Simplified procedures to treat periodontal intraosseous defects in esthetic areas

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ABSTRACT

Treatment of deep intraosseous defects in esthetic areas implies a clinical improvement of the lesion consistent with long-term tooth survival as well as the preservation (or improvement) of esthetics. Hopefully, such treatment endpoints should be reached through procedures (which we have termed as "simplified") which, on one hand can be easily and successfully applied by the majority of clinicians, on the other can be well tolerated by the patient in terms of post-surgical pain and discomfort, adverse events and cost. In the present review, we have described the technical aspects of the available simplified procedures, i.e. non-surgical therapy and the *Single Flap Approach* (SFA) and its variants. Also, we have analyzed the effect of such procedures on clinical parameters and patient-centered outcomes. While non-surgical therapy seems to be appropriate *per se* in lesions with probing depth < 7 mm and a limited intraosseous component, severe intraosseous defects can be successfully treated by simplified surgical procedures. Overall, data support the effectiveness of simplified surgical procedures and indicate that they result in a minimal esthetic impairment (i.e. post treatment recession) and a more tolerable postoperative course when compared to conventional surgical (double-flap) approaches. In particular, the *Single Flap Approach* was shown at least as effective as traditional papilla preservation techniques when evaluated either as stand alone protocol or in combination with regenerative devices. Bioactive agents have shown the most appropriate regenerative technology when matched to simplified surgical procedures.

SIMPLIFIED PROCEDURES FOR THE TREATMENT OF PERIODONTAL INTRAOSSEOUS DEFECT: DEFINITION

Intraosseous defects are defined by the apical location of the base of the pocket with respect to the residual alveolar crest (1). This clinical and radiographic finding is highly prevalent, with 18% to 51% of subjects presenting at least one intraosseous defect (2-9). Such type of lesions are at high risk of further progression, and may lead to tooth loss if left untreated (10).

The treatment of periodontitis, which also encompasses intraosseous defects, is based on the removal of the supra- and sub-gingival biofilm, achieved by patient-performed oral hygiene associated with professional non-surgical periodontal debridement. Since intraosseous defects may be associated with persistent deep pockets and bleeding following conventional non-surgical treatment, these lesions are frequently considered as sites requiring surgical therapy (11). Historically, the “classical” surgical approaches used to access and treat periodontal intraosseous defects were based on flap designs characterized by either minimal tissue resection (12, 13) or total preservation of interdental tissues, such as the *Papilla Preservation Technique* (14) and its variants (15-20). All these flap designs are based on the elevation of a double mucoperiosteal flap involving both buccal and oral aspects (21).

The term “simplify” means the act of making something less complex. Its etymology originates from the Medieval Latin verb *simplificare* which, in turn, derives from the terms *simplex* (simple) and *facere* (make). In the present review, we defined a procedure as “simplified” when characterized by more favorable conditions for either the patient or the clinical operator. Although the terms “simplification” and “minimal invasiveness” may appear as synonyms when referred to periodontal treatment, in our perspective “simplification” implies a substantially different concept. For the operator, a simplified procedure should: (i) require limited surgical equipment; (ii) be characterized by a steep learning curve; (iii) limit the need for the use of additional treatments/devices (through the maximization of the inherent healing potential of the treated lesion). For the patient, a simplified procedure should have a reduced impact on: (i) post treatment daily activities; (ii) post-treatment pain and discomfort (also reducing the required compliance for post-treatment regimens); (iii)

pre-existing esthetics. For both patient and operator, a simplified procedure should reduce: (i) chair-side time needed for treatment administration and follow-up visits; and (ii) treatment costs.

According to our definition, non-surgical therapy as a solo treatment always represents a "simplified" procedure, particularly when compared to surgical approaches. Among the available surgical options, "simplified" surgical procedures, as recently proposed, will be thoroughly revised in the present chapter. These procedures share a common technical aspect, i.e. the elevation of a single flap on the buccal or oral aspect, leaving the tissues on the opposite side intact (see "Technical aspects" for details). All the simplified treatments (either non-surgical or surgical) described here were originally designed and proposed as minimally invasive approaches for periodontal treatment, mainly aimed at minimizing tissue trauma and, consequently, intra- and post-operative morbidity (22). In this respect, it will be shown that the minimal invasiveness of such procedures may be partly due to the simplification of the treatment approaches.

