Regenerative periodontal therapy of infrabony defects using minimally invasive surgery and a collagen-enriched bovine-derived xenograft: a 1-year prospective study on clinical and aesthetic outcome


Abstract
Aim: To evaluate the clinical and aesthetic outcome of regenerative periodontal therapy (RPT) using minimally invasive surgery and a collagen-enriched bovine-derived xenograft (1); to identify risk factors for failure (clinical attachment level (CAL) gain ≤ 1 mm) and advanced gingival recession (REC) increase (> 1 mm) (2).

Material and methods: Ninety-five non-smoking patients, with ≤ 25% full-mouth plaque and bleeding presenting ≥ 6 months after initial periodontal therapy with ≥ 1 isolated inter-dental infrabony defect were recruited. Patients were consecutively treated by the same clinician using minimally invasive surgery and a collagen-enriched bovine-derived xenograft. Clinical, radiographic and aesthetic data were collected before surgery and up to 1 year. Multivariate analyses were used to identify risk factors for failure and advanced REC increase.

Results: Eighty-four patients (39 men, 45 women; mean age 53) complied and demonstrated mean probing depth (PD) of 7.8 mm, CAL of 10.0 mm and defect depth of 5.2 mm before surgery. At 1 year, postsurgery mean PD reduction was 3.5 mm (range 0.0–8.0), CAL gain was 3.1 mm (range 0.0–7.0) and radiographic defect fill was 53% (range 0–100). Forty-nine percentage showed ≥ 4 mm CAL gain, whereas 15% were considered failures. Mean inter-dental and midfacial REC increase was 0.3 mm (range −2.0–2.0) and 0.5 mm (range −1.5–2.0) respectively. Midfacial REC increase and contour deterioration contributed most to a small, yet significant reduction in the Pink Esthetic Score from 10.06 to 9.42 (p = 0.002). Risk factors for failure included defects with a non-supportive anatomy (OR: ≥ 10.4), plaque (OR: 14.7) and complication(s) (OR: 12.0). Risk factors for advanced midfacial REC increase included defects with a non-supportive anatomy (OR: 58.8) and a thin-scalloped gingival biotype (OR: 76.9).

Conclusions: RPT using minimally invasive surgery and a collagen-enriched bovine-derived xenograft demonstrated favourable clinical outcome after 1 year, even though soft tissue aesthetics could not be fully preserved. Defects with a non-supporting anatomy may be at risk for failure and advanced midfacial recession.

Key words: aesthetic; infrabony; periodontal disease; regeneration; xenograft

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Since the early 1990s, the clinical outcome of regenerative periodontal therapy (RPT) has shown substantial progress (Cortellini & Tonetti 2000). This evolution may be explained by a stringent selection of the patient, the surgical site, the surgical procedure and possibly the biomaterials used. With respect to patient selection, only non-smoking patients with excellent compliance in terms of oral hygiene and supportive care may qualify for RPT (Cortellini et al. 1994, Tonetti et al. 1995, Cortellini & Tonetti 2004). Ample multi-centre studies have shown successful outcomes for infrabony defects (Tonetti et al. 1998, 2002, 2004, Cortellini et al. 2001, Sanz et al. 2004, Meyle et al. 2011) and mandibular class II furcations (Garrett et al. 1997, Vernino et al. 1999, Jepsen et al. 2004), which may be related to the fact that such defects are conducive for lateral ingrowth of periodontal ligament cells and bone cells.

