# Socket Preservation Following Extraction of Molars with Severe Periodontitis

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*The efficacy of the socket preservation procedure using deproteinized bovine bone mineral, bioabsorbable collagen membrane, and collagen sponge on molar extraction sites with severe periodontitis was assessed at 6 postoperative months, before implant placement. Results revealed excellent soft tissue healing without loss of keratinized tissue and no statistically significant differences in socket marginal bone changes in 20 molar extraction sockets. High levels of primary implant stability were recorded. Socket preservation using a minimally invasive surgical technique provides good soft and hard tissue healing as well as anticipated stability of implant placement at sites of extracted molars with severe periodontitis.*
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Periodontal disease, which causes destruction of the ligament and alveolar bone supporting the teeth, is the main cause of tooth loss in adults.[1] Once affected by severe periodontal disease, molar teeth are expected to experience inferior treatment outcomes and poor prognosis because of their unique anatomical characteristics.[2] After tooth extraction, the alveolar processes always exhibits atrophic changes, with vertical resorption of the alveolar bone ranging from 11% to 22% and horizontal resorption ranging from 29% to 63% after 6 months of healing.[3,4] Studies of periodontally compromised extraction sockets are sparse, as healing dynamics in compromised extraction sockets are different than those observed for extraction sockets unaffected by periodontitis.[5–7] Socket preservation is defined as any procedure that takes place immediately after tooth extraction to preserve or increase ridge volume within or beyond the skeletal envelope that exists at that time.[8] Reconstruction of alveolar ridge volume in molar extraction sockets affected by severe periodontitis presents clinical challenges. Sisti et al[9] indicated that socket preservation procedures minimized alveolar crest resorption and provided better regeneration results in sites with buccal bone defects > 5 mm

compared with traditional regenerative procedure carried out following socket healing. Meticulous debridement and removal of the infectious source coupled with minimally invasive extraction to minimize trauma to alveolar bone were key aspects of alveolar ridge preservation in infected sockets. The results of an animal study demonstrated that ridge preservation in diseased extraction sockets could compensate for buccal bone resorption.[6] A clinical study revealed that ridge augmentation in periodontally compromised extraction sockets (including anterior and posterior teeth) was safe, with an overall safety rate of 99.4%.[10]

To the present authors' knowledge, human studies of socket preservation restricted to molars extracted due to severe periodontitis are uncommon.[11] A study by Rasperini et al,[12] conducted in the posterior area, reported data only for preserved sockets with four walls intact, while Sisti et al,[9] Barone et al,[13] and Wang et al,[14] although related to severely resorbed extraction sockets, only reported data for sites in the anterior region. Results of a clinical trial about ridge preservation in infected molars with a full-thickness flap and primary closure showed a statistically significant reduction of keratinized tissue width.[15] The purpose of the present study was to evaluate the efficacy of socket preservation using a minimally invasive surgical technique following extraction of a molar with severe periodontitis. The null hypothesis was that no significant changes in alveolar dimensions would be observed after 6 months of healing.

## Materials and Methods

This prospective study was conducted in accordance with the World Medical Association Declaration of Helsinki, registered at Chinese Clinical Trial Registry (ChiCTR-ONN-16009433) and approved by the Institutional Review Boards of the University Medical Ethics Committee (approval no. PKUSSIRB-201310068). Informed consent was obtained from all participants. From January 2015 to January 2017, patients planning implant-supported rehabilitation with molar extraction sockets affected by severe periodontitis were included if they met the following criteria: having chronic periodontitis; aged ≥ 25 years; hopeless molar with probing depth > 6 mm; clinical attachment loss ≥ 5 mm; mobility ≥ II degree (Armitage classification); bone resorption more than half of the root length, confirmed by periapical radiographs; tooth to be extracted having at least one neighboring tooth; and at least two socket walls with 3 mm of alveolar bone height. Exclusion criteria were as follows: having severe systemic conditions that contraindicated surgical procedures; pregnancy or lactation; acute infection in the test tooth or in adjacent areas; and smoking > 10 cigarettes per day. All subjects were assessed with periapical radiographs and clinical periodontal examination to confirm diagnosis of the ailing tooth at least 7 days prior to surgery.

Clinical parameters, including probing depth (PD), gingival recession (REC), bleeding index (BI), and width of keratinized tissue (WKT), were measured and recorded at baseline and 6 months postsurgery. Clinical attachment loss (CAL) was calculated. PD, REC, and CAL were measured to the nearest millimeter at six sites per tooth (mesiobuccal, midbuccal, distobuccal, distolingual, midlingual, and mesiolingual) using a graded probe (Hu-Friedy). WKT was measured midfacially from the mucogingival junction to the gingival margin of the ailing tooth before extraction. All subjects received prophylactic antibiotic therapy (2 g of amoxicillin or 600 mg of clindamycin if allergic to penicillin) 1 hour before tooth extraction.

