International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

A Review on Autologous Tooth-Derived Bone Grafts in Socket Preservation

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Abstract
Alveolar ridge preservation is crucial for maintaining bone volume and contour following tooth extraction to ensure successful implant placement. Conventional grafts such as allografts, xenografts, and alloplasts, though effective, have limitations including immunogenic risks, high cost, and incomplete remodeling. Autologous tooth-derived bone grafts (ATGs) have emerged as a sustainable and biocompatible alternative, utilizing the patient's extracted tooth processed into a demineralized dentin matrix that closely mimics bone in structure and composition. Rich in collagen, hydroxyapatite, and intrinsic growth factors such as BMPs and TGF-β, ATGs demonstrate strong osteoconductive and osteoinductive potential. Clinically, they have shown effective socket preservation, rapid bone regeneration, and high implant success rates. Emerging innovations like nanotechnology-enhanced and stem cell–combined tooth grafts further expand their regenerative applications in endodontics and craniofacial reconstruction, marking a significant advancement in personalized bone regeneration.

Keywords: Autologous tooth-derived grafts, Socket preservation, Dentin matrix, Bone regeneration, Alveolar ridge preservation.

Introduction

Alveolar ridge preservation following tooth extraction is essential for maintaining the bone volume and contour required for successful implant placement and optimal prosthetic outcomes.[1] Tooth extraction often triggers significant bone resorption due to the loss of periodontal ligament stimulation and subsequent remodeling processes, leading to reduced ridge height and width and complicating the achievement of stable, functional, and aesthetic implant-supported restorations.[2] Conventional socket preservation techniques commonly rely on bone substitutes such as allografts (from human donors), xenografts (typically bovine origin), and alloplasts (synthetic materials), which, although effective in providing a scaffold for new bone growth, present limitations including potential disease transmission, immunological reactions, slow or incomplete remodeling, variable bioactivity, and higher costs. In

contrast, autologous tooth-derived bone grafts (ATG) have emerged as an innovative and biologically favorable alternative, utilizing the patient's own extracted tooth processed into demineralized dentin matrix a material that closely resembles bone in both composition and structure.[3] Rich in type I collagen, hydroxyapatite, and intrinsic growth factors such as BMPs and TGF-β, the processed dentin matrix exhibits excellent biocompatibility, osteoconductive and osteoinductive properties, and supports predictable bone regeneration without immunogenic risk or donor site morbidity.[4] Clinically, ATGs have demonstrated significant new bone formation, effective maintenance of alveolar ridge dimensions, good healing with minimal inflammation, and bone quality comparable or superior to conventional grafts, while being gradually resorbed and replaced by vital bone within 3–6 months. By transforming extracted teeth once considered biological waste into a cost-effective, patient-derived graft material, autologous tooth-derived grafts not only overcome many limitations of traditional bone substitutes but also represent a sustainable, biocompatible, and patient-accepted solution in the evolving era of socket preservation.[5]

Review of Literature

Autologous tooth-derived bone grafts have gained considerable attention as an innovative and effective option for socket preservation, offering remarkable potential in promoting bone regeneration following tooth extraction. Derived from the patient's own extracted teeth, these grafts exhibit superior biocompatibility, osteoconductive, and osteoinductive properties, enabling them to maintain alveolar ridge architecture while supporting new bone formation. Numerous studies have demonstrated outcomes comparable to or even exceeding those achieved with conventional grafting materials. Histological and clinical evaluations have confirmed significant new bone formation, with Mahesh et al. (2025) and Cavellini et al. (2025) reporting successful bone regeneration and integration. In a notable multicenter study, Cavellini et al. (2025) documented an average of 41.56% new bone volume formation after five months in 34 socket preservation cases utilizing autologous tooth grafts, underscoring their regenerative efficacy.[6,7] Beyond biological performance, these grafts offer significant clinical and practical advantages. As highlighted by Prasanth et al. (2023), autologous tooth-derived grafts eliminate the need for donor site harvesting, thereby avoiding associated morbidity, surgical time, and costs.[8] Their composition dominated by mineralized dentin matrix closely mirrors that of natural bone, enhancing osteointegration and graft stability (Janjev et al., 2024). Despite these advantages, widespread adoption remains limited, as some clinicians continue to favor traditional graft materials with well-established protocols and long-term data. Nevertheless, as emerging evidence accumulates, the shift toward sustainable, patient-specific, and biologically optimized graft materials like autologous tooth-derived bone grafts represents a significant advancement in contemporary regenerative dentistry.[9] Continued research and well-designed clinical trials are essential to validate long-term outcomes and broaden their applicability across diverse clinical scenarios (Alrmali et al., 2023).[10]

