Effect of Autogenous Cortical Bone Particulate in Conjunction With Enamel Matrix Derivative in the Treatment of Periodontal Intraosseous Defects

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Background: The aim of the present study was to assess the additional clinical benefit of autogenous cortical bone particulate (ACBP) when added to enamel matrix derivative (EMD), compared to EMD alone, in the treatment of deep periodontal intraosseous defects.

Methods: A total of 28 intraosseous lesions in 27 patients with advanced periodontitis were included in this controlled clinical trial and randomly assigned to the EMD group (14 defects) or to the EMD + ACBP group (14 defects). Immediately before surgery (baseline) and after 6 and 12 months, probing depth (PD), clinical attachment level (CAL), and gingival recession (REC) were recorded. Radiographic depth of the defect (DEPTH) was also measured at baseline and 12 months post-surgery.

Results: At 6 and 12 months, PD and CAL significantly improved from baseline in both groups ($P < 0.000$). No significant differences in terms of CAL gain and PD reduction were detected between groups. However, defect distribution according to CAL gain was significantly different between groups ($P < 0.05$). DEPTH significantly decreased from baseline to 12 months in both groups ($P < 0.000$); between-group differences were not significant. At 12 months, a significantly greater REC increase in the EMD group ($1.1 \pm 0.7$ mm) compared to the EMD + ACBP group ($0.3 \pm 0.8$ mm) was observed ($P < 0.05$).

Conclusions: Both EMD and EMD + ACBP treatments led to a significant improvement in clinical and radiographic parameters at follow-up with respect to presurgery condition. The combined approach resulted in reduced post-surgery recession and increased proportion of defects with substantial CAL gain ($\geq 6$ mm). J Periodontol 2007;78:231-238.

KEY WORDS
Autograft; enamel matrix proteins; periodontitis; randomized clinical trial; regeneration; treatment/surgery.

Commercially available enamel matrix derivative (EMD) contains a family of porcine tooth buds–derived proteins (amelogenins), which have been shown to induce the regeneration of periodontal tissues.$^1$-$^9$ Local application of EMD for the resolution of intraosseous periodontal defects has been demonstrated to allow clinical improvements in terms of clinical attachment gain and pocket reduction, higher than the conventional open flap debridement$^{10}$-$^{12}$ and comparable to other more technically demanding regenerative procedures, such as guided tissue regeneration.$^{12,13}$

Due to its gel-like consistency, EMD possesses limited space-making potential, which may potentially affect its regenerative potential.$^7$ To overcome this limitation, a combined approach based on EMD plus a graft biomaterial has been introduced, particularly when the regenerative treatment is addressed to deep, non-contained intraosseous defects.$^{14}$ Recent studies indicated that the combination of EMD with bone substitutes, such as bovine porous bone mineral and demineralized freeze-dried bone allograft, has the potential to enhance the reconstructive outcome compared to EMD alone in terms of clinical attachment level gain$^{15,16}$ or bone fill.$^{17,18}$

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Among the different available graft materials, autogenous bone graft meets several ideal characteristics, because it is potentially osteoinductive, bioabsorbable, low-cost, and easy to handle. It may be speculated that the combined use of EMD and autogenous bone graft could be advantageous, resulting in a synergistic reconstructive effect. In this respect, the autogenous bone graft may enhance the osteogenic potential of the healing site, act as an effective space-maintaining scaffold for bone regeneration, and limit the collapse of supracrestal soft tissues into the defect. On the other hand, EMD may exert its biologic potential at root level, inducing the biologic mechanisms underlying the periodontal regenerative process. However, limited data are available about the use of EMD and autogenous bone graft in the treatment of intraosseous periodontal defects.

A histologic study \cite{19} on non-human primates has investigated this combined approach, reporting encouraging results in terms of amount of new cementum and bone. Recently, we reported a consecutive series of cases where the effectiveness of a regenerative procedure based on the preservation of supracrestal soft tissue in association with an autogenous cortical bone particulate (ACBP)-EMD combination was investigated for the treatment of deep, 1- to 2-wall intraosseous defects. \cite{20} This approach resulted in significant clinical attachment gain and probing depth (PD) reduction and in a reduced marginal gingival recession increase after 6 months of healing. To support the additional use of ACBP in conjunction with EMD, we designed a 12-month prospective randomized clinical trial where the two procedures (EMD alone versus EMD + ACBP) were compared in the treatment of deep intraosseous periodontal defects.

