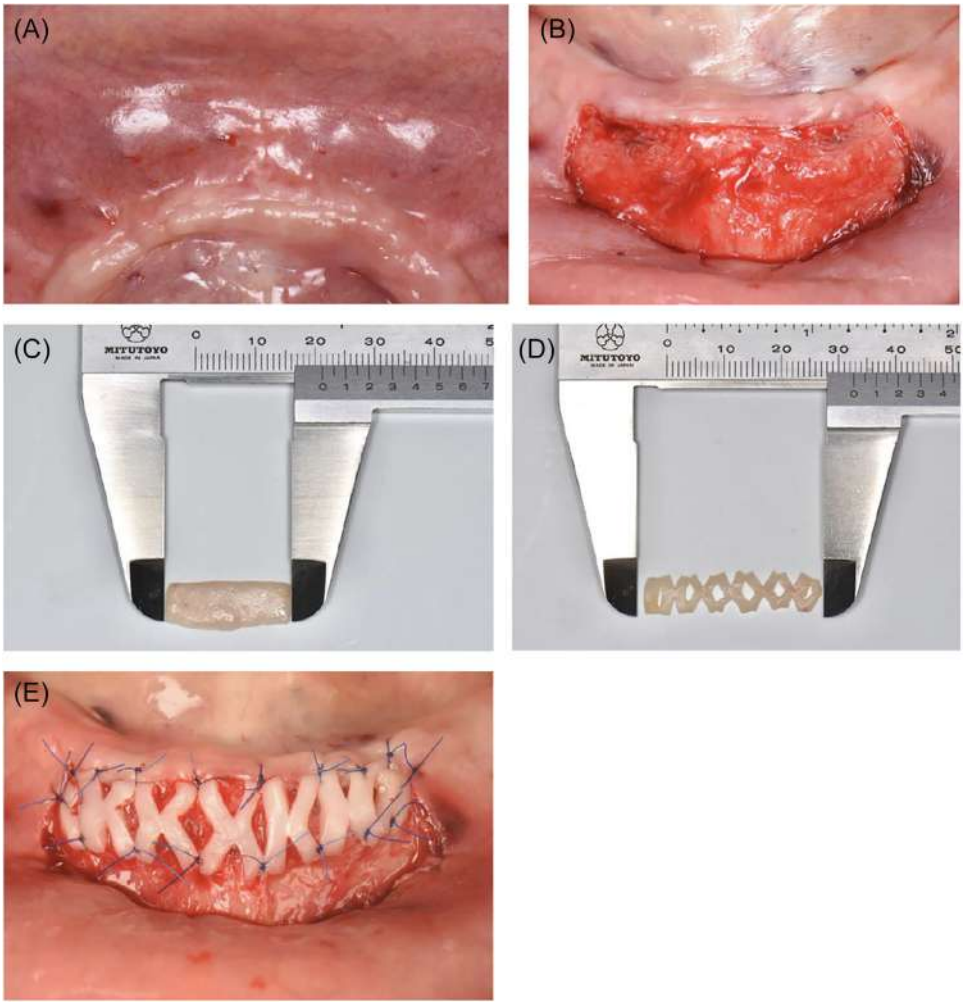

FIGURE 4 The surgical procedure in Patient 2. Initial status of the edentulous mandibula with shallow vestibule and a minimal, irregular board of keratinized mucosa (KM) at the anterior zone (A). Preparation of the recipient site, involving apical suture fixation (B). Harvested free gingival graft (FGG) before mesh-expansion: 21 mm long, 8 mm wide (C). Harvested FGG after mesh-expansion: 32 mm long, 7 mm wide (D). Fixation of the mesh-FGG by multiple simple sutures (E).

FIGURE 5 Healing in Patient 1. Two weeks after the procedure, no signs of necrosis were observed, and sutures were removed. (A) After 4 month healing period, at implant uncover, the case presents a deepened vestibule, a wide board of keratinized mucosal tissue of 6 mm and a great esthetic integration of the graft (B). 6 months after the mucogingival treatment and 2 weeks after prosthetic placement, the implant sites preserve the beforementioned board of keratinized mucosa (KM) and great overall esthetics (C).