Biological Basis and Composition of Tooth-Derived Autologous Bone Grafts

The biological foundation and composition of tooth-derived autologous bone grafts form the core of their effectiveness in alveolar ridge preservation and bone regeneration. The dentin component of the tooth exhibits remarkable structural and compositional similarity to natural bone, making it an ideal autologous graft material.[11] Approximately 70% of dentin consists of inorganic mineral content, primarily hydroxyapatite and calcium phosphate, which mirrors the mineral phase of both cortical and cancellous bone and provides essential rigidity and an osteoconductive scaffold for new bone deposition. The organic

matrix, accounting for about 20% of dentin, is predominantly composed of type I collagen the principal organic structural protein in bone which supports mineral crystal deposition and serves as a natural framework for cell adhesion, proliferation, and differentiation.[12] In addition to its mineral and collagen components, dentin contains a reservoir of bioactive molecules and growth factors such as bone morphogenetic proteins (BMPs), insulin-like growth factors (IGFs), and transforming growth factor-beta (TGF-β), all of which play crucial roles in osteoinduction by recruiting and differentiating progenitor cells into osteoblasts, thereby stimulating new bone formation. Dentin matrix proteins (DMPs), unique to dentin, further enhance osteogenic activity by regulating mineralization and mediating cellular signaling essential for bone remodeling and repair.[13] Although dentin is acellular compared to bone which contains osteoblasts, osteocytes, and osteoclasts their mineralized collagenous matrices are compositionally similar, with dentin's mineral density closely aligning with that of cortical bone. Upon demineralization and processing, the dentin matrix becomes exposed, revealing collagen fibrils and growth factors that significantly enhance its osteoinductive potential, much like demineralized freeze-dried bone allografts (DFDBA). This compositional and biological affinity between tooth dentin and bone explains why tooth-derived autologous grafts demonstrate both osteoconductive and osteoinductive properties, effectively supporting bone regeneration and remodeling in post-extraction sockets.[14]

Preparation and Processing of Autologous Tooth-Derived Bone Grafts

The preparation and processing of autologous tooth-derived bone grafts (ATG) for socket preservation follow a meticulous and standardized protocol designed to ensure biocompatibility, osteoinductive potential, and optimal graft characteristics. Tooth selection is a critical first step—non-carious, vital extracted teeth are preferred, while teeth with prior root canal treatment are generally excluded due to altered biological properties. Teeth extracted for orthodontic, periodontal, or impaction reasons, particularly third molars, can be used if structurally sound, with atraumatic extraction techniques favored to preserve the surrounding alveolar bone.[15] Once extracted, the tooth undergoes thorough cleaning and debridement, involving mechanical removal of soft tissue remnants, calculus, and periodontal ligament, followed by selective elimination of enamel and cementum since enamel contributes minimally to grafting potential and complete pulp tissue removal to prevent postoperative inflammation. The cleaned tooth is then processed through grinding and particle size optimization using specialized systems such as the Smart Dentin Grinder, Auto-Tooth System, or Tooth Transformer.[16] Typically operated at around 700 rpm for approximately 60 seconds, these devices generate particles within a standardized size range of 250 to 1200 µm, which provides an ideal surface area for cellular attachment and bone regeneration; sieving ensures uniform particle size distribution. The subsequent demineralization step, performed using 1 N lactic acid for about 15–20 minutes, partially removes the mineral phase, thereby exposing the collagen matrix and intrinsic growth factors such as BMPs that enhance osteoinductivity.[17] The particles are then thoroughly rinsed with sterile saline to eliminate acid residues. For sterilization, mineralized dentin particles (MDP) are often treated with solutions like 0.5 M NaOH combined with 20% ethanol and subsequently rinsed with phosphate-buffered saline before drying, which may involve lyophilization depending on the chosen system. The resulting graft material either demineralized dentin matrix (DDM), rich in exposed bioactive molecules for osteoinduction, or mineralized dentin particles (MDP), which provide a stable osteoconductive scaffold can then be immediately applied for socket preservation.[18] This streamlined, chairside preparation process harnesses the inherent biological and structural properties of tooth dentin to

create an autologous, cost-effective, and clinically effective grafting material that promotes predictable alveolar ridge preservation and bone regeneration following tooth extraction.[19]

