MAXILLOFACIAL APPLICATIONS OF OSSEOINTEGRATION

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ABSTRACT

The application of osseointegrated fixtures to the cranial skeleton for facial prosthesis retention marks a revolutionary step in the search for the perfect soft tissue replacement. They allow present elastomer technology to be used to its greatest potential by protecting surface coloration, eliminating adhesive-induced base material degeneration, and allowing the long-term retention of fine, but weak peripheral margins. Although not all facial defect patients are candidates for this approach, the concept as applied in our present experience has proved to be a valuable replacement for available adhesive systems.

KEYWORDS: The application of osseointegrated systems.

EXTRA-ORAL APPLICATIONS OF OSSEOINTEGRATION

The history of facial prosthetics provides a remarkable example of the ingenuity of mankind in dealing with facial disfigurement. Facial prostheses were limited in their usefulness by technological limitations and these limitations frequently placed facial prostheses as the last resort for patient and surgeon alike. Introduction of percutaneous osseointegration biotechnology in 1979 to head and neck reconstruction permanently revised the long held view that a facial prosthesis was a last resort for the patient and surgeon alike. Since that time, the use of extra-oral osseointegration has expanded considerably.¹
Prior to the introduction of osseointegration, methods of retaining facial prostheses remained as their primary limiting factor. Mechanical retention and the use of adhesives were the essential methods of retaining facial prostheses. As an example, extrinsic mechanical retention might typically involve spectacle frames to support a nasal or an auricular prosthesis. The use of adhesives persist, but remains controversial. Mechanical and adhesive retention are disadvantageous since they do not provide specific positioning and the retention they provide is not reliable.[2]

In 1977 the first osseointegrated implants were installed in the temporal bone for connecting a percutaneous abutment to support a bone conduction hearing processor. In 1979, the implants were placed in the mastoid region to retain an auricular prosthesis. Since that time osseointegration has been employed internationally in facial reconstruction with facial prostheses.[1]

A wide variety of defects exist; ranging from congenital, surgical or traumatic: absence or loss of either ear, nose or orbit, to major facial defects sometimes in combination with oral abnormalities. The resulting facial defect may be treated with a facial prosthesis, by autogenous reconstruction or a combination of approaches. Major intra-oral defects such as total or partial maxillectomy can be reconstructed using a combination of autologous bone grafts and specially designed anchorage elements and prostheses.[3]

**INDICATIONS AND METHODS OF CARE FOR ASPECTS OF EXTRA-ORAL OSSEOINTEGRATION**[4]

**Indications**

**General indications**

Any condition that influences the ability of the bone to remodel may presumably influence the integrity of the bone-implant interface in osseointegration. The literature cites numerous potential local and systemic factors that may negatively influence osseointegration. Of these local and systemic factors, few are objective contraindications. It appears there is consensus that smoking reduces implant survival although well designed trials are reported lacking. The literature on smoking and implant survival addresses dental implants and not extra-oral osseointegrated implants.

When considering craniofacial osseointegration, age alone does not appear to be a contraindication since patients 2 to 3 years of age and as old as 80 years of age have been
treated. Patients with psychiatric conditions need to be considered carefully as candidates for craniofacial osseointegration. Patients also need to be compliant with homecare regimes and be willing to return for follow-up visits. Patients also need to possess adequate dexterity to manipulate the prosthesis and to carry out hygiene procedures. Combined modality cancer therapy may influence individual implant success rates. Radiation therapy has been associated with craniofacial implant failure but is not seen as an absolute contraindication. Implant loss in the irradiated patient is highest in the zygoma and frontal bone, followed by the maxilla, temporal bone and then mandible. The use of hyperbaric oxygen therapy (HBO) to counter the effects of therapeutic radiation on bone remains controversial.

TREATMENT PLANNING
The need for an interdisciplinary approach to treatment planning, treatment and long term follow-up for craniofacial osseointegration care is widely agreed upon. Planning craniofacial osseointegration treatment is a multi-factorial process and requires tailoring for each patient. Craniofacial osseointegration is however a stepwise protocol driven process. An algorithm for treatment planning has proposed treatment specific charting, preoperative photographs, pretreatment moulages, psychological profiling, planning implant positions and available bone volume assessments where indicated. Preoperative education, counseling and obtaining procedure specific informed consent should be considered essential.\[5\]

The positions of the implants are planned on the skin surface. This may be achieved by use of biometric landmarks and planning templates or trial prostheses. Where concerns exist regarding available bone volume, CT scanning with radiographic templates may be used.

Indications for implant installation simulation planning have been cited as: under 10 years of age; severe trauma; major resections; altered morphology; syndromic patients; a history of problems with implant installation. Rapid prototyping with Stereolithography has been used in patients with dysostosis of the cranial region.\[6\]

SURGERY
Implants that are screw-shaped, cylindrical or plate-like have been used for retaining facial prostheses. For the surgical installation of screw-shaped osseointegrated implants the original surgical technique uses a two-stage approach with three to four months healing between the stages of surgery. More recently, a one-stage approach in the mastoid has been described although a two-stage approach continues to be advocated for pediatric patients, the orbit,
midface applications and patients who have been irradiated. The surgical installation of cylindrical implants for facial prostheses has been described as a two-stage procedure. This procedure advocates a 3-month healing period between implant installation and percutaneous connection. It has been reported that cylindrical implants produced microfracture of the orbital bone and so were not advocated for use in the orbit.\textsuperscript{[2,4,6]}

