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GUIDED BONE REGENERATION FOR JAW BONE AUGMENTATION

OTABEK RAKHMONKULOV
Assistant, Tashkent State Medical University Tashkent, Uzbekistan

Abstract

This article examines the current state of guided bone regeneration (GBR) in dental implantology, focusing on the management of alveolar bone atrophy. The study reviews the biological principles of bone healing, the historical development of the field from Brånemark to modern CAD/CAM technologies, and specific surgical protocols such as the Khoury and Urban techniques. Special attention is given to the evolution of individual 3D-printed titanium meshes, their optimization parameters, and the clinical significance of pseudo-periosteum formation. The article concludes that customized titanium structures represent the peak of bone reconstruction evolution, allowing for predictable 3D augmentation in complex clinical scenarios.

Keywords

Guided bone regeneration, alveolar ridge augmentation, customized titanium mesh, CAD/CAM technology

Introduction

The partial or total absence of teeth remains a primary challenge in modern dentistry [3]. While dental implants have revolutionized the restoration of dentition, clinicians frequently encounter insufficient alveolar bone volume due to atrophy or traumatic deformations [5]. Successful osseointegration and long-term functional stability of implants require a specific bone volume and proper orientation within the jaw [7, 10]. To address these deficiencies, reconstructive interventions aimed at restoring or increasing bone volume are necessary [1, 2].

The concept of osseointegration, fundamentally described by Per-Ingvar Brånemark, established the structural and functional connection between bone and the surface of a titanium implant [16]. Modern Guided Bone Regeneration (GBR) is based on the principle of using barrier membranes to mechanically exclude non-osteogenic cells, allowing osteogenic cells from the native bone to populate the defect [11].

Anatomical and Biological Considerations

After tooth extraction, the alveolar process undergoes inevitable catabolic changes [3, 4]. These changes are initiated by the resorption of the "bundle bone," a tooth-dependent structure only 0.2–0.4 mm thick. Clinical studies indicate that up to 50% of the ridge width can be lost within the first year, with a significant portion of this loss occurring in the first three months [4, 8].

The degree of resorption is highly dependent on the bone phenotype:

* Thin phenotype (≤ 1 mm): Leads to severe vertical bone loss [4].
* Thick phenotype (> 1 mm): Results in significantly higher stability of the alveolar ridge [4].

Interestingly, in thin phenotypes, soft tissues may spontaneously thicken, masking the true extent of the underlying bone defect, which can mislead clinicians during visual examinations [13].

Principles of Bone Regeneration and Grafting Materials

Bone regeneration follows a biological sequence similar to fracture healing: inflammation, soft callus formation, hard callus formation, and remodeling [11]. Success depends on three key factors: osteoconduction, osteoinduction, and osteogenicity [5, 10].

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Materials are categorized into autogenous (the "gold standard"), allogenic, xenogenic, and alloplastic [1, 5]. Autogenous grafts are often harvested from intraoral sites like the mandibular ramus or symphysis, which are associated with lower patient morbidity compared to extraoral sites [1, 10].

Advanced Surgical Techniques

The Khoury Technique (3D Reconstruction)

Professor F. Khoury developed a technique using thin cortical plates harvested from the mandible to create a "box" around the defect [1, 10, 12]. This space is filled with autogenous bone chips, which revascularize faster than solid blocks. This method allows for predictable 3D results even in cases of severe atrophy [12, 13].

The Urban "Sausage Technique"

Dr. István Urban’s methodology focuses on significant horizontal ridge augmentation using native collagen membranes [2]. These membranes are stabilized with titanium pins in a stretched position to fix a mixture of autogenous bone and xenogenic material. The elasticity and biocompatibility of these membranes allow for better vascularization from the periosteum [2].

Evolution of Individual Titanium Mesh (CAD/CAM)

Traditional titanium meshes often required manual cutting and bending, increasing the risk of mucosal irritation and exposure [14, 15]. Modern CAD/CAM and 3D printing technologies allow for the creation of customized, pre-shaped meshes that fit the patient’s anatomy precisely [14].

Optimization of Mesh Parameters

* Thickness: Generally ranges from 0.3 to 0.4 mm to ensure space maintenance [14].
* Pore Size: Essential for nutrient and oxygen exchange. Large pores facilitate blood supply, though they may allow some connective tissue ingrowth [15].
* Roughness: Specific surface topography is recommended to promote osteoblast adhesion while avoiding bacterial colonization [14].

The Concept of Pseudo-periosteum

A layer of fibrous connective tissue, known as pseudo-periosteum, inevitably forms between the titanium mesh and the new bone [14, 15]. Clinicians must plan for hyper-correction during the design phase to compensate for this space-occupying layer.

Clinical Application and Results

The use of customized titanium structures and non-resorbable membranes has shown high success rates in treating complex horizontal and vertical defects [6, 7, 14]. The process involves precise 3D planning using CBCT data, skeletal preparation, and stable fixation of the individual mesh with screws [14].

Discussion

The success of GBR is highly dependent on the stability of the graft and the barrier function of the membrane [8, 11]. While resorbable membranes simplify surgical protocols, non-resorbable individual titanium meshes offer superior mechanical stability for vertical reconstructions [14, 15]. The integration of digital workflows significantly reduces intraoperative time and improves the predictability of the outcome [7, 14].

Conclusion

Guided Bone Regeneration is a predictable method for restoring maxillofacial defects [11]. Individualized titanium constructions represent the pinnacle of this evolution, enabling simultaneous horizontal and vertical ridge reconstruction with high precision [14]. Mastering these digital and surgical techniques allows for bone restoration in virtually any physiological volume, providing a solid foundation for successful dental implantation and patient rehabilitation [1, 2, 10].

REFERENCES

1. Khoury F. Regenerative Methods in Implantology. 2013.
2. Urban I. Vertical and Horizontal Ridge Augmentation. 2017.
3. Nikolsky V.Y. Assessment of Jaw Bone Atrophy After Tooth Extraction.
4. Chappuis V, Araujo M.G, Buser D. Periodontology 2000. 2017.
5. Alfaro F.H. Bone Grafting in Oral Implantology. 2006.
6. Donos N, Kostopoulos L, Karring T. Clin. Oral Impl. Res. 2002.
7. Draenert F.G, et al. German Medical Journal. 2014.
8. Von Arx T, Buser D. Horizontal Ridge Augmentation.
9. Daudova R.D, et al. Gavriil Ilizarov: Genius of Orthopedics. 2014.
10. Khoury F, Antoun H, Missika P. Bone Augmentation in Oral Implantology. 2007.
11. Retzepi M, Donos N. Clin. Oral Impl. Res. 2010.
12. Bolonkin I.V, Fedoseev A.Y. Maestro of Dentistry. 2015.
13. Dzyuba M.V, Izmailov A.A. Dental Implantology and Surgery. 2012.
14. Xie Y, et al. International Journal of Oral Science. 2020.
15. Briguglio F, et al. International Journal of Dentistry. 2019.
16. Brånemark P.I. J Prosthet Dent. 1983.