

Harnessing Magnesium for Biomimetic Healing

A scientific and clinical overview of magnesium-enhanced biomaterials for dental regeneration.

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Modern implant dentistry depends on predictable bone regeneration to restore function and aesthetics following tooth loss, trauma, or disease.

After extraction, the alveolar ridge undergoes rapid resorption, often compromising implant placement and long-term stability. As a result, clinicians rely on bone graft materials that provide structural support and are designed to support the natural healing process.

Calcium phosphate (CaP) bone substitutes have long been used due to their similarity to natural bone.

However, newer biomaterial approaches aim to go beyond passive scaffolding.

By incorporating magnesium (Mg^{2+}) into calcium phosphate structures, bone substitutes can more closely mimic the composition of natural bone while interacting with biological processes involved in regeneration.

This clinical and scientific overview explores how magnesium-enhanced bone substitutes are designed to support clinical performance through biomimetic design.

Natural Bone and the Role of Magnesium



Magnesium regulates bone healing across multiple levels

Human bone is a complex composite material composed of approximately:

- 65% inorganic mineral (primarily hydroxyapatite)
- 25% organic matrix
- 10% water

Magnesium is present in small quantities (~0.5–1.5 wt%), yet it plays a relevant role in bone biology.^{(1) (2) (7)}

It contributes to:

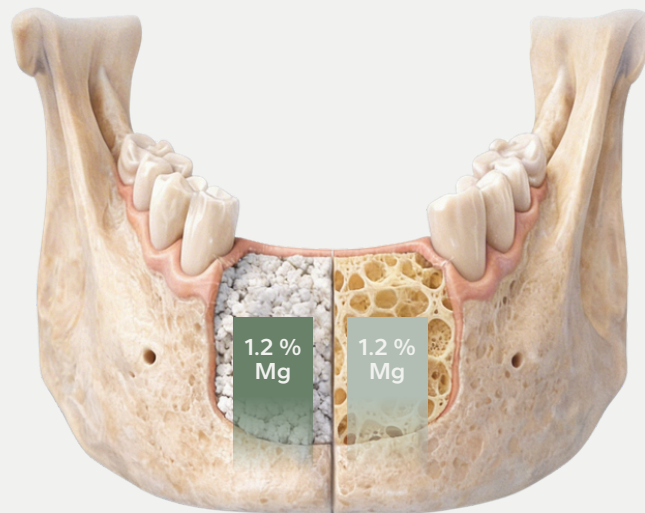
- Regulation of crystal structure⁽²⁾
- Bone remodeling dynamics⁽¹⁾
- Osteoblastic activity^{(3) (7)}

Magnesium is particularly concentrated in areas of active bone formation, highlighting its relevance in regenerative processes.⁽²⁾

Magnesium is known to influence bone healing across multiple levels, including osteogenesis, angiogenesis, and immunomodulation.



Biological Functions of Magnesium



Bioceramed Bone Graft

Natural Human Bone

Osteogenesis

Magnesium has been shown to influence the differentiation of mesenchymal stem cells into osteoblasts and is associated with the expression of key bone-related markers such as alkaline phosphatase (ALP) and osteopontin.^{(3) (7)}

Angiogenesis

Magnesium is associated with vascularization processes, contributing to the formation of new blood vessels and supporting nutrient and oxygen supply to regenerating tissue.^{(4) (5)}

Immunomodulation

Magnesium is associated with modulation of the inflammatory response, supporting a regenerative environment that is important for bone healing.⁽⁶⁾

Magnesium-Enhanced Calcium Phosphate Bone Substitutes

From Passive Scaffold to Bioactive Material

Traditional bone substitutes primarily act as structural scaffolds. In contrast, magnesium-enhanced calcium phosphate bone substitutes are designed to interact with the biological environment, with the aim of supporting the regeneration process.^{(3) (4) (5) (6)}

By integrating magnesium into the material structure, these biomaterials:



Mimic the composition of natural bone



Enable controlled release of Mg^{2+} ions over time



Are associated with key regenerative processes

Physiological Mimicry and Controlled Release

Our bone substitutes are engineered with approximately 1.2 wt% magnesium (~12,000 ppm), within the physiological range found in natural bone.

This design is intended to provide:

- Biomimetic composition
- Controlled and sustained Mg^{2+} release
- Maintenance of biologically relevant concentrations

The porous calcium phosphate structure is designed to enable gradual ion release, avoiding rapid concentration peaks and supporting interaction with the biological environment.^{(5) (8)}



Biological Impact in Dental Regeneration

The incorporation of magnesium into calcium phosphate bone substitutes is associated with multiple aspects of the healing process:

Osteogenesis-related effects

- Associated with increased osteoblastic activity⁽³⁾ ⁽⁷⁾
- Associated with mineralization processes⁽⁵⁾
- May contribute to bone formation⁽³⁾ ⁽⁵⁾

Angiogenesis-related effects

- Associated with vascularization processes⁽⁴⁾ ⁽⁵⁾
- May support graft integration⁽⁴⁾
- Relevant in low-perfusion areas (e.g., posterior maxilla)

Immunomodulatory effects

- Associated with modulation of inflammatory response⁽⁶⁾
- Supports a regenerative environment⁽⁶⁾
- May contribute to stability in challenging oral conditions

Designed for Clinical Performance

Magnesium-enhanced bone substitutes are developed to meet clinical requirements, combining safety with functional design.

