

**Review Article:****Branemark Ear and Nose Prosthesis****Jayita Poduval**Associate Professor, Department of ENT, Pondicherry Institute of Medical Sciences  
Kalapet, Puducherry, India**INTRODUCTION**

Prostheses or prosthetic devices are artificial objects that may be implanted into or attached to the body in order to replace a functioning organ or body part that may be absent from birth or lost to injury or disease. They may be internal-artificial joints, middle ear implants, heart valves, etc.- or external-fillings, dentures, limbs, and faciomaxillary implants.

External implants may be attached to the body in the form of an amalgam, as in teeth fillings; they may be used along with clips, holders or adhesive bands, as in artificial limbs, or they may be implanted directly onto a bony surface, as in osseointegrated implants. The Branemark Ear and Nose prostheses are examples of this variety. These and other faciomaxillary implants like orbital and alveolar prostheses are especially useful in head and neck reconstruction and rehabilitation of the patient. The devices used for oral implantation are classified as transfixation, submucosal, subperiosteal and endosteal implants but this is not applicable to the ear and nose prostheses.

At the cellular level, implants may be retained within the body by

- a) biointegration or bioactive integration,
- b) fibrous or fibro-osseous integration (fibrous encapsulation),

c) osseointegration.

Osseointegration is the most reliable and durable modality of retaining an implant because the surface of the load-carrying implant is structurally and functionally integrated into ordered living bone.

Leventhal in 1951 first used the principle of osseointegration in the field of orthopaedic surgery(1), and Per-Ingvar Branemark of Sweden did groundbreaking work in osseointegrated faciomaxillary prostheses in the 1950's and 60's. Branemark fixtures are therefore considered the gold standard in faciomaxillary prostheses.

**INDICATIONS**

Osseointegration serves to

- 1] Preclude the use of adhesives which may be both unsightly and unsuccessful because of irritation and skin reactions,
- 2] Make the prosthesis more acceptable because it is aesthetically superior, and
- 3] Facilitate rehabilitation where surgical correction or reconstruction is not possible.

These problems are due to

- a) The complex configurations of craniofacial anatomy,

- b)the presence of a large defect,
- c)the need for multiple procedures,
- d)previous or subsequent radiotherapy.

## BACKGROUND

Though the exact mechanism of osseointegration remains unknown the physiochemical process of bone healing which occurs with these implants has been documented(2).

The medium used for osseointegrated prostheses is metal. It can be used as a single element or in combination as alloys. Metals are versatile because of their structural strength, ductility, elasticity and malleability. They are easy to manufacture and can be moulded by machines. With the exception of gold and silver, most metals react with bone and are conducive to osseointegration.

Pure metals, when exposed to air, are covered in an oxide layer which is in contact with host tissues. Titanium, either pure or in alloys, is the best choice. There is no known allergic reaction or carcinogenicity with titanium.

Direct bone to implant contact is seen with titanium and titanium alloys, aluminium oxide ceramics, tantalum, stainless steel, cobalt and nickel-based alloys.

Titanium oxide is inert, practically insoluble and very resistant to body fluids. It can be easily machined into shapes that are small enough to be placed in the jaws and facial bones. It is strong enough to withstand functional, including masticatory, loads which can result in axial loading for upto 500 N. Most important is that the bone predictably grows on the surface of the titanium implant. Human osteoblast cells do not grow well on

and are not able to colonise titanium oxide surfaces that are contaminated but will adhere to and cover the surface of clean implants. The cells lie perpendicular to the implant's titanium oxide surface in a characteristic pattern.

For predictable osseointegration to take place a bio-compatible implant should be placed into bone with as minimally traumatic a technique as possible(3). The implant should not be mobile at the time of insertion and should be extremely stable. An adequate amount of time should be allowed for healing prior to loading with the main prosthesis.

The surgical placement of an implant into bone leads to bleeding and an acute inflammatory response, leading to the formation of a haematoma. The implant surface gets coated with the products of acute inflammation. Macrophages remove bone debris and any metallic particles released during drilling, tapping or implant placement. Undifferentiated mesenchymal cells migrate into the area and produce an extracellular matrix. Within a week of implant placement these cells develop into osteoblasts and produce osteoid. The osteoblasts are responsive to both local and systemic factors. The osteoid gradually organises into an increasingly dense procalculus, with further mesenchymal cells differentiating into osteoblasts and fibroblasts. The osteoblasts produce fibres that calcify. The fibrocartilaginous callus that develops matures into woven bone by the third week. The remodelling of woven bone is brought about by the recruitment of osteoblasts into the area. After 7 weeks, lamellar bone is laid down. This is more mineralised and further stabilizes the implant. Any bone rendered non-vital by the surgery is gradually replaced by living bone. In

effect, the body fails to recognize the implant as a foreign body and it becomes integrated into bone as part of the wound healing process.