**MATERIALS AND METHODS**

**Experimental Design**

Two different approaches for the treatment of deep intraosseous defects were compared in a parallel designed, randomized, controlled clinical trial. The control group was treated by means of EMD\(‡\) alone (EMD group), whereas the test group was treated with EMD in association with an ACBP (EMD + ACBP group). The same surgical procedures and the application of EMD on the root surface were performed in both control and test groups. Grafting with ACBP was the only difference between the experimental groups. Clinical outcomes were measured at baseline and 6 and 12 months postoperatively.

**Study Population**

Patients were recruited among those seeking care for periodontal disease at the Department of Odontostomatological, Orthodontic and Surgical Disciplines, Second University of Naples, Italy, and at the Research Centre for the Study of Periodontal Diseases, University of Ferrara, Italy, from November 2003 to May 2004. Adult patients with advanced chronic or aggressive periodontitis\cite{21} were consecutively enrolled for this study. Informed consent was obtained from the patients after explaining the nature of the investigation being conducted. Informed consent and research protocol were institutionally approved.

Exclusion criteria were: 1) systemic diseases that contraindicated periodontal surgery; 2) medications affecting periodontal status; 3) pregnancy or lactation; and 4) full-mouth plaque score\cite{22} and full-mouth bleeding score >20% at the time of surgical procedure. Furthermore, third molars, teeth with Class III mobility, furcation involvement, inadequate endodontic treatment, or restoration were excluded.

Inclusion criteria were considered as follows: 1) at least one intraosseous defect in need of surgical treatment after initial periodontal treatment and reevaluation; 2) PD ≥6 mm; and 3) radiographic intraosseous defect ≥4 mm.

Patients were given a cause-related treatment consisting of oral hygiene instructions and multiple scaling and root planing sessions, using both hand and ultrasonic instruments. At least 4 weeks elapsed from the completion of the non-surgical therapy until surgery.

**Radiographic Measurements**

Radiographs were performed at baseline and 1 year after surgery. Radiographic measurements included 1) the radiographic depth of the defect (DEPTH), measured as the linear distance (in millimeters) from the most coronal extension of the alveolar crest (as perpendiculary projected on the long axis of the tooth) to the most apical extension of the defect (i.e., where the periodontal ligament space was considered having a normal width);\(\text{9}\) 2) the radiographic defect fill (percentage), calculated as follows: (baseline DEPTH – 12-month DEPTH)/baseline DEPTH \times 100; and 3) the radiographic defect angle (ANGLE) at baseline, determined in degrees as the angle formed between the lines that represent the root surface of the involved tooth and the bone defect surface.\(\text{23}\) All radiographic measurements were performed by a single trained and calibrated examiner (AS), who was masked as to the surgical procedures.

**Clinical Measurements**

The following clinical measurements were taken immediately before surgery (baseline) and 6 and 12 months post-surgery: local plaque score (LPS) and local bleeding score (LBS), recorded dichotomously at surgical site as the presence or absence of supragingival plaque and bleeding on probing, respectively;\(\text{‡}\) Emdogain Gel, Straumann, Basel, Switzerland.
clinical attachment level (CAL); PD; and marginal gingival recession (REC). Measurements were performed at six sites (mesio-buccal, buccal, disto-buccal, mesio-lingual, lingual, and disto-lingual) around the teeth presenting the defect; however, only the defect-specific measurement presenting the highest CAL at the time of presurgery recordings was considered for the analysis. Measurements were performed by trained and calibrated examiners (SB and AS) with a manual sensitive probe (at approximately 0.3 N force) with 1-mm increments and rounded up to the nearest millimeter. Examiners were not masked to the surgical procedures.

**Intrasurgical Measurements**

Intrasurgical measurements, recorded immediately after defect debridement, included probing bone level, as the distance from the cemento-enamel junction (CEJ) to the apical end of the defect; and intrabony component of the defect, as the distance from the most coronal extension of the interproximal bone crest to the apical end of the defect.

