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EXTRACTED TOOTH AS AN AUTOGENOUS BONE GRAFT MATERIAL IN DENTAL IMPLANTOLOGY AND PROSTHODONTICS: BIOLOGICAL BASIS, CLINICAL APPLICATIONS, AND FUTURE PERSPECTIVES

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ABSTRACT

Alveolar bone resorption following tooth extraction presents a major challenge in implant-supported prosthodontic rehabilitation. Ridge preservation and augmentation procedures are often required to establish adequate bone volume for implant placement and long-term prosthetic success. Traditional graft materials include autogenous bone, allografts, xenografts, and synthetic substitutes. However, limitations such as donor site morbidity, cost, risk of disease transmission, and variable resorption rates have prompted exploration of alternative biomaterials. The use of extracted teeth processed into autogenous graft material has emerged as a biologically rational and clinically promising strategy. Due to its compositional similarity to bone, dentin-derived graft material demonstrates osteoconductive, osteoinductive, and potentially osteogenic properties. This review provides an in-depth analysis of the biological rationale, processing methods, histological outcomes, clinical applications, advantages,

limitations, and future directions of extracted tooth-derived bone graft materials in implant dentistry and prosthodontics.

KEYWORDS: autogenous dentin graft, tooth-derived graft, bone regeneration, ridge preservation, implant dentistry, prosthodontics.

1. INTRODUCTION

The preservation and reconstruction of alveolar bone are fundamental prerequisites for predictable implant-supported prosthodontic rehabilitation. Following tooth extraction, physiologic remodeling results in significant horizontal and vertical bone loss, particularly within the first three to six months. Studies indicate up to 50% reduction in ridge width during early healing, potentially compromising implant placement and prosthetic outcomes.

To address these deficiencies, numerous grafting materials have been introduced, including:

- Autogenous bone (intraoral and extraoral sources)
- Allogenic bone substitutes
- Xenografts
- Synthetic alloplasts

Although autogenous bone remains the gold standard due to its osteogenic capacity, it requires a secondary donor site, increasing morbidity and operative time. Allografts and xenografts eliminate donor morbidity but introduce concerns regarding immunogenicity, disease transmission, cost, and slower remodeling.

Recently, the concept of recycling extracted teeth as autologous graft material has gained attention. Since dentin and bone share similar embryological origins and biochemical compositions, the extracted tooth represents a readily available autogenous biomaterial that may serve as an effective bone substitute.

2. Biological Basis for Using Extracted Teeth as Graft Material

2.1 Structural Similarity Between Dentin and Bone

Both alveolar bone and dentin originate from neural crest-derived ectomesenchyme. Their structural compositions are remarkably similar:

Component	Dentin	Bone
Inorganic phase	~65–70%	~60–70%
Organic matrix	~20%	~20–25%
Water	~10–15%	~10–15%

Component	Dentin	Bone
Major protein	Type I collagen	Type I collagen

The inorganic phase consists primarily of hydroxyapatite crystals. The organic matrix contains type I collagen and non-collagenous proteins such as osteocalcin, osteonectin, dentin sialophosphoprotein (DSPP), and dentin matrix protein-1 (DMP-1).

This compositional similarity underpins the rationale for dentin's application as a bone substitute.

2.2 Growth Factors Embedded in Dentin Matrix

Dentin contains numerous bioactive molecules sequestered within its mineralized matrix, including:

- Bone morphogenetic proteins (BMP-2, BMP-7)
- Transforming growth factor-beta (TGF-β)
- Insulin-like growth factors (IGF-I, IGF-II)
- Fibroblast growth factors (FGF)

Demineralization exposes these growth factors, enhancing osteoinductive capacity. Experimental studies have demonstrated that demineralized dentin matrix (DDM) stimulates mesenchymal stem cell differentiation into osteoblast-like cells.

2.3 Mechanisms of Bone Regeneration

Osteoconduction

Tooth-derived particulate provides a scaffold allowing vascular infiltration and osteoblast migration.

Osteoinduction

Demineralized dentin releases growth factors that recruit progenitor cells and induce osteoblastic differentiation.

Osteogenesis

Although dentin itself lacks living osteogenic cells, its matrix proteins promote bone formation through cellular signaling pathways.