At the molecular level, at the interface between the titanium oxide layer and the environment, water molecules are split into hydroxyl ions. Depending on where these are in relation to the adjacent titanium ions, either a basic or an acidic polarity exists. Photoelectron spectroscopy has demonstrated that amino acids, having a bipolar characteristic, form a strong bond with titanium oxide. These amino acids build together to produce the proteoglycan glue that binds cells together, and form the substructure into which bone is built(4).

A very thin layer of proteoglycan of upto 500 nanometre thickness exists between the bone and the implant surface of all osseointegrated implants.

The final stages of healing involve maturation of the bone at the implant interface. There is an increase in bone hardness and density that is associated with loading and functional use, and which continues even a year after implant placement. A rough implant surface is better able to provide a connective tissue fibre attachment. The results of osseointegration are better when done in cortical bone.

#### PATIENT CONSIDERATIONS

Osseointegration procedures require a multidisciplinary or team approach where the surgeon and maxillofacial prosthodontist are the key players but which is not complete without a physician, psychiatrist, counsellor, nurse and occupational therapist.

Proper planning and assessment of the patient are essential. Medical factors like immunosuppression, smoking and previous radiotherapy need to be taken

into account. Psychological factors like patient's acceptance of complex dental procedures and body image, psychiatric disorders, hygiene and aftercare must also be considered. Counselling must be offered to every patient as this is a labour-intensive and long-drawn out process.

Last but not the least, local factors like peri-implant infections, availability and quality of bone and soft tissue, are of utmost importance.

#### PREPARATION

Diagnostic wax-up and/or models must be constructed in clear acrylic. An accurate template and stent can thus be made. A stent containing radio-opaque markers can be produced over the proposed implant sites to facilitate radiological scanning. Implant sites and angles of insertion can be transferred from the study casts directly into the site during the operation.

The position of the lipline at rest and in function should be noted for aesthetic purposes. In a patient with a high smile line and showing tooth and gum, achieving an acceptable appearance may be very difficult.

#### ROLE OF IMAGING

CADCAM models and CT-3D imaging are also helpful. Software programs like SimPlant 8 provides an ideal implant site from CT data. CADCAM enables custom-made surgical templates which fit directly into the operative site and guarantee correct implant position and angulation. The correct implant length can be preselected. The site of implant placement can be determined according to superstructure design, patient factors and radiographic findings. CT 8 (software enhanced to produce 1:1 3D images) is

recommended where concerns exist about other anatomical structures or defects. Advanced digital technology improves prosthetic techniques and CT or laser scanning can provide a mirror image of scan to make a model.

### COST ANALYSIS

Overall costs such as the estimated clinical time, review appointments, laboratory costs, audit, documentation and maintenance costs must also be calculated for the purpose of insurance cover and reimbursements.

### TECHNIQUE

Essential steps in the insertion of an osseointegrated prosthesis are(5)-

- 1]proper surgical technique
- 2]prophylactic antibiotics
- 3]atraumatic minimal access via a mucoperiosteal flap
- 4]irrigation and cooling of bone
- 5]surgical tapping and threading of bone to increase surface area of contact
- 6]allowing time for osseointegration before loading
- 7]maintenance

Implants are placed according to the Branemark protocol with sequential preparation of osteotomy sites under copious irrigation after which a two-layer closure of the skin and pericranium is required. Implants remain uncovered for 4 months. It is a 2-stage surgery where the 1<sup>st</sup> stage is performed under local or general anaesthesia or sedation. The 2<sup>nd</sup> surgery is performed in the Outpatient Department using a tissue punch or small incision over the implants. Healing caps are placed and peri-

implant tissue is allowed to heal prior to initiating the prosthetic techniques for fabrication of the prosthesis. Further soft-tissue modification is carried out once abutments are placed.

Broadly, implants are of 2 types-

- 1]screw implant
- 2]push-fit implant

Connection of prosthesis to implant requires a customised bar framework for retention with gold clips or magnets used as abutments directly onto the implant. Use of titanium for bar frameworks may minimise peri-implant skin reaction.

