

Craniofacial Implant: An Retentive Aids in Maxillofacial Prosthesis

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Abstract: "It is the God given right of every human being to appear human" Facial disfigurement can be the result of a congenital anomaly or any pathological condition. One defect due to pathological or congenital causes is one of the most challenging areas of oral and maxillofacial reconstruction. The main purpose of reconstructive efforts is to protect and improve patient quality of life by trying to restore normal form and function. Craniofacial prostheses, also known as EPISTHESES, are artificial substitutes for facial defects. There are various retentive aids for maxillofacial prosthesis. Implant is retentive aids has various advantages. This review article describes craniofacial implant, criteria and principle for success of implant, coupling of implant and prosthesis, biomechanical consideration and extraoral implant system.

Keywords: Extraoral Implant, Maxillofacial Prosthesis Retentive Feature, Extra Oral Implant System

1. Introduction

Maxillofacial prosthetics is defined as that branch of Prosthodontics concerned with the restoration, replacement, of both of stomagnathic and associated facial structure by artificial substitutes that may or may not be removed. It encompasses prosthetic rehabilitation of patients with oral, paraoral, or facial defects, which may be naturally acquired (developmental or congenital) or resulting from disease or trauma.¹

Facial disfigurement can be the result of a congenital anomaly caused by malformation and developmental disturbances, or acquired, caused by pathologies such as necrotizing diseases and oncosurgeries or secondary to trauma or tumour surgery or a result from a disease process and or its treatment. Maxillofacial deformities are embarrassing to patients and may negatively affect their physical and psychological health, potentially resulting in serious psychiatric, familial, and social problems.² Rehabilitation of such defect is a complex process. Fabrication of a successful maxillofacial prosthesis is often a significant challenge. Therefore team effort is essential for the effective and efficient treatment of patients with maxillofacial problems. With the coordinated, team effort; the maxillofacial defect can be restored close to reality in function and appearance in many cases. The Dentist in general and Prosthodontist in particular has a major role in maxillofacial prosthetics because of his knowledge of anatomy, physiology and pathology as well as his skill and experience in using materials that are compatible with the patients remaining tissues.

Scope of Maxillofacial Prosthetics

The most important objectives of maxillofacial prosthetics and rehabilitation include ³:

- 1) Restoration of esthetics or cosmetic the patient's disease.
- 2) Restoration of function.
- 3) Protection of tissues
- 4) Therapeutic or healing effect.
- 5) Psychological therapy

Three factors are necessary in evolving a successful prosthetic replacement (Rahn & Boucher, 1970) ⁴

- i. Creative ability
- ii. Technical
- iii. Knowledge
- iv. Materials

Classification of Maxillofacial Prostheses⁵:

Craniofacial prostheses, also known as EPISTHESES, are artificial substitutes for facial defects. In general, maxillofacial prostheses can be classified as restorative or complementary. Restorative prostheses substitute for bone loss or repair deformities of facial contour. They can be located internally within the tissue or externally as oral, ocular, or facial prostheses. Complementary prostheses help with plastic surgery, in the pre-, trans-, or postoperative period, or in radiotherapy sessions. Facial prostheses can be retained by several methods.

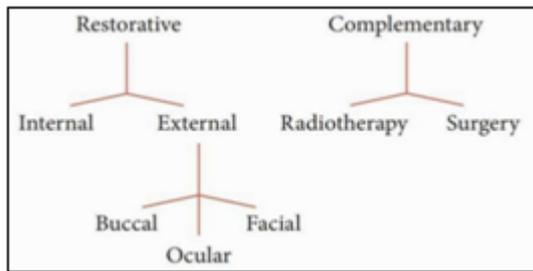


Figure 1: Representative scheme of the classification of maxillofacial prostheses

Methods of Retention used for maxillofacial prostheses fall into four categories ⁶:

- 1) Anatomical, in which the retentive contours existing at the site of deformity are used to retain the prosthesis. e.g. extra-oral and intra-oral
- 2) Chemical, in which adhesive materials are used to retain the prosthesis. e.g. Adhesive, Silicon adhesive, Pressure sensitive tapes, Rubber based liquid, Combination of adhesive
- 3) Mechanical. e.g. Eye glasses and frame, Extensive from denture, Precision attachment. Elastic and non elastic strayses, Magnets
- 4) Surgical anchorage e.g. using surgically created retention elements
- 5) Implant, in which implant fixtures anchored into the bone are used to retain the facial prosthesis.