Purpose of the review

The purpose of the present review is to describe the (i) technical aspects and (ii) effect on clinical parameters and patient-centered outcomes of the simplified procedures for the treatment of periodontal intraosseous defects, particularly when located in the esthetic area. Particular emphasis will be given to studies comparing simplified and classical procedures as well as the application of simplified surgical procedures in addition to regenerative devices.

Simplified procedures for the treatment of periodontal intraosseous defects: technical aspects

Non-surgical procedures

Table 1 summarizes the studies on non-surgical therapy for the treatment of intraosseous defects. All studies incorporated a thorough subgingival instrumentation, performed with manual instruments either alone (23, 24) or in combination with mechanical instruments (25-28).

Recently, minimally-invasive non-surgical periodontal therapy (MINST) has been introduced as a concept aimed at obtaining extensive subgingival debridement with minimal tissue trauma (27). Minimally-invasive non-surgical periodontal therapy is based on the following principles: (i) thorough debridement of the root surface up to the bottom of the periodontal pocket, avoiding root planing and gingival curettage; (ii) use of a magnification system; (iii) prevalent use of a ultrasonic device with specific thin tips, complemented by Gracey minicurettes; (iv) caution to preserve the integrity of soft tissues.

Surgical procedures

In 2007, the first simplified surgical procedure was proposed (29). This procedure, which was defined as *Single Flap Approach*, is based on the elevation of a flap on one aspect only (buccal or oral, depending on the extension / morphology of the lesion), thus preserving the integrity of the interdental soft tissue (Figure 1). The elevation of a single flap to access the intraosseous defect may pose several clinical advantages. First, it may facilitate flap repositioning and suturing; the flap can be easily stabilized to the undetached papilla, thus optimizing wound closure for primary intention healing. Moreover, by leaving a great volume of supracrestal soft tissues intact, accelerated re-establishment of the local vascular supply may occur. Wound stabilization and preservation of an intact interdental papilla may also contribute an enhanced preservation of the pre-existing gingival esthetics.

A pre-requisite to apply the *Single Flap Approach* principles is that the morphology of the defect is compatible with a thorough root/defect debridement when accessed by either buccal or oral side only. Whenever the bucco-oral extension of the defect prevents the successful removal of the oral biofilm from the root surface as well as the complete degranulation of the intraosseous component of the defect, conventional double-flap approaches are to be performed. However, data derived from the distribution of intraosseous defects according to the bone morphology (8, 30) combined with observation from a prospective trial (31) seem to suggest that a single-flap (usually buccal) access to intraosseous defects may be feasible in a relevant proportion of surgically treated defects.

Single Flap Approach (29, 32)

The *Single Flap Approach* is a simplified surgical approach to access periodontal intraosseous defects (29, 32) (Figure 1). The basic underlying principle of the *Single Flap Approach* consists of the elevation of a limited mucoperiosteal flap to allow access to the defect from either the buccal or oral aspect only, depending on the main buccal/oral extension of the lesion (as diagnosed by pre-operative bone sounding and periapical radiographs), preserving the integrity of the interproximal supracrestal gingival tissues.

Single Flap Approach mainly consists of an envelope flap. Sulcular incisions are performed on the buccal or oral side (for defects with a prevalent extension on the buccal or oral side, respectively) following the gingival margin of the teeth included in the surgical area. The mesio-distal extension of the flap is kept as limited as possible while ensuring proper access for defect debridement (as well as positioning/application of a regenerative device, if indicated). The priority in terms of flap extension, therefore, is given to provide adequate surgical access, sometimes extending the incision to involve the papillae of adjacent teeth in order to limit the use of vertical releasing incisions. In the interproximal area (i.e., at the level of the interdental papilla) overlying the intraosseous defect, an oblique or horizontal, butt-joint incision is made following the profile of the underlying bone crest. The distance between the tip of the papilla and the apico-coronal level of the interdental incision is based on the apico-coronal dimension of the supracrestal soft tissues. Pre-operatively, probing measurements are carefully performed to properly assess the horizontal component of the bone loss and, therefore, the apico-coronal dimension of the soft tissues overlying the bone crest. The greater the distance from the tip of the papilla to the underlying bone crest, the more apical (i.e., close to the base of the papilla) the incision in the interdental area. This is done to provide an adequate amount of untouched supracrestal soft tissue connected to the undetached papilla to ensure flap adaptation and suturing as well as to warrant proper access to the intraosseous defect for debridement and, when needed, graft/membrane positioning.

