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# Retention in maxillofacial prosthetics: A review

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**Abstract**
The facial region defects caused by trauma, accident, tumour or congenital defects are treated with maxillofacial prostheses. A part from esthetics, the most common problem encountered with these prostheses is the retention of prostheses. Recent techniques along with newer materials, treatment options, and its application are described. The success of maxillofacial prostheses in meeting the expectations of patients and prosthodontists is on rise with the development of adhesive material science, the emergence of technical knowledge, and the development of implant technology. Increase in retention provides ease of use and psychological acceptance by the patient thereby improving the long-term prognosis of the prosthesis. In the present article review, the methods used for the retention of prostheses from past to present along with the advantages of adhesives and implants, implementation of 3D technology and rapid prototyping were critically appraised.

**Keywords:** maxillofacial prosthesis, adhesives, retention, implants, rapid prototyping, 3D technology

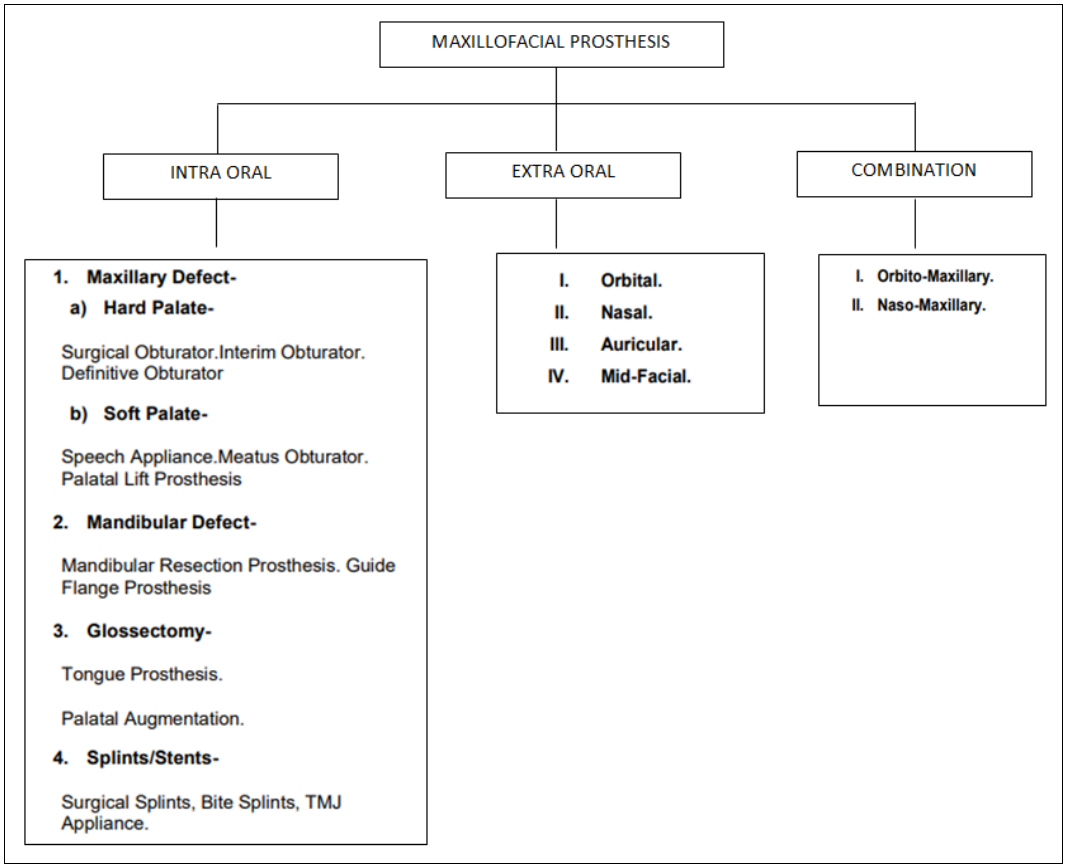
## Introduction
Face forms the physical basis for personal recognition. As the father of Indian surgery Sushrutha Samhitha said hundreds of years ago, “the love of face is next only to the love of our life and thus the mutilated cry for help.” Hence ours is appearance conscious society. Any defect whether acquired or congenital defects may affect patients’ speech, mastication, quality of life, psychology, and social behaviour [1]. Prosthodontist in particular has a major role in maxillofacial prosthetics because of his knowledge of anatomy, physiology and pathology. However, the Prosthodontist is limited by inadequate materials available for facial restorations, movable tissue beds, difficulty in retaining large prosthesis, and the patient’s capability to accept the final result [3].

