PROSTHETIC REHABILITATION OF CRANIO FACIAL DEFECT WITH MAXILLO FACIAL IMPLANTS

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Abstract

Restoration of craniofacial defects with autogenous reconstruction are limited. Hence a prosthesis may be preferred for rehabilitation of the defect. Previously skin adhesives, eyeglasses, and anatomic undercuts in the defect area were commonly used as aids for the retention of the prosthesis, yet the results were not satisfactory both for the clinician and the patient. However, skin adhesives caused adverse skin reactions, deformation at the edges of the prosthesis, loss of adhesion due to perspiration, and extensive tissue coverage to increase retention while eyeglasses and undercuts provide insufficient retention accompanied with discomfort to the patient. Prostheses retained by extra oral implant retained increased life span of the prosthesis with improved retention and stability. These extra oral implants are safe, reliable and most effective method of retaining maxillofacial prosthesis with high survival rate thus providing enhanced comfort for the patient and ease of maintenance. However careful patient selection, pre-surgical evaluation of both systemic status and bone quality at the implant site, along with the patient's interest to perform daily home care, must be done to achieve a successful result on long term basis.

Keywords: maxillofacial defect, maxillofacial implant, nasal, auricular, extra oral, orbital, eye prosthesis

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1. Introduction

Maxillofacial defects have an immense psychological impact on patients. The rehabilitation of these defects, not only restore normalcy to the patient's face, but also restore self‐ image and the ability to function and interact in a social environment either by the use of fixed or removable prosthesis. Defects in the maxillofacial region occur as a result of congenital malformation, trauma or during the management of head and neck oncology (1). Restoration of such defects can be done by use of maxillofacial prosthetics. Extending from the biblical times over the centuries in growth of civilization evidences shows Egyptian mummies, ancient Italy, Chinese and Indian population used of maxillofacial prosthetics (2).

It was Ambroise Parre (3) in 1517 who gave the first writing on this subject, later Pierre Fauchard, Mortan, Delabarre redefined prosthetics. However, the material available those days were insignificant to produce a prosthetic success (4,5). From copper pegs to bamboo sticks, vulcanite, porcelain, MMA's, PVC's were used previously (6). But it was after the invention of silicones that maxillofacial prosthesis felt promising, Maxillofacial prosthetics is the art and science of anatomic, functional, or cosmetic reconstruction, by means of non-living substitutes, of those regions in the maxilla, mandible, and face that are missing or defective because of surgical intervention, injury, or congenital malformation (7).

Over the period of time use of skin adhesives, skin pockets, eyeglasses, hard and soft tissue undercuts, and other modalities were used to retain the prosthesis, yet they possessed discoloration, prosthesis deterioration, skin reactions, loss of adhesion, poor stability, discomfort, and lack of acceptance (8). After the invention of implants its use to retain the prosthesis was implemented. Hence it was Brånemark and Albrekttsson in 1977 who first used implants for prosthetic rehabilitation of craniofacial defects. Implant is any object or material, such as a alloplastic substance or other tissue, which is partially or completely inserted or grafted into the body for therapeutic, diagnostic, prosthetic or experimental purposes (9,10). It provides accurate placement of prosthesis, patient comfort and decreases the daily maintenance. However, the successful utilization of dental implants depends on many factors including the availability and position of sufficient bone, arch shape, un-irradiated tissues and patient motivation.

2. Discussion

Any defect of the face or associated structures may be congenital or acquired. Congenital defects are the defects or malformations present from birth whereas the acquired defects may be due to accidents, gunshot injuries, cancer treatment, ablative surgery and animal bite (11,12). These malformations affect the well-being of the individual affecting them psychologically depriving the confidence levels. So the reconstruction of these lost or malformed structures is essential. Maxillofacial defect reconstruction can be made by three ways they are surgical reconstruction by alloplastic or autogenous grafts, Maxillofacial or craniofacial prosthesis rehabilitation and Combination of the above two (13).

