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Retention Alternatives in Maxillofacial Prosthodontics: Adhesives, Prosthesis Design, and New Attachment Systems

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Abstract

Retention of maxillofacial prostheses is a critical factor influencing functional stability, esthetics, patient comfort, and overall quality of life. The success of a prosthesis depends on proper fit, material properties, and the method of retention, ensuring stability during speech, mastication, and facial expressions. Retention strategies are broadly categorized into adhesives, prosthesis design modifications, and attachment systems. Adhesive systems—including acrylic, silicone, and rubber-based formulations—provide non-invasive retention but may require frequent reapplication. Prosthesis design modifications exploit anatomical undercuts, extensions, or accessories for mechanical retention, suitable for patients unable to undergo surgery. Attachment systems—including bar-and-clip mechanisms, magnetic attachments, and ball/O-ring systems—offer robust and predictable retention, particularly for large or complex defects, although they require surgical intervention. This review critically evaluates each retention modality, emphasizing clinical applications, advantages, limitations, and future trends. Comparative tables highlight practical considerations, enabling clinicians to select optimal retention strategies tailored to individual patients. Hybrid approaches combining adhesives with implants, advanced biomaterials, and digital prosthetic design offer promising avenues for improving long-term outcomes.

Keywords: Maxillofacial prosthodontics; Prosthesis retention; Adhesive retention systems; Prosthesis design modification; Attachment systems; Bar-and-clip attachments; Magnetic attachments; Ball and O-ring attachments; Implant-retained prostheses; Facial prostheses; Mechanical retention; Esthetics and function; Patient comfort; Digital prosthetic design; Hybrid retention approaches.

Introduction

Maxillofacial prosthodontics is a specialized branch of prosthodontics focused on rehabilitating patients with congenital or acquired craniofacial defects resulting from trauma, tumor resection, or surgical interventions. These defects can cause functional impairments, including difficulties in speech, mastication, swallowing, and facial expressions, as well as profound psychosocial impacts affecting self-esteem, social integration, and overall quality of life.[1–3]

Successful rehabilitation depends not only on esthetic reconstruction but also on functional stability of the prosthesis. Among the critical determinants of success, retention is central. Retention refers to the ability of a prosthesis to remain securely in place during normal functional activities without displacement. Achieving optimal retention is challenging due to anatomical variability, soft-tissue mobility, irregular defect morphology, and the absence of supportive structures.[4,5]

Retention strategies are broadly classified into adhesive systems, prosthesis design modifications, and attachment systems. Adhesives provide non-invasive retention, prosthesis design modifications exploit anatomical undercuts, and implant-based attachment systems offer robust stability.[6–8] Selection of retention method depends on defect size, tissue quality, patient dexterity, esthetic demands, cost, and overall health. This review provides a comprehensive analysis of retention alternatives, their clinical applications, and emerging trends.

2. Adhesive System

Adhesives provide non-invasive retention by forming a temporary bond between the prosthesis and underlying tissues. They are particularly useful for patients unable to undergo surgery or with small to moderate defects.

2.1 Properties of Ideal Adhesives

- Biocompatible and non-irritating

- Moisture-resistant for functional activities
- Easy to apply and remove
- Durable with sufficient retention under functional stress[9,10]

2.2 Types of Adhesives

Several types of adhesives are used in maxillofacial prosthetics:

- Acrylic-resin adhesives: Composed of an acrylic resin solvent, providing strong and durable adhesion. Surface preparation is essential for optimal bonding.
- Silicone-based adhesives (RTV): Flexible and moisture-resistant, suitable for repeated applications but can be costly and require frequent re-application.
- Rubber-based adhesives: Made from natural rubber in an organic solvent; easy to use but less durable and may cause skin irritation.
- Pressure-sensitive tapes: Applied on both surfaces; simple but weaker under functional stress.

Mechanical testing has shown variation in adhesive bond strength among products. For example, one study demonstrated that Dow Corning 355 adhesive had significantly higher bond strength in tensile and torsion tests compared to other adhesives.[11] Another study found acrylic emulsion adhesives to offer improved skin compatibility compared to solvent-based formulations.[16]

Advantages: Non-invasive, easy to remove, minimal surgical morbidity.

Limitations: Reduced retention during functional activity, frequent reapplication, skin irritation/allergic reaction, and gradual degradation of adhered prostheses (typically retained ≤7–12 months).[7,18,23]

3. Prosthesis Design Modification

Mechanical design enhancements improve retention by utilizing anatomical undercuts, extensions, or accessories, without requiring surgery.