Extraoral Implants

Following the discovery of the osseointegration of titanium in the 1950s, dental implants have been made of titanium in the 1960s. In 1977, the first extraoral titanium implant was inserted in a patient. Defects or deformities in the head and facial are almost always lead to a ever emotional burden requiring rehabilitation ⁷. Tjellstrom and others further demonstrated the feasibility of using transcutaneous, osseointegrated implants in the temporal bone for retaining ear prostheses. Parel, Jacobson, and others have gone on to demonstrate the success of osseointegrated skin penetrating titanium fixtures in retaining facial prostheses. ⁸ Aydin C et al (2008) found implant success rate to be 100% for silicone auricular prosthesis. ⁹ Few of the cranial, frontal, ocular, maxillary and mandibular defects are being reconstructed by 3D printing using PEEK (Polyetherether ketone). PEEK implants can be machined to many organic shapes and fixated to the adjacent

bone standard screws and plates. Implants have been made of many different materials, shapes, and types throughout the years. Some examples are gold, silver, glass, silicone, cartilage, bone, fat, cork, titanium mesh, acrylics, wool, rubber, catgut, peat, agar, polyethylene, hydroxyapatite, bioceramic etc.

Extraoral implants placement for retaining prosthesis depends on a number of factors such as:

- Presence of bone
- Proximity of vital structures the dexterity of the patient
- Soft tissue conditions
- Prognosis
- Patient's health, - Radiation therapy
- Economic conditions.

The use of extraoral implants provides excellent **support and retentive** abilities to improve aesthetics as well as quality of life (QOL). Implants offer a high degree of **stability and retention**.

Generally four types of thread forms are suggested for implants-

- V-form
- Square
- Buttress
- Reverse buttress.

Out of these, V- form is most commonly used as endosseous intraoral implant. Though square thread is able to transmit high compressive and low shear forces to bone, it is unsuitable for small implant length. **Buttress thread form are considered as more suitable for supporting maxillofacial prosthesis**. Reverse buttress thread form can take care of the pull out force to a greater extent because the outward thread face is flat. So reverse buttress thread forms can also be used in supporting the maxillofacial prosthesis. Modifications of extraoral implants are less diverse. These are comparatively shorter in length and have a dual structure with an endosseous part and a thread in abutment. Generally a perforated flange is provided to increase the implant surface area to have more bone to implant contact (BIC) to facilitate initial immobilization and prevent undue intracranial pressure.

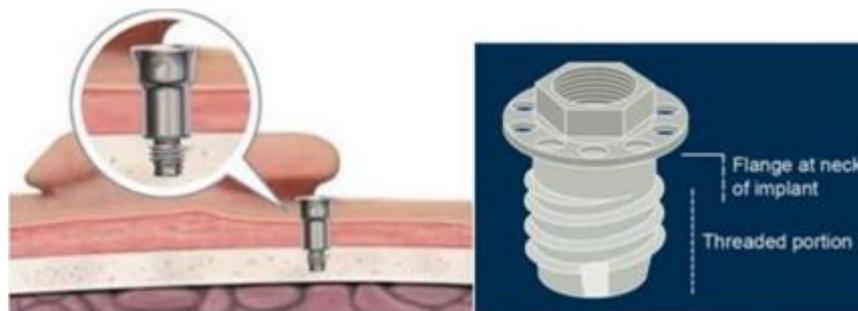


Figure 2: Craniofacial implant

Craniofacial implants are classified based on site as:

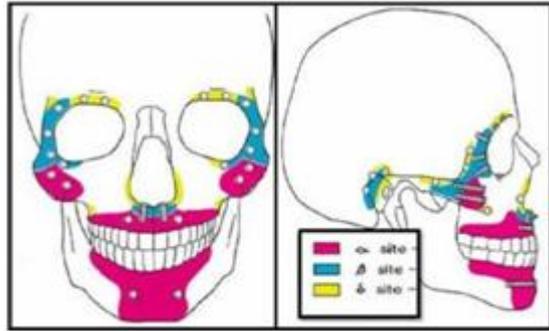


Figure 3: (1) alpha, (2) beta and (3) delta sites

- **ALPHA 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. Zygoma, anterior maxilla and mandible are the alpha sites in craniofacial region.
- **BETA SITES:** These are found in the periorbital but also in the temporal, zygomatic, and anterior nasal fossa locations. These use short dental fixtures (5mm) or phalanged fixtures (4mm).
- **DELTA SITES:** include the buttress, pyriform, zygomatic arch, medial orbit, temporal and frontal bones, and zygomatico frontal process. Implant fixtures used are 3mm or less.

Criteria for Success of Craniofacial Osseointegrated Implants

According to "Swedish council on Technology assessment in Health care". The criteria for success is as follows.¹⁰

- 1) Implants are immobile as verified by clinical examination.
- 2) No prolonged symptoms, such as pain, infection, tactile disorders or nerve damage should be present in connection with the implants.
- 3) Penetrated soft tissue should be free from irritation in at least 85% of regular out patient postoperative checks.
- 4) At least 95% of the temporal bone implants and at least 75% of other extraoral implants should be functional after 5 years. According to JACOBSON et al.¹¹:
 - a) Individual unattached implants should be immobile when tested clinically.
 - b) Soft tissue reactions around skin penetrating abutments should be type zero (reaction free) or type 1 (slight redness not demanding treatment) in more than 95% of all observations.
 - c) Individual implant performance should be characterized by the absence of persistent or irreversible signs and symptoms such as pain, infections, neuropathies or parasthesia.
 - d) In the context of the above, a success rate of 95% in mastoid process and 90% in orbital region in nonirradiated bone tissue, at the end of 5 years observation period should be minimum criterion for success.

Schnitman & Shulman 1979 proposed standards for success of implants at the National Institute of Health – Harvard conference as follows.¹²

- a) Mobility is less than 1mm in all directions.
- b) Radiographically observed radiolucency graded, but no success criteria is defined.
- c) Bone loss no greater than a third of vertical height of the implant.
- d) To be considered successful, the implant should provide functional service for 5 years in 75% of cases.

In 1986, Albrektsson, Zarb, Worthington and Eriksson proposed the following standards:

- 1) That an individual, attached implant is immobile when tested clinically.
- 2) That a radiograph does not demonstrate any evidence of periimplant radiolucency.
- 3) That vertical bone loss be less than 0.2mm annually following the implants 1st year of service.
- 4) That an individual implant performance be characterized by an absence of persistent and / irreversible signs such as pain, infections, neuropathies, parasthesia.
- 5) That in context of above, a success rate of 85% at the end of a 5 year observation period and 80% at end of a 10 year period be a minimum criteria for success.

Principles of Craniofacial Implants¹³

The biomedical principles are based on proper choice of suitable patients, the biomechanical planning of fabrication of prostheses, and the correct selection of the implant site. The **first** and most important medical principle of treatment; avoid tissue damage. Most materials used in maxillofacial prosthetics have relatively good biocompatibility with the skin and the mucous membrane.

The **second** principle: retention for esthetics. The rehabilitation of patient's appearance must be near to "normal".

The **third** principle: retention for function. There are many important functions in the head and neck region that can be partially impaired or damaged totally. The functions of sight, hearing, breathing, mastication, swallowing and phonetics have an important role for survival of the patient, but also for total rehabilitation.