Following administration of local anesthesia, an internal bevel incision on the bone crest was performed approximately 0.5 to 1 mm below the buccal and lingual free gingival margin of the tooth to remove the inner wall of the periodontal pocket without flap elevation. The ailing tooth was extracted atraumatically. Sockets were carefully examined and meticulously debrided with P24G Periosteal Elevator and CL86 Lucas Surgical Curette (Hu-Friedy) to remove all granulation tissue, then irrigated with sterile saline solution. Full-thickness flaps were elevated buccally and lingually for exposure of just 2 mm of the socket's alveolar bone crest. After an integrity assessment, sockets were filled with deproteinized bovine bone mineral (DBBM; Bio-Oss, Geistlich) in the form of granules (diameter range: 0.25 to 1 mm). An absorbable collagen membrane (Bio-Gide, Geistlich) was applied to completely cover the socket, with 2 mm extending over the alveolar

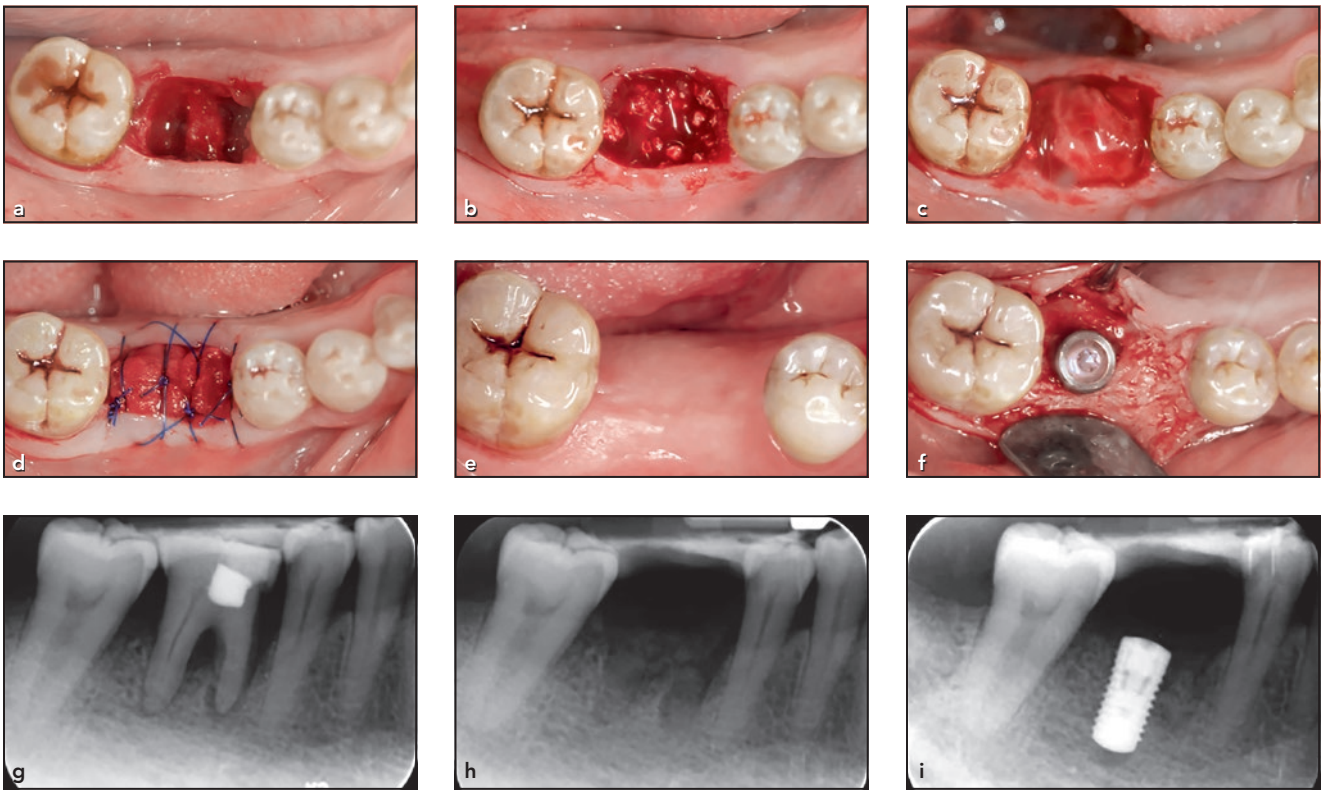


**Fig 1** (a) *Severe buccal bone defect after minimally invasive surgical extraction of the mandibular right first molar.* (b) *The socket was grafted with DBBM and* (c) *covered with a collagen membrane.* (d) *A collagen sponge was inserted on top of the collagen membrane and secured with cross-mattress sutures.* (e) *Maturation of the soft tissues after a 6-month healing period.* (f) *An implant was placed in the preserved socket in a prosthetically guided position.* (g) *Periapical radiographs of the tooth before extraction,* (h) *of the grafted socket immediately after ridge preservation, and* (i) *immediately after implant placement.*

bone crest. The site was then covered with a medical collagen dressing (Collagen Sponge, Wuxi BIOT), which does not require primary soft tissue closure. A cross-mattress tension-free 5-0 suture (Seralon, Serag-Wiessner) was placed over the area to achieve soft tissue stability.

Baseline CBCT scans and digital intraoral periapical radiographs were taken immediately after surgical procedures. Patients were recalled once a month thereafter. Six months after socket preservation procedure, a second CBCT scan was obtained before implant surgery. At the implant placement visit, WKT was measured from the most coronal part of the edentulous crest to the mucogingival