Medical-Grade Calcium Sulfate Hemihydrate (Surgiplaster) in Healing of a Human Extraction Socket—Histologic Observation at 3 Months: A Case Report

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Purpose: *Following tooth extraction, wound healing is characterized by remodeling and resorption of the alveolar bone at the extraction site. This produces reduction in ridge volume. Medical-grade calcium sulfate hemihydrate (MGCSH) has been proposed as a graft material for extraction sockets to minimize the reduction in ridge volume. The aim of this study was to investigate the influence of MGCSH on the histopathologic pattern of intrasocket regenerated bone and to evaluate histologically the healed MGCSH-grafted extraction socket site at 3 months postextraction.* ***Materials and Methods:*** *MGCSH was grafted in a fresh human extraction socket, and at 3 months a cylindric tissue specimen, 2.5 mm in diameter, was trephined from the previously grafted site and an implant was placed. Nondecalcified specimens were sectioned at a horizontal plane and stained for histologic and histomorphometric evaluation.* ***Results:*** *The mean trabecular area was 58.6% ± 9.2% in the coronal sections, 58.1% ± 6.2% in the middle sections, and 58.3% ± 7.8% in the apical sections. The differences in mean trabecular area between sections were not statistically significant.* ***Discussion:*** *It is significant that the MGCSH underwent complete resorption and replacement by newly formed bone because the most important negative attribute of other graft materials is the resorption time. Moreover, calcium sulfate shows great potential for guided bone regeneration in surgical sites.* ***Conclusion:*** *MGCSH seems to be an acceptable graft material for extraction socket bone regeneration because it is completely resorbable and allows new trabecular bone arrangement in a limited 3-month period.* Int J Oral Maxillofac Implants 2005;20:636–641

Key words: *bone regeneration, calcium sulfate, tooth extraction, wound healing*

Regeneration of alveolar bone lost or injured as a result of disease or trauma may pose therapeutic problems in implant dentistry because bone defects can fail to heal, or heal with a type of tissue different than the original tissue with respect to morphology and function. Bone resorption and healing following tooth extraction are 2 main causes of alveolar bone deformities that require augmentation.[1,2] Controlled clinical studies have documented an average of 4.0 to 4.5 mm of horizontal bone resorption following extraction procedures.[3,4] Other studies have documented significant dimensional changes in the surrounding alveolar bone following extraction procedures.[5–7] The resorption and remodeling process presents a problem for implant placement, especially in the anterior maxilla, where the dimension and morphology of the alveolar ridge cannot properly accommodate implants.[8] In an attempt to preserve alveolar bone and avoid the necessity of ridge augmentation prior to implant placement, various grafted materials have been used immediately following tooth extraction to fill and/or cover the socket. Some histologic studies have reported positive healing responses with alloplast[9] and xenograft,[10] while others have shown negative results with demineralized freeze-dried bone

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allograft (DFDBA), bovine bone, and even autologous bone.[11,12]

The aim of this study was to investigate the influence of medical-grade calcium sulfate hemihydrate (MGCSH) on the histopathologic pattern of intrasocket regenerated bone.

Calcium sulfate hemihydrate exists in 2 forms, alpha and beta. The most common is the beta form, which is used in most commercial medical-grade materials. It uses large amounts of water (0.69/9 of hemihydrate) in setting and sets to form a less dense material than the alpha form. A number of biocompatible salts have been shown to greatly accelerate setting. Sodium chloride, sodium sulfate, potassium chloride, and potassium sulfate have all been shown to decrease the setting times of calcium sulfate cements when used in relatively low concentrations. Historically, calcium sulfate was one of the first bone substitutes used in orthopedic medicine and dentistry because of its basic desirable properties: It is readily available, easily sterilized, inexpensive, completely and rapidly resorbable, and biocompatible.[13–16] Although calcium sulfate is not osteoinductive in itself, in the presence of bone it almost always becomes osteogenic.[17,18] In previous studies[19,20] MGCSH has been examined histologically and histomorphometrically at augmented sinus floor sites. The material was well tolerated by its hosts, completely resorbable, and mingled with newly formed bone. This case report was designed to histologically evaluate the healing of an extraction socket at 3 months where MGCSH was used as a filler material in fresh extraction sockets.