**Surgical Procedures**

Two operators (LG and LT) performed all surgeries. Each defect was randomly assigned to either EMD group (14 defects) or EMD + ACBP group (14 defects). After local anesthesia, buccal and lingual sulcular incisions were made and mucoperiosteal flaps were elevated. Maximum care was exercised to preserve the marginal and interdental tissues. Flap design in the interdental area consisted of one of the following alternatives: 1) sulcular incisions with the split of buccal and lingual papilla; 2) incision with the preservation of the buccal papilla, according to the simplified papilla preservation technique; 3) incision with the preservation of the buccal papilla, according to the modified papilla preservation technique; or 4) incision with the preservation of the lingual-palatal papilla, according to interproximal tissue maintenance procedure. Selection of flap design was based on: 1) width of the interdental space, evaluated as the distance from the CEJ of the tooth presenting the bone defect to the CEJ of the adjacent tooth; 2) distance from the contact point or area to the bone crest, as radiographically assessed; 3) apico-coronal width of interdental keratinized tissue in the area of intraosseous defect; and 4) location and morphology of the bone defect, as determined with bone sounding. The gingival tissue was incised at least one tooth mesial and distal to the defect site to provide access for visualization and instrumentation of the defect and, in the test group, for the following phase of bone harvesting. Vertical incisions were placed mesial or distal to the treated defect, if they were considered necessary for better access or primary closure of the surgical wound.

After flap reflection, all soft tissue was removed from the defect, and the root surface was scaled and planed with hand and ultrasonic instruments. In all cases, the exposed root surfaces were conditioned with 24% EDTA gel for 2 minutes. The defect was then thoroughly rinsed with saline to remove gel remnants.

For the EMD + ACBP group, an adequate amount of cortical bone particulate was harvested from the buccal cortical plate by means of a bone scraper. The bone graft was collected from the surgical site adjacent to the intraosseous defect. A first layer of EMD was injected to condition the bone defect and the more apical portion of the root surface. ACBP was positioned to fill only the intrabony component of the defect, avoiding any packing of the graft. Finally, a second layer of EMD was injected to cover the grafted autogenous bone particles and to condition the portion of the root surface coronal to the bone crest. Therefore, a “sandwich” technique was adopted to treat the defect (i.e., apical layer of EMD, ACBP, and coronal layer of EMD).

For the EMD group, the EDTA-treated root surface and surrounding bony walls were conditioned with the amelogenin gel according to the manufacturer’s instruction.

Data Analysis

Statistical software was used for data analysis. Because no differences were observed whether the patient or the defect was regarded as statistical unit, we reported our data based on the number of defects. Measurements from each group were expressed as

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**Notes:**

1. UNC 15, Hu-Friedy, Chicago, IL.
2. PrefGel, Straumann.
3. Micross, Meta C.G.M., Reggio Emilia, Italy.
6. Augmentin, SmithKline Beecham, Milan, Italy.
7. NCSS-PASS, Number Cruncher Statistical Systems, Kaysville, UT.
mean values ± SD. The presence of any randomization imbalance between the two experimental groups at baseline was tested by unpaired Student t test and \( \chi^2 \) analysis. Within-group comparisons for outcome variables were performed by paired Student t test, whereas between-group differences were evaluated by unpaired Student t test at 6- and 12-month observation intervals. A power analysis indicated that 26 unpaired defects (13 in each group) would be sufficient to demonstrate statistical significance at the \( P<0.05 \) level with a power of 0.85. In our study, 14 defects for each experimental group were treated.

### RESULTS

#### Study Population and Defect Characteristics

A total of 27 patients (13 men and 14 women, 30 to 65 years old; mean age: 46.3 ± 8.7 years) with 28 intraosseous defects were selected and treated. Twenty-six patients contributed one defect, one patient contributed two defects. Fourteen defects in 14 patients were treated with EMD, 14 defects in 13 patients were treated with EMD + ACBP. All defects showed a predominant 1- to 2-wall component. Mean age in the EMD + ACBP and EMD groups was 44.1 ± 6.9 years and 48.4 ± 9.9 years, respectively. There were seven females and two smokers in each group.