The **fourth** principle: retention for prevention. The stable retention of epithesis and prosthesis in rest and function obtained with osseointegration of titanium fixtures will prevent objectionable overloading of delicate soft tissue and bone structures irritation, and decubitus ulcer, especially in patients who are experiencing postsurgical and radiologic cancer rehabilitation.

The **fifth** principle: maximal direct bone transfer loading. Direct bone fixation is clearly the best method of transfer of the functional and static loading of prostheses. The system of direct bone loading by osseointegration will stimulate remodeling of the bone and prevent resorption.

The **sixth** principle: combined direct bone and soft tissue transfer loading or retention. For patients with extensive

defects that involve movable structures of the head and neck region, it has been necessary to transfer the load to support the epithesis or intraoral prosthesis on the adjacent soft tissues. This combined method has improved retention of the epithesis and prosthesis.

The **seventh** principle: psychologic and social rehabilitation of patient. The osseointegrated method of prosthesis retention has provided stability to all prosthesis without the need for auxiliary devices.

Biomechanical Considerations of Implants in Maxillofacial Prosthesis:¹⁴

- a) Design of craniofacial and intraoral implant:-
- b) Micromotion at the Bone-Implant Interface:
- c) Stress Transfer from implants to bone:
- d) Load distribution to several screws:
- e) Impact of implant stiffness on stress distribution:
- f) Impact of the implant shape on stress distribution:
- g) Impact of the implant surface on stress distribution:
- h) Clinical Measurement of implant stability and Osseointegration:

Extra-Oral Implant System:

Different systems available in maxillofacial prosthesis with implants are

- 1) Bar and clip system,
- 2) Magnets,
- 3) Mushroom and ball retention system

Oral implant systems: There are 2 systems available, solitary and grouped. In solitary systems single implants are available whereas in grouped implants, grid or plate systems are present which are secured by several screws. Extraoral implants with solitary systems are Branemark systems, ITI systems, IMZ system, ankylose system, southern implants and epiplant system. Grouped implant systems are epitec and epiplating systems.

Extra-oral systems with “solitary implants” A.

Branemark system:

The Brånemark system was the first implant system to be used extraorally.¹⁵ The long stand most extensive experience has been gathered with this system¹⁶. Since the introduction of self-tapping implants, the necessity for tapping has ceased.¹⁷ For the extraoral area, titanium screws of a length of 3 and 4mm (and 5.5 mm) are available. The flange was originally designed to avoid an intracranial dislocation of the implant due to trauma. The flange is now available in closed form. At present flangeless screws are also obtainable. Abutments can be held by a special clamp. It must be understood, however, that the clamp only reduces the torque by 10Ncm so that care must be taken not to inadvertently over wind the implant. Currently the Brånemark system is being marketed by the Cochlear Company under the brand name Vistafix.



Figure 4: Bone anchored auricular prosthesis made from silicone and auditory canal atresia

B) ITI systems

With ITI implants (International Team for Implantology) marketed by the Straumann company, a sand-blasted, large grit, acid-etched surface was introduced, the so-called SLA surface. There sulting roughness is two-staged: the greater roughness of ca.20µm is over laid by a finer roughness of 2µm intervals.¹⁸ For the extraoral region self-tapping titanium screws with a diameter of 3.3 mm and a counter sunk depth of 3.5 or 5 mm with a coned seat, as well as with a diameter of 2.5 or 4 mm with flange. The longer screws which were designed for the extraoral region are also available with the hydrophilic SL Active surface.



Figure 5: Implant system for bone anchored craniofacial prosthesis Left: Epitech system, backleft: branemark system, back right: ITI system, front: universal plate of the Epiplating system, right; titanium bone screw with the length of 4, 5, 5.5, and 7 mm

Other systems with solitary implants:-

Some systems which were designed for the extra oral region, as for example the IMZ system¹⁹ marketed by Friatec (Friadent), or the epiplant system marketed by Mathys, are no longer on the market.

