Clinical and Histologic Outcomes of Calcium Sulfate in the Treatment of Postextraction Sockets

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**Objectives:** The aim of this prospective study was to assess the clinical and histologic outcomes obtained with calcium sulfate (CS) used as a filler material in fresh premolar and molar postextraction sockets.

**Materials and Methods:** Sixty premolar or molar postextraction sockets were filled with CS. Among the 60 grafted sockets, after 3 months, 50 underwent implant placement and clinical assessment. The removal of a sample core of newly generated intrasocket tissue was performed in 19 sockets. Collected samples were sent for histologic examination. The percentage of vital bone, nonvital bone, residual CS, amorphous material, and connective areas in every sample was calculated and recorded.

**Results:** Fifty postextraction regenerated sockets that underwent implant placement 3 months after tooth removal were included in this study.

A partial postoperative exposition of the graft was observed in 12 of 50 sockets. At the surgical reentry, the augmented extraction sockets were completely filled by a hard material with an adequate alveolar crest in 41 cases. Histologic examination of the cores revealed that 63.16% of the intrasocket tissue was new vital bone, 2.1% was nonvital bone, 4.74% was fibrous tissue, and 30% was amorphous material. No residual CS was identified in bone cores.

**Conclusions:** This study confirmed that CS is an ideal grafting material. The clinical adequacy aspect of filled sockets at surgical reentry seemed to be indicative of a qualitatively better bone regeneration. Postoperative exposition of graft material after a first intervention seemed to constitute an important risk factor for a worse bone regeneration.

**Key Words:** Calcium sulfate, postextraction sockets, bone regeneration


Alveolar ridge resorption and structural bone changes are frequently observed in fresh sockets after extraction procedures.1–3 Indeed, in the first 6 months after tooth removal, noticeable reduced alveolar height (up to 40%) and width (up to 60%) may be encountered.1–3 Therefore, the severity of bone resorption can make implant placement challenging.7–9

As Torres-Lagares et al7 said, the treatment of postextraction sockets promotes the preservation of the alveolar crest. Several bone substitutes have been used for this reason after tooth removal.4–6 The ideal graft biomaterial should be safe, biocompatible, nonantigenic, noncarcinogenic, completely resorbable, osteoconductive, osteoinductive, and inexpensive.5–8 The criterion standard in bone regeneration is still autogenous bone thanks to its biologic properties. In fact, several studies confirm its superiority to other biomaterials because of its compatibility and osteogenic potential to form the new bone by processes of osteogenesis, osteoinduction, and osteoconduction.9–12 However, it presents several disadvantages, such as a limited amount of material, a donor site morbidity, and discomfort for the patient.9–12

Calcium sulfate (CS) has a long clinical history as a resorbable bone substitute, both in craniofacial and long bone defects.6–8 Calcium sulfate is a simple, available, inexpensive, highly biocompatible, completely bioabsorbable, and osteoconductive graft substitute material. It is well tolerated by host tissues, not determining foreign body reaction.2,13–15 Calcium sulfate rapidly resorbs, leaving a calcium phosphate lattice that promotes osteoconductive activity and therefore bone regeneration.7,8 It has been used in periodontal disease, endodontic treatments, postextraction sites, and maxillary sinus augmentation and as a barrier in guided tissue regeneration.7,8

The aim of this prospective study was to assess the clinical and histologic outcomes obtained with a type of CS (NewPlaster NP170; ClassImplant, Rome, Italy) used as a filler material in fresh postextraction sockets.

**MATERIALS AND METHODS**  
Between January 1, 2008, and December 31, 2009, 35 patients (26 women and 9 men) with a mean age of 47.8 years (range, 18–69 y) underwent postextraction sockets bone regeneration by medical-grade CS hemihydrates after 1 or more tooth extraction in premolar and molar regions at the Division of Maxillofacial Surgery of the University of Turin (Turin, Italy).

