Intraosseous defects are defined by the apical location of the base of the pocket with respect to the residual alveolar crest (31). Clinically and radiographically, 18–51% of subjects present at least one intraosseous defect (7, 22, 30, 33, 41, 42, 54, 60). Intraosseous defects are at high risk of further progression and may lead to tooth loss if left untreated (32). The treatment of periodontitis, which also encompasses intraosseous defects, is based on removal of supra- and subgingival biofilm, achieved by patient-performed oral hygiene associated with professional nonsurgical periodontal debridement. As intraosseous defects may be associated with persistent deep pockets and bleeding following conventional nonsurgical treatment, these lesions are frequently considered as sites requiring surgical therapy (17). Historically, the ‘classical’ surgical approaches used to access and treat periodontal intraosseous defects were based on flap designs characterized by either minimal tissue resection (21, 35) or total preservation of interdental tissues, such as the papilla-preservation technique (43) and its variants (2–4, 15, 26, 45). All these flap designs are based on the elevation of a double mucoperiosteal flap involving both buccal and oral aspects (47).

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). We define a procedure as ‘simplified’ when it provides more favorable conditions for either the patient or the clinical operator. Although the terms ‘simplification’ and ‘minimal invasiveness’ may appear as synonyms when referring 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 and short learning curve; and (iii) limit the need for the use of additional treatments/devices (through maximizing the inherent healing potential of the treated lesion). For the patient, a simplified procedure should have reduced impact on: (i) post-treatment daily activities; (ii) post-treatment pain and discomfort (also reducing the required compliance for post-treatment regimens); and (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.

Nonsurgical therapy as a solo treatment always represents a ‘simplified’ procedure, particularly when compared with surgical approaches. Among the surgical options available, ‘simplified’ surgical procedures, as recently proposed, will be thoroughly revised in this chapter of Periodontology 2000. These procedures share a common technical aspect, namely the elevation of a single flap on the buccal or oral aspect, leaving the tissues on the opposite side intact (see the ‘Technical aspects’ section for details). All the simplified treatments (either nonsurgical 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 postoperative morbidity (16). In this respect, it will be shown that the minimal invasiveness of such procedures may be partly a result of the simplification of the treatment approaches. We describe here the technical aspects and the effect on clinical parameters and patient-centered outcomes of...
the simplified procedures for the treatment of periodontal intraosseous defects, specifically when located in the esthetic area. Particular emphasis is on 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

Nonsurgical procedures

Table 1 summarizes the studies on nonsurgical therapy for the treatment of intraosseous defects. All studies incorporated a thorough subgingival instrumentation performed with manual instruments, either alone (20, 36) or in combination with mechanical instruments (19, 28, 29, 37). Recently, minimally invasive nonsurgical periodontal therapy has been introduced as a concept aimed at obtaining extensive subgingival debridement with minimal tissue trauma (37). Minimally invasive nonsurgical periodontal therapy is based on the following principles: (i) thorough debridement of the root surface to the bottom of the periodontal pocket, avoiding root planing and gingival curettage; (ii) use of a magnification system; (iii) prevalent use of an ultrasonic device with specific thin tips, complemented by Gracey minicurettes; and (iv) caution to preserve the integrity of soft tissues.

Surgical procedures

In 2007, the first simplified surgical procedure was proposed (48). This procedure, which was defined as a 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 (Fig. 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 to enhanced preservation of the pre-existing gingival esthetics.

A prerequisite to apply the single flap approach principles is that the morphology of the defect is compatible with thorough root/defect debridement when accessed by either the buccal or oral side only. Whenever the bucco-oral extension of the defect prevents 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 should be performed. However, data derived from the distribution of intraosseous defects according to the bone morphology (44, 54), combined with observation from a prospective trial (6), seem to suggest that a single-flap (usually buccal) access to intraosseous defects may be feasible in a relevant proportion of surgically treated defects.