Reconstruction of facial defects is a complex modality either surgically or prosthetically driven depending on the site, size, etiology, severity, age and the expectation of the patient (14). Whenever surgical reconstruction is not possible or failure of the alloplastic or autogenous graft occurs, maxillofacial or craniofacial prosthesis becomes an alternative method. Maxillofacial prosthetics defined as "the branch of Prosthodontics concerned with the restoration and/or replacement of the stomatognathic and craniofacial structures with prostheses that may or may not be removed on a regular or elective basis" (7).

Retentive mechanisms: - Maxillofacial prosthesis is retained through various methods for their retention and support. Each retentive mechanism is having its own advantage and disadvantage. The various retentive aids available are adhesive, skin tapes/ straps/ suture material, spectacle frames, soft tissue or bony undercuts, anatomic projections as mechanical interlocks and implants. These retentive aids are selected based on the various factors such as the extent of prosthesis, availability of bone, radiation therapy, patient's dexterity, location, amount of hard and soft tissue available and compliance of the patient (15). Since 1979, there had been a shift towards the implant retained prostheses, which were preferred by most of the patients (16). The most significant advance in craniofacial prosthesis over the last several decades had been the application of osseointegration to address the problem of retention of extraoral prosthesis (17). Factors to be considered for the prosthodontic rehabilitation are as follows:

1. Amount of remaining supportive tissue;
2. Number, position and condition of the remaining teeth;
3. Patient preferences regarding surgical versus prosthetic reconstructions;
4. Pathologic findings;\
5.Age and medical condition of the patient;
6. Technical skills of the reconstructive surgeon and prosthodontist;
7. Psychological status and manual dexterity of the patient to deal with maxillofacial prosthesis and

8. Availability of adequate supportive care in case the patient is not able to take care of the prosthesis (18,19).

Biomechanical Considerations of Implants in Maxillofacial Prosthesis

a) Design of craniofacial and intraoral implant: - Craniofacial implants are less diverse than intraoral implants. They are available in smaller lengths of 3-4mm as the availability of bone is limited. It has a flange with perforations which increases surface area enhancing initial mechanical stability of implant design during healing period and also helps prevent tilting of the implant under the action of lateral forces and movements.

b) Micromotion at the Bone-Implant Interface: - Implants placed should be relatively immobile in order to have enhanced osseointegration. Any micromotion in such site causes formation of fibrous tissues leading to failure in osseointegration.

c) Load distribution to several screws: - When prosthesis is supported by several screws, the resulting combined structure forms a unit in which the distribution of any applied load is distributed evenly among all the members involved, which depends on the relative stiffness and geometry of their arrangement.

d) Impact of the implant shape on stress distribution: - The stress conditions around an implant can also be improved by selecting an appropriate implant shape. Because force transfer into bone should be as even as possible, implants showing rational symmetry can be considered more favorable for stress distribution.

e) Stress Transfer from implants to bone: - Implants should never be stressed beyond their loading capacity. Unlike intraoral implants which are stressed 50 - 200 N craniofacial implants are stressed 0.1 – 1N. The designing of implant screw transmits an axial tensile or compressive load to the surrounding bone, primarily by compression on the inclined faces of the screw.

f) Impact of implant stiffness on stress distribution: - Stiffness of implant depends on the diameter of the implant. If the diameter is increased by 30%, implant stiffness will be five times higher, and the stresses around the implant neck are thus reduced dramatically.

g) Impact of the implant surface on stress distribution: -The implant surface used for force transfer should be as large as possible. To minimize the compressive forces, the implant surface can be enlarged by applying threads or by plasma spray coating or surface roughening and acid etching (20).

Craniofacial Implant Classification: - Based on the amount of bone available for the placement of implant fixtures craniofacial implants are classified as

1)**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.

2) **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).

3)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.
Surgical procedures for placement of extraoral implants and their abutments are similar to those for intraoral implants (21,22).