MATERIALS AND METHODS

The patient was a 60-year-old man with no systemic disorders. The extraction of a maxillary second premolar was scheduled, followed by restoration with implant at a later stage (3 months postextraction).

Labial and palatal local infiltration with lidocaine 1:100,000 epinephrine was used as the anesthetic agent. An intracrevicular incision was extended to the mesial and distal teeth, and a conservative mucoperiosteal flap was raised (Fig 1a). Following careful extraction, MGCSH (Surgiplaster; Classimplant, Rome, Italy) was grafted in the socket (Fig 1b). Different consistencies were used: In the apical portion prehardened particles of MGCSH (G 170) were grafted, in the middle portion MGCSH was compacted with dry gauze against the first layer, and in the coronal portion fast-set solution (potassium chloride) was used to speed the hardest consistency possible (Fig 1c). No osteopromotive regenerative barrier was used. The flap was then closed and sutured. No attempts were made to completely cover the graft material where the tooth previously protruded through the soft tissue.

Systemic amoxicillin was prescribed for 1 week postoperatively, and 0.2% chlorhexidine mouthwash was used for 45 seconds twice daily for 2 weeks. Sutures were removed after 10 to 14 days. Radiographically, the MGCSH was observed regularly during follow-up. After 3 months, the extraction site was re-entered surgically for implant placement (Fig 1d). 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 7-mm-long cylindric sample core of newly generated intrasocket tissue was obtained. Following removal of the core, the implant was placed. Before histologic preparation, the tissue sample was marked to identify the crestal and depth size. Samples were fixed in 4% buffered formaldehyde, dehydrated in a graded series of alcohols from 50% to 100%, and embedded in methylmethacrylate resin (Merck-Schuchardt, Hohenbrunn, Germany).

Cross sections of 70 μm were obtained with a Leica SP 1600 diamond saw (Leica, Milan, Italy). They were stained with Fast Green (Sigma-Aldrich, Milan, Italy), acid fuchsin, von Kossa's, and toluidine blue and observed with a Zeiss Axioscope microscope (Carl Zeiss, Göttingen, Germany).

Histomorphometric measurements were performed on all the stained slides. Only preserved, rounded sections were submitted for these examinations. The core area of every section (0.1 mm^2) was submitted to morphometric analysis, and the percentage area of each component in each section was measured automatically using Kontron KS 300 software (Kontron Electronics, Münich, Germany). To evaluate bone quality, trabecular bone volume was measured according to the standards approved by the American Society of Bone and Mineral Research.[21] Bone area fraction in the coronal, middle, and apical sections was compared using the Student *t* test. Results were considered significant where $P < .05$.

RESULTS

At 3 months, upon surgical re-entry, the augmented extraction socket site was found to be clinically well preserved in its volume dimension. Histologic examination revealed new bone formation in all the specimens. No MGCSH, connective tissue, or inflammatory cells were observed. In all sections bone presented a trabecular arrangement without differences between the apical, middle, and coronal levels.

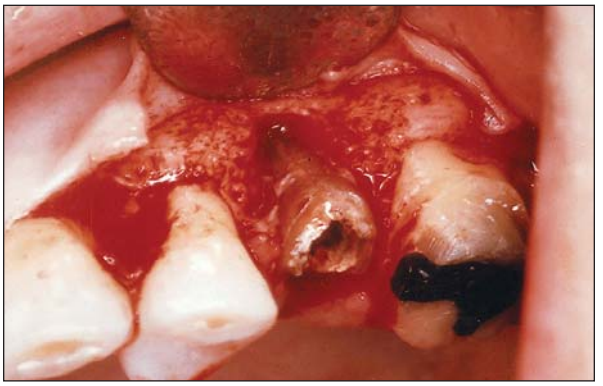

Fig 1a Intraoperative view of bone resorption around the tooth.