Albeit careful patient and site selection are imperative, optimization of the surgical procedure has probably contributed most to the progress in the field of regenerative periodontics (Cortellini & Tonetti 2011). Key elements for success include space creation, site protection and wound stability. Initially, guided tissue regeneration (GTR) was based on the use of non-resorbable barrier membranes providing a stable space for a blood coagulum that in turn allows for ingrowth of periodontal ligament cells and bone cells. Given a high risk for complications, however (Murphy 1995), a shift towards resorbable membranes and bone replacement grafts developed. Minimally invasive papilla preservation flaps were introduced by Cortellini and co-workers (1995) and optimally protect the site of regeneration. These techniques of flap management and modifications are based on soft tissue preservation and tension-free primary closure contributing to a stable wound (Cortellini et al. 1995, 1999, Cortellini & Tonetti 2007, 2009). With respect to the latter, tooth mobility should also be avoided and if necessary, splinting needs to be considered (Cortellini et al. 2001).

Finally, the biomaterials used for RPT may also be important to consider, as not all have shown regenerative capacity. In this context, one should realize that the ultimate goal of RPT is “restitutio ad integrum”, meaning regeneration of alveolar bone, root cementum and periodontal ligament (Garret 1996). Histological studies have demonstrated such regeneration for GTR (Gottlow et al. 1986, Stahl et al. 1990), allografts (Bowers et al. 1989), xenografts (Mellonig 2000, Nevins et al. 2003, 2005, Sculean et al. 2004, 2005, Hartman et al. 2004, Stavropoulos & Wikesjö 2010) and enamel matrix derivative (EMD) (Yukna & Mellonig 2000, Sculean et al. 2000, 2008). On the other hand, alloplastic materials failed to demonstrate such regenerative capacity and are therefore merely bone fillers.

A prerequisite for broad application of RPT is procedural simplicity. RPT by means of EMD may be considered straightforward in this respect in contrast to GTR, which requires highly skilled surgeons for meticulous membrane positioning. In addition, significantly more complications may be expected following GTR when compared with EMD application (Sanz et al. 2004). On the other hand, EMD may not be ideal for treating wide defects (Tsitoura et al. 2004), especially those with a non-supportive anatomy (Tonetti et al. 2002). The use of a collagen-enriched bovine-derived xenograft may overcome some of these limitations and could be applied without a membrane. Clinical and histological studies have demonstrated periodontal regeneration following the application of such a graft in infrabony defects with and without a membrane (Nevins et al. 2003, 2005, Sculean et al. 2004, 2005, Hartman et al. 2004, Stavropoulos & Wikesjö 2010). However, to the best of our knowledge, the clinical outcome of RPT using a collagen-enriched bovine-derived xenograft has never been documented in a large cohort. Hence, the primary objective of this study was to evaluate this treatment concept in a high number of well-selected patients.

The indication for RPT is often based on aesthetic considerations, besides the fact that the long-term prognosis of the treated tooth may be improved (Cortellini & Tonetti 2008). This aesthetic indication may be considered logical, as soft tissue preservation is a key element for contemporary RPT. However, these aspects have never been thoroughly investigated. Consequently, another primary objective of this study was to objectively assess the aesthetic outcome of RPT. The secondary objective was to identify risk factors for failure (CAL gain ≤ 1 mm) and advanced recession increase (>1 mm) using multivariate analyses.

Material and Methods

Patient selection

Ninety-five patients were consecutively treated between March 2008 and January 2011 for at least one infrabony defect by the same clinician (JC). Patients were treated in two private practices and at the University Hospital in Ghent. They were selected during a screening visit on the basis of inclusion and exclusion criteria.

Inclusion criteria were as follows:

1. Good oral hygiene defined as full-mouth plaque and bleeding score ≤ 25% (O’Leary et al. 1972).
2. Initial periodontal therapy (scaling and root planing and oral hygiene instructions) terminated at least 6 months prior to screening.
3. Presence of at least one isolated inter-dental infrabony defect around a single-rooted tooth or mandibular molar (flat surface) with ≥ 3 mm radiographic depth and ≥ 6 mm probing depth.
4. Signed informed consent.

Exclusion criteria were as follows:

1. Systemic diseases.
2. Smoking.
3. History of surgical treatment at the tooth with the infrabony defect.
4. Adjacent teeth with infrabony defects.
5. Furcation involvement.