I)ORBITAL IMPLANTS

Ever since Sumerian and Egyptian civilization removal of orbital globe and rehabilitation of the defect have been in place. However, advancements in the field started only in the late 18th century using aesthetic glass spheres and implants, such innovations and improvements in surgical techniques, use of various implant designs have significantly improved the clinical outcomes of the rehabilitation. Over the centuries, a wide variety of materials has been used to replace the anophthalmic socket volume and restore the aesthetic appearance to the patient's face. The use of metals like gold, silver, platinum, stainless steel, wool or cork, ivory, asbestos have been documented (23-25). Various types of orbital implants have been proposed some of which are

1)Non-integrated implants

These implants do not usually contain any specific apparatus for attachment to the extraocular muscles, do not allow fibrovascular in-growth (they are non-porous) and have no direct attachment to the ocular prosthesis. Mules in 1885 placed first orbital implant after evisceration with brown glass sphere, though it better fitted the anatomy the implant was brittle (26). Kamal-Siddiqi et al (27) implanted into 60 enucleated patients the Sahaf orbital implant type I, which was characterized by a two-piece design wherein the posterior hemispherical portion gave

support to hold recti muscles and the anterior convex curvature supported the ocular prosthesis.

2)Quasi-integrated implants

These implants are characterized by a specific apparatus for attachment to the extraocular muscles and there is no interruption of conjunctival lining, but their irregular anterior surface allows the translation of movement to ocular prosthesis. There is no direct contact between orbital implant and ocular prosthesis. In 1946, Cutler introduced the basket implant, having four openings through which the rectus muscles were pulled through and sutured, together with the patient's conjunctiva closed over it (28). Pegging is a surgical procedure that can be optionally performed after some months from orbital implant placement in the anophthalmic socket (29).

3)Magnetically integrated implants

These implants are characterized by a magnet incorporated in the frontal part which allows movement transfer to the ocular prosthesis, which has another magnet placed on its posterior surface; the conjunctiva is sandwiched between the implant and the prosthesis. This approach was introduced after WWII and led to the development of a number of early models(30). Roper-Hall developed a magnetic implant derived from the Allen design and consisting of a 21 mm PMMA hemisphere with a flat anterior face into which a magnet was embedded; a ring of the same material stood forward of the face and had tunnels through which the four rectus muscles might pass (31).

4)Mechanically integrated implants

These implants are characterized by a specific apparatus for attachment to the extraocular muscles and the conjunctival lining is interrupted in order to allow direct coupling of the implant to the ocular prosthesis. These implants generally gave excellent movement, but their long-term results were unsatisfactory. Choyce (32) found that the rate of survival after a 2 year follow-up was from 40 to 50%, depending on the implant type; infection due to bacterial colonization of peg/tissues was the reason for extrusion and subsequent removal in 80% of cases. For this reason, the use of mechanically integrated implants were progressively abandoned.

5)Porous implants

These implants allow fibrovascular tissue in-growth and may or may not have direct coupling with the ocular prosthesis, depending on the use of a peg system. They involved the use of deproteinized (antigen-free) bone from calf fibulae, and confirmed that the mineral matrix of cancellous bone was readily incorporated into the tissues and that small exposures were followed by spontaneous crumbling of the exposed bone, with healing of the overlying conjunctiva. This implant, however, is significantly more porous and, accordingly, more fragile than other available HA implants (33).

6)**Porous quasiintegrated implant**

These implants are quasiintegrated devices made of porous materials, potentially allowing fibrovascular tissue in-growth. The advantages of porous and quasiintegrated implants, in terms of fibrovascular in-growth and motility, respectively (34). Then osteointegrating bioglass implants became popular. These implants not only have the ability to bond to bone, but have also been found to stimulate new bone growth and to bond to soft tissues, hence better suited for orbital implants. So once after implants were placed provisional conformers can be given (35-37).

II) AURICULAR IMPLANT

Auricular defects are mostly due to tumor resection, congenital malformations, and trauma. The use of craniofacial titanium implants for restoring auricular defects may came into place (38). A number of extraoral implant systems came into existence, of which the ankylose extraoral implant is the most recent having special thread with irregular flank geometry and depth. The curvature of the thread flanks, which begins at the cervical area and increases towards the apex in the relatively elastic bone region while reducing loads in the areas near the cortex (39). The available craniofacial bone is between 3 and 4 mm, because of the close proximity to the anatomical structure, the length is lesser when compared with the intraoral implant. Another feature is that the implant will have a flange at the top, which prevents accidental perforation of implant through thin bone sites that may be encountered in the craniofacial anatomy (40).