junction of the edentulous area. By means of intracrevicular incisions minimally extended to the neighboring teeth, a full-thickness mucoperiosteal flap was elevated 3 to 4 mm from the buccal/lingual bone crest. An osteotomy was performed for placement of a dental implant (SLA Bone Level, Straumann). Implant stability quotient (ISQ) values were measured by resonance frequency analysis (Osstell ISQ). For each implant, two ISQ measurements were recorded (buccally and mesially) according to the manufacturer's instructions. All surgical procedures were performed by a single operator (W.H.). The full treatment phase is presented in Fig 1.

Baseline and 6-month CBCT scans were taken using a NewTom VG imaging unit (Aperio Services) with a pixel size of 0.125 mm. Two sets of DICOM (Digital Imaging and Communications in Medicine) data were generated and transferred to volumetric imaging software (Mimics 17.0, Materialise). The two data sets were aligned by the inferior border of the mandible and the palatal vault of the maxilla in three planes (coronal, axial, and sagittal). To set a reference point, the most coronal point of the inferior alveolar nerve

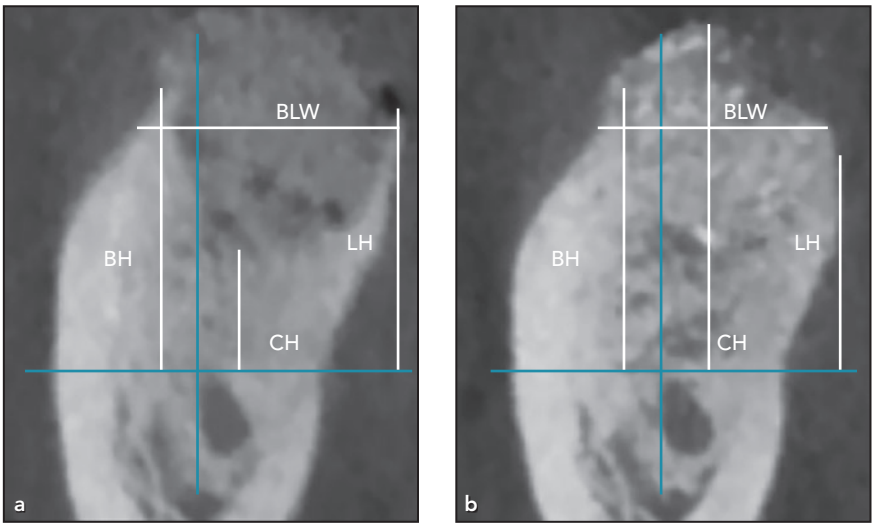


**Fig 2** *A representative coronal section of a CBCT image at the center of a mandibular first molar extraction site* (a) *immediately after socket preservation and* (b) *at 6 months of healing. Blue lines are the reference lines. BH means height of the buccal crest; CH means height at the bottom of the socket; LH means height of the lingual crest; BLW means buccolingual width at the initial lingual crest bone for those cases with the buccal bone crest higher than the lingual bone plate at the center of the socket.*

canal or maxillary sinus was defined in the baseline image, and vertical and horizontal reference lines were drawn for measuring mean marginal bone level and socket changes. The following radiographic measurements were recorded at the mid-socket coronal slice: height of the buccal crest; height of the palatal/lingual crest; height at the center of the socket; and buccopalatal/lingual width at the initial buccal or lingual bone crest (whichever was lower). Measurements were taken in triplicate and rounded to the nearest 0.1 mm, and the mean of the three values was recorded (Fig 2).