3. Processing Protocols of Extracted Teeth

3.1 Case Selection

Not all extracted teeth are suitable for graft preparation. Contraindications include:

- Extensive root canal filling materials containing toxic components
- Large amalgam restorations
- Severe periapical pathology (relative contraindication)
- Vertical root fractures with contamination

Teeth with caries and restorations may still be processed after removal of contaminated structures.

3.2 Processing Steps

Step 1: Cleaning

Removal of calculus, periodontal ligament remnants, caries, enamel, restorations, and pulp tissue.

Step 2: Grinding

Teeth are crushed into particulate sizes typically between 300–1200 μm. Optimal size improves revascularization and remodeling.

Step 3: Demineralization

Partial demineralization using hydrochloric acid or EDTA exposes collagen and growth factors.

Step 4: Sterilization

Chemical disinfection and sterile saline rinsing are performed. Some systems utilize ultrasonic cleaning and UV sterilization.

4. Forms of Tooth-Derived Grafts

1. **Particulate Dentin Graft**
   - Used in extraction sockets and minor ridge augmentation.
2. **Demineralized Dentin Matrix (DDM)**
   - Enhanced osteoinductivity.
3. **Tooth-Derived Block Graft**
   - Used in vertical ridge augmentation.
4. **Tooth Ash (Calcined Tooth)**
   - High mineral content; limited osteoinductivity.

5. Clinical Applications in Implant Prosthodontics

5.1 Ridge Preservation

Socket grafting with tooth-derived particulate reduces ridge collapse and maintains bone volume prior to delayed implant placement.

Clinical outcomes:

- Reduced horizontal resorption
- Improved ridge contour
- Enhanced implant positioning

5.2 Horizontal Ridge Augmentation

Used in cases of narrow ridges (<5 mm width). Combined with barrier membranes, dentin grafts promote significant width gain.

5.3 Vertical Ridge Augmentation

Tooth block grafts can be secured with titanium screws for vertical reconstruction. Studies report promising integration with minimal resorption.

5.4 Sinus Floor Elevation

Tooth-derived graft material has been successfully applied in lateral window and transcrestal sinus augmentation procedures, demonstrating comparable new bone formation to xenografts.

5.5 Peri-implant Defects

Used to treat dehiscence and fenestration defects around implants, supporting bone fill and stability.

6. Histological and Radiographic Findings

Histological evaluation typically shows:

- New woven bone formation within 4–8 weeks
- Progressive maturation into lamellar bone
- Partial resorption of dentin particles
- Direct contact between new bone and graft particles

Radiographically:

- Gradual increase in radiopacity
- Maintenance of ridge dimensions
- Successful osseointegration

7. Advantages Over Conventional Grafts

- Completely autogenous
- No disease transmission risk
- No second surgical donor site

- Lower cost
- Environmentally sustainable (biological recycling)
- High patient acceptance

8. Limitations and Concerns

- Lack of long-term (>10 years) data
- Technique sensitivity
- Standardization challenges
- Potential contamination risk if improperly processed
- Limited availability in edentulous patients

9. Comparison with Other Grafting Materials

Parameter	Autogenous Bone	Xenograft	Alloplast	Tooth-Derived Graft
Osteogenic	Yes	No	No	Indirect
Osteoinductive	Yes	Limited	No	Yes
Donor Morbidity	Yes	No	No	No
Disease Risk	No	Minimal	No	No
Cost	High	Moderate	Moderate	Low

10. Prosthodontic Implications

Adequate bone volume influences:

- Implant positioning
- Emergence profile
- Prosthetic contour
- Esthetic outcomes
- Long-term stability

By preserving ridge architecture, tooth-derived grafts directly contribute to improved prosthodontic predictability.

11. Current Evidence and Clinical Studies

Clinical trials and case series report:

- Implant survival rates comparable to conventional grafts
- Favorable histomorphometric bone formation
- Minimal inflammatory response
- Stable marginal bone levels

However, most studies are short- to medium-term.

12. Future Perspectives

- Standardized global protocols
- Integration with platelet concentrates (PRF)
- Nanotechnology-based modifications
- Combination with stem cell therapy
- Long-term randomized controlled trials

13. CONCLUSION

Extracted tooth-derived bone graft material represents a biologically sound, clinically effective, and economically advantageous alternative for alveolar bone regeneration in implant dentistry and prosthodontics. While promising results have been reported, further high-quality long-term clinical trials are necessary to establish standardized protocols and confirm durability of outcomes.

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