# Alveolar Socket Preservation Graft Using the Combination of BMP and Xenograft S1

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**Abstract**

**Background**: Tooth loss requires replacement with an effective artificial restoration, among which dental implantation is considered the best option. However, when immediate implantation is contraindicated, wound healing is accompanied by collapse of the tooth socket, resulting in a reduction of its volume. Bone deficiency often complicates dental implant placement, necessitating quantitative bone augmentation through the use of bone substitute materials **(1,2).**
**Aim**: The aim of this study is to perform preventive socket augmentation immediately after tooth extraction to preserve socket volume. In this approach, an osteoconductive mineral graft is combined with an osteoinductive agent—bone morphogenetic protein (BMP)—to achieve quantitatively and qualitatively adequate bone formation **(8,11)**.
**Methods**: Following tooth extraction and curettage, the socket is filled with a bone substitute material (xenogeneic bone combined with BMP) and covered with a resorbable collagen membrane. Dental implant placement is performed after 4–6 months. Ethical approval for this single-case study was obtained, and informed consent was acquired from the patient.
**Results**: The study confirms preservation of the residual alveolar ridge volume with minimal changes (~8% reduction in buccolingual width and ~10% in vertical height), accompanied by formation of well-developed trabecular bone and vascularization. This approach helps avoid secondary, invasive augmentation procedures.
**Conclusions**: Socket augmentation performed in a single visit simultaneously with tooth extraction ensures optimal preservation of socket volume with virtually no loss after healing. The combined use of a mineral xenogeneic bone graft and BMP results in fully mature, high-quality bone formation. Larger cohort studies with long-term follow-up are warranted to confirm these results and optimize BMP-graft combinations. **(TCM-GMJ May 2026; 11 (1): P06-P09)**

**Keywords:** Bone augmentation, Xenograft, Bone morphogenic protein, Bone graft.

## Introduction

Following tooth extraction, the alveolar bone undergoes rapid remodeling due to its tooth-dependent nature. Collapse of the extraction socket leads to the formation of an edentulous ridge with significant reduction in both vertical and horizontal dimensions. This volumetric bone loss may compromise optimal implant positioning and often necessitates secondary augmentation procedures.

Long-term observational studies have demonstrated that the greatest proportion of alveolar bone resorption occurs within the first year after extraction, with continued but slower resorption thereafter **(1)**. Consequently, bone grafting procedures are frequently performed either immediately after extraction or following ridge resorption to preserve alveolar dimensions, improve esthetic outcomes, and facilitate future implant placement **(2,3).**

Immediate socket preservation using bone substitute materials, often combined with barrier membranes, has been shown to significantly reduce post-extraction bone loss. Compared with spontaneous healing, socket preservation can reduce horizontal bone loss by approximately 1.5–2.0 mm and vertical loss by around 2 mm **(4).** Preservation of alveolar ridge dimensions facilitates ideal implant placement, reduces the risk of thread exposure or unfavorable angulation, and improves esthetic outcomes, particularly in the anterior maxilla.

The biological activity of bone graft materials is based on three fundamental mechanisms: osteoconduction, osteoinduction, and osteogenesis **(5).** Osteogenesis refers to new bone formation by viable cells within the graft, as observed in autogenous bone. Osteoconduction involves provision of a three-dimensional scaffold that supports migration and proliferation of osteogenic cells and blood

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vessels. Osteoinduction is the process by which undifferentiated mesenchymal stem cells are recruited and stimulated to differentiate into osteoblasts, a function characteristically mediated by bone morphogenetic proteins. To address post-extraction bone deficiency and enhance graft performance, the present approach combines an osteoconductive xenogeneic bone graft with an osteoinductive bone morphogenetic protein.