The defect is approached by elevating a flap only on the buccal or oral side and leaving the opposite portion of the inter-dental supracrestal soft tissues undetached. The full-thickness elevation of the marginal portion of the flap should be performed with a microsurgical periosteal elevator. Partial-thickness dissection, if needed, must be limited to the apical portion of the flap to ensure flap replacement and suturing without tension.

Once root and defect debridement has been completed, a horizontal internal mattress suture is placed coronal to the mucogingival junction between the flap and the base of the undetached papilla in order to provide the flap re-positioning. Then, a vertical or horizontal internal mattress suture (or an interrupted suture) is placed between the most coronal portion of the flap and the most coronal portion of the intact papilla to ensure primary closure. Suture removal is performed 14 days after surgery.

Variants of the Single Flap Approach

More recently, other Authors proposed variants of the *Single Flap Approach* where only a single buccal flap is raised to access the intraosseous defect (33-35).

In 2008, Checchi et al. (33) modified the original technique of the *Single Flap Approach* by coronally advancing the flap, with the intention to minimize the esthetic impairment related to the surgical procedure and optimize soft tissue closure at the incision margin. This technique was named Coronally Positioned Single Flap Approach (CP-SFA). In order to coronally advance and stabilize the flap, split-thickness preparation of the tissues in the apical portion of the flap and the de-epithelization of the interdental papillae were recommended.

The Modified Minimally Invasive Surgical Technique (M-MIST) was proposed in 2009 (34). A substantial overlapping exists between Modified Minimally Invasive Surgical Technique and buccal *Single Flap Approach*, including aspects related to the interdental flap incision and flap management. However, in the Modified Minimally Invasive Surgical Technique the mesio-distal extension of the incision is kept at minimum (ideally, within the mid-buccal area of the involved teeth) to allow the reflection of a triangular buccal flap. A

micro-blade is used to cut through the interdental tissues, with an inclination suitable to intercept the buccal side of the lingual bone crest, as close as possible to its coronal edge, to isolate the granulation tissue filling the intraosseous component of the defect from the supracrestal, papillary tissues. Wound closure is obtained with a single, modified internal mattress suture positioned at the defect-associated interdental area.

More recently, Zucchelli et al. (35) combined the *Single Flap Approach* with a connective tissue graft in order to treat challenging intraosseous defects associated with Miller's class IV gingival recessions. To ensure sufficient graft coverage, the flap was coronally advanced and fixed to the de-epithelized interdental papillae. The entirety of the interdental supracrestal soft tissue is pushed in a palatal direction until the tip of the interdental papilla is shifted in the most coronal position in order to facilitate flap stabilization in the area overlying the intraosseous defect. No attempt is made to elevate an oral flap.

SIMPLIFIED PROCEDURES FOR THE TREATMENT OF PERIODONTAL INTRAOSSEOUS DEFECTS: EFFECT ON CLINICAL PARAMETERS AND PATIENT-CENTERED OUTCOMES

Non-surgical procedures

Clinical parameters

Data regarding the effectiveness of non surgical therapy in the treatment of intraosseous defects are reported in Table 1. In general, defects showing a probing depth (PD) < 7 mm and a radiographic depth of the angular component ≥ 2 mm were included. Although improvements in clinical and radiographic parameters were reported at 6-18 months follow-up, substantial heterogeneity in treatment outcomes was observed among studies. Some studies reported a mean gain in clinical attachment level (CAL) of 0.8 - 1.6 mm, an increase in bone height of 0.9%, and a mean residual probing depth of 4.2 - 5.2 mm (23, 24). Differently, when non-surgical treatment was administered according to minimally-invasive non-surgical periodontal therapy, greater clinical improvements were observed (27, 28). At 6 months, a clinical attachment level gain of 2.56 mm and a probing depth reduction of 3.13 were reported by Ribeiro et al. (27). Similarly, an average reduction in

the radiographic vertical defect depth of 2.93 mm, accompanied by a clinical attachment level gain of 2.8 mm and a probing depth reduction of 3.12 mm, was observed at 12 months following treatment by Nibali et al. (28).