Conflict of interest and source of funding statement

The authors declare that they have no conflict of interests. Part of the biomaterials was provided by Mediplus, Rixensart, Belgium.
The study was conducted in accordance with the Helsinki declaration of 1975 as revised in 2000, and the protocol was approved by the ethical committee of the University Hospital in Ghent.

Surgical approach
A minimally invasive surgical technique (MIST) or modification (M-MIST) was used as initially described by Cortellini & Tonetti (2007, 2009). Figures 1 and 2 illustrate the procedure. Surgery was preceded by oral and peri-oral disinfection using chlorhexidine 0.2%. A bevelled incision was performed with a microsurgical blade (Stainless fine steel surgical blade Swann-Morton, Sheffield, England) and was limited to the inter-dental area with the infrabony defect, if possible. If access to the bottom of the defect was deemed insufficient, the flap was extended to the neighbouring inter-dental area. A simplified papilla preservation flap (Cortellini et al. 1999) was performed, whenever the inter-dental space was ≤2 mm. In case of a wide inter-dental space, a modified papilla preservation flap (Cortellini et al. 1995) was performed. Whenever the infrabony defect did not extend to the palatal/lingual side, the modified minimally invasive surgical technique (M-MIST) was performed. That is, flap elevation was limited to the buccal side, hereby keeping the supracrestal inter-dental tissues attached to the palatal/lingual side. Upon flap reflection, granulation tissue was dissected and root debridement was performed using ultrasonic and hand instruments. Chemical root conditioning was never performed. Following intra-surgical data registration, a collagen-enriched bovine-derived xenograft (Bio-Oss Collagen® 100 mg; Geistlich Biomaterials, Wolhusen, Switzerland) was individualized, applied into the defect and slightly condensed. Attention was paid not to overfill the defect. Finally, the flap was replaced at the original position. Tension-free primary closure of the inter-dental papilla was attained by means of an internal vertical matrass suture using monofilament material (Seralon® 5/0; Serag Wiessner, Nail, Germany). Neighbouring inter-dental areas were closed by means of a single suture. Post-operative medication included amoxicillin 1000 mg (twice a day during 4 days), ibuprofen 600 mg (as deemed necessary by the patient) and local application of chlorhexidine 0.2% by means of a spray (twice a day during 2 weeks). Mobile teeth were splinted and inter-dental cleaning was omitted during 1 month. After 2 weeks, sutures were removed and teeth were polished using chlorhexidine gel (1%). The latter was repeated after 1 month. Patients received supportive periodontal treatment after 3 months and every 3 months thereafter, which included professional plaque and calculus removal and polishing. If necessary, oral hygiene was reinforced.

Outcome variables
The following clinical/radiographic parameters were registered by the same clinician (JC):

1. **Gingival biotype** was determined at the midfacial aspect of the tooth with the infrabony defect before surgery. It was based on the transparency of a periodontal probe through the gingival margin when probing the buccal sulcus (not transparent = thick biotype; transparent = thin-scalloped biotype) (De Rouck et al. 2009).

2. **Plaque score** was registered at the deepest inter-dental point of the defect before surgery, after 1 month, 3 months and every 3 months thereafter. A dichotomous score was given (0 = no

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Fig. 1. Pre-operative view and result after 1 year of a representative case. (a) Pre-operative clinical view of an infrabony defect at the mesial aspect of tooth 45: PD 8 mm, CAL: 11 mm. (b) Pre-operative radiograph. Defect depth: 5 mm. (c) Result after 1 year. PD: 3 mm, CAL: 7 mm. (d) Radiograph after 1 year. Radiographic defect fill: 94%.

Fig. 2. Surgical procedure. (a) Modified minimally invasive surgical technique. (b) Predominantly two-wall defect of 5 mm depth. (c) Defect filled with collagen-enriched bovine-derived xenograft. (d) Internal vertical matrass suture at the mesial aspect of tooth 45 and single suture at the distal aspect.