**Bone Morphogenetic Proteins.** Bone morphogenetic proteins are multifunctional growth factors belonging to the transforming growth factor-β superfamily. They play a critical role in skeletal development, bone remodeling, and tissue regeneration. BMPs exert their biological effects by binding to specific cell surface receptors on osteoblasts, chondrocytes, and mesenchymal stem cells, activating intracellular signaling pathways that regulate osteogenesis, angiogenesis, and chondrogenesis **(6).**

In implant dentistry, BMPs are widely used to stimulate bone formation in areas of insufficient bone volume, including alveolar ridge augmentation, sinus floor elevation, and reconstruction of bone defects caused by trauma or infection. Their clinical effectiveness is enhanced when combined with bone graft materials, which act as carriers and ensure sustained local delivery of growth factors.

Among the BMP family, BMP-2 and BMP-7 are the most extensively studied and clinically applied osteogenic proteins. BMP-2, in particular, promotes differentiation of mesenchymal stem cells into osteoblasts, activates osteogenic gene expression, and accelerates bone matrix synthesis and mineralization. Recombinant human BMP-2 is currently used for osteoinduction due to its availability, controlled production, and favorable safety profile compared with animal-derived proteins. (Fig.2).

**S1 Bone Graft Material.** S1 Bone is a xenogeneic bone graft material of bovine origin developed for bone regeneration in oral and maxillofacial surgery. It consists of processed cancellous bone particles combined with a hydrogel carrier, which improves handling characteristics and supports the healing process. The graft is composed primarily of hydroxyapatite and β-tricalcium phosphate, forming a biphasic calcium phosphate structure. Hydroxyapatite closely resembles the mineral phase of natural bone and provides an osteoconductive scaffold that supports osteoblast adhesion, proliferation, and new bone formation. Its interconnected porous structure facilitates vascular ingrowth and cellular migration, promoting integration with host bone. The incorporated hydrogel, based on hydroxypropyl methylcellulose, confers a sticky and moldable consistency, allowing precise adaptation to the extraction socket or alveolar ridge. This property ensures stable fixation without particle displacement and helps maintain the shape and volume of the defect, creating a favorable environment for predictable bone regeneration. (Fig.1) Preclinical studies have demonstrated that S1 Bone promotes osteogenic differentiation of human mesenchymal stem cells, with increased expression of alkaline phosphatase, runt-related transcription factor 2, and osteocalcin **(7)**.

**BMP and Bone Graft Combination.** For effective bone regeneration, BMPs require a biocompatible carrier that maintains space, supports cell adhesion, and is gradually replaced by newly formed bone. Calcium phosphate-based grafts fulfill these requirements by providing both structural stability and biological compatibility. Macroporous biphasic calcium phosphate scaffolds composed of hydroxyapatite and tricalcium phosphate have demonstrated strong affinity for BMP-2, allowing efficient binding and sustained release. Micropores facilitate mineral deposition, while macropores provide space for vascularization and bone maturation **(7,8,9**).

The synergistic combination of an osteoconductive mineral scaffold and osteoinductive BMP closely mimics natural bone healing. BMPs recruit mesenchymal stem cells to the graft site, stimulate their differentiation into osteoblasts, and promote osteoid formation, mineralization, and subsequent remodeling into lamellar bone. This coordinated process results in rapid formation of high-quality bone suitable for implant integration **(11).**

## Methods

**Study Design and Ethical Considerations.** The present study is designed as a prospective clinical case series evaluating alveolar socket preservation following tooth extraction using a combination of an osteoconductive xenogeneic bone graft and an osteoinductive agent—bone morphogenetic protein (BMP). All procedures were conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from both patients prior to treatment, including consent for the use of anonymized clinical and radiographic data for scientific publication.

**Surgical Protocol.** In both cases, atraumatic tooth extraction was performed to preserve the integrity of the surrounding alveolar bone. Following extraction, meticulous socket curettage and irrigation with sterile saline solution were carried out. The extraction sockets were then filled with a mineral xenogeneic bone graft (S1) and covered with a resorbable collagen membrane. Bone morphogenetic protein was applied either by impregnation of the graft material or via local injection into the augmented site. Implant placement was planned after a healing period of 4 –6 months.