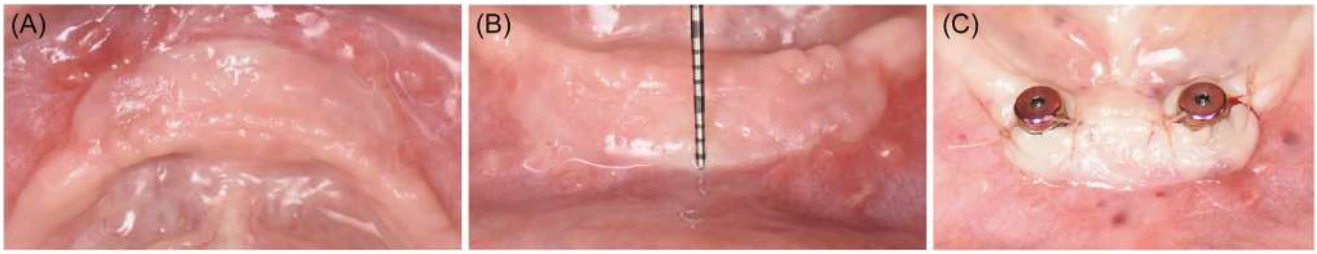

FIGURE 6 Healing in Patient 2. Four months postoperatively an eventful healing was observed: (A) During this consultation before implant uncover, the case presents a deepened vestibule, a wide board of keratinized mucosal (KM) tissue of 8 mm, and a great esthetic integration of the graft; (B) after implant uncovering, the implant sites preserved this beforementioned board of KM (C).

et al. proposed to use thin strips of FGGs placed parallel to each other and fixed to the most apical extension of the prepared periosteal bed, leaving the exposed connective tissue area between the graft strips to heal by secondary intention.[7] To further reduce patient morbidity, Urban et al. evaluated the use of strips of gingival autografts in combination with xenogeneic CM. A mean KT width gain of 6.33 mm was achieved after 1 year of healing, which is in accordance with observations made in our current case report.[9]

To overcome the limitation of the donor tissue in the conventional FGG, Rateitschak et al. proposed to modify the harvested graft extra-orally aiming at expanding its size.[6] With definite incisions, the length of the FGG could be expanded up to nearly 50%. With the meshed modification currently proposed, the longitudinal expansion could mathematically reach up to 70%. However, discrepancy between the theoretical expectation and clinical feasibility of the graft expansion should be taken into consideration. Although care was taken to avoid stretching the graft too much and create unfavorable enhanced tension, a mean longitudinal extraoral expansion of 49% was achieved in the current clinical cases.

Clinically, the expanded size of the mesh-FGG equals the addition of the original dimension of the graft, the expansion of the honeycomb pattern, and its elasticity. Thus, the expansive nature of the mesh graft allows adaptation to irregular contours and surface without adverse tension or deformation. However, dimensional changes of gingival grafts may occur during the healing period. Although an exact shrinkage rate cannot be evaluated due to the absence of standardized measurement at different time points, a visual estimation by the end of this clinical investigation revealed that the overall amount of shrinkage of the mesh-FGG was minimal. Published studies have demonstrated that, compared with autogenous graft, the use of xenograft or allografts resulted in extensive and greater shrinkage (43% and 50%, respectively), although they offered less morbidity and higher comfort for the patient.[16,17]

The poor color integration of the graft with the surrounding tissue has often been reported as a major shortcoming of FGGs harvested from the palate.[18] Interestingly, in the present case report, the patients were satisfied with the esthetical integration of the mesh-FGG. As demonstrated by Khouri et al., the underlaying cells of the recipient site profuse the created iterations, due to the body's natural capability to regenerate across small gaps[19] and therefore could vastly improve the tissue matching and thus overall esthetics, consequently minimizing the "patchwork" like appearance.

The present study presents with limitations, that the reader should be aware of: The number of patients included was small, the follow-up period covered 4 months only, and no patient was treated with conventional FGG as a control group.

CONCLUSIONS

This case report introduced an innovative mesh-FGG approach for increasing the width of KM at edentulous ridge areas. Randomized controlled clinical trials comparing mesh-FGG to conventional FGG and other commonly applied techniques are required to assess the long-term efficacy of this novel technique in terms of soft-tissue thickness, width of peri-implant KM, and patient-reported outcomes.

AUTHOR CONTRIBUTIONS

Alexander De Greef, Ventseslav Stankov, Benjamin Cortasse, Gustavo Giordani, and Eric Van Dooren contributed to study conception and design. Alexander De Greef and Greet De Mars performed all the clinical procedures and were responsible for data collection. Alexander De Greef and Olivier Carcuac prepared the manuscript. All authors revised the manuscript.

ACKNOWLEDGMENTS

The authors like to thank Prof. Em. Dr. Eric Fossion, past professor of the faculty of medicine University Hospital Leuven, for broadly explaining the origin of the dermatology meshing concepts.

CONFLICT OF INTEREST STATEMENT

All (co)-authors declare that they have no potential conflicts of interest in relation to the present series. The present work was self-funded by the authors.

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How to cite this article: De Greef A, Carcuac O, De Mars G, et al. The expanded mesh free gingival graft: A novel approach to increase the width of keratinized mucosa. *Clin Adv Periodontics*. 2023;1-8. https://doi.org/10.1002/cap.10264