The magnitude of postoperative increase in gingival recession (REC) following non-surgical treatment of intraosseous defects also shows evident variations among studies (Table 1). While some studies report a gingival recession increase of 0.8 to 1.8 mm (23, 24), a more limited post-treatment recession was observed in recent trials. In particular, a mean gingival recession increase of 0.2 - 0.45 mm was reported following minimally-invasive non-surgical periodontal therapy (27, 28).

In one arm of a randomized controlled trial (27), the mean chair time (as assessed from injection of the local anesthesia to the completion of the professional instrumentation of the tooth surfaces) for minimally-invasive non-surgical periodontal therapy was 29.15 ± 4.30 minutes.

Patient-centered outcomes

Data stemming from one arm of a randomized controlled trial (27) where non-surgical treatment of intraosseous defects was based on minimally-invasive non-surgical periodontal therapy principles indicated:

- low levels of pain and discomfort following the procedure. Also, the mean dose of consumed analgesic medication was low (lower than one analgesic tablet per patient);
- a negligible extent of discomfort, root hypersensitivity, and edema during the first week following treatment. In addition, no patients reported an interference with daily activities during the post-treatment period;
- at 6 months, patient judgement on treatment outcome ranged from “very satisfied” (92.30%) to “satisfied” (7.7%).

Surgical procedures

Clinical parameters

Data from studies evaluating the effectiveness of simplified surgical procedures in the treatment of intraosseous defects are reported in Table 2. In general, defects with a mean pre-surgery probing depth > 7 mm and an intraosseous component of the lesion ≥ 5 mm were included.

When the principle of *Single Flap Approach* or its variants were applied to treat deep intraosseous defects, substantial clinical and radiographic outcomes were reported at 6-12 months following surgery (Table 2). The majority of the studies showed a mean clinical attachment level gain of at least 3.5 mm and a mean radiographic bone fill ranging from 33.7% to 78%. Mean probing depth reduction ranged between 3.82 mm and 5.3 mm.

The postoperative recession of the gingival margin generally comprised within 1 mm (range: 0.1 -1.5 mm) at 6-12 months postoperatively (Table 2). Although showing that these simplified approaches may minimize the surgical trauma during the manipulation of soft tissues (Figure 2), a high heterogeneity in gingival recession change was observed among and within studies. Recently, a retrospective analysis was conducted to evaluate the influence of patient-related and site-specific factors as well as the adopted regenerative strategy on gingival recession change at 6 months following *Single Flap Approach* (36). The results showed that the change in buccal recession was significantly predicted by the depth of the buccal osseous dehiscence and pre-surgery interproximal probing depth (Figure 3a). In particular, an increase in buccal gingival recession may be expected when a buccal osseous dehiscence > 2 mm and a pre-surgery interproximal probing depth > 5 mm are present. In light of these findings, the Authors reinforce the need to combine the *Single Flap Approach* with specific additional procedures/technologies whenever a limited to null post-surgery shrinkage of the gingival margin is of paramount importance (such as in esthetic-sensitive areas). In this respect, different Authors have proposed the coronal advancement of the *Single Flap Approach* (33) or the combination of *Single Flap Approach* with an autologous soft-tissue graft (35, 37) (Figure 4) or a tridimensional collagen matrix (38). Although the combination of *Single Flap Approach* with a connective tissue graft has been shown

to led to defect resolution with a concomitant substantial root coverage (35), the efficacy of these procedures in controlling the postoperative recession increase needs to be further evaluated.

The average chair-time for Modified Minimally Invasive Surgical Technique, as measured from the delivery of local anaesthesia to the completion of sutures, ranged between 52.9 ± 5.6 minutes and 58.9 ± 6.2 min (31, 34).