The primary aim in rehabilitating the maxillofacial defect patients are to restore the function of mastication, deglutition, speech, and to achieve normal orofacial appearance. Reconstruction of facial defects can be done either surgically or prosthetically or combination of both depending on the site, size, etiology, severity, age and the expectation of the patient. When surgical is not possible or failure of the alloplastic or autogenous graft occurs, maxillofacial or craniofacial prosthesis becomes an alternative method. Maxillofacial prosthetics defined by the current Glossary of Prosthodontic Terms - “as the branch of Prosthodontics concerned with the restoration and/or replacement of the stomatognathic (jaws) and craniofacial (facial) structures with prostheses that may or may not be removed on a regular or elective basis” [1]. Historically maxillofacial prosthesis was defined as the restoration of hard and soft tissues of the stomatognathic system and surrounding maxillofacial structures that are lost or missing due to congenital anomalies or acquired defects. More recently, the term that is closely associated with intraoral and adjacent structures [6]. Historically, the first facial prosthesis according to official records was by French surgeon Ambroise Pare. Developments in facial dentures were accelerated during World War I. Until the 1930s, the most widely used vulcanite was replaced with plastic, methyl methacrylate, glass, and silica [21]. With the advent of silicone for the facial prostheses in 1946, the success of prosthetics has increased both in terms of aesthetics and function.

Large facial defects are difficult to restore prosthetically due to lack of anatomic undercuts, limited means of retention, mobility of soft tissues, and weight of prosthesis [4]. Retention has always been a problem in maxillofacial prosthodontics. Increased retention improves comfort as well as the confidence in the patient [2]. Various methods of auxiliary retention include eyeglasses, magnets, adhesives, and implants and combinations of the above. Advances in techniques used for retention of maxillofacial prosthesis and the materials used have been remarkable in the past several years [2].

Over the last two decades, Osseo integrated implants have been used to improve the hold and retention of facial prosthesis. Implants have been employed for retention in the intra or extraoral craniofacial regions. Different systems available with implants are 1) bar and clip system, 2) magnets, 3) mushroom and ball retention system [8, 20].

**Classification**




**Intra oral prosthesis**

**Obturators:** A prosthesis that fits into and closes a defect within the oral cavity or other body defect. Obturators can be for both congenital and acquired defects. For congenital defects simple plate type prosthesis to aid in feeding, or palatal lift prosthesis or an overlay obturator can be fabricated. For acquired defects surgical, interim or definitive obturators are fabricated. The different type of intraoral prosthesis include:

1. Obturators for defects involving hard palate
   - **Surgical obturator:** A surgical obturator is one that is fabricated prior to resection of the maxilla.
   - **Definitive obturator:** After the interim obturator has been worn for 6-12 weeks the definitive obturator is fabricated.
   - **Obturators for defects involving soft palate:** Speech aid prosthesis/Pharyngeal obturator/Speech bulb prosthesis: Palatopharyngeal insufficiency is a condition where there is lack of effective closure between the soft palate and one or more of the pharyngeal walls during swallowing or speech sounds. Speech bulb prosthesis is an ideal choice for these defects
   - **Meatus obturator:** The meatus obturator was first described by Schalit in 1946. It only provides static obturation and is not dependent on surrounding muscle activity to provide physiologic separation between the oral and nasal structures. In cleft palate rehabilitation, obturation of the defect results in only partial improvement of speech. In cleft palate rehabilitation, obturation of the defect results in only partial improvement of speech.
   - **Palatal lift prosthesis:** The palatal lift prosthesis (PLP) is used to improve soft palate dysfunction. For dentulous patients, the palatal section of the PLP is securely retained by the teeth while the palatopharyngeal section physically raises the soft palate. A PLP for the edentulous patient, therefore, must include a movable palatopharyngeal section
2. Prostheses for mandibular continuity defects
   - Mandibular resection prosthesis
   - Guide flange prosthesis
3. Prostheses for total/partial glossectomy
   - Tongue prosthesis
   - Palatal augmentation prosthesis
4. Splints and Stents: Surgical & bite splints - for stabilizing the bite.
5. TMJ appliance: Appliances that help in relieving TMJ trismus and increase mouth opening. These appliances

are basically "Jaw exercisers."
6. Radiation stents: Basically anti-radiation stents that protect areas other than the operated site from harmful gamma radiation [24].