The single flap approach is a simplified surgical approach that is used to access periodontal intraosseous defects (48, 49) (Fig. 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 preoperative bone sounding and periapical radiographs), preserving the integrity of the interproximal supracrestal gingival tissues. A 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 mesiodistal 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). Therefore, priority, in terms of flap extension, 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 apicocoronal level of the interdental incision is based on the apicocoronal dimension of the supracrestal soft tissues. Preoperatively, probing measurements are carefully performed to assess the horizontal component of the bone loss and therefore the apicocoronal dimension of the soft tissues overlying the bone crest. The greater the
Table 1. Clinical studies evaluating the effectiveness of non-surgical therapy in the treatment of intraosseous defects

<table>
<thead>
<tr>
<th>Study</th>
<th>Experimental design</th>
<th>Number of defects</th>
<th>Radiographic depth of intraosseous component</th>
<th>Baseline probing depth (mean, mm)</th>
<th>Treatment approach</th>
<th>Localization of intraosseous defects</th>
<th>Follow-up (months)</th>
<th>Clinical outcomes</th>
<th>Radiographic outcomes</th>
<th>Patient-centered outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isidor et al. 1985 (20)</td>
<td>Split-mouth, prospective clinical trial</td>
<td>13</td>
<td>≥ 15% of root length</td>
<td>7.6</td>
<td>Root planing with manual instruments</td>
<td>Lateral incisors, canines, premolars</td>
<td>12</td>
<td>Mean gain, 1.6 mm</td>
<td>Reduced to 4.2 mm</td>
<td>Mean increase, 1.8 mm</td>
</tr>
<tr>
<td>Renvert et al. 1985 (36)</td>
<td>Split-mouth, prospective clinical trial</td>
<td>25</td>
<td>Not available</td>
<td>6.7</td>
<td>Root planing with manual instruments</td>
<td>All tooth types</td>
<td>6</td>
<td>Mean gain, 0.8 mm</td>
<td>Reduced to 5.2 mm</td>
<td>Mean increase, 0.8 mm</td>
</tr>
<tr>
<td>Hwang et al. 2008 (19)</td>
<td>Case series</td>
<td>39 (sites)</td>
<td>≥ 3 mm</td>
<td>6.57</td>
<td>Scaling and root planing using mechanical and manual instruments</td>
<td>All tooth types</td>
<td>6</td>
<td>Not available</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Nibali et al. 2011 (29)</td>
<td>Retrospective study</td>
<td>126</td>
<td>Mean, 3.8 mm</td>
<td>6.5</td>
<td>Scaling and root planing using mechanical and manual instruments with/without systemic or local antibiotics</td>
<td>All tooth types</td>
<td>Range, 12–18</td>
<td>Mean gain, 1.42–1.50 mm</td>
<td>Mean reduction, 2.24–2.29 mm</td>
<td>Mean increase, 0.5–0.7 mm</td>
</tr>
<tr>
<td>Ribeiro et al. 2011 (37)</td>
<td>Parallel-arm randomized controlled trial</td>
<td>13 patients with ≥ 1 defect</td>
<td>≥ 4 mm</td>
<td>6.35</td>
<td>Scaling and root planing using micacuttes and an ultrasonic device with specific thin tips under an operating microscope (minimally-invasive nonsurgical periodontal therapy)</td>
<td>Single-rooted teeth</td>
<td>6</td>
<td>Mean gain, 2.56 mm</td>
<td>Mean reduction, 3.13 mm</td>
<td>Mean increase, 0.45 mm</td>
</tr>
<tr>
<td>14 patients with ≥ 1 defect</td>
<td>4 mm</td>
<td>7.07</td>
<td>Minimally invasive surgical technique (4)</td>
<td>Single-rooted teeth</td>
<td>6</td>
<td>Mean gain, 2.85 mm</td>
<td>Mean reduction, 3.51 mm</td>
<td>Mean increase, 0.46 mm</td>
<td>Mean number of analgesic medications, 0.40</td>
<td>92.85% of patients very satisfied at 6 months</td>
</tr>
</tbody>
</table>
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 undertaken 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 interdental supracrestal soft tissues undetached. The full-thickness elevation of the marginal portion of the flap should be performed using 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 repositioning. 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.