An analysis of defect characteristics at baseline revealed no significant differences between groups (\( P>0.05 \)) (Table 1).

### Table 1.

#### Baseline Defect Characteristics (SD)

<table>
<thead>
<tr>
<th></th>
<th>EMD (control) ( (N=14) )</th>
<th>EMD + ACBP (test) ( (N=14) )</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxilla/mandible</td>
<td>6/8</td>
<td>7/7</td>
<td>NS</td>
</tr>
<tr>
<td>I-CP-M</td>
<td>7/7</td>
<td>5/9</td>
<td>NS</td>
</tr>
<tr>
<td>LPS (%)</td>
<td>21.4</td>
<td>21.4</td>
<td>NS</td>
</tr>
<tr>
<td>LBS (%)</td>
<td>71.4</td>
<td>50.0</td>
<td>NS</td>
</tr>
<tr>
<td>CAL (mm)</td>
<td>10.6 ± 1.3</td>
<td>10.3 ± 1.5</td>
<td>NS</td>
</tr>
<tr>
<td>PD (mm)</td>
<td>9.6 ± 1.7</td>
<td>9.1 ± 1.6</td>
<td>NS</td>
</tr>
<tr>
<td>REC (mm)</td>
<td>1.1 ± 1.0</td>
<td>1.1 ± 0.9</td>
<td>NS</td>
</tr>
<tr>
<td>PBL (mm)</td>
<td>11.7 ± 1.7</td>
<td>10.9 ± 2.0</td>
<td>NS</td>
</tr>
<tr>
<td>IBD (mm)</td>
<td>6.2 ± 2.0</td>
<td>7.0 ± 1.2</td>
<td>NS</td>
</tr>
<tr>
<td>DEPTH (mm)</td>
<td>6.5 ± 2.9</td>
<td>6.5 ± 1.8</td>
<td>NS</td>
</tr>
<tr>
<td>ANGLE (degrees)</td>
<td>31.5 ± 12.4</td>
<td>30.9 ± 12.6</td>
<td>NS</td>
</tr>
</tbody>
</table>

1 = incisors; C = canine; P = premolars; M = molars; PBL = probing bone level; IBD = intraosseous component of the defect; NS = not significant (\( P>0.05 \)).

All 27 patients completed the study, and complied with the 6- and 12-month reexaminations.

#### Clinical Changes at 6 and 12 Months

Incidence of LPS-positive defects was 21.4% at baseline and remained unchanged (21.4%) at 12 months in both groups (\( P>0.05 \)). Incidence of LBS-positive defects decreased from 71.4% at baseline to 7.1% at 12 months in the EMD group (\( P<0.05 \)), and from 50% at baseline to 7.1% at 12 months in the EMD + ACBP group (\( P<0.000 \)). No statistically significant differences were detected between groups in terms of incidence of LPS- and LBS-positive defects at 6 or 12 months.

Clinical and radiographic measurements at baseline and 6 and 12 months are summarized in Table 2.

At 6 months, CAL and PD significantly improved from baseline (\( P<0.000 \)) in both groups. The 12-month CAL and PD measurements did not significantly change from the 6-month measurements, remaining significantly improved with respect to baseline (\( P<0.000 \)). In the EMD group, REC varied from 1.7 ± 0.7 mm at 6 months to 2.1 ± 0.9 mm at 12 months, whereas REC remained almost unchanged in the EMD + ACBP group. No significant differences in CAL gain and PD reduction were detected between groups at 6 and 12 months. At 12 months, a significantly greater REC increase in the EMD group compared to the EMD + ACBP group was observed with respect to baseline REC (\( P<0.05 \)). A significantly different distribution of defects according to 12-month CAL gain was observed between groups (\( P<0.05 \)) (Table 3): 50% of defects showed a CAL gain of ≥6 mm and 21% showed a CAL gain of 4 to 5 mm in the EMD + ACBP group compared to 21% and 57%, respectively, in the EMD group.