Patient-centered outcomes

Postoperative pain, discomfort and consumption of analgesics

In a recent randomized clinical trial (39), significantly lower pain levels were self-reported during the first postoperative days by patients treated with *Single Flap Approach* compared to patients undergoing double flap approach (DFA) with papilla preservation techniques (Figure 5). The mean number of analgesics consumed during the first 2 postoperative weeks was 2.73 in the *Single Flap Approach* group and 8.69 in the *double flap approach* group, with a significantly greater dose of analgesics being used in the *double flap approach* group compared to the *Single Flap Approach* group (3.2 versus 1.1, respectively) at day +1 (39). Data from other clinical trials on Modified Minimally Invasive Surgical Technique consistently showed low postoperative pain levels and a limited consumption of analgesics (31, 34). In the study by Cortellini & Tonetti (34), only 3 patients reported very limited discomfort in the first 2 days of the first post-operative week, and none of the 15 treated patients reported significant postoperative pain at week 1. In a more recent study (31), none of the patients experienced postoperative pain at week 1. Average Visual Analogue Scale (VAS) scores (on a 100-mm scale) for postoperative discomfort ranged from 10.7 to 12.3. The mean number of analgesics was below 1, with a maximum of 3 analgesics used during the postoperative period (31).

Incidence and severity of adverse events

Neither infective complications nor adverse reactions (oedema or haematoma) were reported following simplified surgical procedures (31, 32, 34, 36, 39-44). These data support the safety of these procedures in the treatment of intraosseous lesions.

MAY SIMPLIFIED SURGICAL PROCEDURES ENHANCE POST-SURGERY WOUND STABILITY?

The significance of primary closure and wound stability as a determinant of the regenerative outcome has been universally recognized (45, 46). In particular, the first postoperative weeks seem to be critical for the maintenance of wound stability (45, 47, 48). Wound dehiscence may compromise wound stability, which in turn would jeopardize the cascade of biologic events leading to periodontal regeneration (49-52). Furthermore, when flap surgery is used in association with regenerative devices, the postoperative loss of primary closure may lead to partial or complete exfoliation of the implanted graft, contamination of the membrane, or premature clearance of the bioactive agent. In this context, the surgical management of the supracrestal soft tissues, including flap design and suturing technique, is of paramount importance in controlling the chances of wound failure during the early phases of healing (53).

Data from several studies on the early postoperative healing following *Single Flap Approach* and Modified Minimally Invasive Surgical Technique either alone or in combination with bioactive agents indicate that the use of these techniques may result in high proportion of sites showing complete flap closure during the first postoperative weeks (31, 34, 39, 40, 42). In particular, a retrospective analysis of defects treated with *Single Flap Approach* (42) consistently showed that 84% of defects showed a complete closure of the incision wounds at 2 weeks, as assessed by an Early Healing Index (EHI) score (54) of 1 to 3. In particular, 54% of the treated defects showed optimal conditions (i.e. Early Healing Index score =1) of wound closure (Figure 2). The results also suggest an impact of the different early healing patterns on the 6-month clinical outcomes of the procedure (42), with a trend towards better clinical outcomes (greater clinical attachemnt level gain, less buccal gingival recession increase) when defects showed optimal wound closure compared to incomplete wound closure.

More recently, a randomized clinical trial demonstrated that the *Single Flap Approach* may optimize the quality of early wound healing of defects compared to a *double flap approach* based on papilla preservation techniques (39). Surgical access was combined with recombinant human platelet-derived growth factor BB (rhPDGF-BB) and β-tricalcium phosphate (β-TCP). At 2 weeks, 12 sites in the *Single Flap Approach* group and 6 sites in the *double flap approach* group showed complete flap closure (i.e., Early Healing Index = 1, 2 or 3). The frequency of sites showing optimal wound healing (i.e., Early Healing Index = 1) was 8 and 3 in the *Single Flap Approach* and DFA group, respectively. Improved clinical outcomes in SFA group compared to DFA group were partly ascribed to enhanced early wound healing (39).

Single or double flaps?

Adequate surgical access to provide proper root/defect instrumentation of the intraosseous lesion is of paramount importance in affecting clinical and histologic outcomes. In this respect, the extension and morphology of the defect represents a key aspect when selecting a flap design. On the other hand, data from recent studies indicate that, should the anatomical conditions permit it, *Single Flap Approach* may lead to improved clinical outcomes compared to *double flap approach*. In this respect, 2-3 walled, intraosseous defects received surgical debridement according to either *Single Flap Approach* or *double flap approach* (according to papilla preservation techniques) (41). No regenerative devices were used in addition to surgical access. At 6 months, treatment resulted in 1-mm greater clinical attachment level gain and probing depth reductions compared to the elevation of a flap at both buccal and oral aspects. A trend towards a greater clinical attachemnt level gain for *Single Flap Approach* compared to conventional *double flap approach* (papilla preservation techniques) was also reported in association with the use of a bioactive agent+graft (39).