More recently, other authors proposed variants of the single flap approach in which only a single buccal flap is raised to access the intraosseous defect (1, 5, 63). In 2008, Checchi et al. (1) 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 the coronally positioned single flap approach. In order to coronally advance and stabilize the flap, split-thickness preparation of the tissues in the apical portion of the flap and de-epithelization of the interdental papillae were recommended. The modified minimally invasive surgical technique was proposed in 2009 (5). Substantial overlap exists between the modified minimally invasive surgical technique and the buccal single-flap approach, including aspects related to the interdental flap incision and flap management. However, in the modified minimally invasive surgical technique the mesiodistal extension of the incision is kept at a minimum (ideally, within the mid-buccal area of the involved teeth) to allow reflection of a triangular buccal flap. A microblade is used to cut through the interdental tissues, with an inclination suitable to intercept the buccal side of the lingual bone crest, as
Fig. 1. Operative steps to perform a surgical access according to the principles of the single flap approach. (A) Pre-operative probing following non-surgical treatment of a defect located at the mesio-buccal aspect of a maxillary lateral incisor. (B) The defect has a minimal to null extension on the palatal aspect, as detected by pre-operative probing. (C) Pre-operative periapical radiograph. (D) An oblique or horizontal, butt-joint incision is performed at the level of the interdental papilla. The incision is extended intrasulcularly at the adjacent teeth. (E) Buccal flap elevation with a microsurgical periosteal elevator. The oral portion of the interdental supra-crestal soft tissues is left undetached. (F) In this case, the intraosseous component of the defect (depth, 5 mm) is left filled with a blood clot only. (G) First horizontal internal mattress suture at the base of the papilla. (H) Second internal mattress suture at the most coronal portion of the papilla. (I) Complete wound closure and absence of fibrin line in the interproximal area (equivalent to an early healing index of 1, as proposed by Wachtel et al. (55)) are observed at suture removal (2-week post-surgery). (J) Healing at 6 months after surgery. (K, L) Clinical and radiographic aspect at 3 years following surgery (re-adapted from Trombelli et al. (51)). This figure is reproduced with permission from the American Academy of Periodontology.
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. (63) 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-epithelialized 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

Nonsurgical procedures

Clinical parameters

Data on the effectiveness of nonsurgical therapy in the treatment of intraosseous defects are reported in Table 1. In general, defects showing a probing depth of < 7 mm and a radiographic depth of the angular component of ≥ 2 mm were included. Although improvements in clinical and radiographic parameters were reported at 6–18 months of follow-up, substantial heterogeneity in treatment outcomes was observed among studies. Some studies reported a mean gain in clinical attachment level 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 (20, 36). In contrast, when nonsurgical treatment was administered according to minimally invasive nonsurgical periodontal therapy, greater clinical improvements were observed (28, 37). 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. (37). 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 by Nibali et al. (28) at 12 months following treatment. The magnitude of postoperative increase in gingival recession following nonsurgical treatment of intraosseous defects also shows variations among studies (Table 1). While some studies report a gingival recession increase of 0.8–1.8 mm (20, 36), a more limited post-treatment recession has been observed in recent trials. In particular, a mean gingival recession increase of 0.2–0.45 mm was reported following minimally invasive nonsurgical periodontal therapy (28, 37). In one arm of a randomized controlled trial (37), the mean chair-time (as assessed from injection of local anesthesia to completion of the professional instrumentation of the tooth surfaces) for minimally invasive nonsurgical periodontal therapy was 29.15 ± 4.30 min.

Patient-centered outcomes

Data stemming from one arm of a randomized controlled trial (37), in which nonsurgical treatment of intraosseous defects was based on minimally invasive nonsurgical periodontal therapy principles, indicated:

- Low levels of pain and discomfort following the procedure. Also, the mean dose of analgesic medication consumed was low (fewer 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 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 presurgery probing depth of > 7 mm and an intraosseous component of the lesion of ≥ 5 mm were included. When the principle of the single flap approach or its variants was 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 from 3.82 to 5.3 mm. The postoperative recession of the gingival margin was generally within 1 mm (range: 0.1–1.5 mm) at
Table 2. Clinical trials* evaluating the effectiveness of simplified surgical procedures in the treatment of intraosseous defects