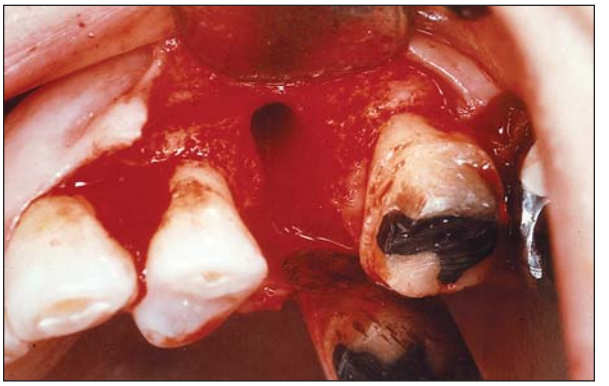

Fig 1b Intraoperative view of the extraction socket.

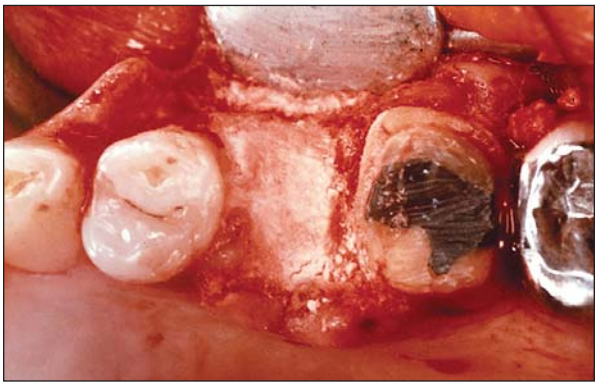

Fig 1c The Surgiplaster placed as a graft material.

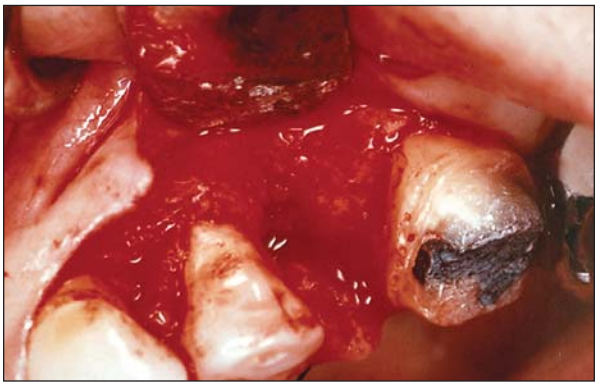

Fig 1d Re-entry surgery at 3 months.

In the coronal sections the average trabecular bone area fraction was 58.6% ± 9.2%, in the middle sections it was 58.1% ± 6.2% and in the apical sections it was 58.3% ± 7.8%. Differences between the ratios of these sites were not statistically significant. Organized connective tissue and foreign material were not observed in any of the sections (Figs 2 and 3).

DISCUSSION

The goal of any grafting procedure is to achieve the formation of 100% living bone tissue surrounding the implants.[22] A wide variety of graft materials have been proposed for bone regeneration, but it is not clear which is the material of choice because most of them seem to possess some negative properties.[10,23,24]

The formation of 100% living bone within the extraction socket grafted with MGCSH was evident by histologic examination in all the specimens analyzed in this investigation. This finding is in agreement with other studies supporting calcium sulfate as a bone substitute.[13–20] The complete absence of graft remnants indicated that MGCSH underwent complete resorption and replacement by newly formed bone. The bone replacement mechanism of MGCSH was studied by Ricci and colleagues.[25] They used an implantable microchamber in the distal lateral femur of a dog and studied the bone ingrowth. The calcium sulfate that filled the channels started to dissolve at the openings of the channels, and the Faxitron radiographic image showed the presence of radiopaque deposits in the form of bands roughly parallel to the surface of the dissolving calcium sulfate. The authors suggested that calcium sulfate dissolved at a rate of 1 mm per week from the outward ends of the channels inward. In an in vitro study[25] the same researchers studied calcium sulfate dissolution in a simulated tissue and body fluid environment. Using backscattered electron imagining and x-ray microanalysis, they found an unanticipated interaction between calcium sulfate and bone ingrowth. The calcium sulfate material was observed to dissolve and leave behind not mineral deposits of undissolved calcium sulfate but deposits that consisted of calcium, phosphorus, and oxygen in proportions similar to those found in bone mineral. These