Simplified surgical procedures: an effective access flap protocol?

Data (Table 2) have shown that surgical access based on the elevation of a single flap represents a valuable treatment even when used *per se* (i.e., without additional use of reconstructive devices or bioactive agents)

(31, 40, 41, 43) (Figure 1). The magnitude of clinical attachment level gain observed for the simplified procedures (ranging on average from 2.6 to 4.5 mm) largely exceeds those reported for a double-flap access, including the most conservative papilla preservation techniques (55). Obviously, the assessment of clinical improvement by probing recordings prevents from evaluating the nature of the wound healing following tissue maturation phase.

The potential of the simplified procedures *per se* to treat intraosseous lesions may partly explain the findings from 3 randomized controlled trials evaluating the efficacy of different regenerative technologies (31, 40, 43). In essence, the results from these studies failed to find any significant benefit from the use of a resorbable membrane with bone substitutes (40), enamel matrix derivative (EMD) with or without a xenograft (31), or recombinant human platelet-derived growth factor BB (43) when combined with a simplified single-flap procedure. However, these findings must be interpreted with caution in view of the baseline defect characteristics and the appropriateness of the regenerative device selected for study.

In this respect, in two studies (31, 43) defect selection resulted in mainly 2-3 walled defects with a narrow defect angle, which are characterized by enhanced healing response (56, 57). Although limiting the indication for a simplified procedure as a solo treatment, these results indicate that a surgical access based on a single flap may be effective when performed in defects more prone to a spontaneous healing (Figure 1, 2).

In the Trombelli et al. study (40), the combination of *Single Flap Approach* with a resorbable membrane and a hydroxyapatite-based graft resulted in incomplete early wound closure (i.e. Early Healing Index = 4) in 5 out of 12 defects, whereas the *Single Flap Approach* group showed complete wound closure in all defects. Early wound failure may have partly compromised the additional clinical benefit exerted by guided tissue regeneartion (GTR) when compared to access flap surgery (58), thus questioning whether the use of a membrane represents a suitable regenerative choice when matched to *Single Flap Approach*.

WHICH REGENERATIVE TECHNOLOGY IN ASSOCIATION WITH SIMPLIFIED SURGICAL PROCEDURES?

Several studies demonstrated the effectiveness of simplified surgical procedures when used in association with various regenerative technologies (Table 2). A series of studies investigated the combination of *Single Flap Approach* with membranes or bioactive agents, with and without graft biomaterials (29, 32, 36-40, 42, 44, 59). Modified Minimally Invasive Surgical Technique was combined with bioactive agents alone (34, 43) or enamel matrix derivative and a bovine-derived xenograft (31).

If the additional benefit of using a membrane-graft combination with *Single Flap Approach* has been challenged (40), improved treatment outcomes following use of bioactive agents (enamel matrix derivative, recombinant human platelet-derived growth factor BB) with or without bone substitutes in association with *Single Flap Approach* have been recently reported (36, 44). 24 deep periodontal intraosseous defects were treated with a buccal *Single Flap Approach* and enamel matrix derivative with or without deproteinized bovine bone mineral (DBBM) according to the surgeon's discretion. Both treatments were clinically effective in terms of clinical attachemnt gain and probing depth reduction. Interestingly, the adjunctive use of deproteinized bovine bone mineral in wider, predominantly one-wall defects seemed to compensate for the unfavorable effect of osseous characteristics on treatment outcomes (44). The results published in 2015 by Farina et al. (36) showed that the change in gingival recssion at the interproximal level was significantly predicted by pre-surgery interproximal probing depth and treatment modality. Defects treated with *Single Flap Approach* in combination with enamel matrix derivative + deproteinized bovine bone mineral were less prone to recession increase compared to defects treated with *Single Flap Approach* with enamel matrix derivative (Figure 3b). This finding was consistent with previous studies showing that the combined use of enamel matrix derivative and a graft may significantly temper the postoperative recession compared to enamel matrix derivative alone in the treatment of deep intraosseous defects (60-62). On the basis of these findings, the combined use of enamel matrix derivative with a xenograft seems to be indicated when deep intraosseous defects of unfavourable morphology are located at esthetic areas (Figure 6).