<table>
<thead>
<tr>
<th>Study</th>
<th>Experimental design</th>
<th>Number of defects</th>
<th>Intraosseous component (mm)</th>
<th>Baseline probing depth (mean, mm)</th>
<th>Flap design and reconstructive technology</th>
<th>Localization of intraosseous defects</th>
<th>Follow-up (months)</th>
<th>Clinical outcomes</th>
<th>Radiographic defect fill (%)</th>
<th>Patient-centered outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trombelli et al. 2009 (49)</td>
<td>Case series</td>
<td>10</td>
<td>Range, 5-14</td>
<td>9.0</td>
<td>Single flap approach + graft/guided tissue regeneration</td>
<td>All tooth types</td>
<td>Range, 6-14</td>
<td>4.0</td>
<td>5.2</td>
<td>0.4</td>
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<td></td>
<td></td>
<td>Not available</td>
<td>Not available</td>
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<tr>
<td>Cortellini &amp; Tonetti 2009 (5)</td>
<td>Case series</td>
<td>15</td>
<td>Range, 4-9</td>
<td>7.7</td>
<td>Modified minimally invasive surgical technique + enamel matrix derivative</td>
<td>Not available</td>
<td>12</td>
<td>4.5</td>
<td>4.6</td>
<td>0.07</td>
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<td></td>
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<td></td>
<td>Mean, 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not available</td>
<td>Week 1: no patients reported pain; three patients reported slight discomfort</td>
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<tr>
<td>Trombelli et al. 2010 (51)</td>
<td>Parallel-arm randomized controlled trial</td>
<td>12</td>
<td>Mean, 6.1</td>
<td>8.5</td>
<td>Single flap approach alone</td>
<td>All tooth types</td>
<td>6</td>
<td>4.4</td>
<td>5.3</td>
<td>0.8</td>
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<td>Not available</td>
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<td></td>
<td></td>
<td>12</td>
<td>Mean, 8.0</td>
<td>9.1</td>
<td>Single flap approach + graft/guided tissue regeneration</td>
<td>All tooth types</td>
<td>6</td>
<td>4.7</td>
<td>5.3</td>
<td>0.4</td>
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<td>Not available</td>
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<tr>
<td>Cortellini &amp; Tonetti 2011 (6)</td>
<td>Parallel-arm randomized controlled trial</td>
<td>15</td>
<td>Mean, 5.2</td>
<td>7.5</td>
<td>Modified minimally invasive surgical technique alone</td>
<td>Not available</td>
<td>12</td>
<td>4.1</td>
<td>4.4</td>
<td>0.3</td>
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<td></td>
<td>77</td>
<td>Week 1: no patients reported pain; mean discomfort (100-mm visual analog scale), 10.7; mean number of analgesic medications, 0.4</td>
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<td></td>
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<td>15</td>
<td>Mean, 5.3</td>
<td>7.8</td>
<td>Modified minimally invasive surgical technique + enamel matrix derivative</td>
<td>Not available</td>
<td>12</td>
<td>4.1</td>
<td>4.4</td>
<td>0.3</td>
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<td></td>
<td>71</td>
<td>Week 1: no patients reported pain; mean discomfort (100-mm visual analog scale), 11.5; mean number of analgesic medications, 0.3</td>
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<td></td>
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<td>15</td>
<td>Mean, 5.2</td>
<td>7.3</td>
<td>Modified minimally invasive surgical technique + enamel matrix derivative</td>
<td>Not available</td>
<td>12</td>
<td>3.7</td>
<td>4.0</td>
<td>0.3</td>
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<td></td>
<td></td>
<td>78</td>
<td>Week 1: no patients reporting pain; mean discomfort (100-mm visual analog scale), 12.3; mean number of analgesic medications, 0.5</td>
<td></td>
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<tr>
<td>Trombelli et al. 2012 (52)</td>
<td>Parallel-arm randomized controlled trial</td>
<td>14</td>
<td>Mean, 5.8</td>
<td>8.7</td>
<td>Single flap approach alone</td>
<td>All tooth types</td>
<td>6</td>
<td>4.5</td>
<td>5.2</td>
<td>0.7</td>
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<td>Not available</td>
<td>Not available</td>
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<tr>
<td></td>
<td></td>
<td>14</td>
<td>Mean, 5.9</td>
<td>7.4</td>
<td>Double flap approach² alone</td>
<td>All tooth types</td>
<td>6</td>
<td>3.4</td>
<td>3.9</td>
<td>0.5</td>
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<td></td>
<td>Not available</td>
<td>Not available</td>
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<tr>
<td>Study</td>
<td>Experimental design</td>
<td>Number of defects</td>
<td>Intrabony component (mm)</td>
<td>Baseline probing depth (mean, mm)</td>
<td>Flap design and reconstructive technology</td>
<td>Localization of intrabony defects</td>
<td>Follow-up (months)</td>
<td>Radiographic defect fill (%)</td>
<td>Clinical outcomes</td>
<td>Patient-centered outcomes</td>
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<tr>
<td>Farina et al. 2013 (10)</td>
<td>Case series</td>
<td>43</td>
<td>≥3 mm (on radiographs)</td>
<td>8.9</td>
<td>Single flap approach alone&lt;br&gt;Single flap approach + enamel matrix derivative&lt;br&gt;Single flap approach + graft&lt;br&gt;Single flap approach + graft/enamel matrix derivative&lt;br&gt;Single flap approach + graft/guided tissue regeneration</td>
<td>All tooth types</td>
<td>6</td>
<td>3.4</td>
<td>4.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Mishra et al. 2013 (25)</td>
<td>Parallel-arm randomized controlled trial</td>
<td>14 Mean, 5.08 (on radiographs)</td>
<td>7.64</td>
<td>Modified minimally invasive surgical technique alone</td>
<td>All tooth types</td>
<td>6</td>
<td>2.64</td>
<td>3.02</td>
<td>0.53</td>
<td>35.02</td>
</tr>
<tr>
<td>Farina et al. 2014 (9)</td>
<td>Pragmatic trial</td>
<td>12 Mean, 5.5</td>
<td>8.8</td>
<td>Single flap approach + enamel matrix derivative</td>
<td>All tooth types</td>
<td>6</td>
<td>3.8</td>
<td>4.9</td>
<td>1.2</td>
<td>Not available&lt;br&gt;Not available</td>
</tr>
<tr>
<td>Farina et al. 2015 (8)</td>
<td>Retrospective study</td>
<td>74 Range, 1-14 Mean, 5.8</td>
<td>8.3</td>
<td>Single flap approach alone&lt;br&gt;Single flap approach + enamel matrix derivative&lt;br&gt;Single flap approach + graft/enamel matrix derivative&lt;br&gt;Single flap approach + graft/platelet-derived growth factor BB&lt;br&gt;Single flap approach + graft/guided tissue regeneration</td>
<td>All tooth types</td>
<td>6</td>
<td>3.7</td>
<td>4.5</td>
<td>0.9</td>
<td>Not available&lt;br&gt;Not available</td>
</tr>
<tr>
<td>Schincaglia et al. 2015 (39)</td>
<td>Parallel-arm randomized controlled trial</td>
<td>15 Mean, 7.7</td>
<td>8.7</td>
<td>Single flap approach + platelet-derived growth factor BB</td>
<td>All tooth types</td>
<td>6</td>
<td>4.0</td>
<td>4.1</td>
<td>0.1</td>
<td>33.7§</td>
</tr>
<tr>
<td>Farina et al. 2015 (8)</td>
<td>Parallel-arm randomized controlled trial</td>
<td>13 Mean, 3.0</td>
<td>7.7</td>
<td>Double flap approach + graft/platelet-derived growth factor BB</td>
<td>All tooth types</td>
<td>6</td>
<td>3.2</td>
<td>3.6</td>
<td>0.4</td>
<td>40.3§</td>
</tr>
</tbody>
</table>

