Title:

Osseous topography in biologically driven flap design in minimally invasive regenerative therapy. A classification proposal.

Running Head:

Biologically Driven Flap Design: A classification Proposal

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One Sentence Summary: A classification proposal of flap design in minimally invasive regenerative periodontal therapy based on osseous topography.

Summary: This manuscript proposes a flap design classification based on the osseous topography of the infrabony defects during biologically driven minimally invasive surgical regenerative therapy.

This communication tool will help guide clinicians with incision tracing, extension flap elevation and delivery of biomaterials when addressing infrabony defects in the natural dentition.

Abstract

Minimally invasive periodontal regenerative surgical procedures are a paradigm shift that demands a unique approach encompassing specialized armamentarium, magnification tools, knowledge of handling properties of biomaterials and specific flap designs.

Biologically driven flap design is dictated by optimal soft and hard tissue handling, flap perfusion and wound stability, all in the pursuit of primary intention healing. The unique architecture of the infrabony defect is a determining factor on incision tracing, boundaries of flap extension and biomaterial selection.

The purpose of this article is to propose a flap design classification based on the osseous topography of the infrabony defects during biologically driven minimally invasive surgical periodontal regenerative therapy.

Introduction

On an editorial published in the British Journal of Surgery in 1990, Fitzpatrick and Wickham concluded that changes occurring in the operating theatres across surgical specialties had one common denominator: ensuring that trauma of surgical access was reduced to a minimum while still achieving the intended therapeutic aims.[1] The field of regenerative periodontal therapy has not been excluded of these revolutionary surgical changes. Since Harrell and Rees illustrated the concept of minimally invasive surgical (MIS) procedures for periodontal regeneration in 1995,[2] different flap designs and suture techniques have been introduced with the purpose of minimizing surgical access, diminishing

tissue trauma, enhancing wound closure, providing stability and protection to the blood clot, and avoiding soft tissue recession while facilitating visual and mechanical access to infrabony defects. The MIS technique was subsequently illustrated in several other publications.[3-5]

Flap design has played an important role in the development and application of MIS principles. Takei et al.[6] introduced a papilla preservation technique to protect the interproximal space hosting the infrabony defect by avoiding incisions directly on the col area thus facilitating primary closure and protecting grafting material placed in the interproximal spaces. The palatal approach proposed by this technique was modified ten years later when Cortellini et al.[7] described both the modified papilla preservation technique and a few years later, the simplified papilla preservation flap.[8] These novel techniques provided surgical access from the buccal aspect instead. This surgical modality required a well-defined protocol on incision extension and location, soft tissue manipulation, suturing and wound closure. It is important to recall that non-absorbable and resorbable barriers were being utilized as standard of care at that time, and due to their size and nature, incision and flap extension had to be more extensive.

The evolution of the MIS approach has witnessed the incorporation of the minimally invasive surgical technique (MIST) which limits the mesio-distal flap extension and coronal-apical reflection while minimizing trauma and maximizing tissue stability.[9] In an effort to further maximize wound stability and blood clot protection, a modified MIST (M-MIST) technique was described and illustrated with clinical cases followed up for 12 months.[10] Utilization of enamel matrix derivatives was recommended when performing periodontal regenerative therapy utilizing both the the MIST and M-MIST techniques.

A novel technique has been introduced, the entire papilla preservation technique (EPP) to treat isolated interproximal infrabony defects. This technique utilizes a tunnel approach with a vertical incision fully elevating a mucoperiosteal flap to access the infrabony defect. [11]

Flap design continued its evolution defined by increased knowledge and experience pertaining to biologic guiding principles such as wound stability, blood clot protection and introduction of

biomaterials that were more compatible with minimally invasive procedures. The incorporation of magnification tools such as the operating microscope (OM) allowed for optimal visual access and illumination, two fundamental requirements when executing surgical therapy in narrow, deep, and constrained spaces.

The understanding of the architectural topography of infrabony defects has played a defining role in determining flap design and wound management. The purpose of this article is to propose a flap design classification based on the osseous topography of the infrabony defects during biologically driven minimally invasive surgical regenerative therapy.

Infrabony Defects.

An infrabony defect is a periodontal lesion in which the base of the defect is located apical to the alveolar crest.[12] Goldman and Cohen[13] proposed a classification based on osseous morphology and dependent on the location and number of osseous walls defining the osseous defect. According to the number of walls remaining, a defect would be classified as a 3 wall, 2 wall or 1 wall. A combination of these categories was recognized as feasible depending on the apico-coronal features of each individual lesion. Therefore, it was possible to have a 3 wall-2 wall-1 wall, or a 2 wall-1 wall osseous defect. FIG.1

The topography of the osseous lesion can be determined by three methods.