CONCLUSIVE REMARKS

Treatment of deep intraosseous defects in the esthetic areas implies a clinical improvement of the lesion consistent with long-term survival of the affected tooth, preferably associated with a true regeneration of the lost attachment apparatus, as well as the preservation (or improvement) of the esthetic appearance of the patient. Hopefully, such treatment endpoints should be reached by procedures (that we have termed as "simplified") which, on one hand can be easily and successfully applied by the majority of clinicians, on the other can be well tolerated by the patient in terms of post-surgical pain and discomfort, adverse events and cost.

In the present review, we have described the technical aspects and analyzed the effect on clinical and patient-centered outcomes of non-surgical and simplified surgical procedures. On the basis of the available evidence, the following conclusions can be drawn:

1. Whenever indicated, treatment selection should be oriented towards the adoption of a "simplified" procedure. Data support the effectiveness of non-surgical and simplified surgical treatments when compared to conventional approaches. However, the appropriateness of such procedures appears strictly related to patient and defect selection as well as treatment endpoints;
2. Preliminary data from recent studies have shown that non-surgical treatment according to a minimally-invasive technique (MINST) may result in substantial clinical attachment level gain and probing depth reduction at 6-18 months following treatment, with limited remodeling of the gingival profile. Consistently with previous data (11), these studies also indicate that such technique may be appropriate in lesions with probing depth < 7 mm and a limited intraosseous component. It should be, however, considered that histologic studies in humans indicated that the healing process of intraosseous lesions following non-surgical treatment is reparative rather than regenerative (63). Moreover, the long-term effectiveness of minimally-invasive technique remains to be assessed;
3. Should local conditions following non-surgical therapy be not compatible with a good prognosis of the tooth presenting the defect (e.g. persistent bleeding pocket), a corrective surgical treatment is recommended. After proper diagnosis of defect morphology, severe intraosseous defects can be

successfully treated by surgical procedures based on the elevation of a single flap. Considerable clinical attachment level gain and probing depth reduction associated with no adverse events have been reported in observational and experimental studies. *Single Flap Approach* was shown at least as effective as traditional papilla preservation techniques, when evaluated either as stand alone protocol or in combination with regenerative devices. Successful outcomes may be, at least in part, due to enhanced condition of wound stability during early wound healing phase;

4. Simplified surgical procedures are associated with minimal esthetic impairment (i.e. post treatment recession). The magnitude of the recession is similar to that observed following minimally-invasive technique. However, a certain amount of gingival shrinkage is to be expected even if the interdental papilla is left untouched. Since the postoperative recession increase has been related to specific defect characteristics, variants of *Single Flap Approach* which include additional procedures/devices aimed at controlling the post-surgery recession have been proposed (33, 35, 37, 38);
5. Surgical access based on a single flap without any regenerative device may result in improved clinical conditions when performed in defects characterized by favorable prognosis (mainly 2-3 walled defects with a narrow angle);
6. *Single Flap Approach* and Modified Minimally Invasive Surgical Technique have also been effectively used in combination with different regenerative strategies, such as resorbable membranes or bioactive agents with or without graft biomaterials. Beside their potential for new attachment formation, bioactive agents have shown the most appropriate regenerative device when matched to simplified surgical procedures;
7. When dealing with deep intraosseous defects of unfavorable morphology, particularly at esthetic areas, the combination of bioactive agent and graft biomaterial may ensure a substantial attachment gain while limiting the post-surgery recession;
8. Simplified surgical procedures result in a more tolerable postoperative course when compared to conventional approaches. The lower postoperative pain levels and dose of analgesics compared to conventional double flap procedures may be due to reduced invasiveness and operative time.

Despite these encouraging results, some of the key principles of “simplification” still need to be investigated for such procedures. In particular, limited to no information is currently available with regard to generalizability, learning curve and cost-benefit ratio. Moreover, the clinical improvements (radiographic defect fill, clinical attachment gain) observed when simplified surgical procedures were used *per se* needs to be histologically characterized and long-term evaluated. Finally, the efficacy of *Single Flap Approach* variants which were proposed to preserve/improve the pre-existing esthetics of the patient needs to be thoroughly evaluated.

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