*Case reports were excluded.
†Positive value indicates an increase.
‡According to papilla preservation techniques (2, 3).
§Calculated ad hoc for this review (data not shown in the study).
6–12 months postoperatively (Table 2). Although showing that these simplified approaches may minimize the surgical trauma during the manipulation of soft tissues (Fig. 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 a single flap approach (8). The results showed that the change in buccal recession was significantly predicted by the depth of the buccal osseous dehiscence and presurgery interproximal probing depth (Fig. 3A). In particular, an increase in buccal gingival recession may be expected when a buccal osseous dehiscence of > 2 mm and a presurgery interproximal probing depth of > 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 postsurgery shrinkage of the gingival margin is of paramount importance (such as in esthetic-sensitive areas). In this respect, different authors have proposed coronal advancement of the single flap approach (1) or the combination of a single flap approach with an autologous soft-tissue graft (50, 63) (Fig. 4) or a tridimensional collagen matrix (38). Although the combination of a single flap approach with a connective tissue graft has been shown to lead to defect resolution with concomitant substantial root coverage (63), the efficacy of these procedures in controlling the postoperative recession increase needs to be evaluated further. The average chair-time for a modified minimally invasive surgical technique, as measured from the delivery of local anesthesia to the completion of sutures, ranged from 52.9 ± 5.6 to 58.9 ± 6.2 min (5, 6).