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visible plaque at the gingival margin; 1 = visible plaque at the gingival margin).

(3) **Probing depth (PD)** was registered at the deepest inter-dental point of the defect to the nearest 0.5 mm using a manual probe (CP 15 UNC; Hu-Friedy©, Chicago, USA). Probing depth was measured before surgery and after 1 year.

(4) **Recession (REC)** was registered at the deepest inter-dental point of the defect (inter-dental REC) and at the midfacial aspect (midfacial REC) to the nearest 0.5 mm using the same manual probe. REC was defined as the distance from the free gingival margin to the cement–enamel junction and was measured before surgery and after 1 year.

(5) **Clinical attachment level (CAL)** was calculated for the deepest inter-dental point of the defect as the sum of PD and REC before surgery and after 1 year.

(6) **Radiographic defect fill** was calculated as the difference between the defect depth before surgery (distance in mm between bottom of the defect and the alveolar crest) and after 1 year. The parameter was expressed as a percentage of the original defect depth. Data were based on digital intra-oral radiographs taken before surgery and after 1 year, using the paralleling technique. Designated software was used for linear measurements (DBSWIN; Dürr Dental AG, Bietigheim-Bissingen, Germany).

(7) **Pink esthetic score (PES)** and its seven criteria (Fürhauser et al. 2005) were registered for the tooth with the infrabony defect before surgery and after 1 year. Each criterion was assessed with a 0–1–2 score, with 2 being the best and 0 being the worst score. Papillae were evaluated for completeness; the other variables were assessed by comparison with the contralateral tooth for incisor and cuspid replacements and the neighbouring (pre)molar for (pre)molar replacements.

(8) **Complications** were registered at all occasions and included wound dehiscence, loosening of the splint (if applied) and suppur-ration.

Inter-assessor reliability was assessed on the basis of 20 cases that were randomly selected for duplicate registration of PD, radiographic defect fill and PES by another clinician (RC).

The following intra-surgical parameters were registered by the same clinician (JC):

(1) **Defect anatomy.** A distinction was made between predominantly one-wall, predominantly two-wall and predominantly three-wall infrabony defects (Goldman & Cohen 1958).

(2) **Defect depth** defined as the distance in mm between bottom of the defect and the alveolar crest was registered at the deepest inter-dental point of the defect. The parameter was measured to the nearest 0.5 mm using the same manual probe.

**Statistical analysis**

The patient was the statistical unit in all analyses. If more than one isolated inter-dental infrabony defect was treated in the same patient, the defect closest to the midline was selected. Data analysis included descriptive statistics with frequency distributions on advanced REC increase (>1 mm) and CAL gain (treatment failure: ≤1 mm CAL gain; 2–3 mm CAL gain; ≥4 mm CAL gain). Binary logistic regression was performed using a forward stepwise method with treatment failure and advanced REC increase as dependent variables. Gender, age, tooth category (maxillary incisor/cuspid, maxillary premolar, mandibular incisor/cuspid, mandibular premolar, mandibular molar), surgical technique (MIST versus M-MIST), defect anatomy, defect depth, endodontic (re)treatment, complications, visible plaque during at least one-third of the examinations and the gingival biotype were included as independent variables. The variance inflation factor (VIF) was calculated for each independent variable to evaluate multicollinearity and the model quality was assessed by means of Nagelkerke R-square and Hosmer and Lemeshow goodness of fit.

Paired comparisons for the PES and its seven criteria were performed by means of the Wilcoxon signed ranks test. The level of significance was set at 0.05.

**Results**

Eighty-four patients (39 men, 45 women; mean age of 53 with a range of 28–79) complied with the study protocol, whereas 11 dropped out during aftercare. As 1-year data were lacking on the latter, all analyses were based on 84 cases.