Postextraction sockets were classified according to a new proposed postextraction socket classification. According to our classification, sockets are classified according to the number of bony walls: from class 5 (with only the occlusal wall missing) to class 1 (all lateral bony walls missing) (Fig. 1). Only sockets belonging to class 4 and 5 were included in the study. In total, 60 sockets were filled with NewPlaster NP170 (ClassImplant). The surgical protocol included labial and lingual/palatal local anesthesia with 2% mepivacaine containing 1:100,000 adrenaline (Carboplyina; Dentsply Italia, Rome, Italy). After a conservative mucoperiosteal flap was raised, an atraumatic careful extraction was performed (Figs. 2–5). Then, CS was grafted in the socket (Fig. 6). Radiographically, the CS was observed regularly during follow-up.
Postoperative prescribed treatment included an antibiotic (1 g of amoxicillin every 12 h for 5 d [Zimox; Pfizer Italia, Milan, Italy]), a nonsteroidal anti-inflammatory drug (80 mg of ketoprofene every 12 h for 3 d [OKI granulare; Dompe L’Aquila, Italy]), and corticosteroids (1 mg of β-methasone every 12 h for 3 d [Bentelan; Defiante Farmaceutica LDA, Rome, Italy]). Patients were advised to eat soft and cold diet for 8 days and to maintain an adequate oral hygiene.

Beginning the day after surgery, patients rinsed twice daily with 0.20% chlorhexidine solution for 10 days. The sutures were removed 10 days later (Fig. 7). Postoperative graft exposition and complications, such as infections, were recorded.

Among the 60 grafted sockets, after 3 months, 50 underwent implant placement, and clinical assessment of the degree of filling of the previous surgical defect, the height, and the width of alveolar crest was performed (with the aid of panoramic radiographs) and recorded. The degree of the obtained bone regeneration was classified as follows. An alveolar crest less than 8 mm high and 5 mm wide was considered to be “insufficient,” whereas a post-extraction regenerated socket with a height between 8 and 10 mm and a width from 5 to 6 mm was rated as “sufficient.” Finally, an alveolar crest higher than 10 mm and wider than 6 mm was considered to be “adequate,” with an optimal degree of bone regeneration.

Eleven patients (in total, 19 sockets) agreed with harvesting bone core and underwent the removal of a sample core of newly generated intrasocket tissue. In these 11 patients, osteotomy for implant placement was performed in an axial coronal-apical direction using a trephine bur with a 3.0-mm-wide external diameter. A cylindric sample core of newly generated intrasocket tissue was obtained. Collected samples were sent for histologic examination (Figs. 8–10). Histologic examination involved hematoxylin and eosin, Masson trichrome, and silver staining: vital bone, nonvital bone, residual CS, amorphous material, and connective areas were searched for and analyzed. The percentage of each component in every sample was calculated and recorded.

**RESULTS**

Fifty postextraction regenerated sockets (in 28 patients) that underwent implant placement 3 months after tooth removal were suitable for inclusion in this study. Clinical healing was uneventful, with neither infectious episodes nor clinical symptoms. A partial postoperative exposition of the graft was observed in 12 of 50 sockets within the first 2 weeks after intervention.
At the surgical reentry, the augmented extraction sockets treated with CS were completely filled by a hard material, which, on probing, exhibited the consistency of bone. No particles of CS were noticed.

In 41 cases, an optimal degree of bone regeneration was observed with an adequate alveolar crest. Instead, 8 cases were considered sufficiently regenerated, and only 1 was rated as insufficient. Among the 19 sockets that underwent harvesting bone core, 52.7% (n = 10) could be rated as class 4, according to our classification, whereas 47.3% (n = 9) were class 5 defects. Bone regeneration in these 19 sockets was considered to be adequate in 79% (n = 15) of cases and sufficient in the remaining 21% (n = 4).

Histologic examination of the cores taken from test sockets revealed that 63.16% of the newly generated intrasocket tissue was new vital bone, 2.1% was nonvital bone, 4.74% was fibrous tissue, and 30% was represented by amorphous material that could be considered as CS in transformation. No residual CS was identified in bone cores.

Mean percentages of components of the newly generated tissue were related to the clinically observed outcomes and to the presence of partial postoperative exposition of the graft (Tables 1 and 2). Therefore, clinically adequate and nonexposed grafted sockets presented a qualitatively better bone regeneration. Finally, at the 6-month follow-up, among the 50 cases that underwent implant placement, a survival rate of 98% was reported.

**DISCUSSION**

Several graft materials have been used for bone regeneration, but there is still no consensus about the material of choice for postextraction sockets regeneration. In the current study, CS was confirmed to be a useful and efficacious material in bone regeneration.