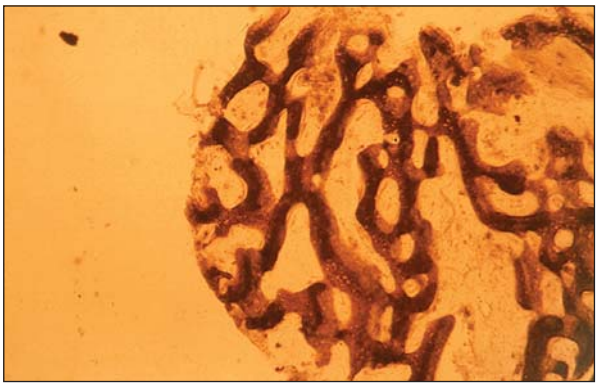

Fig 2 A cross section of the intrasocket tissue (von Kossa's; original magnification ×5).

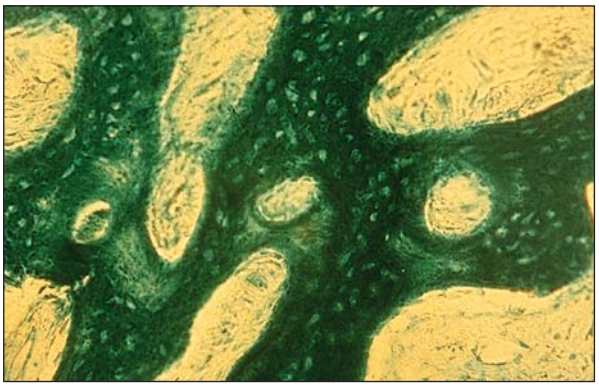

Fig 3a A coronal section of intrasocket tissue (Fast Green; original magnification ×10).

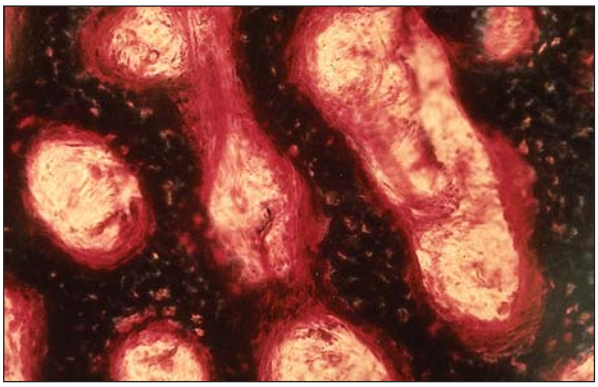

Fig 3b A middle section of intrasocket tissue (Fast Green-acid fuchsin; original magnification ×10).

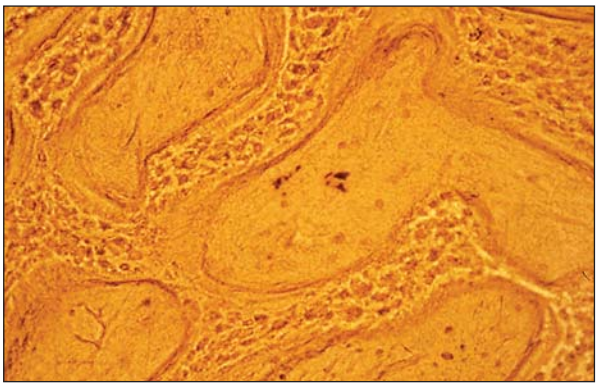

Fig 3c An apical section of intrasocket tissue (toluidine blue; original magnification ×10).

deposits seemed to consist of a granular hydroxyapatite-like calcium phosphate mineral and were stable in the short term, acting as an osteoconductive trellis for new bone formation which was then remodeled as the bone matured.