Thirty-six teeth were in an upper incisor/cuspid position, 11 in an upper premolar position, 10 in a lower incisor/cuspid position, 18 in a lower premolar position and 9 in a lower molar position.

Eight teeth had already been endodontically treated at screening. As three of these treatments were deemed unsatisfactory, endodontic retreatment was performed. Primary endodontic treatment was performed in four cases. Patients underwent RPT at least 3 months following endodontic (re)treatment.

Before surgery mean PD was 7.8 mm (SD 1.5; range 6.0–12.0), mean inter-dental REC was 2.2 mm (SD 1.5; range 0.0–5.0) and mean CAL was 10.0 mm (SD 2.3; range 6.0–17.0).

Fifteen cases were predominantly one-wall defects, 47 predominantly two-wall defects and 22 predominantly three-wall defects. Mean defect depth was 5.2 mm (SD 1.7; range 3.0–10.0). Eleven teeth were splinted immediately following RPT because of mobility.

Inter-assessor reliability was satisfactory for PD, radiographic defect fill and PES with intra-class correlation coefficients ≥0.465 (p <0.001).

**Clinical and aesthetic outcome**

Mean PD reduction was 3.5 mm (SD 1.6; range 0.0–8.0) and mean CAL gain amounted to 3.1 mm (SD 1.6; range 0.0–7.0). Fifteen per cent demonstrated 0–1 mm CAL gain and 36% showed 2–3 mm CAL gain and 49% showed ≥4 mm CAL gain. Mean radiographic defect fill was 53% (SD 35; range 0–100). Mean inter-dental REC increase was 0.3 mm (SD 0.7; range 2.0–2.0). Advanced deteriora-
tion (>1 mm) was observed in four cases. Mean midfacial REC increase was 0.5 mm (SD 0.7; range 1.5–2.0). Soft tissue gain was found in five cases (Fig. 3 e,f), whereas advanced deterioration (>1 mm) was demonstrated in 12 patients (Fig. 3 a,b).

Twenty-three patients demonstrated visible plaque at the defect site during at least one-third of the examinations. Eighteen patients demonstrated complications. Wound dehiscence was observed in 13 patients and suppuration was found in two patients. Three patients showed multiple complications (wound dehiscence and loosening of the splint (2); wound dehiscence, loosenings of the splint and suppuration (1) – Fig. 3 a,b).

Table 1 shows the results of the PES before surgery and after 1 year. Note that the PES could only be registered in 66/84 patients because of a missing neighbouring and/or contralateral tooth. Midfacial level and contour showed significant deterioration after 1 year ($p \leq 0.008$), whereas the other five criteria remained fairly stable over time ($p \geq 0.101$). This resulted in a small, yet significant reduction in the PES from 10.06 to 9.42 ($p = 0.002$). Figure 3 shows three cases with varying aesthetic outcome.

Discussion

In the present prospective study, the clinical outcome of RPT was evaluated using minimally invasive surgery and a collagen-enriched bovine-derived xenograft. It was decided not to use a membrane on top of the grafting material to keep the clinical procedure as straightforward and associated costs as low as reasonably possible. This decision was based on the histological evidence of periodontal regeneration following the application of such a graft in infrabony defects as a single measure of treatment (Nevins et al. 2003, 2005, Hartman et al. 2004). Apart from these studies with limited cases, this treatment concept has never been clinically documented. The results of the present study demonstrated mean CAL gain of 3.1 mm with nearly half of the cases showing $\geq 4$ mm CAL gain. This outcome seems somewhat inferior to

Risk factors for failure and advanced recession increase

Table 2 shows the results of the logistic regression analysis on treatment failure. There was no multicollinearity, as the highest VIF was 1.690. The model identified three risk factors for failure. Defect anatomy (OR: $\geq 10.4$ for predominantly one-wall defects), presence of visible plaque during at least one-third of the examinations (OR: 14.7), and occurrence of one or more complications (OR: 12.0) increased the risk for failure.