1) Bone sounding performed with a periodontal probe allows determination of the presence and height of remaining osseous walls.

2) Radiographic evaluation utilizing conventional 2-dimensional images is most reliable in determining horizontal osseous dimensions when visualizing interproximal spaces. Evidence to justify the use of cross-sectional images (i.e., CBCT scans) is limited and its utilization is not yet recommended for this purpose[14].

3)Surgical exploration allows for the most definitive anatomical description and helps determine the type of treatment to be performed.

Infrabony defect morphology influences periodontal regenerative surgical outcomes. Baseline defect depth (>4mm), narrower angles(<37^{o}) and increased number of walls (3-walls) have a positive influence on bone gain and clinical attachment gain. [15] Understanding the anatomy of the defect is of paramount importance for anticipating the potential regenerative result of the infrabony defect as well as in executing appropriate flaps designs that allow optimal access, visualization and utilization of biomaterials as indicated.

Minimally Invasive Surgical Procedures

Incision tracing protocols have been aiming at the preservation of interproximal tissues by protecting the papillary-col complex. The papilla preservation techniques applied palatally[6,16] or buccally[7, 8, 10,17-19], are part of these efforts. Novel remote access techniques employing horizontal[20] or vertical incisions[21] have been recently added to this body of work. The common denominator remains blood clot protection, space maintenance, optimization of wound closure, and facilitation of first intention wound healing by enhancing flap perfusion.

Patient reported outcomes seem to favor the less invasive nature of these procedures by reporting lower pain during the first post operative days when comparing single versus double flap approach procedures[22]. However, according to Clementini et al,[23]a juxtaposition of minimally invasive surgical procedures and traditional regenerative surgical therapy cannot be established due to the paucity of studies targeting this type of comparison.

Horizontal and vertical extension of the designed flap boundaries will be determined by achieving optimal visual access allowing thorough inspection of the osseous and radicular anatomy of the infrabony defect. Establishing the osseous topography, verifying the integrity of the root surface, identifying etiologic factors and placing biomaterials needed for regenerative purposes will be facilitated by proper access. Utilization of magnification devices with coaxial illumination, such as operating microscopes, will refine minimally invasive efforts when approaching infrabony defects[24]. Awareness of macrovascular and microvascular tracks during incision tracing and flap design, will translate into proper angiogenesis and wound healing.[25,26]

Biomaterials

A Biomaterial has been defined as "any substance (other than a drug) or combination of substances, synthetic or natural in origin, which can be used for any period of time, as a whole or as a part of a system which treats, augments, or replaces any tissue, organ, or function of the body" [27] When looking at biomaterials in the field periodontics, there is evidence of periodontal regeneration in humans (restoration of lost or diminished cementum, periodontal ligament and alveolar bone) for bone grafts such as decalcified freeze-dried bone allograft (DFDBA),[28] and demineralized bovine bone mineral (DBBM),[29] and bioactive substances and growth factors such as enamel matrix derivative (EMD)[30], recombinant human platelet-derived growth factor-BB (rhPDGF-BB),[31] and recombinant human growth differentiation factor -5 (rhGDF-5)[32]

Synthetic polymers and naturally derived membranes have been utilized in guided tissue regeneration procedures. Membranes must be biocompatible and must have occlusive properties and adequate mechanical properties conducive to space maintenance. Depending on their composition, these biomaterials could be biologically active, biodegradable, and tolerant to exposure. For a more detailed analysis on biomaterials the reader is referred to Sanz M, Dahlin C, Apatzidou D, et al. 2019[33].

Infrabony Defect Driven Biologic Flap Design

Infrabony Defect Topography

One of the primary components of the biologically driven flap design, is the anatomy of the infrabony defect. Sounding anesthetized gingival tissues with a probe allows establishing the underlying topography of the alveolar bone.

In order to develop clinical surgical guidelines on how to approach infrabony defect driven flap design, the following infrabony defect classification is being proposed. The buccal-lingual and mesio distal extension of the infrabony defect are the primary differentiating factors among the three different categories.