**Modes of retention**

**a. Intra oral**

**1. Anatomical [2]**

Intraoral retention includes the use of both hard and soft tissues-teeth and mucosal and bony tissues. Undercuts in palatal area, cheek, retromolar, labial, septal, posterior nasal pharyngeal or anterior nasal spine areas. Additional aids to anatomic retention include proper occlusion, proper post dam, and surface adhesion.

Extra-oral retention necessitates the use of both hard and soft tissues of the head and neck area.

**2. Mechanical**

- **Eyeglass:** Is a possible means of retaining a nasal, ear, eye prosthesis by utilizing newly designed eyeglass frames for the patients. The eyeglass frame should be opaque in colour rather than translucent to prevent retention marks from becoming visible.
- **Magnets:** Presented a technique for the implantation of magnets in the jaw to enhance retention of the prosthesis. Especially useful in maxillectomy patients and in microstomia patients. E.g. neodymium iron boron (Nd-Fe-B) [9, 10]. They are considered to be the best possible source to obtain retention stabilization and maintenance for the maxillofacial prosthesis.
- **Cast clasps:** The most common method for retaining an intraoral prosthesis uses a cast metal clasp which enters an undercut. The properly designed and fabricated clasp will provide stability, splinting, bilateral bracing, and reciprocation, as well as retention. Retainers are probably the most important components contributing to the success of the obturator prosthesis.it helps in favourable load distribution and also help in retention of prosthesis [10].
- **Acrylic buttons:** Acrylic buttons retained facial prostheses usually have an acrylic substructure that fits into the defect and one or more mushroom - shaped acrylic projections (buttons) attached to the substructure. The final prosthesis is fabricated so that it will snap over the mushroom buttons for retention.
- Retentive clips [2] are metallic or plastic clips that snap over the bar used as a superstructure connected to the implants. Retentive clips have more retentive ability in terms of breakaway retentive force than magnets.
- **Precision Attachment:** [9] Bar clips, telescopic crown, extra-coronal ball attachment are most commonly used precision attachment.

**3. Adhesives**

Ideal requirements for Adhesive in maxillo facial prosthesis [9]:

1. It should have good bond to the facial skin and prosthesis.
2. Biocompatibility of the adhesive.
3. Material used in fabrication of prosthesis.
4. Components of the adhesive.
5. Texture of patient's skin.
6. Ease of handling of the adhesive by patient.

**Composition**

E.g. sodium carboxyl methyl cellulose, karaya gum, tragacanth, polyethylene oxide, flavouring agents, antimicrobial agents.

Various materials include acrylic resin, latex, silicone, pressure sensitive tapes, spirit gum, water-based adhesives. Acrylic resin adhesives are soluble in water and gain elasticity when water evaporates [21]. The MDX silicone material has greater edge strength than other silicone materials and its further reinforcement with nylon mesh provides it adequate edge strength facilitating its use in thinner areas which are responsible for blending with the adjacent skin.

**Advantages:** Cost-effectiveness, non-invasiveness, and lack of aggressive side effects.

Disadvantages: It can damage both the prosthesis surface and the skin during insertion and removal, can cause contact dermatitis, can alter the colour of prosthesis, Adhesives can disrupt the prosthesis structure and abrade [9, 21].

**4. Implants**

Endosseous implants may be used as an alternative anchorage system for the diminished retention, stability and support and can be used in edentulous and partially edentulous jaw and can be used for congenital, developmental, traumatic defect [10].

