Oral soft tissue regeneration utilizing absorbable scaffolds

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ABSTRACT
Background Oral soft tissue regeneration procedures are performed to facilitate plaque control, to improve patient comfort, to prevent future recession, and in conjunction with restorative, orthodontic, prosthetic, and implant dentistry. Recent evolutions in the field of periodontology have shown that oral soft tissue regeneration may no longer be solely dependent on palatal tissue. The aim of this paper is to discuss traditional and current treatment approaches for oral soft tissue regeneration.

Methods Literature review and presentation of current alternative methods for oral soft tissue regeneration that do not depend on the use of palatal tissue for grafting. A case reporting the use of an absorbable soft tissue scaffold (Mucograft, Geistlich Pharma AG) to promote gingival regeneration is also presented.

Results The patient was successfully treated without palatal tissue harvesting. Stable results were confirmed at the 12 months follow up. The patient was also extremely satisfied with the final results, that were not only acceptably functional, but also esthetic.

Conclusion This paper demonstrates that alternative methods have the potential to minimize the need for palatal tissue harvesting during oral soft tissue regeneration. These materials may still not be capable of producing the same results observed when autogenous tissue is used. However, they are capable of positively influence soft tissue development, wound healing, and regeneration. Future development of these materials and surgical techniques associated with their application may improve these outcomes.

Introduction
Oral soft tissue regeneration procedures are performed to facilitate plaque control, to improve patient comfort, to prevent future recession, and in conjunction with restorative, orthodontic, prosthetic, and implant dentistry. These procedures are also indicated in order to reconstruct oral soft tissue that was lost due to pathology, such as excisional biopsy procedures. Recent evolutions in this field of periodontology have shown that oral soft tissue regeneration may no longer be solely dependent on palatal tissue. The aim of this paper is to discuss traditional and current treatment approaches for oral soft tissue regeneration.

Mucogingival deformities
The oral cavity is covered by two main types of soft tissues: oral mucosa and gingival tissues. Gingival tissues have unique features when compared to other soft tissues. Gingival epithelium is comprised of stratified squamous keratinizing epithelium and covers the neighboring areas of teeth and the palate. It is limited by the mucogingival junction and the gingival margin and also merges with the palatal epithelium at the borders of the palate. Gingival tissues are firmly attached to underlying structures, and are capable of resisting trauma from mastication and tooth brushing. Oral mucosa is covered by non-keratinized stratified squamous epithelium that can be easily injured during oral hygiene and mastication. Oral mucosa is also mobile and not firmly attached to the underlying structures. The 2012 Glossary of Periodontal Terms of the American Academy of Periodontology defines mucogingival deformities as “A departure from the normal dimension and morphology of, and/or interrelationship between gingiva and alveolar mucosa; the abnormality may be associated with a deformity of the underlying alveolar bone”. This is characterized by the absence of gingival tissues around a tooth or teeth, which may be associated or not with gingival recession. When gingival tissues are absent or lost, oral mucosa is present. Oral mucosa is not adapted for masticatory forces or oral hygiene, which results in trauma being transmitted to tooth supporting structures and possible deterioration.
Hence, treatment is needed in order to reverse this condition and to protect tooth supporting structures.

**Periodontal biotype**

Periodontal biotype includes soft tissue and bone thickness. Periodontal biotype is influenced by genetics, but may also be influenced by tooth eruption patterns and orthodontic movement, affecting tooth position within the arch. Teeth positioned more buccally within the arch may be more prone to mucogingival deformities. Although there is consensus on the need of a minimum tissue thickness, there is no evidence defining this thickness. In fact, a valid measurement of tissue thickness has not been developed. Certain surgical techniques may enhance soft tissue thickness, but are unlikely to change it. The development of a thicker gingival biotype may result in better esthetic outcomes, and possibly create tissue that would be more resistant to traumatic injuries.

**Oral soft tissue regeneration**

The American Academy of Periodontology (AAP) published in 2015 consensus reports on all available regenerative strategies utilized currently in Periodontology (22-25). During the development of these systematic reviews it was determined, based on current knowledge, that under optimal plaque control conditions and absence of clinical inflammation, there is no need for a minimum amount of keratinized tissue for preventing attachment loss. In other words, gingival tissues are only necessary where plaque control is inadequate, resulting in soft tissue inflammation (22-23). Very rarely, patients are capable of maintaining adequate plaque control. When plaque control is inadequate clinical inflammation develops, resulting in attachment loss and gingival recession, unless there is a minimum amount of keratinized tissue (KT). A minimum amount of 2 mm of KT with 1 mm of attached gingiva has been recommended under these circumstances (22-23).

There are other clinical scenarios of traumatic etiology, such as the presence of subgingival restorative margins or clasp from removable appliances, specific orthodontic tooth movement or anatomical situations where the literature does not provide guidelines on the needed minimum amount of KT. There is lack of evidence on the interplay between gingival inflammation and/or direct mechanical trauma (e.g.
tooth brushing) in sites with minimum KT as the etiology of progressive recessions (22-23).

Treatment approaches

Autogenous gingival grafts harvested from the patient’s palate have been considered to be the “gold standard” methods of correction of mucogingival deformities. These surgical procedures may be limited by the donor site availability, which may also influence the frequency and severity of surgical complications in the form of post-operative bleeding and substantial discomfort. Palatal soft tissue grafts are used in two ways: by keratinized epithelium transplantation, Free Gingival Graft (FGG), or transplantation of gingival connective tissue, Connective Tissue Graft (CTG).