Advanced surgical techniques include-

- 1]ridge expansion,
- 2]bone expansion with osteotomies,
- 3]bone grafts and guided tissue regeneration,
- 4]sinus floor augmentation,
- 5]distraction techniques,
- 6]osteotomies and inter-positional bone grafts,
- 7]soft tissue and mucosal grafts

Apart from the Branemark protocol, another approach is the ITI system which uses a transmucosal transcutaneous single-stage approach(6).

In a single operative procedure, the following points are to be kept in mind-

- 1]continuous implant assessment is done during the healing period
- 2]soft tissue maturation should be equal to that of the bone

3]wounds are closed with non-irritant sutures

4]junction between the implant and the abutment may be above soft tissue so that cleaning is easier

5]better leverage conditions exist when the abutment-implant junction is closer to the prosthesis

These enable easier placements of the abutments under direct vision.

### EAR PROSTHESIS

The anatomy of the temporal bone is complex and unpredictable in patients with congenital deformities. The external auditory meatus (EAM) is the landmark for correct implant placement, as the auricular prosthesis will be fitted around this(5).If the meatus or ear remnants are in the wrong position, then assessment against the other side is carried out provided this is normal. Otherwise, anthropometric landmarks, such as the Frankfort plane and alar tragal line, are used to correctly site the implant (5).

The outer table of temporal bone is usually dense cortex into which implants can be placed easily. The upper posterior quadrant where the apex of the quadrant is the centre of the EAM, is chosen as the site for placing the implant correctly(5).The implant should be placed 18-22 mm from the epicenter of the EAM with two or three abutments. Usually 2 implants are placed-at 1 and 4 o'clock for the left ear and at 8 and 11 o'clock for the right ear.

A diagnostic surgical template from a fully contoured waxed sculpture provides a better position of the implant. This is based on the greatest depth of internal ear anatomy away

from the external auditory meatus and within the area bounded by the helix of the ear. The implant is sited under the concha, which is the point of the greatest depth of the auricle. The mastoid air cells become progressively smaller away from the mastoid apex and in the normal temporal bone they rarely hinder implant placement (5).The position of the posterior cranial fossa and the sigmoid and superior petrosal sinuses may vary, but it is usually in children that these structures are encountered or in congenital deformities where the temporal bone is very atrophic or underdeveloped. CT scanning is useful to demonstrate the sigmoid sinus and most appropriate bone volume for placement.

Owing to the shallow depth of bone short implants are preferred. If the vascular sinuses are encountered the implant is quickly inserted to plug the hole and haemorrhage is arrested. Cerebrospinal fluid leaks can also be arrested by placing the implant. Implants are generally avoided in children, as osseointegration can impair normal growth of adjacent bone. In this context, a bone-anchored hearing aid(BAHA)is an exception as there is significant impact on hearing and therefore speech and language development.

Excessive thickness or cartilaginous remnants can be trimmed or amputated. Split-skin grafting of suitable thickness may be additionally required and coverage ensured for hygienic maintenance. The tragus should be preserved for aesthetic purposes.

A semilunar incision about 3 cm away from the EAM facilitates primary wound closure of the pericranium and skin.

## NOSE PROSTHESIS

Implants at the nasal bridge should engage the frontal bone, hence adequate length should be ensured. Bone volume should be sufficient so that successful placement and osseointegration of an implant can occur.

The prosthetic nose is best produced as a single aesthetic unit. It is therefore sometimes necessary to undertake excision of the whole nose if it has been decided that an autogenous reconstruction is not going to be attempted(5). The alae, columella, anterior nasal septum and nasal bone are trimmed back so that implants can be placed easily.

As with any defect, the best support and retention of the implant are provided by placing implants as far apart as possible around the nasal rim, with the pyriform outline inferiorly and the nasal bridge superiorly.

In the nasal bridge region, the nasal bones are very thin and frequently fracture or split along the midline suture if the implant is placed at this level. By resecting the nasal bone back to the nasion the implant can be placed in the wider, denser part of the frontal bone. The implant is angled so that the emergence profile is behind the line of the nasal bridge.

In edentulous patients atrophy of the anterior maxilla can limit the length of the implant that can be placed at this site. Greater bone is available laterally, in the region of the canine buttress, so oral implants are angled downwards and backwards into the strut of bone that separates the medial aspect of the maxillary sinus from the lateral nose. The depth available is limited by the height of the palate.