DEPTH significantly decreased from baseline to 12 months in both groups (\( P<0.000 \)). DEPTH gain was 4.3 ± 2.4 mm corresponding to a radiographic defect fill of 64.8% ± 24.1% for the EMD group, and 4.3 ± 1.3 mm corresponding to a radiographic defect fill of 68% ± 17.3% for the EMD + ACBP group. No significant differences were detected between groups at 12 months (\( P>0.05 \)). Defect distribution, according to DEPTH gain, was similar between groups (\( P>0.05 \); Table 4).

### DISCUSSION

The clinical effect of EMD to achieve the reconstruction of lost periodontal tissues has been extensively revised and confirmed. Available data from systematic reviews indicate that all EMD reconstructive treatment produces a more favorable clinical improvement in hard and soft tissue parameters of healing response (i.e., clinical attachment gain, pocket reduction, and bone fill) compared to...
conventional open flap debridement procedure. However, although all studies generally showed an additional benefit with the use of EMD, a high degree of variability in treatment outcomes (heterogeneity) was found in the included trials.29 This heterogeneity may be partly explained by differences in the patient and defect selection among studies. For instance, the use of a biomaterial with a gel-like consistency, such as EMD, in a non–self-supporting intraosseous defect may result in a limited clinical outcome due to the collapse of the flap into the bone defect during the early healing phase, particularly in deep, non-containing intraosseous defects.14 These observations seem to emphasize the clinical relevance to adapt the selection of the reconstructive strategy to the anatomy of the treated area and the physical and biologic characteristics of the regenerative materials used.29,30

In this perspective, the present study was undertaken to evaluate whether and to what extent the additional use of ACBP in conjunction with EMD may improve the clinical effect of EMD alone when used in deep intraosseous defects, with a predominant 1- to 2-wall component. The results indicate that both the EMD + ACBP and EMD procedures led to a statistically significant and clinically relevant CAL gain with respect to presurgery condition, with more than 70% of the defects presenting a CAL gain of at least 4 mm for both treatment groups. No significant differences were detected between treatment groups in terms of conventional open flap debridement procedure. However, although all studies generally showed an additional benefit with the use of EMD, a high degree of variability in treatment outcomes (heterogeneity) was found in the included trials.29 This heterogeneity may be partly explained by differences in the patient and defect selection among studies. For instance, the use of a biomaterial with a gel-like consistency, such as EMD, in a non–self-supporting intraosseous defect may result in a limited clinical outcome due to the collapse of the flap into the bone defect during the early healing phase, particularly in deep, non-containing intraosseous defects.14 These observations seem to emphasize the clinical relevance to adapt the selection of the reconstructive strategy to the anatomy of the treated area and the physical and biologic characteristics of the regenerative materials used.29,30

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### Table 2.