The use of a FGG has been shown to predictably increase the width of KT. Free gingival grafts undergo contraction during the healing process. Hence, clinicians should plan for graft dimension accordingly, considering that the average contraction of FGG’s range from 25-40% has been reported. This procedure is mostly indicated in non-esthetic areas since blending with the surrounding tissues is usually inadequate. The reported KT augmentation ranges from 3.1 to 5.6 mm (1-6). CTG have been proposed as an alternative to the FGG, although the amount of epithelium keratinization achieved is less predictable (7). However, GTGs are significantly superior for root coverage. These procedures usually result in better esthetic outcomes when compared to FGGs, and may also result in better enhancement of patient’s gingival biotype, depending on the thickness of the connective tissue harvested from the palate and used during grafting procedures.

Alternative methods

Alternative graft techniques and biomaterials have been studied and applied in clinical practice with the purpose of avoiding donor site morbidity and to overcome limited availability of autogenous tissue. The scientific evidence on the efficacy of these alternative techniques is limited, but under specific situations, these materials can be considered as an adequate replacement of palatal grafts. Obvious advantages of alternative methods include unlimited supply, less surgical complications, and less discomfort for the patient. The most accepted alternative methods include the following.

- Living Cellular Construct (LCC) is a bioengineered construct composed of living allogeneic human fibroblasts and keratinocytes, bovine collagen and human extracellular proteins (Apligraf®, Organogenesis Inc). This material has been used for gingival augmentation around teeth. It has been tested in 2 randomized clinical trials and 1 case series reporting average gains in keratinized tissue ranging from 1.3 to 1.8 mm (14-16).

- Acellular Dermal Matrix (ADM) is a commercial product made of processed human dermis (AlloDerm®, BioHorizons; PerioDermTM, Dentsply). The use of allogeneic dermal grafts for keratinized gingival tissue augmentation have reported conflicting results, with limited gains in the width of keratinized tissue. The esthetic outcome of this procedure has also been reported as compromised with the appearance.
of scar tissue formation, which has been confirmed histologically. This material is primarily used internally, to thicken tissues, and for root coverage procedures.

- Bilayer Collagen Matrix (BCM) is a completely absorbable xenogeneic type I and III collagen soft tissue scaffold of porcine origin (Mucograft® Seal, Geistlich Pharma AG). Its use as grafting material for gingival augmentation around teeth has been tested in 3 randomized clinical trials reporting an average gain in KT of 2.5 mm (11-13). In two studies, patient reported outcomes were analyzed in comparison with control treatment using autogenous grafts demonstrating significant pain reduction, less analgesic drug consumption and better patient’s acceptance (12, 13). This product offers unique flexibility of use since it can be used either internally, as a connective tissue replacement material, or externally, as a free gingival graft replacement and/or biologic wound dressing material.

Case report

This case illustrates the use of an alternative method of oral soft tissue regeneration. The material used in this case was a BCM. The advantage of this material is that not only it can be used as alternative to CTG but it can also be used as an alternative to FGG, since it can be left exposed without complications.

The patient was a 39 year-old Caucasian male, who presented with gingival enlargement of bluish appearance associated with the gingival margin of tooth #11 (Fig. 1). The enlargement appeared to have started to develop 6 months prior to initial consultation. The patient did not report any discomfort. The tooth was vital, and no radiographic changes were observed. An oral pathologist was consulted, and he recommended and excisional biopsy of the lesion, which was immediately performed (Fig. 2).

The specimen was placed in 10% buffered formalin for fixation, and sent out for histopathology. Histologic results confirmed the diagnosis of pyogenic granuloma. Based on the location of the lesion, excisional biopsy of the area would have probably resulted in the creation of a large recession defect on the tooth (Fig. 3). Hence, decision was made to use BCM as an absorbable soft tissue scaffold to maximize the regenerative potential of the area, and to minimize the severity of the gingival recession following biopsy removal. The material was cut to shape, and easily secured in place using 6.0 polypropylene sutures (Fig. 4).

Follow-up photographs demonstrate that the material was gradually replaced by new soft tissue formation. Not only the extent of the recession defect was substantially minimized, but it also resulted in the formation of keratinized wound margins, where no keratinized epithelium was left following biopsy (Fig. 5).

Three months later, the patient presented for reconstruction of the gingival recession defect created after biopsy removal. The patient also presented a pre-existing similar recession defect on tooth #6 and less severe gingival recession on tooth #9 (Fig. 6). Both canines were treated with Coronal Flap Advancement (CFA) following the Zucchelli approach (26), and BCM was once again used. BCM was adapted over the exposed root surfaces and stabilized with internal periosteal 4.0 chromic gut sutures (Fig. 7). Flap
advancement was achieved with periosteal releasing incisions. Flaps were stabilized with a combination of sling and suspensory sutures with 6.0 polypropylene sutures. Tooth #9 was treated with a semilunar flap (SF) as described by Tarnow (27) (Fig. 8). Uneventful healing was observed at 14 days, demonstrating high level of biocompatibility of BCM with oral soft tissues. Sutures were removed, and the patient was instructed on oral hygiene procedures to minimize pressure and trauma of the treated sites (Fig. 9). The patient returned one year later for re-evaluation. Stability of all treated sites was confirmed. BCM in conjunction with CFA resulted in substantial coverage of the exposed root surfaces and clinical attachment level gains of 3-4 mm (Fig. 10). The patient was extremely satisfied with the results.

Conclusions
This paper demonstrates that alternative methods have the potential to minimize the need for palatal tissue during oral soft tissue regeneration. These materials may still not be capable of producing the same results observed when autogenous tissue is used, however, they are capable of positively influence soft tissue development, wound healing, and regeneration. Future development of these materials and surgical techniques associated with their application may improve these outcomes.

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