<table>
<thead>
<tr>
<th>New Tissue Components, %</th>
<th>Sufficient Bone Regeneration (n = 4)</th>
<th>Adequate Bone Regeneration (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vital bone</td>
<td>53.75</td>
<td>65.67</td>
</tr>
<tr>
<td>Nonvital bone</td>
<td>0</td>
<td>2.67</td>
</tr>
<tr>
<td>Amorphous material</td>
<td>23.75</td>
<td>31.67</td>
</tr>
<tr>
<td>Fibrous tissue</td>
<td>22.5</td>
<td>0</td>
</tr>
</tbody>
</table>
TABLE 2. Mean Percentages of Components of the Newly Generated Tissue in the 2 Groups of Exposed and Nonexposed Sockets

<table>
<thead>
<tr>
<th>New Tissue Components, %</th>
<th>Sockets With Exposed Graft (n = 6)</th>
<th>Sockets With Nonexposed Graft (n = 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vital bone</td>
<td>35</td>
<td>73.21</td>
</tr>
<tr>
<td>Nonvital bone</td>
<td>0</td>
<td>2.85</td>
</tr>
<tr>
<td>Amorphous material</td>
<td>47</td>
<td>23.92</td>
</tr>
<tr>
<td>Fibrous tissue</td>
<td>18</td>
<td>0</td>
</tr>
</tbody>
</table>

presenting several important qualities. Indeed, it is completely resorbable in a relatively short period with minimal inflammation; it is easily sterilized; it provides a local increase in Ca ion concentration, which may stimulate osteoblastic activity; it furnishes a resorbable scaffold for bone growth; and it is inexpensive.4,7,14,16

The mechanism of action of CS is complex and not completely understood yet. However, a molecular activation on bone formation control by CS has been demonstrated. In fact, CS acts on a preribosomal level determining a global downregulation of microRNAs, which corresponds to an enhancement of the translation process. Therefore, bone morphogenetic protein 1 and 7, transforming growth factor-β, some hormones such as parathyroid hormone and calcitonin-related polypeptide alpha and bone receptors such as fibroblast growth factor receptor 1 are overtranscribed.8,15 Furthermore, as Slater et al.15 stated, CS has been reported to increase the expression of genes involved in fracture healing including alkaline phosphatase, type II collagen, and fibronectin 1.

Calcium sulfate alters local pH, thus determining an increased acidity in association with its dissolution. Therefore, it causes demineralization, releasing growth factors previously incorporated into the bone matrix.7,16 Finally, a hemostatic effect of CS has been recently shown.7

Several applications of CS have been proposed in literature: fenestrations and dehiscences, periodontal defects, maxillary sinus augmentation procedures, postextraction sockets, bone defects after cysts or wisdom teeth removal, ridge preservation, or barrier membranes.7,15,16,18–20

As summarized by Thomas and Pulero,16 CS has been used in combination with various materials: allograft bone, autogenous bone, bioactive glass, calcium phosphate, carboxymethylcellulose, chitosan encapsulation, gelatin, hydroxyapatite, hyaluronic acid, platelet-rich plasma, poly-lactic acid and tricalcium silicate.

In our study population, CS showed good results. Bone volume had been almost completely preserved, and the alveolar crest seemed to be adequately or at least sufficiently regenerated in almost all cases. Uneventful clinical healing was observed in all patients. At the surgical reentry, bone presented good consistency, and no particles of CS were noticed.

We chose a flap technique to provide a better protection of the graft material and avoid postoperative exposition of CS because the time during which the underlying bone tissue is exposed may be a critical factor in the development of bone complications.5

The resorptive behavior of CS was clearly confirmed in histologic examinations of this case series. In fact, bone biopsies taken at 3 months after graft showed that the particles of CS have been completely resorbed and substituted by newly formed bone or amorphous material that could be considered as CS in transformation. Only small amounts of nonvital bone and fibrous tissue have been found. Therefore, CS confirmed to be a completely resorbable material that can guide new bone formation in association with its resorption.7 Our findings are in agreement with several studies about CS as a bone substitute.4,7,14,16,21–23

The comparison between histologic data from sufficiently and adequately regenerated sockets highlighted that clinically adequate sockets presented a qualitatively better bone regeneration with higher percentages of vital bone and amorphous material compared with clinically sufficient sockets.

Moreover, nonexposed grafted sockets also presented a qualitatively better bone regeneration compared with exposed graft sockets that presented lower percentages of vital bone and considerable quantity of fibrous tissue. Early prognosis at 6 months of placed implants with a survival rate of 98% showed a good result with the studied material.

CONCLUSIONS

In conclusion, this study confirmed that CS is an ideal grafting material with many favorable characteristics, such as bio-compatibility, rapid and complete resorbability, wide availability, and reasonable cost. The clinical adequacy aspect of filled sockets at the surgical reentry seemed to be indicative of a qualitatively better bone regeneration. Postoperative exposition of graft material after the first intervention seemed to constitute an important risk factor for a worse bone regeneration.

REFERENCES