**Clinical and Radiographic Measurements at Baseline and 6 and 12 Months (mean ± SD)**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Baseline</th>
<th>6 Months</th>
<th>ΔD₀-6</th>
<th>p₀-6</th>
<th>ΔD₀-12</th>
<th>p₀-12</th>
<th>ΔD₀-12</th>
<th>p₀-12</th>
<th>ΔD₀-12</th>
<th>p₀-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL (mm)</td>
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</tr>
<tr>
<td>EMD</td>
<td>10.6 ± 1.3</td>
<td>6.2 ± 0.7</td>
<td>4.4 ± 1.3</td>
<td>‡</td>
<td>6.1 ± 0.9</td>
<td>‡</td>
<td>4.6 ± 1.3</td>
<td>‡</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>EMD + ACBP</td>
<td>10.3 ± 1.5</td>
<td>5.9 ± 1.5</td>
<td>4.4 ± 1.5</td>
<td>‡</td>
<td>5.4 ± 1.7</td>
<td></td>
<td>4.9 ± 1.8</td>
<td>‡</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>P (EMD versus EMD + ACBP)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
<td>NS</td>
<td></td>
<td>NS</td>
<td></td>
<td></td>
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<tr>
<td>PD (mm)</td>
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</tr>
<tr>
<td>EMD</td>
<td>9.6 ± 1.7</td>
<td>4.5 ± 0.8</td>
<td>5.1 ± 1.9</td>
<td>‡</td>
<td>3.9 ± 0.7</td>
<td>‡</td>
<td>5.6 ± 1.7</td>
<td>‡</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>EMD + ACBP</td>
<td>9.1 ± 1.6</td>
<td>4.5 ± 1.4</td>
<td>4.6 ± 1.3</td>
<td>‡</td>
<td>4.0 ± 1.4</td>
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<td>5.1 ± 1.7</td>
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<td>P (EMD versus EMD + ACBP)</td>
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<td>NS</td>
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<td>NS</td>
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<td>NS</td>
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<td>REC (mm)</td>
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<tr>
<td>EMD</td>
<td>1.1 ± 1.0</td>
<td>1.7 ± 0.7</td>
<td>0.6 ± 1.0</td>
<td>NS</td>
<td>2.1 ± 0.9</td>
<td>†</td>
<td>1.1 ± 0.7</td>
<td>†</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>EMD + ACBP</td>
<td>1.1 ± 0.9</td>
<td>1.4 ± 1.2</td>
<td>0.3 ± 0.7</td>
<td>NS</td>
<td>1.4 ± 1.1</td>
<td></td>
<td>0.3 ± 0.8</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>P (EMD versus EMD + ACBP)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<td>NS</td>
<td></td>
<td>NS</td>
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<tr>
<td>DEPTH (mm)</td>
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<td></td>
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</tr>
<tr>
<td>EMD</td>
<td>6.5 ± 2.9</td>
<td>2.3 ± 1.5</td>
<td>4.3 ± 2.4</td>
<td>‡</td>
<td></td>
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</tr>
<tr>
<td>EMD + ACBP</td>
<td>6.5 ± 1.8</td>
<td>2.2 ± 1.7</td>
<td>4.3 ± 1.3</td>
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<td></td>
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<tr>
<td>P (EMD versus EMD + ACBP)</td>
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<td>NS</td>
<td></td>
<td>NS</td>
<td></td>
<td>NS</td>
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</tr>
</tbody>
</table>

ΔD₀-6 = difference between baseline and 6 months; ΔD₀-12 = difference between baseline and 12 months; NS = not significant (P > 0.05).

* *P < 0.05.
† *P < 0.01.
‡ *P < 0.000.

### Table 3.

**Defect Distribution According to CAL Gain at 12 Months**

<table>
<thead>
<tr>
<th>CAL Gain (mm)</th>
<th>% EMD</th>
<th>% EMD + ACBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2-3</td>
<td>21</td>
<td>29</td>
</tr>
<tr>
<td>4-5</td>
<td>57</td>
<td>21</td>
</tr>
<tr>
<td>≥6</td>
<td>21</td>
<td>50</td>
</tr>
</tbody>
</table>

* Significant difference between groups (P < 0.05).

### Table 4.

**Defect Distribution According to DEPTH Gain at 12 Months**

<table>
<thead>
<tr>
<th>DEPTH Gain (mm)</th>
<th>% EMD</th>
<th>% EMD + ACBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>2-3</td>
<td>29</td>
<td>43</td>
</tr>
<tr>
<td>4-5</td>
<td>50</td>
<td>43</td>
</tr>
<tr>
<td>≥6</td>
<td>14</td>
<td>14</td>
</tr>
</tbody>
</table>

* No significant difference between groups.
average CAL gain, PD reduction, and defect bone fill. However, EMD + ACBP treatment significantly increased the proportion of defects with substantial CAL gain (≥6 mm) and determined a smaller postoperative REC increase with respect to EMD alone.

Recent studies indicated that the combination of EMD with bone substitutes, such as bovine porous bone mineral and demineralized freeze-dried bone allograft, has the potential to enhance the reconstructive outcome compared to EMD alone in terms of clinical attachment level gain or bone fill. The choice to use ACBP in addition to EMD was supported by data from a randomized controlled trial showing a greater CAL gain after an access flap procedure with autogenous bone graft compared to an access flap procedure alone, for the reconstructive procedure with autogenous bone graft compared to an access flap procedure alone, for the reconstructive treatment of deep intraosseous defects. Furthermore, we previously showed that the adjunctive application of ACBP with EMD resulted in clinically significant attachment gain and PD reduction in deep intraosseous defects, with a predominant 1- to 2-wall intraosseous component. In our study, the lack of substantial additional benefits observed in the EMD + ACBP group compared to EMD seems to confirm the biologic potential of EMD per se to support the clinical reconstruction of the lost attachment apparatus, and to limit the additional application of an autogenous bone particulate to enhance the EMD-induced periodontal reconstruction.