The recent development of the zygomatic implants has made nasal reconstruction more flexible as these implants can be placed horizontally from the middle of the nasal defect through the maxillary sinus under the eye, engaging the cortical bone of the zygoma. These implants are useful where the anterior maxilla has been lost and pyriform rim implants are not possible. Care is taken to avoid the infra-orbital nerve and injury to the eye.

## COMPLICATIONS

Soft tissue complications include inflammation, bleeding, tissue overgrowth, granulation tissue and infection.

Inflammation and excessive loading can cause bone resorption(7). Overloading, even after several years, can cause microfractures in the bone that heal into scar tissue and cause the implant to become loose.

## OUTCOMES

Silicon polymers used in facial prosthetics require maintenance. UV light can degrade colour and tear strength at margins may not last. Improvement of strength characteristics of silicon polymers and patient education ensure a long life for the prosthesis.

Adjunctive implant techniques and/or implant salvage may be necessary in cases of atrophy or sinus enlargement. In these cases onlay grafting with rib, iliac crest, collagen sheets or oxidised cellulose gauze are used. Demineralised, freeze-dried bone, glass derivatives, hydroxyapatite and hard tissue replacement are also

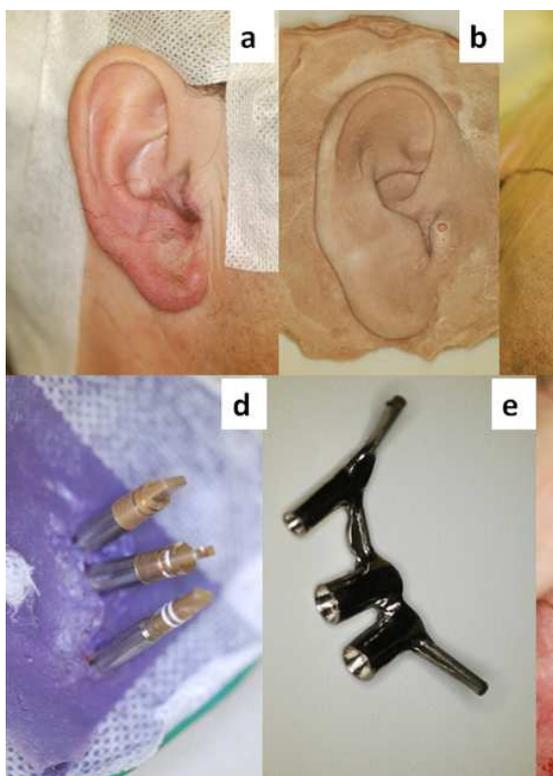
available. Vestibuloplasty and soft tissue contouring may have to be done. Guided bone regeneration using autogenous bone, allografts, xenografts or bone substitutes is another option. Trephines to remove prosthesis, membranes to maximise bone height, autogenous modification of fibrin glue, platelet-rich plasma (PRP) and sectioning of a long implant at the level of bone or fracture of residual bone may be undertaken additionally.

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## IMAGES

1]EAR PROSTHESIS-stages in the creation of an ear prosthesis



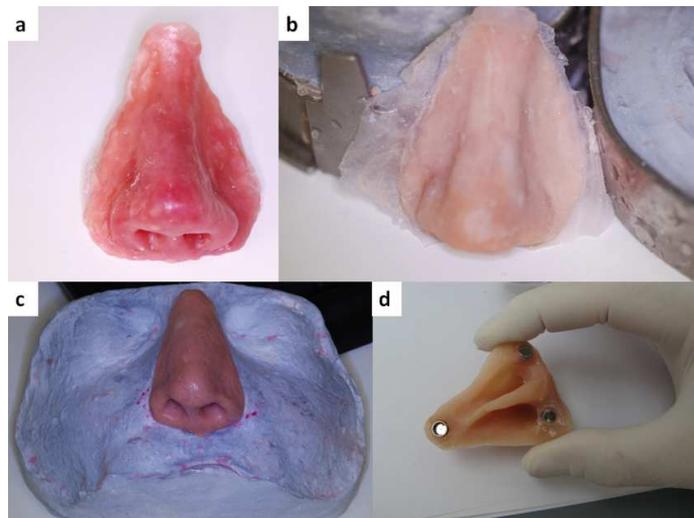
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2]EAR PROSTHESIS-fitting of prosthesis onto abutment



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3]NOSE PROSTHESIS-waxup model and colour adjustment of nose prosthesis



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4]NOSE PROSTHESIS-fitting of prosthesis onto abutment



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