Location for Placing Implant

The position of implant decides the final esthetic result. The implants should be placed 20 mm distance to the center of the external auditory meatus in 8 and 11 o'clock positions for right side of the face and the 1 and 4 o'clock position for left side (37). With correct position of implant 20 mm from the ear canal and 15 mm between the implant, the prosthesis support bar will be underneath the helix. In certain situations, like poor bone quality or insufficient bone volume, implants will be located less or more than 20 mm from the external ear canal(41).

Number of Implants

In the early days of implant retained auricular prosthesis, three implants were placed; finally, it was concluded that two implants will be sufficient. Tjellstrom et al recommended that two well-spaced

implants 15 mm apart are adequate for an auricular prosthesis (42).

Retention System in Implant retained Auricular Prosthesis

Bergstrom description for making bar and clip superstructure states that 0.2 mm gold bar should be used and it should be positioned under the antihelix of the ear. The cantilever should not extend more than 8 to 10 mm beyond the abutment; when the distance is greater than 8 to 10 mm from the distal abutment greater bending moment applied to the implant can compromise the long-term success (41). Bar and clip provide the highest retention than magnetic system; number of clips or magnet does influence initial retention and final retention capacity (40).

III) NASAL IMPLANT

Reconstruction of nasal defects has a long history dating back almost 2000 years to the days of Sushruta, the famous Indian surgeon, and the pharaohs. Various alloplastic materials have been experimented with, including cork, paraffin, ivory, gold, and silver. Infection and extrusion limited the success of these early implants. The ideal nasal implant does not exist. Although some implant choices exhibit many of the qualities of the ideal implant, no implant satisfies all requirements. The ideal nasal implant should be readily available, inexpensive, inert, nontoxic, noncarcinogenic, serializable, easy to sculpt, easily camouflaged, and able to provide volume and mechanical support. Furthermore, the ideal implant should interact favorably with surrounding tissues, maintain its form over time, resist trauma, infection and extrusion, and remain easy to remove (43,44). In a patient who had undergone a total rhinectomy. The use of osseointegrated implants to support a nasal prosthesis has been widely spoken of. In the absence of suitable local bone for implant anchorage, the use of zygomatic implants has been described; however, this can be challenging, and the course of the implant is not straightforward (45). The various types of nasal implants are

1)Silicone implants

Silastic implants are not porous and do not interact directly with host tissues. The body's response to the presence of solid silicone is to form a capsule around the implant. This encapsulation may be disadvantageous. If the silicon implant is not secured in place by surrounding tissue, chronic inflammation may result. Over time, chronic inflammation leads to seroma formation and implant extrusion. In the nose, the use of silastic implants has been limited by excessive mobility and high extrusion rates (46).

2)Meshed implants

Meshed implants composed of various synthetic polymers that are interspersed with large interstices of empty space. They are easy to customize into a desired size and shape. Unlike silicon, graft–tissue interaction is extensive. Host tissue ingrowth of the implant imparts stability and also minimizes infection. The disadvantage of meshed implants is the difficulty encountered when graft removal is undertaken. Polyamide mesh is one of the first meshed nasal implants. High rates of resorption were encountered with this material, however. It is no longer considered a viable implant alternative in the nose. Polyester mesh is more resistant to the resorption seen with polyamide mesh. Its uses include dorsal augmentation and tip refinement. The chief disadvantage of polyester mesh is its 3.5% to 8% infection rate (47).

3)Porous implants

Like meshed implants, porous implants interdigitate solid synthetic polymer with empty spaces. Implant porosity allows host tissue ingrowth to provide stability with respect to surrounding tissues, but not so much ingrowth that implant removal is overly difficult. Host– implant interactions depend on several variables endowed by the manufacturing process, including chemical composition, pore size, and percent porosity. Porous high-density polyethylene (PHDPE) is manufactured through a process of sintering in which small particles are fused at high temperature and pressure. PHDPE is 50% porous by volume and contains pores ranging from 100 to 250 mm in size, with an average pore size of 150 mm (48,49). The disadvantages of using PHDPE include a prerequisite for wide tissue undermining during surgical implantation, implant rigidity, difficulty in implant removal, and a documented infection rate.