The observed values for CAL gain, PD reduction, and REC increase in the EMD group compared to some studies, whereas they differed from others where less favorable outcomes had been observed. The reason for these discrepancies may be found in a wide range of predictors, including patient selection, defect characteristics, maintenance phase, and surgical variables. In our material the same surgical approach based on supracrestal soft tissue preservation was used for both treatment groups; the only investigated variable was the application of ACBP to fill the intraosseous component of the defect. In all cases flap design and suture technique were adequately selected with respect to the morphologic characteristics of the defect to preserve an adequate amount of supracrestal soft tissue and achieve primary closure in the interdental area. Primary closure eliminates or, to a greater extent, reduces the chances of post-surgical infection and contamination of the blood clot and, possibly, the biologic agent or the graft. Incomplete primary closure may be of particular concern when a non-supportive material, such as EMD, is used to reconstruct in toto the attachment apparatus, including alveolar bone. In this respect, proper soft tissue management, leading to optimal EMD-induced wound healing process, may partly account for the limited clinical benefit derived from the additional use of ACBP. Previous reports where a similar surgical approach was associated to EMD treatment resulted in comparably favorable clinical outcomes. A significantly smaller REC increase was found in the EMD + ACBP group compared to the EMD group at the 12-month reevaluation. ACBP may efficiently have sustained the soft tissue healing, avoiding collapse into the bony defect, during the tissue maturation phase. This result compared to those stemming from clinical trials where EMD treatment was used in conjunction with slowly bioabsorbable biomaterials, such as bovine porous bone mineral. These observations seem to suggest the additional use of ACBP in deep, non-self-supporting intraosseous defects, especially in areas of the dentition where the esthetic outcome is considered of paramount importance.

Our results indicate that both EMD and EMD + ACBP reconstructive procedures result in comparable outcomes in terms of attachment gain and bone fill. However, defect distribution according to CAL gain significantly differed between groups. In particular, a higher prevalence of defects showing a CAL gain of ≥6 mm was observed in the EMD + ACBP group compared to the EMD group (Table 3). In contrast, defect distribution according to DEPTH gain was similar between groups (Table 4). These data suggest that part of the defects in the EMD + ACBP group showed a CAL gain greater than the corresponding DEPTH gain, whereas in EMD-treated defects CAL gain substantially paralleled DEPTH gain. The presence of a graft supporting supracrestal tissues during the healing phase could explain this observation. However, whether and to what extent the additional use of ACBP to EMD may affect the wound healing dynamics of deep periodontal defects compared to mere EMD application needs be clinically and histologically confirmed. In this respect, several histologic studies in humans demonstrated the periodontal regenerative potential of the autogenous bone, leading to cementum and bone formation. In contrast, inconsistent histologic results have been reported on the regenerative potential (i.e., presence and extent of newly formed bone and cementum) of EMD in the treatment of intraosseous defects.

Two considerations about data analysis must be made. First, among the 28 treated defects, four defects were present in smoker patients. Due to the limited number of smokers in the study population, statistical analysis of treatment outcome between smokers and non-smokers was not performed. Second, clinical examiners were not masked as to the surgical procedures, so that a potential bias in outcome assessment cannot be completely excluded. However, it must be considered that the examiners...
were expert and rigorous clinicians, trained and calibrated to ensure accuracy and reproducibility of clinical measurements.

CONCLUSIONS
With the limits of the present study, our data support the clinical effectiveness of a regenerative procedure based on EMD application, either alone or in combination with an ACBP, in the treatment of deep intrabony defects. The combined EMD + ACBP procedure led to a reduced post-surgery recession and increased proportion of defects with substantial CAL gain (≥6 mm).

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