**Case 1**

A 32-year-old patient underwent atraumatic extraction of tooth 46. After alveolar curettage and irrigation with saline, CBCT revealed a buccolingual width of 10 mm and a distance of 14.5 mm from alveolar crest to mandibular canal. A flap was elevated, and a mixture of S1 bone and BMP was placed into the socket. The graft was condensed up to the socket margins, covered with a resorbable collagen membrane, and stabilized with simple interrupted sutures (Fig.3,4). The patient provided informed consent, and the procedure adhered to the Declaration of Helsinki [**14**]. Implant placement was planned after 6 months.

**Case 2**

A 47-year-old patient (N.L.) presented with a subgingival crown fracture of tooth 11, for which atraumatic extraction was performed using a piezodesmotome. The integrity of both the buccal and palatal cortical plates was preserved.

Following socket curettage and irrigation with sterile saline solution, the extraction socket was filled with the mineral bone graft S1 and subsequently covered with a resorbable collagen membrane. Bone morphogenetic protein (BMP) solution was then administered into the augmented area via injection. (Fig.5,6)

This procedure was performed with the aim of preserving the volume of the residual alveolar bone to facilitate subsequent implant placement. Dental implant insertion is planned 5–6 months post-extraction.

## Results and discussion

Clinical and radiographic evaluation demonstrated successful preservation of alveolar ridge dimensions in both cases.

Quantitative comparison revealed that horizontal ridge width reduction after healing was limited to approximately 4–6% in Case 1 and 5–7% in Case 2. Vertical bone loss was minimal, measuring less than 3% in both cases. Radiographic analysis showed well-organized trabecular bone formation and adequate vascularization within the augmented sites. No signs of infection, membrane exposure, or graft loss were observed during the healing period. Both sites demonstrated sufficient bone volume and density to allow prosthetically driven implant placement without the need for secondary augmentation procedures.

The combination of S1 bone xenograft and BMP addresses both structural and biological requirements for ridge preservation. S1 bone provides a porous scaffold, facilitating osteoblast attachment, proliferation, and mineralization, while BMP stimulates MSC recruitment and differentiation into osteoblasts **(8,9).**

Compared to extraction alone, socket preservation reduces horizontal bone loss by ~1.9 mm and vertical loss by ~2 mm **(2)**. In this case, volumetric reduction was only 8–10%, demonstrating effective preservation.

The staged bone formation process closely mimics natural bone healing: MSCs differentiate into pre-osteoblasts and osteoblasts (3–7 days), secrete osteoid and type I collagen (7–14 days), followed by hydroxyapatite mineralization (2–4 weeks), trabecular bone formation, and remodeling by osteoclasts and osteoblasts (1–6 months) **(11,12).**

**Clinical Relevance:** The BMP + S1 approach allows predictable preservation of alveolar ridge volume and quality, potentially reducing the need for secondary augmentation and improving implant stability and esthetic outcomes.

### Esthetic Zone Considerations

Socket preservation in the anterior maxilla is of particular clinical importance due to its impact on esthetic outcomes. Even minimal horizontal or vertical bone loss in this region may result in soft tissue collapse, gingival recession, and compromised implant positioning. Preservation of the buccal cortical plate and maintenance of ridge contour are therefore critical for achieving optimal pink and white esthetics.

The addition of BMP to an osteoconductive scaffold appears to enhance not only bone volume preservation but also bone quality, promoting faster maturation and improved vascularization—key factors for long-term implant stability in the esthetic zone.

### Limitations and Future Perspectives

The main limitation of this study is the small sample size and the absence of histological evaluation. Future studies should include larger patient cohorts, control groups, and long-term follow-up to better assess implant survival and esthetic outcomes. Histomorphometric analysis would further clarify the quality of newly formed bone induced by BMP-enhanced socket preservation.

## Conclusion

Within the limitations of this clinical case series, immediate alveolar socket preservation using a xenogeneic bone graft combined with bone morphogenetic protein proved effective in minimizing post-extraction bone loss and preserving ridge dimensions. This approach is particularly advantageous in the esthetic zone, where maintenance of hard and soft tissue architecture is essential. Further controlled clinical studies are warranted to validate these findings and optimize treatment protocols. Single-visit socket augmentation performed simultaneously with tooth extraction provides predictable preservation of alveolar socket volume. The combined use of a mineral xenogeneic graft and bone morphogenetic protein promotes formation of mature, high-quality bone suitable for subsequent implant placement.