No significant regression model could be found on advanced interdental REC increase. Table 3 shows the results of the logistic regression analysis on advanced midfacial REC increase. The model identified two risk factors for advanced midfacial REC increase. Defect anatomy (OR: 58.8 for predominantly one-wall versus predominantly two-wall defects) and thin-scalloped gingival biotype (OR: 76.9) increased the risk for advanced midfacial REC.

Fig. 3. Pre-operative view and result after 1 year of three cases with varying aesthetic outcome. (a) Infrabony defect at the distal aspect of tooth 11. PES: 8. (b) Result after 1 year demonstrating the worst observed deterioration in soft tissue levels and aesthetics. PES: 2. (c) Infrabony defect at the distal aspect of tooth 21. PES: 7. (d) Result after 1 year demonstrating fairly stable soft tissue levels and aesthetics. PES: 6. (e) Infrabony defect at the mesial aspect of tooth 44. (f) Result after 1 year demonstrating midfacial soft tissue gain of 1.5 mm.
Table 1. Results of the Pink Esthetic Score before surgery and after 1 year (n = 66)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Before surgery</th>
<th>1 year</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Mesial papilla</td>
<td>14</td>
<td>38</td>
<td>14</td>
</tr>
<tr>
<td>Distal papilla</td>
<td>18</td>
<td>29</td>
<td>19</td>
</tr>
<tr>
<td>Midfacial level</td>
<td>8</td>
<td>23</td>
<td>35</td>
</tr>
<tr>
<td>Midfacial contour</td>
<td>6</td>
<td>22</td>
<td>38</td>
</tr>
<tr>
<td>Alveolar process</td>
<td>3</td>
<td>10</td>
<td>53</td>
</tr>
<tr>
<td>Deficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft tissue colour</td>
<td>4</td>
<td>15</td>
<td>47</td>
</tr>
<tr>
<td>Soft tissue texture</td>
<td>0</td>
<td>17</td>
<td>49</td>
</tr>
<tr>
<td>Mean PES</td>
<td>10.06 (SD 1.98; range 6–14)</td>
<td>9.42 (SD 2.60; range 2–14)</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Table 2. Logistic regression with treatment failure (0: CAL gain >1 mm; 1: CAL gain ≤1 mm) as dependent variable

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Regression coefficient</th>
<th>p-value</th>
<th>OR</th>
<th>95% CI OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defect anatomy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-wall versus three-wall</td>
<td>3.020</td>
<td>0.034</td>
<td>20.5</td>
<td>1.8–231.4</td>
</tr>
<tr>
<td>Two-wall versus three-wall</td>
<td>0.673</td>
<td>0.511</td>
<td>2.0</td>
<td>0.3–14.6</td>
</tr>
<tr>
<td>One-wall versus two-wall</td>
<td>2.347</td>
<td>0.027</td>
<td>10.4</td>
<td>1.3–83.3</td>
</tr>
<tr>
<td>Frequent plaque</td>
<td>2.689</td>
<td>0.003</td>
<td>14.7</td>
<td>2.4–90.9</td>
</tr>
<tr>
<td>Complications</td>
<td>2.487</td>
<td>0.002</td>
<td>12.0</td>
<td>2.4–58.8</td>
</tr>
</tbody>
</table>

Nagelkerke R-square: 0.591.
Hosmer and Lemeshow goodness of fit: p = 0.947.