4)Expanded-polytetrafluoroethylene implants

Expanded polytetrafluoroethylene (e-PTFE) composed of a polymer arranged as solid nodes attached to fine fibrils in a grid-like pattern. For more than 20 years e-PTFE has been used safely and reliably as a vascular implant. The pore size of e-PTFE ranges from 10 to 30 mm, allowing some host tissue ingrowth, but to a significantly lesser degree than allowed by PHDPE or meshed implants (47). A new formulation of e-PTFE reinforced with fluorinated ethylene propylene (FEPRePTFE) was designed to enhance pliability and firmness. Material available in sheets, blocks, strands, and preformed shapes. In late 2006 the manufacturer announced that these e-PTFE SAM facial implants would be withdrawn from the market for nonmedical reasons (49-50).

IV) ZYGOMATIC IMPLANT

Endosseous implants have become a very common mode of treatment for partially and completely edentulous patients, unfortunately restrictions have appeared in the use of oral implants. One of them is the lack of sufficient bone volume, especially in the posterior maxilla (51,52). In 1997 Branemark developed a specific implant called the zygomaticus fixture to provide fixed solutions even when the conditions for implant insertion were poor in the posterior maxilla (53). Malevez et al described zygomatic implants as self-tapping screws in commercially pure titanium with a well-defined machined surface. They are available in 8 different lengths, ranging from 30 to 52.5 mm (51).

Anatomic Considerations / Measurements for Zygomatic Implant Placement

Uchida et al said that a zygoma bone can be compared to a pyramid, offering an interesting anatomy for the insertion of implants (54). Based upon various studies on zygomatic bone the following conclusions can be made: zygoma shows regular trabeculae and compact bone with an osseous density of up to 98%, zygomatic bone can be used for the insertion of miniplates in maxillofacial fractures,zygoma can be used for fixed anchorage to allow dental arch retractions and to anchor a screwed prosthesis, and surgical drilling guides should be encouraged for zygomatic implant placement.Based on the results, it was clear that zygomatic implants developed by Branemark are seen as an alternative for patients presenting severe atrophy of the maxilla (55,56).

Zygomatic Implant Placement: There are 2 modified techniques that have been used, which are the modified zygomatic implant placement technique and the extra sinus zygomatic implant placement technique(57). The zygomatic implant has an angulated head. This angulation allows for the platform of the implant to be in the same plane as the conventional implants in the premaxilla (58,59). Placement of implants in 3 possible locations is described below:

1. The most posterior implant is placed first. The palatal entrance is made in the second molar region, with the implant running slightly posterior to the buttress and perforating the zygoma from the medial side. The entrance in the zygoma should be low and posterior.
2. The second implant is placed in the premolar region, running along the infrazygomatic crest inside the sinus and perforating the middle aspect of the zygoma.
3. The third implant is placed in the lateral incisor region, running along the lateral nasal wall initially and perforating the zygoma high, close to the lateral orbital rim. Removal of any interfering crestal bone is suggested.

Extra-sinus zygomatic implant placement technique: The zygomatic implant site is planned by striving to place the implant head at or near the top of the crest, usually in the second premolar/first molar regions. Moreover, the implant body should preferably engage the lateral bone wall of the maxillary sinus, while entering the zygomatic bone (60). As a result, the zygoma implant enters the crestal bone or sinus cavity from the palate crest of the premolar/molar area, then comes out through the lateral maxillary sinus wall close to the sinus ground/maxillary basal bone (61). Finally, the implant head penetrates the zygoma arch, and it appears in the superior part of the zygomatic arch(62).

3. Conclusion

These extra oral implants are safe, reliable and most effective method of retaining maxillofacial prosthesis with high survival rate thus providing enhanced comfort for the patient and ease of maintenance. However careful patient selection, pre-surgical evaluation of both systemic status and bone quality at the implant site, along with the patient's interest to perform daily home care, must be done to achieve a successful result on long term basis.

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