In the present study, to determine the healing pattern of newly formed tissue in relation to the presence of grafted material and evaluate the influence of socket depth, cross sections along tissue cores from the socket sites were examined histomorphometrically. From the most superficial to the deeper section cuts, differences were not statistically significant in trabecular percentage area. Histologic studies of natural healing of extraction sockets in humans have shown very little osteogenetic activity in the superficial area of the extraction socket, where osteoblasts have presented only occasionally.[26] This phenomenon seems to be related to tissue competition in the healing process of nongrafted sockets, which heal by secondary intention. The presence of MGCSH during the healing process in the most superficial size of sockets seems to promote osteogenic activity; in fact, differences in trabecular area percentage between coronal and apical sections were not found in this investigation. Better results using MGCSH during healing by secondary intention were found in an experimental study by Payne and associates.[27]

The authors reported that calcium sulfate, in comparison with polytetrafluoroethylene and polylactic acid, offers greater potential for guided tissue regeneration in surgical sites where the primary wound cannot be obtained. Artzi and coworkers,[10] using cancellous porous bovine bone, found in the superficial sections a mean lamellar area fraction of 15.9%. Furthermore, in the same study, the authors reported in the superficial cuts a mean connective tissue area fraction of 52.4%. In another study using a dog model, a similar woven bone dominance was reported in sites grafted with DFDBA.[27]

In a human study, Froum and colleagues[24] reported on the percentage of vital bone and residual implanted material when DFDBA and bioactive glass were used as filler materials in extraction sockets. The mean vital bone measurements for bioactive glass and DFDBA-treated sockets were (respectively) 59.5% and 32.4%, while in the control unfilled sockets, the mean vital bone percentage was 34.7%. In

the same study, the authors reported that the area accounted for by residual graft material was 13.5% in DFDBA-treated sockets and 5.5% in sockets grafted with bioactive glass.

In the present study, a good consistency of bone was found in the calcium sulfate–grafted extraction socket at 3 months. Bone volume had been almost completely preserved to achieve an ideal position of the implants. This clinical observation is very important in relation to the histologic data because in all the sections examined the presence of grafted material was not seen. This is in agreement with other studies in which the authors have demonstrated that calcium sulfate is completely and rapidly resorbable and has the ability to guide new bone formation, which occurs in association with its resorption.[19,28]

In comparison with the results of other studies, the present data seem relevant because the most important negative attribute of other grafted materials is the resorption time. Different data have been reported regarding the resorption capability of other graft materials. In earlier reports,[29–31] bovine bone derivatives were reported to be resorbable in nature; however, in subsequent studies[32–34] contradictory findings were reported. In a clinical and histologic study at 9 months of grafted human extraction sockets, Artzi and associates[10] found the presence of the graft material, cancellous porous bovine bone, in percentages ranging between 26.4% and 35.1%. Since osteoclasts could not be identified, the authors suggested that partial degradation rather than resorption of the grafted particles had probably occurred and that biocompatibility of the bovine bone substitute was sufficient to obtain new living bone. This is an issue that deserves further investigation, since the presence of a reactive peri-implant bone may be required to maintain osseointegration over time.

In another histologic study, Becker and colleagues[12] placed microscrews into extraction sockets treated with xenogenic bovine bone, DFDBA, and intraoral autologous bone. Biopsies from the bovine bone– and DFDBA-implanted sockets revealed dead particles entrapped within dense connective tissue. They concluded that neither xenogenic bovine bone, DFDBA, nor autogenous bone contributed to bone-to-microscrew contact and that none of these materials could be recommended for the enhancement of vital bone-to-implant contact.[12]

CONCLUSION

Many variables, including type and size of defect, time of healing response, as well as differences in host response, make study comparisons and conclusions difficult. The results of the present study suggest that MGCSH appears to be an acceptable graft material in extraction socket bone regeneration because of its ready availability, complete and rapid resorbability, and biocompatibility. Further studies with greater numbers of sites are indicated to determine the osteogenic activity of calcium sulfate; however, histologic results of the present study seem to confirm its osteogenic capability.

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