Table 3. Logistic regression with advanced midfacial recession increase (0: ≤1 mm; 1: >1 mm) as dependent variable

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Regression coefficient</th>
<th>p-value</th>
<th>OR</th>
<th>95% CI OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defect anatomy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-wall versus three-wall</td>
<td>1.713</td>
<td>0.024</td>
<td>5.6</td>
<td>0.5–62.5</td>
</tr>
<tr>
<td>Two-wall versus three-wall</td>
<td>–2.359</td>
<td>0.063</td>
<td>0.1</td>
<td>0.0–1.13</td>
</tr>
<tr>
<td>One-wall versus two-wall</td>
<td>4.072</td>
<td>0.007</td>
<td>58.8</td>
<td>3.1–1000.0</td>
</tr>
<tr>
<td>Thin-scalloped biotype</td>
<td>4.371</td>
<td>0.001</td>
<td>76.9</td>
<td>5.7–1000.0</td>
</tr>
</tbody>
</table>

Nagelkerke R-square: 0.492.
Hosmer and Lemeshow goodness of fit: p = 0.968.

Besides procedural aspects and costs, the one reported by Sculean et al. (2005) on comparable treatment with the additional use of a collagen membrane (mean CAL gain: 4.1 mm; 69% ≥4 mm CAL gain). Albeit these findings suggest an additional benefit of membrane application, one should take into account that Sculean and co-workers (2005) treated 16 patients with a xenograft and membrane, whereas the present study reports on 84 cases. In addition, mean CAL gain of 3.1 mm seems to correspond well with multicentre studies on the clinical outcome of GTR (Tonetti et al. 1998, 2004, Cortellini et al. 2001, Sanz et al. 2004) or RPT using EMD (Tonetti et al. 2002, Sanz et al. 2004) with mean CAL gain ranging from 2.5 to 3.5 mm. Another remark that could question the need for membrane application comes from recent studies without the use of any biomaterials. These have shown that an optimal surgical approach may even outweigh the need for biomaterials (Cortellini & Tonetti 2011, Graziani et al. 2012). On the other hand, if clinicians want to consider the use of biomaterials, complication rates should be taken into account besides procedural aspects and costs. In this study, 21% of the patients experienced one or more complications, which is clearly lower than what has been reported for GTR (100%), yet higher when compared with EMD (6%) (Sanz et al. 2004).

Albeit the clinical outcome of RPT may be highly affected by a stringent selection of the patient, the surgical site and the surgical procedure, failures defined as CAL gain ≤1 mm may still be expected in 10–25% of the cases when optimizing these aspects (Tonetti et al. 2002, 2004, Cortellini et al. 2001, Sanz et al. 2004). With a failure rate of 15%, the present study corresponds well with these data. Interestingly, however, risk factors for failure under such “ideal” conditions have never been identified. In this respect, the multivariate analysis on treatment failure we performed could add relevant information to optimize predictability of RPT. Defects with a non-supportive anatomy, frequent plaque accumulation and one or more complications were identified as risk factors for treatment failure. An interesting observation was that the odds ratios on these risk factors demonstrated large confidence intervals. As there was no multicollinearity, these may relate to the sample size of the study. The most common complication observed in this study was wound dehiscence, which may commonly result from impaired vascularization and/or tensile forces acting on the wound margins. Bacterial contamination may be regarded as subsequent to this phenomenon.

Given the fact that the indication for RPT is often based on aesthetic considerations (Cortellini & Tonetti 2008), stable soft tissue levels and soft tissue aesthetics become of pivotal importance. It is clear that such aspects of treatment outcome have never been identified. In this respect, the existing literature usually provides information on inter-dental REC increase ranging from 0.3 to 1.0 mm in multi-centre studies (Tonetti et al. 1998, 2002, 2004, Cortellini et al. 2001, Sanz et al. 2004). We observed mean inter-dental REC increase of 0.3 mm, which corresponds to the lower limit. Note that Sculean et al. (2005) described mean inter-dental REC increase of 1.3 mm, also following RPT using a
collagen-enriched bovine-derived xenograft. The disparity between this and aforementioned studies including the present one is probably related to that fact that papilla preservation flaps were used by all but Sculean et al. (2005). This observation stresses the importance of a minimally invasive approach when maximal soft tissue preservation is pursued. Unlike most reports in the literature, the present study also provided data on midfacial REC amounting to 0.5 mm on average. Multivariate analysis identified defects with a non-supportive anatomy and a thin-scalloped gingival biotype as risk factors for advanced midfacial REC increase (>1 mm).