Key Features

1

Biomimetic Composition

Replicates natural bone mineral structure

2

Controlled Ion Release

Designed to enable sustained Mg^{2+} availability⁽⁵⁾ (8)

3

High Biocompatibility

Maintains Mg^{2+} concentrations within physiological ranges

4

Enhanced Bioactivity

Designed to support the healing process



Clinical Applications

Magnesium-enhanced calcium phosphate bone substitutes can be used across a wide range of dental procedures:

Socket Preservation & Ridge Augmentation

Used in procedures aimed at maintaining bone volume and enabling future implant placement

Sinus Floor Elevation

Associated with processes related to angiogenesis and bone formation under the sinus membrane

Peri-implant Defects

Used in procedures targeting regeneration around compromised implants

Periodontal Defects

Used in procedures aimed at supporting regeneration in intrabony defects

Supporting Regenerative Solutions

Magnesium-based technologies can also be applied to complementary regenerative solutions, such as barrier membranes used in guided bone regeneration.

These solutions are designed to:

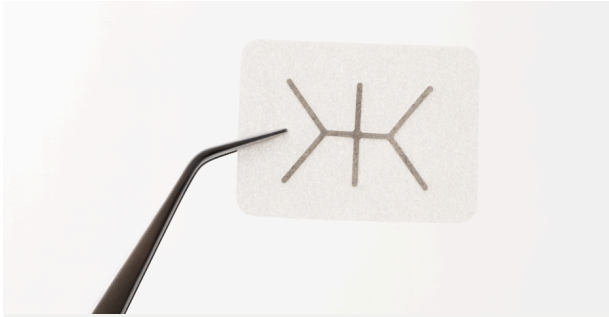
- Maintain space for bone formation
- Protect the regenerative environment

While these materials play an important supporting role, the bone graft remains the central component of the regenerative process.

When used together, graft materials and membranes may contribute to a more stable and controlled healing environment.

Combined Regenerative Approach

When used together, bone substitutes and barrier membranes may contribute to a comprehensive regenerative strategy.



Barrier membranes:

- Maintain space for bone formation
- Protect the graft from soft tissue invasion



Bone substitutes:

- Provide structural support
- Enable controlled release of Mg^{2+} ions⁽⁵⁾

This combination may contribute to clinical predictability, particularly in complex defects.



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Biomimetic Concept: Natural Bone vs Synthetic Bone

To better understand the concept of biomimicry:



Natural bone

- Hydroxyapatite
- Collagen matrix
- Magnesium (~1 wt%)(²) (⁷)
- Natural remodeling processes



Magnesium-Enhanced Bone Substitute

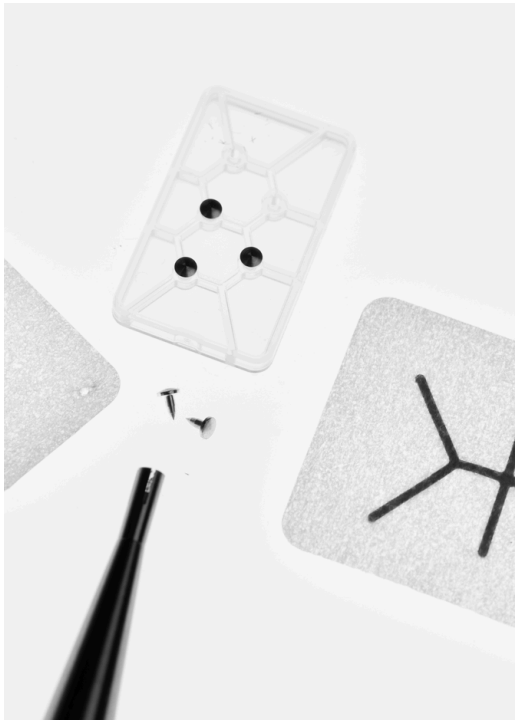
- Replicate mineral composition
- Enable controlled Mg^{2+} release
- Be associated with osteogenesis and vascularization processes

This biomimetic approach is inspired by natural bone structure and supported by material design strategies.

Key Features

Inspired by nature. Enhanced by science.





Magnesium Across the Portfolio

Magnesium-based approaches extend beyond bone substitutes into complementary regenerative solutions.

Examples include:

- Magnesium-enhanced bone grafts (core solution)
- Magnesium-reinforced membranes (supporting role)

Together, these solutions may contribute to a broader regenerative strategy.

Conclusion

Bone regeneration is evolving from passive materials toward more biomimetic and bioactive approaches.

Magnesium-enhanced calcium phosphate bone substitutes represent a relevant development in this field.

By combining:

- Physiological composition
- Controlled ion release
- Interaction with biological processes

These materials are designed to support the bone regeneration process.

When integrated into clinical practice, they may contribute to:

- Greater predictability
- Support of the healing process
- Favorable long-term outcomes

Magnesium is a natural component of bone and plays an important role in its biology.^{(1) (3) (4) (6)}

In biomimetic bone substitutes, it represents a key element in material design.

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