Normality of the data was tested by Shapiro-Wilk test. Paired samples *t* test (or Wilcoxon signed rank test for any data that were not normally distributed) was used to evaluate differences in socket height and width between baseline and 6 months. All statistical tests were two-tailed with a significance level of .05, calculated using SPSS 20.0 software (IBM).

## Results

Demographic and clinical measurements at baseline are presented in Table 1. Tables 2 and 3 present changes in alveolar process dimensions following tooth extraction and socket preservation of the maxillary and mandibular sockets, respectively. A significant increase of ridge height was observed (0.9 ± 0.7 mm; $P < .05$) at the palatal bone crest of maxillary sockets. After a 6-month healing period, mean marginal bone loss was 0.8 mm ± 0.9 mm ($P = .225$) on the buccal side and 0.4 ± 0.8 mm ($P = .085$) in the lingual bone plate of mandibular sockets. The mean marginal bone loss was 0.4 ± 0.6 mm ($P = .297$) of decreased width and 0.2 ± 1.0 mm ($P = .234$) of decreased height. Significant increases in ridge height at the center of both maxillary (6.2 ± 1.1 mm; $P < .05$) and mandibular (7.6 ± 2.4 mm; $P < .05$) sockets were observed. The buccolingual bone plate width decreased by 0.5 ± 0.3 mm ($P > .05$) in mandibular sockets, but increased by 0.2 ± 0.7 mm ($P > .05$) in maxillary sockets. Six months after socket preservation, mean changes in WKT were 0.1 ± 1.8 mm for maxillary sockets and 0.2 ± 1.5 mm for mandibular sockets, showing no statistically significant differences between baseline and 6 months (Table 4). No further bone augmentation was conducted at the time of implant placement. At implant placement, mean ISQ values ranged from 69.8 ± 6.9 to 77.2 ± 3.0, showing excellent initial stability (Table 5). Statistically significant differences in the ISQ values of implants placed in maxillary vs mandibular sockets were observed for both buccolingual and mesiodistal locations ($P < .05$).

## Discussion

This prospective study reports on the application of socket preservation following extraction of molars with severe periodontitis. No

**Table 1 Baseline Demographics and Clinical Measurements by Extraction Site Location**

| | Maxilla | Mandible | *P* |
|---|---|---|---|
| Age, y | 46.3 ± 11.7 | 42.8 ± 7.1 | .435 |
| Gender (M:F) | 5:3 | 7:3 | |
| Clinical attachment loss, mm | 7.1 ± 2.1 | 7.3 ± 1.4 | .513 |
| Probing depth, mm | 6.3 ± 2.0 | 6.6 ± 1.1 | .743 |
| Gingival recession, mm | 0.8 ± 1.4 | 0.9 ± 1.0 | .266 |
| Width of keratinized tissue, mm | 4.6 ± 1.9 | 4.4 ± 1.6 | .588 |

All values are shown as mean ± SD unless otherwise specified. There were 8 patients with extraction sites in the maxilla, and 10 patients with extractions sites in the mandible.

marginal bone loss was revealed in maxillary molar sites after preservation procedures nor at the 6-month follow-up. However, statistically significant height increases were observed in the center of both the maxillary and mandibular molar sockets at 6 months. Therefore, the null hypothesis was partially rejected. Previous studies have described the biocompatibility and the integration of DBBM into newly formed bone when used in extraction sockets.[16–18] Histologic studies designed to determine the composition of tissues that formed after 6 months of healing in extraction sites grafted with DBBM material revealed a significant reduction in dimensional bone loss when compared with nongrafted control sites.[19,20] Application of a collagen sponge prevents the infiltration of soft tissues to the lower area and maintains bone graft materials. Such methods that do not require primary soft tissue closure minimize patient morbidity and decrease surgical time and cost. A clinical study that evaluated the efficacy of the socket preservation technique using a col-

**Table 2 Alveolar Dimensions at Maxillary Extraction Sites at Baseline and 6 Months Postsurgery**

| Parameter | Baseline | 6 mo | Change | *P* |
|---|---|---|---|---|
| BH, mm | 7.4 ± 2.5 | 8.2 ± 1.8 | 0.5 ± 1.2 | .091 |
| CH, mm | 3.9 ± 2.1 | 10.2 ± 1.7 | 6.2 ± 1.1 | < .001* |
| PH, mm | 6.6 ± 1.7 | 7.5 ± 1.3 | 0.9 ± 0.7 | .021* |
| BPW, mm | 13.7 ± 1.6 | 13.9 ± 1.7 | 0.2 ± 0.7 | .474 |

BH = height of the buccal crest; CH = height in the center of the socket; PH = height of the palatal crest; BPW = buccopalatal width of the buccal and palatal crest bone.
Measurements are shown as mean ± SD.
*Statistically significant difference.