To the best of our knowledge, no one has ever attempted to evaluate the aesthetic outcome of RPT. Apart from the fact that aesthetics is always difficult to assess as it is affected by many parameters, an important prerequisite for objective evaluation is homogeneity in terms of defect location and surgical approach. As the present study only included isolated inter-dental infrabony defects that had been treated using the same concept, the PES could be used for objective aesthetic rating. This index was introduced by Fürhauser and coworkers in 2005 to evaluate soft tissue aesthetics around single implants. The results on RPT indicated a small, yet significant reduction in the PES from 10.06 before surgery to 9.42 after 1 year, which mainly related to midfacial REC increase and contour deterioration. Hence, soft tissue aesthetics may not be fully preserved following RPT using a minimally invasive approach, although alterations may be of questionable clinical relevance. Given the doubtful or even poor initial prognosis of the treated teeth (mean CAL 10.0 mm), some may consider a single implant a viable alternative for RPT. In this respect, the fact that soft tissue aesthetics may be fully preserved following single implant treatment becomes an important argument (Cosyn et al. 2012). However, to accomplish that goal, it has been shown that additional connective tissue grafting is necessary in about one-third of the patients, which is considerable (Cosyn et al. 2012). Note that such additional surgery to optimize aesthetics was not performed in the present study.

An important limitation of the present study is the fact that a control group was not included. Given the objectives, however, it was not our intention to compare treatment modalities. Moreover, there are meta-analyses on the clinical outcome of conventional open flap debridement demonstrating mean CAL gain between 1.3 mm and 1.9 mm (Lang 2000, Graziani et al. 2012), which is clearly lower than 3.1 mm as demonstrated in the present study. On the other hand, one could question whether this outcome was affected by the biomaterial we used, as open flap debridement may even result in mean CAL gain up to 3.5 mm when using a minimally invasive approach (Graziani et al. 2012), which corresponds perfectly to the range of 2.5 mm to 3.5 mm as described in multi-centre studies on RPT (Tonetti et al. 1998, 2002, 2004, Cortellini et al. 2001, Sanz et al. 2004). Given the significant centre effect, as demonstrated in multi-centre studies on RPT (Tonetti et al. 1998, 2002, 2004, Cortellini et al. 2001, Sanz et al. 2004), the outcome of periodontal surgery may essentially come down to the surgical skills of the clinician with limited impact of the biomaterials used.

In conclusion, the present prospective study included data on 84 patients who were treated for an isolated inter-dental infrabony defect using minimally invasive surgery and a collagen-enriched bovine-derived xenograft. Mean CAL gain was 3.1 mm with nearly half of the cases showing ≥4 mm CAL gain. Despite careful patient, site and procedural selection, 15% of the cases were still considered failures (CAL gain ≤1 mm). Defects with a non-supportive anatomy, plaque and one or more complications were identified as risk factors for treatment failure. Mean inter-dental REC increase was 0.3 mm and mean midfacial REC increase amounted to 0.5 mm. Defects with a non-supportive anatomy and a thin-scalloped gingival biotype were identified as risk factors for advanced midfacial REC increase (>1 mm). Midfacial REC increase and contour deterioration contributed most to a small, yet significant reduction in soft tissue aesthetics following RPT.

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References


Clinical Relevance

Scientific rationale for the study: There are no data on the clinical and aesthetic outcome of regenerative periodontal therapy (RPT) of isolated inter-dental infrabony defects using minimally invasive surgery and a collagen-enriched bovine-derived xenograft.

Principal findings: RPT demonstrated favourable clinical outcome after 1 year, even though soft tissue aesthetics could not be fully preserved.

Practical implications: Defects with a non-supportive anatomy may be at risk for failure and advanced midfacial recession.