**b. Extra oral**

- Anatomical: Anatomic undercuts may be utilized
- Implants in maxillofacial prosthodontics
- Computed tomography (CT) scans or other radiographic evaluations of bone mass are important. CT scan records can be analysed and used in the planning of an implant. Implant planning software allows for the assessment of bone volume and density [21].
- Asar *et al*. interpreted the classification of the bone regions in which the facial implants made by Jensen and his colleagues could be placed as follows.
  - **ALFA sites:** In these sites amount of bone available is more ranging from 6mm or greater. Bone can withstand greater loads and regular fixtures. These may be used to retain complex facial prosthesis or dental prosthesis. The anterior aspect of maxillary, zygomatic arch, and zygoma are examples [1, 21].
  - **BETA sites:** These are found in the periorbital but also in the temporal, zygomatic, and anterior nasal fossa locations. In 4-5 mm bone volumes, 4 mm craniofacial implants can be used [1, 21].
  - **DELTA sites:** Include the buttress, pyriform, zygomatic arch, medial orbit, temporal and frontal bones, and zygomatico frontal process. The margin areas are 3 mm or less in bone mass. They require the use of craniofacial implants of 3 mm or less [1, 21].

**Biomechanical considerations of implants in maxillofacial prosthesis**

a) Design of craniofacial and intraoral implant
b) Integration at bone-implant interface
c) Stress Transfer from implants to bone
d) Designing of implant screw
e) Load distribution
f) Implant stiffness, implant shape, implant surface
g) Implant stability and Osseo-integration: Measured by periotest and RFA

**Surgical implant procedure in maxillofacial prosthetics**

Implant placement procedures are of 2 types. They are

1) Single stage procedure and
2) Two stage procedure

In single stage surgical procedure, recovery screws are placed and the incision is closed in wire sutures followed by dressing with ointment soaked with gauze to protect the skin [11].

Two surgical procedures are carried out in two stage procedure. First surgery deals with the implant placement into the planned location of craniofacial defect. After sufficient healing period and osseo-integration second stage surgery is carried out [17].

**Implant retained auricular prosthesis**

**Position of implants:** Implants can also be placed in the mastoid area 15mm apart keeping a distance of 20 mm from auditory canal opening. Usually 2 implants are placed.

**Other retentive mechanisms:** Used are bar and clip, ball clips and magnetic retentive cap systems [11].

Healing period is usually 3-4 months.

**Implant retained eye prosthesis**

**Mode of retension:** Adhesive, Straps, Spectacle frames and Implants.

Anatomic undercuts must be utilized in conjunction with flexible conformer in the defective space [12]. Conformer will fit into the socket and holds the prosthesis, maintaining the size of socket. Prevents scar tissue contractures from distorting the socket bed and also maintains competence of the eyelids and residual muscle movement.

**Position of implants:** Implant can also be placed in outer canthus or inner canthus and superior orbital rim. Additional implant or two was often placed in the inferior orbital rim or zygoma [13]. The implant should not be angled facially [14]. Length of the implant is usually 3-4 mm and there 10 - 12 mm space between the implants to allow access for hygiene. The most commonly used retentive mechanisms with implants are magnets [16].

Healing period is usually 6-8 months.

Type of implants used in orbital prosthesis are:

Non-integrated (e.g.: - PMMA and Silicone implants)

Semi integrated (Allen implants)

Integrated (Cutler's implants) implants

Bio integrated (Hydroxyapatite, structures with or without integration porus polyethylene, with the prosthesis Aluminium oxide)

Biogenic implants (Dermis-fat graft the prosthesis Cancellous bone) [15].

**Implant retained nasal prosthesis**

**Mode of retension:** Adhesive, straps, spectacle frames and implants [16].

**Implant position:** Implant are placed are floor of the nose, piriform ridge or inferior orbital foramen and also in glabella. Usually 4 mm or longer fixtures are used g [14]. 7-10 mm is used in case of supporting both intraoral and extraoral prosthesis. Such implants are called bifunctional implants as they support oral prosthesis both on intraoral and extraoral prosthesis at the other end [14].

Healing period is 6-8 months.

Other retentive mechanisms used are mini magnets (mostly) and rarely by bar and clip [16].

**Implants in irradiated patients**

Individuals with diabetes mellitus, osteoporosis and especially irradiated patients are relatively contraindicated for implant placement.

In order to reduce risk reduction by trauma on the irradiated tissue. It is advised to wait for a period of 6 months to 1.5 year after radiation therapy [18]. According to literature hyperbaric oxygen therapy can improve the implant success rate by 38% [19].

**Survival rate and complications of extra oral implant placement**

From several studies conducted it is found that the implant survival rate is high for auricular prosthesis followed by nasal and orbital areas, the most common complication seen is peri-implantitis which is related to hygiene maintenance around the implant site [13, 20].