Type I:

The osseous defect is limited to the interproximal space between teeth. It could be confined to one interproximal wall (i.e., the mesial wall of the first premolar) or could be a “crater” defect involving both interproximal walls of the teeth adjacent to each other (i.e., the mesial wall of the first premolar and the distal wall of the canine) FIG.2

Type II:

The interproximal osseous defect extends mesially and/or distally and it is limited to either the buccal or the lingual surfaces. FIG. 3

Type III:

The interproximal osseous defect extends mesially and distally and it affects both the buccal and the lingual surfaces. Defects found on the distal or mesial aspects adjacent to an edentulous ridge and extending to the buccal and/or lingual aspects of the affected tooth also fall into this category. FIG.4

Flap Design

The anatomical extension of the infrabony defect will determine the placement of incisions within this minimally invasive approach. Flap elevation must allow adequate visual access to correctly identify the boundaries of the infrabony defect, facilitate mechanical instrumentation and delivery of biomaterials.

Allocation of biomaterials will be defined by the number of walls defining the infrabony defect or defects being treated. In well contained defects such as 3-wall defects, bioactive substances and growth factors can be utilized alone or in combination with an osseous graft. For 2-wall and 1-wall infrabony defects, and wide 3-wall infrabony defects[34], combinations of osseous grafts, bioactive substances/growth factors and membranes are to be considered as primary choices to reconstruct missing hard tissues with the intention to establish a hemostatic condition compatible with periodontal health.

Papilla preservation incision techniques and intrasulcular incisions are preferred. Vertical incision tracing is to be avoided and when incorporated (usually determined by the vertical dimension of the infrabony defect), the apico coronal extension is to be minimized as to protect micro and microcirculatory components. The following flap design modalities correspond to their respective infrabony defect types.

Type A Flap Design:

When treating a Type I infrabony defect, papilla preservation incision techniques are the default choice. Slight intrasulcular extension towards the immediately adjacent interproximal line angles as needed for osseous defect boundary identification and debridement. Vertical incisions are not needed with this type of osseous topography. FIG. 5. VID.1

Type B Flap Design:

Type II infrabony defects can be handled with a combination of papilla preservation incision techniques and intrasulcular incisions. The extension of the intrasulcular mesial and/or distal incisions is to mirror the extension and direction of the underlying infrabony defect. Vertical incisions are to be avoided. When visualization and access are compromised and a vertical incision(s) will facilitate treatment execution, its apico-coronal extension is to be as minimal as possible. FIG. 6 VID.2

Type C Flap Design:

Incision tracing for type III infrabony defects will maintain a combination of papilla preservation incision techniques and intrasulcular incisions extending mesially, distally, buccally and lingually matching the extension and direction defining the infrabony defect being treated. When dealing with multiple teeth, continuation of the intrasulcular incisions on the interdental space will be advised in the absence of an infrabony defect. If an infrabony defect is present, depending on its anatomy and depth, a step back incision or a papilla preservation incision technique is then to be considered.

When addressing an infrabony defect on the distal or mesial aspects adjacent to an edentulous ridge and extending to the buccal and/or lingual aspects of the affect tooth, intrasulcular incisions in

combination with supracrestal incisions incorporating minimally extended vertical incisions are recommended to get visual access and facilitate therapy execution. FIG.7 VID 3.

Summary

Classification systems are valuable communication tools that help expedite understanding of clinical scenarios and diagnostic conditions. These communication tools establish a common ground that facilitates execution of tasks and completion of procedures in an orderly and efficient manner.

This manuscript proposes a flap design classification based on the osseous topography of the infrabony defects during biologically driven minimally invasive surgical regenerative therapy This communication tool will help guide clinicians with incision tracing, extension flap elevation and delivery of biomaterials when addressing infrabony defects in the natural dentition.

Validation of classification systems by conducting further studies incorporating reliability tests are recommended for future research.

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Competing Interests: None

Figure Legends

Figure 1. Infrabony Defects Classification: 3 wall, 2 wall and 1 wall. Combinations of these defects are clinically feasible.

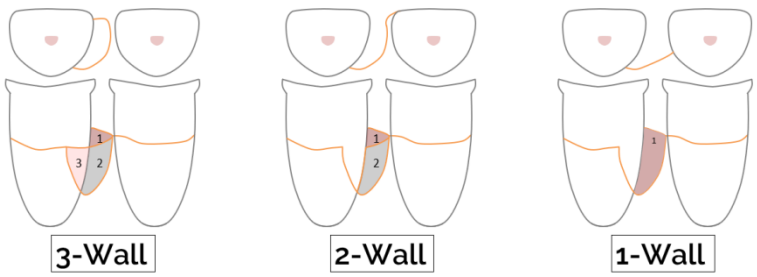


Figure 2: Frontal and axial views of infrabony defect Type I. a). Defect is confined to one interproximal surface. b). Defect (crater type) is involving both interproximal surfaces.