**Patient-centered outcomes**

In a recent randomized clinical trial (39), significantly lower pain levels were self-reported during the first postoperative days by patients treated with a single flap approach compared with patients undergoing a double flap approach with papilla preservation techniques (Fig. 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 higher dose of analgesics being used in the double flap approach group than in the single flap approach group (3.2 vs. 1.1, respectively) at day +1 (39). Data from other clinical trials on modified minimally invasive surgical techniques consistently showed low postoperative pain levels and a limited consumption of analgesics (5, 6). In the study by Cortellini & Tonetti (5), only three patients reported very limited discomfort in the first 2 days of the first postoperative week, and none of the 15 treated patients reported significant postoperative pain at week 1. In a more recent study (6), none of the patients experienced postoperative pain at week 1. Average visual analogue scale scores (on a 100-mm scale) for postoperative discomfort ranged from 10.7 to 12.3. The mean number of analgesics was < 1, with a maximum of three analgesics being used during the postoperative period (6). Neither infective complications nor adverse reactions (edema or hematoma) were reported following simplified surgical procedures (5, 6, 8–10, 25, 39, 49, 51, 52). These data support the safety of these procedures in the treatment of intraosseous lesions.

**May simplified surgical procedures enhance postsurgery wound stability?**

The significance of primary closure and wound stability as a determinant of the regenerative outcome has been universally recognized (34, 59). In particular, the first postoperative weeks seem to be critical for the maintenance of wound stability (18, 56, 59). Wound dehiscence may compromise wound stability, which in turn would jeopardize the cascade of biologic events leading to periodontal regeneration (14, 23, 58, 61). 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 (57). Data from several studies on the early postoperative healing achieved following a single flap approach and modified minimally invasive surgery, 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 (5, 6, 10, 39, 51). In particular, a retrospective analysis of defects treated with a single flap approach (10) consistently showed that 84% of defects showed complete closure of the incision.
wounds at 2 weeks, as assessed by an early healing index score (55) of 1–3. In particular, 54% of the treated defects showed optimal conditions (i.e. early healing index score = 1) of wound closure (Fig. 2). The results also suggest an impact of the different early healing patterns on the 6-month clinical outcomes of the procedure (10), with a trend toward better clinical outcomes (greater clinical attachment level gain, less buccal gingival recession increase) when defects showed optimal wound closure compared with incomplete wound closure. More recently, a randomized clinical trial demonstrated that a single flap approach may optimize the quality of early wound healing of defects compared with a double flap approach based on papilla preservation techniques (39). Surgical access was combined with recombinant human platelet-derived growth factor BB and beta-tricalcium phosphate. At 2 weeks, 12 sites in the single flap approach group and six 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 eight in the single flap approach group and three in the double flap approach group. Improved clinical outcomes in single flap approach group compared with a double flap approach group were partly ascribed to enhanced early wound healing (39).

Fig. 2. Treatment of a narrow, mainly 3-wall intraosseous defect with the single flap approach in combination with enamel matrix derivative. (A) Persistent bleeding, 8-mm pocket at the mesio-buccal aspect of a left maxillary central incisor as observed at 6 months following non-surgical therapy. (B) Pre-surgery radiograph. (C) Sulcular incisions performed on the buccal aspect. (D) Oblique, butt-joint incision at the level of the interdental papilla. (E) Elevation of a buccal single flap. (F) The defect is characterized by a narrow angle and a 6 mm – deep intraosseous component (as measured at the completion of surgical debridement). (G) The defect is mainly 3-walled. (H) Application of enamel matrix derivative to root surface and defect. (I) Primary intention wound closure. (J) Complete wound closure and absence of fibrin line in the interproximal area (equivalent to an early healing index of 1, as proposed by Wachtel et al. (55)) is observed at 2 weeks following surgery. (K, L) Clinical and radiographic aspect at 1 year following surgery. A clinical attachment gain of 5 mm and a residual probing depth of 2 mm have been obtained. Also, a partial remineralization of the intraosseous component of the defect is evident. (M, N) Clinical and radiographic aspect at 5 years following surgery. Probing depth is 3 mm and the residual angular component of the defect is minimal to null.