3.1 Design Strategies

- Undercut engagement: Uses soft-tissue or bony undercuts to mechanically engage the prosthesis; limited by tissue quality and defect size.
- Extension into anatomic structures: For example, auricular prostheses may extend into the auditory canal, offering additional support but potentially impacting hearing.
- Integration with external structures: Prostheses attached to eyeglass frames or spectacle arms provide discreet support but depend on proper fit.
- Tissue-adaptive contours: Custom shaping of the prosthesis improves adaptation and reduces displacement; requires precise impression or scanning techniques.

These approaches provide intermediate solutions for patients unable or unwilling to undergo implants. Success depends on defect morphology, tissue mobility, patient dexterity, and periodic re-lining.

4. Attachment Systems

Implant-based systems provide superior retention for large or complex defects and are often considered the "gold standard" when feasible.

4.1 Types of Attachment Systems

- Bar-and-clip systems: Implant-supported bars offer high retention and durability; ideal for large defects. Complex fabrication and maintenance required.[19]
- Magnetic attachments: Magnets embedded in the implant abutment and prosthesis facilitate easy placement/removal. Retention is lower under heavy functional loads.[15]
- Ball or O-ring attachments: Simple, cost-effective, and removable; suitable for small to moderate defects. Stability may be limited for extensive defects.
- Stud attachments: Compact and easy to use; appropriate for smaller or simpler defects.

Clinical evidence shows improved quality of life and patient satisfaction with implant-retained prostheses. Prospective and retrospective studies

report significant increases in satisfaction post-treatment.[1]

Advantages: Robust mechanical retention, predictable stability, improved longevity, patient confidence.

Limitations: Surgical placement required, higher costs, maintenance needs, potential peri-implant complications.[4]

Hybrid systems, combining adhesives or design modifications with implants, are increasingly explored for complex or partially supported defects.

5. Discussion: Comparative Analysis of Retention Methods

Adhesives: Suitable for small to moderate defects, temporary retention, non-invasive, easy to use, inexpensive; limitations include frequent reapplication and skin irritation.

Prosthesis design modifications: Use existing anatomy for mechanical retention; effective for defects with anatomical support; avoids surgery. Limited by defect size and tissue mobility.

Bar-and-clip systems: Excellent for large/complex defects; provide functional stability; require surgical placement and higher cost.

Magnetic attachments: Moderate defect use; easy placement/removal; patient-friendly; lower retention under stress.

Ball/O-ring attachments: Small to moderate implant-supported defects; simple and cost-effective; less stable for large defects.

Hybrid systems: Optimal for complex defects; combine adhesives with implants; superior stability but require patient compliance and complex fabrication.

Clinical decision considerations:

- Small defect, limited dexterity, surgical contraindication → adhesives or design modifications.
- Moderate defect, good anatomy, implant refusal → design modifications (± adhesives).
- Large defect, good health, willing for surgery → implant-based systems.
- Mixed conditions → hybrid systems and digital workflows.

Practical points: Patient education, prosthesis maintenance, digital workflows (CAD/CAM, 3D scanning/printing), cost-benefit analysis, tissue quality assessment.[2,3,9]

6. Future Perspectives

- Hybrid retention systems: Combine adhesives with implants for partially supported defects.
- Digital workflow: CAD/CAM, 3D printing for improved fit, reduced chair-time, predictable retention.[2,3,9]
- Advanced biomaterials: Biocompatible adhesives with improved bond strength and moisture resistance.[16]
- Patient-specific solutions: Custom implants, tailored prosthesis design considering defect morphology and lifestyle.
- Long-term outcome studies: Comparative trials on retention modalities, survival rates, QoL metrics, cost-effectiveness.[19]
- Emerging technologies: Smart materials, magnetically controlled retention, augmented reality for planning.

7. Conclusion

Retention is central to successful maxillofacial prosthetic rehabilitation. Adhesives provide solutions for small defects, prosthesis design modifications exploit anatomy for mechanical retention, and implant-based attachment systems offer robust retention for complex defects. Clinicians must evaluate each patient individually, considering functional needs, esthetic demands, tissue conditions, systemic health, cost, and patient preference. Combining multiple retention strategies with advancements in biomaterials and digital prosthetic design can improve functional outcomes, esthetics, and patient satisfaction.

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