Mechanisms of Bone Regeneration

Autologous tooth-derived bone grafts promote bone regeneration through a combination of biological mechanisms that closely replicate the natural processes of bone healing and remodeling. Acting first through osteoconduction, the processed tooth material whether mineralized or demineralized dentin matrix serves as a biocompatible scaffold composed of collagen and hydroxyapatite, facilitating cell attachment, migration, and proliferation while providing the structural framework necessary for new bone ingrowth from surrounding host tissue.[20] Osteoinduction further enhances regeneration as the demineralization process exposes and releases critical bioactive molecules such as bone morphogenetic proteins (BMPs), insulin-like growth factors (IGFs), and transforming growth factor-beta (TGF-β). These growth factors recruit mesenchymal stem cells from adjacent bone and soft tissue and induce their differentiation into osteoblasts, thereby initiating new bone formation and accelerating healing.[21] In some cases, osteogenesis also contributes to regeneration, as freshly processed grafts may retain viable odontoblast-derived cells capable of participating directly in bone formation, although the predominant mechanism remains the recruitment and activation of host osteoprogenitor cells by dentin-derived factors. Following placement, the graft integrates seamlessly into the recipient site through a process of remodeling, during which the dentin particles gradually resorb and are replaced by new, vital bone within approximately three to six months.[22] This dynamic process involves osteoclastic resorption of the graft material and concurrent osteoblastic deposition of new bone, ultimately resulting in a stable, well-vascularized alveolar ridge with minimal residual graft remnants. The harmonious interplay of osteoconduction, osteoinduction, and potential osteogenesis, combined with predictable graft integration and remodeling, underscores the regenerative success and clinical reliability of autologous tooth-derived grafts in socket preservation and alveolar bone regeneration.[23]

Clinical Applications of Autologous Tooth-Derived Bone Grafts

Autologous tooth-derived bone grafts have shown remarkable clinical efficacy in various aspects of alveolar bone regeneration, including socket preservation, sinus lift procedures, ridge augmentation, and the management of periodontal and peri-implant defects. In socket preservation, these grafts are placed immediately after tooth extraction to fill the socket and prevent post-extraction bone loss, effectively maintaining both vertical and horizontal ridge dimensions.[1,4] Numerous clinical studies have demonstrated that autologous tooth grafts significantly reduce buccal bone resorption and preserve ridge height and width while enhancing bone density within 3–4 months compared to ungrafted sockets.[24] When evaluated against xenografts and allografts, tooth-derived grafts produce comparable or even superior results in terms of bone quality, volume, and new bone formation, with minimal residual graft particles and high implant success rates, thereby eliminating the need for additional augmentation before implant placement. In sinus lift and ridge augmentation procedures, autologous tooth grafts, often combined with platelet-rich fibrin (PRF) or other biomaterials, have proven highly effective for bone regeneration in atrophic maxillae.[25] Their osteoconductive and osteoinductive properties facilitate rapid new bone formation, promote osseointegration, and ensure stable implant support even in sites with limited native bone height, contributing to predictable long-term rehabilitation outcomes. Similarly, in periodontal and peri-implant defect management, tooth-derived grafts have demonstrated significant regenerative potential when used

in guided tissue regeneration.[16] Their rich organic matrix and bioactive components enhance the regeneration of periodontal ligament, cementum, and alveolar bone, while providing a stable scaffold that supports cellular proliferation and tissue integration.[7] Clinically, their use has been associated with improved outcomes such as reduced probing depths, increased clinical attachment levels, and enhanced bone fill in both intrabony and furcation defects, as well as around compromised implants.[18]

Conclusion

Combining demineralized dentin matrix (DDM) with stem cells, platelet-rich fibrin (PRF), or bioactive peptides further amplifies regenerative capacity and healing outcomes. These advanced applications extend to regenerative endodontics and craniofacial reconstruction, marking a new frontier in personalized bone regeneration. Autologous tooth-derived bone grafts represent a paradigm shift in socket preservation by combining biological efficacy, cost-efficiency, and patient-centered sustainability. Continued research, standardized processing, and long-term trials are essential to solidify their position as the gold standard in alveolar ridge preservation and beyond.

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