Fig. 3. Prediction of 6-month buccal gingival recession following single flap approach. (A) Six-month gingival recession increase at the buccal aspect as predicted on the basis of presurgery probing depth (PD) and buccal osseous dehiscence (bCEJ–BC). (B) Six-month gingival recession increase at the interdental aspect as predicted on the basis of presurgery probing depth and treatment modality. (reprinted from Farina et al. (8)). DBBM, deproteinized bovine bone mineral; EMD, enamel matrix derivative; GTR, guided tissue regeneration; HA, hydroxyapatite; iREC, interproximal recession, rhPDGF-BB, recombinant platelet derived growth factor BB. This figure is reproduced from Farina et al. (8).
Fig. 4. Single flap approach in combination with a connective tissue graft to prevent postoperative gingival recession. (A, B) Nine-mm pocket positive to bleeding upon probing at the disto-buccal aspect of a maxillary canine. (C) The intraosseous defect is accessed with a buccal single flap approach. The defect is mainly 2-walled and is associated with the partial loss of the buccal cortical bone of the affected tooth. (D) A connective tissue graft is harvested from the tuber maxillae and fixed to mesial portion of the buccal single flap with an internal mattress suture. (E) The intraosseous component of the defect is treated with a combination of enamel matrix derivative and a bovine-derived xenograft according to the sandwich technique. (F, G) The fixation of the graft to the single flap is completed with an internal mattress suture. Wound closure in the interdental area is achieved according to the original suturing technique described for the single flap approach (two internal mattress sutures) completed by an additional interrupted suture. (H) Wound healing at 1 week following surgery. (I) At 6 months following surgery, substantial regenerative outcomes (clinical attachment gain, 5 mm; probing depth reduction, 5 mm) have been obtained along with the stability of the gingival margin. (J, K) Clinical and radiographic aspect at 2 years following surgery.
Single or double flaps?

Adequate surgical access to provide proper root/defect instrumentation of the intraosseous lesion is of paramount importance in achieving the desired clinical and histologic outcomes. In this respect, the extent 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 anatomic conditions permit it, a single flap approach may lead to improved clinical outcomes compared with the double flap approach. In this respect, two- to three-walled intraosseous defects were treated with surgical debridement using either a single flap approach or a double flap approach (according to papilla preservation techniques) (52). 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 reduction compared with elevation of a flap at both buccal and oral aspects. A trend toward a greater clinical attachment gain for a single flap approach compared with a 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 the additional use of reconstructive devices or bioactive agents) (6, 25, 51, 52) (Fig. 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 (11). Obviously, the assessment of clinical improvement by probing recordings prevents evaluation of the nature of the wound healing following the tissue-maturation phase. The potential of the simplified procedures per se to treat intraosseous lesions may partly explain the findings from three randomized controlled trials evaluating the efficacy of different regenerative technologies (6, 25, 51). In essence, the results from these studies failed to find any significant benefit from the use of a resorbable membrane with bone substitutes (51), enamel matrix derivative (with or without a xenograft) (6) or recombinant human platelet-derived growth factor BB (25) 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 (6, 25) defect selection resulted in mainly two- to three-walled defects with a narrow defect angle, which are characterized by an enhanced healing response (46, 53). Although limiting the indication for a simplified procedure as a solo treatment, these results indicate that surgical access based on a single flap may be effective when performed in defects more prone to spontaneous healing (Figs 1 and 2). In the study by Trombelli et al. (51), the combination of a 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 five 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 regeneration compared with access flap surgery (27), thus questioning whether the use of a membrane represents a suitable regenerative choice when combined to a single flap approach.
Fig. 6. Treatment of a deep, non-containing intraosseous defect with the single flap approach in combination with enamel matrix derivative and a bovine-derived xenograft. (A–C) Clinical and radiographic aspect (as observed at 6 months following initial therapy) of a maxillary central incisor presenting a deep intraosseous defect at the mesiobuccal aspect (probing depth, 11 mm). (D) Horizontal, butt-joint incision at the level of the interdental papilla and intrasulcular incisions at adjacent teeth. (E) After the elevation of a buccal single flap and the surgical debridement of the lesion and root surface, a wide, mainly 2-wall defect with a 9-mm intraosseous component is identified. (F) Following a first application of enamel matrix derivative, the intraosseous component of the lesion is filled with a bovine derived xenograft mixed with the bioactive agent. (G) Application of second layer of enamel matrix derivative. (H) Wound closure is obtained with two internal mattress sutures and additional interrupted sutures (due to the wide mesio-distal dimension of the interdental papilla). (I) At 2 weeks following surgery, complete flap closure is maintained, and a fibrin clot is present in the interproximal area (early healing index = 3; Wachtel et al. (55)). (J) Six-month clinical attachment gain of 6 mm and residual probing depth of 4 mm. A 1-mm increase in gingival recession can be observed compared to pre-surgery. (K, L) Clinical and radiographic aspect at 5 year following surgery.