**Recent advances in mailofacial prosthetics**

**1. Rapid prototyping**

In 2003, Wolfaardt *et al*. [15] suggested rapid prototyping as an adjunctive tool in digitally designing maxillofacial prosthesis in head and neck construction [23].

- In nasal prosthesis: In case of rhinectomy nasal defects, fabrication of nasal prosthesis should not be just for cosmetic purpose, but should be functional. With the use of intra anatomy airway replication design, the prosthesis and its sub-dermal prosthesis structure re-direct the air flow to a normal pattern thereby

  Advantages:
  - Reducing chances of displacement of prosthesis in movements which may occur as in coughing or sneezing
  - Maintain the cosmetic prosthesis
  - Maintains voice resonance
  - Intra anatomy designs maintain the sub-dermal section of the prosthesis.
- In calvarian reconstruction: Earlier used materials for reconstruction are commonly used for cranioplasty reconstruction is tantalum, titanium, stainless steel (austenite), vitallium. There are a number of disadvantages associated with metal cranial implants like their high thermal conductivity which may precipitate headache and other neurological symptoms, infection, less biocompatible and difficult to interpret radiologically. Heat polymerized polymethyl – methacrylate are widely used in cranioplasty with no complications like infection. Only drawback with this is the radiolucency and it becomes difficult to locate it radiographically in case of fracture. A newer implantable material, high-density porous polyethylene (HDPE) which is available in various shapes and forms is found to be an excellent alternative to existing methods of calvarial reconstruction. These HDPE hemispheres are used to recontour the natural shape of the skull [24].

One of the latest innovations in the field of rapid prototyping is the Infinite Technologies Orthotics and Prosthetic 3D scanner which is used currently in fabrication of cranial helmets, smaller paediatric devices such as a prosthetic finger, foot orthotics, and small componentry used to put together the helmet. Every effort should be made to prevent scarring or contracture of scar that may impact on person's self-perception and well-being. The formation of these scars can be reduced by fabricating burn mask.

**2. Laser scanning, computer-aided design/computer-aided manufacturing**

It is a faster technique to manufacture provisional prosthesis can be digitally designed and fabricated

- Restores the esthetics of patients
- Adds comfort to the patients
- Affordable cost and simple technique

**3. Three-dimensional printing along with digital scan**

**In ocular prosthesis**

Recent advances in digital technique like 3dMD face™ system (3dMD, Atlanta, GA). In this technique, impression is taken without contacting the impression surface in a 3-d pattern, so there is less discomfort to the patient and without distorting the soft tissue as occurs in conventional impression material [23].

- It creates more life-like facial prosthetics that gives more accurate fit,
- Used In burn patients and in acid attack patients.
- Affordable cost and simple technique

Much research has to be carried out in the field of tissue engineering for the regeneration of new tissue, which may have impact in orofacial reconstruction in the future.

## Discussion

In a large number of studies point to some new techniques for the treatment of congenital and acquired orofacial defects. Recent studies identified several areas for further investigation into mode of retention in maxillofacial prostheses and their management. Also, there are studies suggesting the role of implants in intraoral and especially extra-oral prosthesis. Ferreira foresaw the development of new prostheses that substitute for bone tissue without requiring bone grafts, thus reducing the morbidity and the recovering time, as a possible future approach in maxillofacial reconstruction. According to Ferreira, these new prostheses should be produced using engineering, computer-aided design and manufacturing (CAD-CAM), Rapid Prototyping Technique, lasers and surgical guides. Several steps in the fabrication of maxillofacial prostheses still depend on artistic skill and time of prosthodontist. Modern techniques for ocular, auricular, nasal prosthesis fabrication, such as 3D printing and digital imaging, are able to reduce the treatment time, better replicate the patient characteristics, eliminate taking facial impressions, and reduce the complexity of wax pattern sculpting. [22] However, modern techniques still need improvements, along with reduced cost and wider availability, to lead to a promising future for maxillofacial reconstructions.

## Conclusion

Maxillofacial prosthesis is a challenging field of dentistry. This field involves in the restoration of several types of oro-facial defects along with patient's quality of life. The current situation is promising, and there are positive expectations for the future.

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