Extraoral systems with grouped implants

In 1956, Köle and Wirth²⁰ described subperiosteal frame implants made of Wisil®, a cobalt chrome alloy. These subperiosteal implants were adapted to the bone surface, without being anchored in to the bone itself. The prosthesis attachment takes place on parts of the frame implant projecting through the skin. A patient with an auricular prosthesis and one with a nasal prosthesis were treated in this way. Both implants had healed with no adverse reactions after 8 years. In contrast to this, the analogous use of subperiosteal implants in the jaw for fixing dental prostheses was less successful, which could be put down to the higher mechanical load.²¹ Both systems described in the following are also used subperiosteally, but fixed with bone screws also used in osteosynthesis. In contrast to the solitary implants, the forces are distributed across the plate over several titanium bone screws. An already thinned out area can be used again following the loss of another (solitary)

implant. In this way a secure fixing in anatomically difficult regions with limited bone are a impossible.

A) Epitec system

The Epitec system, credited with being developed in 1991 by Mostafa Farmand²² and the company Leibinger, represents a great advancement. The system consists of a mould able quadratic titanium grid with 16th read holes, the so-called 3D carrier plate, and self-tapping 2 mm titanium screws which are available in lengths of 4.5 and 6mm. The 3D carrier plate has to be cut to their required shape. For reasons of stability, as many connecting bridges between the single screw holes as possible must be maintained. Single extensions are not stable. Plate retention results primarily from the use of these monocortical bone screws. Secondary to this, the 1 mm thick connecting bridges of the 3D carrier plate will be covered over by bone. A thinning of the skin is usually not recommended. Due to the easy pliancy, constructions extending in to the defect are currently no longer recommended. In order to screw the mountings, only a thread height of 1mm with 2 screw leads is available.

B) Epiplating system

The Epiplating system was developed in 2000 by the Medicon company in collaboration with P. Federspil, Ph.A. Federspil and M. Schneider. It is the adaptation of the 2.0 titaniummini-plate system produced by Medicon and used in traumatology to the requirements of anaplastology. Specially adapted implants are available for the auricular, orbital and nasal regions, as well as a universal plate.



Figure 6: Examples for the attachment of implants of the Epiplating system in the auricular, nasal an orbital region. The trimmed universal plate in the glabella is only expedient in the case of resected nasal bone

The titanium plates of the Epiplating system are 1 mm thick, but 2 mm in width and are thus stronger than the Epitec grid system. In the area of the tapped holes provided for the mountings, the thickness of the plate is 2mm, appropriate for 4th read turns, which counter balance any tendency of loosening of the percutaneous base posts or magnets. To anchor the plates, titanium screws of 2 mm in breadth are used which are supplied as standard in the following lengths: 4, 5.5 and 7mm. Thus the high stability known from plate osteosynthesis can be achieved. At the same time, the plates are more resistant against rotational forces which occur when screwing down and unscrewing the mountings. A counter instrument such as this as is usual in solitary implants does therefore not have to be used. Magnets can either be screwed directly into the plate or onto a base posts,

as the height of the mounting requires. In addition, the Epiplating system can be combined with the hearing device abutment of the BAHA system.^{23, 24}

2. Conclusion

Sophistication in the surgical and prosthetic reconstruction of structural and functional defects in the cranio-maxillofacial region improves the final rehabilitation results, if carefully planned, unbiased rehabilitation regimens are established. Initial decision on primary handling of traumatic defects or meticulous planning of surgical reconstruction can change the final result of surgical endeavours. Bone anchored implant retention offers patients who wear facial prosthesis increased security, especially with large defects or where the prosthesis rests on highly mobile tissues. The implant team must develop a coordinated treatment plan that is delivered in an efficient manner. The highest standards of anesthetics and retention should be met. As much attention should be paid to the fitting and care of soft tissues as to issues of hardware articulation and registration. A commitment of follow-up for the clinical evaluation of implant tissues and the maintenance and periodic replacement of the facial prosthesis are a team responsibility and in the best interests of the patient.

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