**Table 3 Alveolar Dimensions at Mandibular Extraction Sites at Baseline and 6 Months Postsurgery**

| Parameter | Baseline | 6 mo | Change | *P* |
|---|---|---|---|---|
| BH, mm | 12.5 ± 2.2 | 11.7 ± 2.5 | –0.8 ± 0.9 | .225 |
| CH, mm | 6.9 ± 3.1 | 14.4 ± 2.1 | 7.6 ± 2.4 | .005* |
| LH, mm | 12.9 ± 3.0 | 12.5 ± 2.5 | –0.4 ± 0.8 | .085 |
| BLW, mm | 11.8 ± 1.4 | 11.3 ± 1.4 | –0.5 ± 0.3 | .227 |

BH = height of the buccal crest; CH = height in the center of the socket; LH = height of the lingual crest; BPW = buccopalatal width of the buccal and palatal crest bone.
Measurements are shown as mean ± SD.
*Statistically significant difference.

**Table 4 Dimensions of Keratinized Tissue Width (in mm) at Baseline and 6 Months Postsurgery**

| Location | Baseline | 6 mo | Change | *P* |
|---|---|---|---|---|
| Maxilla | 4.6 ± 1.9 | 4.5 ± 1.2 | 0.1 ± 1.8 | .859 |
| Mandible | 4.4 ± 1.6 | 4.3 ± 0.9 | 0.2 ± 1.5 | .660 |

Measurements are shown as mean ± SD.

**Table 5 Implant Stability Quotient at Maxillary and Mandibular Sites**

| | Maxilla | Mandible | *P* |
|---|---|---|---|
| Mesiodistal | 69.8 ± 6.9 | 75.4 ± 3.4 | .034* |
| Buccolingual | 69.8 ± 7.0 | 77.2 ± 3.0 | .013* |

Measurements are shown as mean ± SD.
*Statistically significant difference.

lagen sponge and a xenograft after tooth extraction concluded that the combined procedure prevents horizontal resorption of the alveolar ridge, blocks the infiltration of soft tissues, and enhances bone fill.[21] This technique may be particularly advantageous for cases with abundant loss of the wall after advanced periodontal molar extraction.

From clinical and radiographic perspectives, residual ridge dimensions remained nearly stable, as highlighted by the overall calculated mean height (0.2 mm) and width (0.4 mm) of bone resorption. These results are consistent with previous randomized controlled trials that reported a mean height loss of 0.46 mm and a mean buccolingual width loss of 1.04 mm when socket preservation proceeded with DBBM and bioabsorbable membrane in premolar or molar sockets with three walls intact and at least 80% of four walls intact.[16] Accordingly, a recent retrospective analysis reported a volume loss of 9.9% when fresh sockets were grafted with DBBM, covered by an absorbable collagen barrier, and left to heal for 6 months.[17] The dimensional changes observed in the present study were less than those previously reported for nongrafted sockets. For example, in a recent report, postextraction molar sockets underwent a horizontal dimensional reduction of 3.11 ± 3.83 mm and vertical bone loss of 2.60 ± 2.06 mm after 3 months of unassisted healing.[22] Thus, socket preservation appears to result in less horizontal and vertical ridge alteration in comparison with nongrafted sockets.

The bone quality of healed grafted sockets may influence the primary stability of implants placed in regenerated sites.[23] Primary stability is believed to play a crucial role in successful osseointegration and may lead to adequate secondary stability, thus contributing to long-term implant success.[24,25] The present results suggest that the socket preservation technique used is effective at minimizing marginal bone loss as well as creating favorable ridges for implant placement after 6 months of healing.

The limitations of this prospective study include the small number of participants, a short follow-up time, and absence of a control group. In addition, using radiographs to measure bone formation when radiodense graft products are utilized should be considered with caution.

## Conclusions

Within the limitations of this study, the application of minimally invasive surgical techniques and socket preservation procedures allowed good soft and hard tissue healing at extraction sites of molars with severe periodontitis. After 6 months of healing, successful implant placement was achieved with good primary stability.

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