Fig.1

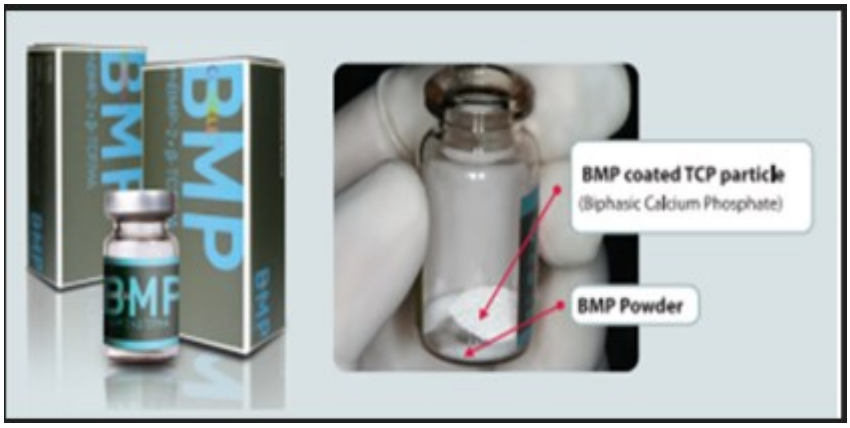


Fig.2

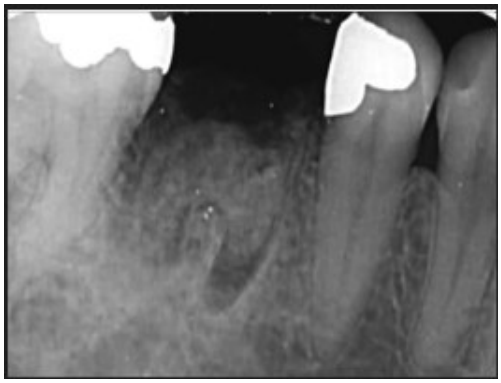

Fig.3

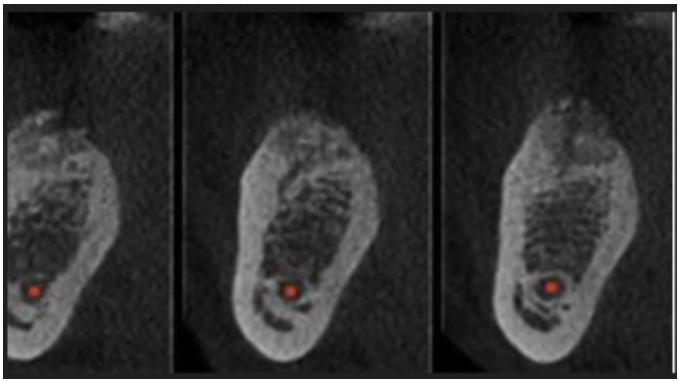

Fig.4

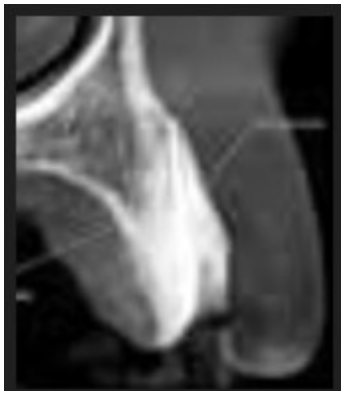

Fig.5

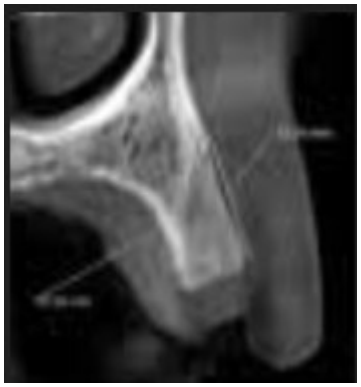

Fig.6

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