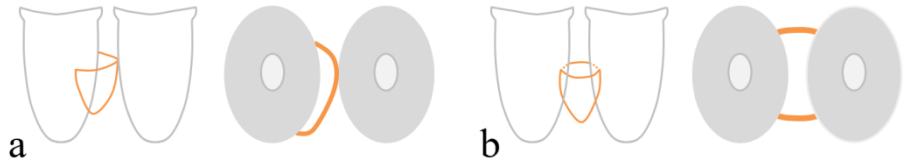


Figure 3: Frontal and axial views of infrabony defect Type II. a) Defect extends beyond the interproximal aspect in only one direction (either mesial or distal) towards the buccal or lingual region. b) Defect extends beyond the interproximal aspect in both directions (mesial and distal) towards the buccal or lingual region.

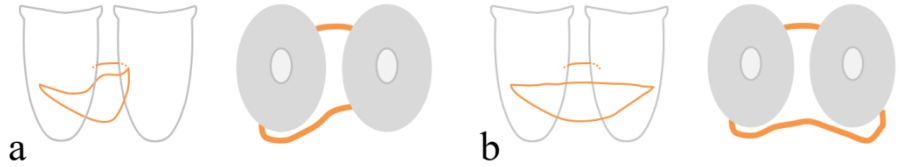


Figure 4: Frontal and axial views of infrabony defect Type III. a). The interproximal osseous defect extends mesially and distally and it affects both the buccal and the lingual surfaces. b). Defects affecting the distal or mesial aspects adjacent to an edentulous ridge and extending to the buccal and/or lingual aspects of the affect tooth are part of this group.

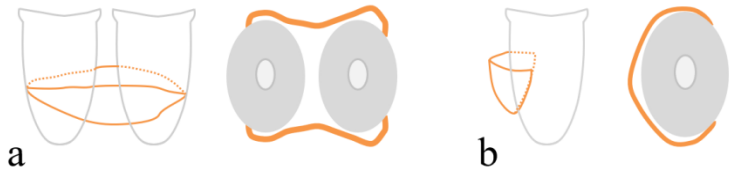


Figure 5: Flap Design A: papilla preservation incision techniques are the default choice when treating Type I infrabony defects. a) and b).

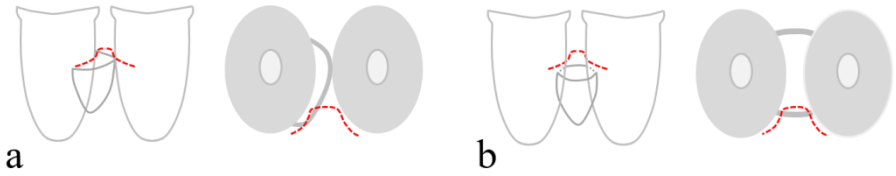


Figure 6: Flap Design B: type II infrabony defects can be accessed with a combination of papilla preservation incision techniques and intrasulcular incisions. a) and b).

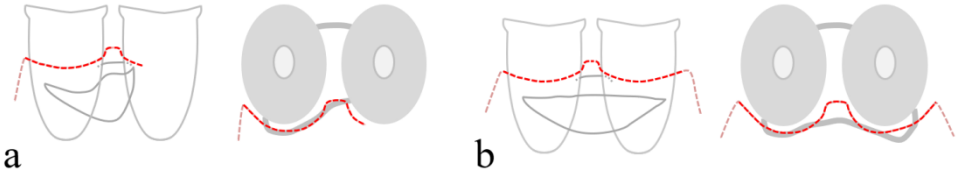
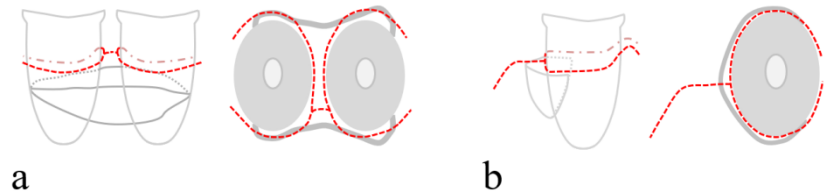


Figure 7: Flap Design C: a). Incision tracing for type III infrabony defects will maintain a combination of papilla preservation incision techniques and intrasulcular incisions. b). Intrasulcular incisions in combination with supracrestal incisions incorporating minimally extended vertical incisions are recommended when addressing infrabony defects adjacent to edentulous ridges.



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