Which regenerative technology in association with simplified surgical procedures?

Several studies have demonstrated the effectiveness of simplified surgical procedures when these are used in association with various regenerative technologies (Table 2). A series of studies investigated the combination of a single flap approach with membranes or bioactive agents, with and without graft biomaterials (8–10, 38–40, 48–51). A modified minimally invasive surgical technique was combined with bioactive agents alone (5, 25) or with enamel matrix derivative and a bovine-derived xenograft (6). The additional benefit of using a membrane–graft combination with a single flap approach has been challenged (51), and 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 the single flap approach, were recently reported (8, 9). Twenty-four deep periodontal intraosseous defects were treated with a buccal single flap approach and enamel matrix derivative, with or without deproteinized bovine bone mineral, according to the surgeon’s discretion. Both treatments were clinically effective in terms of clinical attachment 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 (9). The results published in 2015 by Farina et al. (8) showed that the change in gingival recession at the interproximal level was significantly predicted by presurgery interproximal probing depth and treatment modality. Defects treated with a single flap approach in combination with enamel matrix derivative + deproteinized bovine bone mineral were less prone to recession increase compared with defects treated with a single flap approach with enamel matrix derivative (Fig. 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 with the use of enamel matrix derivative alone in the treatment of deep intraosseous defects (13, 24, 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 unfavorable morphology are located at esthetic areas (Fig. 6).

Concluding remarks

Treatment of deep intraosseous defects in esthetic areas implies clinical improvement of the lesion consistent with long-term survival of the affected tooth, preferably associated with true regeneration of the lost attachment apparatus, as well as preservation (or improvement) of the esthetic appearance of the patient. It is hoped that such treatment end points may be reached by procedures (‘simplified’) which, on the one hand can be easily and successfully applied by the majority of clinicians and, on the other hand, are well tolerated by patients in terms of postsurgical 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 nonsurgical and simplified surgical procedures. On the basis of the evidence available, the following conclusions can be drawn:

- Whenever indicated, treatment selection should be oriented toward the adoption of a ‘simplified’ procedure. Data support the effectiveness of nonsurgical and simplified surgical treatments when compared with conventional approaches.
However, the appropriateness of such procedures appears to be strictly related to patient and defect selection as well as to treatment end points.

- Preliminary data from recent studies have shown that nonsurgical treatment using a minimally invasive technique 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. Consistent with previous data (17), these studies also indicate that such a technique may be appropriate in lesions with probing depth < 7 mm and a limited intraosseous component. However, it should be borne in mind that histologic studies in humans have indicated that the healing process of intraosseous lesions following nonsurgical treatment is reparative rather than regenerative (12). Moreover, the long-term effectiveness of this minimally invasive technique remains to be assessed.

- Should local conditions following nonsurgical therapy not be compatible with a good prognosis of the tooth presenting the defect (e.g. persistent bleeding pocket), 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. A single flap approach was shown to be at least as effective as traditional papilla-preservation techniques, when evaluated either as a stand-alone protocol or in combination with regenerative devices. Successful outcomes may be, at least in part, a result of enhanced wound stability during the early wound-healing phase.

- 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 the minimally invasive technique. However, a certain amount of gingival shrinkage is to be expected, even if the interdental papilla is left untouched. As the postoperative recession increase has been related to specific defect characteristics, variants of the single flap approach, which include additional procedures/devices aimed at controlling the postsurgery recession, have been proposed (1, 38, 50 63).

- Surgical access based on a single flap without any regenerative device may result in improved clinical conditions when this procedure is performed in defects with a favorable prognosis (mainly two- to three-walled defects with a narrow angle).

- A single flap approach and a 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 combined to a single flap approach.

- When dealing with deep intraosseous defects of unfavorable morphology, particularly at esthetic areas, the combination of bioactive agent and graft biomaterial may ensure substantial attachment gain while limiting the postsurgery recession.

- Simplified surgical procedures result in a more tolerable postoperative course when compared with conventional approaches. The lower postoperative pain levels and dose of analgesics compared with conventional double flap procedures may be the result of reduced invasiveness and shorter 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 evaluated long term. 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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