The surgical installation of the plate-like implant system differs from that of the screw-shaped or cylindrical systems. In certain conditions and some anatomical locations, bone availability may be limited for screw or cylindrical implant installation. While the screw-shaped or cylindrical systems are typical osseointegration systems, the plate-like system is retained with mini-screws. The process of installing the plate-like system is similar to typical bone plate installation. The plate houses threads into which percutaneous posts of varying length can be screwed. These percutaneous posts provide the sites for connection of the retentive elements. A period of 4 weeks healing has been used prior to prosthesis construction. The plate-like system has been advocated for use in the mastoid, orbit and nasal region.\textsuperscript{[3]}

Regardless of the system used, it appears there are several fundamental principles that are important. The bones into which implants for facial prostheses are installed rely upon periosteal blood supply; minimizing periosteal reflection is considered important particularly where the bone has been compromised; the surface of the implant must not be compromised and nor must the surface of titanium instruments used to manipulate titanium components be compromised; bone drills must be sharp and used with ample irrigation to prevent damage to the bone that would render it non-vital, drill speeds and torques should be controlled to the protocol for the drills used; implants should not be placed too closely together as this creates problems for hygiene control; electrocoagulation should be used sparingly, particularly in the midface, orbit, one-stage and irradiated patients; the skin should be thinned to limit relative motion between the skin and the percutaneous connector; the skin surrounding the abutment should be hair free.\textsuperscript{[4]}

Bone volume availability may be a limiting factor in the installation of osseointegrated implants to support a facial prosthesis. This may be encountered particularly in patients with congenital malformations and in the mid-face. Bone volume availability may be expanded in certain situations with the use of membranes and guided tissue regeneration.\textsuperscript{[7]}
Patients with facial defects may present with complex deformities that require management by a combination of both autogenous and osseointegration techniques. Typically, these patients have both bony and soft tissue deficits that must be addressed in conjunction with the osseointegration procedure.

PROSTHETIC TREATMENT
Biomechanics is considered important to the future understanding of modulating the bone-implant interface. It appears to be frequently assumed that loads delivered to extraoral osseointegrated implants retaining facial prostheses are trivial and insignificant when compared to intraoral implants.\(^8\)

It appears that current understanding of biomechanics in relation to extraoral osseointegrated implants is very limited. Much of contemporary belief emerges from concepts such as Frost’s Mechanostat theory. The theory proposes that in long bones, below 200\(\mu\) bone loss occurs whereas equilibrium by remodeling occurs between 200\(\mu\) and 2500\(\mu\) in compression and 1500 \(\mu\) in tension.\(^9\)

In the extraoral experience, high implant loss rates are associated with irradiated bone where presumably the remodelling capacity is reduced. It is possible to speculate that in these situations the strain history is exceeding the remodelling capacity. It may be assumed that the loads on extraoral implants are not trivial and that their capacity to withstand strain may have a lower tolerance in some bones and certain conditions, than is generally anticipated.\(^{13}\)

ORTHOPEDIC APPLICATIONS OF OSSEOINTEGRATION FOR LIMB, HAND, AND DIGIT PROSTHESES
Orthopaedic applications of osseointegration for limb, hand and digit prostheses represents an interesting development for the future. It is reported that work began on lower limb prostheses in 1990. Osseointegration has also been used in forearm amputation with implants being installed in the ulna and radius.\(^9\)

An interesting concept arising from osseointegration and studied in the orthopaedic application of osseointegration is that of osseoperception. Osseoperception is a term that refers to the restitution of some sensory and tactile function. With vibrometric tests, it was shown that the normal hand extremity and osseointegrated hand prosthesis had similar threshold responses for vibrotactile stimuli. By distinction, conventional hand prostheses had
an average 70% of the threshold response of that of normal extremities. Osseointegration has also been used for finger prostheses.\[^{10}\]

Currently, hand prostheses remain primitive in function, provide no sensation and are limited to opening and closing of the hand through signals from the extensor and flexor muscles. More advanced central systems for hand prostheses are under development and involve a range of technologies, including microchips implanted in peripheral nerves.\[^{11}\]

**THE FUTURE OF EXTRA-ORAL OSSEOINTEGRATED IMPLANTS**

There are several areas of development that appear important to the future of extra-oral osseointegration and its application to facial prosthetics. A remaining challenge is that the soft tissues do not attach to the percutaneous abutment. Early work has been undertaken to understand how soft tissue attachment to the abutment may be promoted. Conventional prototyping, rapid prototyping and image data acquisition systems are seen to be likely to play an increasingly important role in treatment planning and treatment. Of the current rapid prototyping technologies, stereolithography and fused deposition modelling are thought to be important but appropriate technology selection for head and neck reconstruction applications is yet to be defined.\[^{12}\]

**SUMMARY**

The application of osseointegrated fixtures to the cranial skeleton for facial prosthesis retention marks a revolutionary step in the search for the perfect soft tissue replacement. They allow present elastomer technology to be used to its greatest potential by protecting surface coloration, eliminating adhesive-induced base material degeneration, and allowing the long-term retention of fine, but weak peripheral margins. Although not all facial defect patients are candidates for this approach, the concept as applied in our present experience has proved to be a valuable replacement for available adhesive systems.

**REFERENCES**


