The Modern Methods in the Surgical Reconstruction and Rehabilitation of the Orofacial Region: A Review of the Literature

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Clinical Points:

- Advances in the reconstruction of defects in the orofacial are now carried out by use of microvascular free tissue transfer, osseointegration of dental implants and the use of new bone growth promoting substances.
- Microvascular free tissue transfer is a highly successful technique that involves harvesting of tissue from distant sites for reconstruction via re-anastomosis of tissue blood vessels to vessels in the recipient area.
- Prosthetic rehabilitation is carried out via dental implants, which can integrate with bone (osseointegration), and is followed by construction of dental prostheses.
- The use of scaffold materials, growth factors, distraction osteogenesis and alloplastic materials are advances that may prove beneficial with further research and development.

ABSTRACT
Maxillofacial and dental defects often cause detrimental effects to patient health and appearance. A holistic approach of restoring lost dentition along with bone and soft tissue is now the standard treatment of these defects. Recent improvements in reconstructive techniques over the past number of decades especially osseointegration, microvascular free tissue transfer and improvements in bone engineering have yielded excellent functional and aesthetic outcomes. This article reviews the literature on these modern reconstructive and rehabilitation techniques.

INTRODUCTION
Reconstructive maxillofacial surgery refers to the wide range of procedures designed to rebuild or enhance soft or hard tissue structures of the maxillofacial region. Reconstructions of jaw and mouth defects represent a challenge to the surgeon (1,2,3,4,5) and are most commonly indicated in patients with oral squamous cell carcinoma (SCC). They are also used in cases of benign tumours, trauma, osteoradionecrosis, infection, chronic non-union of bone, clefts, congenital deformities and old age (5,6,7). The development of antibiotics, improved diagnostic imaging and anaesthesia have heralded a new era of success in maxillofacial reconstruction (1,2,4,6). In the past twenty years, the development of bone technology (8,9,10,11,12), osseointegration (13,14,15,16,17) and microsurgery (7,18,19) and improved dental prosthodontics have revolutionised maxillofacial reconstruction. Following surgery, early wound closure and the restoration of form, cosmetics and function are the goals of reconstructive surgery (1,6). This article seeks to review the modern methods employed in the reconstruction and rehabilitation of the form and function of the jaws and mouth such as free tissue transfer, prostodontics and dental implants.

RECONSTRUCTION
Maxillofacial reconstruction is of prime importance in the management of orofacial defects caused by disorders such as neoplastic disease. The modern techniques for reconstruction are discussed below.

Vascularised Free Tissue Transfer
Vascularised free tissue transfer (VFTT), also known as free flap transfer, is now considered the gold standard for maxillofacial reconstruction (4,6). It involves the harvesting and detachment of tissue with it's blood and nerve supply and transferring it to repair a defect, where its blood and nerve supply are re-established by re-anastomosis to suitable recipient site vessels (6). Success rates are estimated at between 90% and 94% (20-22). VFTT is advantageous over non-vascularised transfer, as post-operative radiation affects the vascularied flap less severly compared to the non-vascularised flap due to the transferred blood supply. A number of different donor sites are used for VFTT, the selection of which depends on the recipient site and type of tissue being replaced (5-7,13,18,20-30). The principle types of flaps used in reconstruction are discussed below.

Fibula free flap is regarded as the mainstay in mandibular reconstruction (19,20,23,31). Long vascularised cortical bone is provided from the fibula and can restore angle to angle mandibular defects. The fibula allows placement of osseointegrated dental implants (19). Disadvantages include donor site morbidity and numbness of the foot and toe (32).

Radial forearm free flap is used mainly to restore lateral edentulous defects. The main disadvantages of this flap are inadequacy of available bone and donor site morbidity such as limited motion, grip strength and supination (4,32). Limited bone stock reduces the quality of osseointegration (19). Frodel et al. showed that the radial flap had the largest number of specimens with inadequate bone volume for implant placement (13). However the advantages of this flap are that it offers a sensate skin paddle for intra-oral reconstruction and allows a two-team operative approach (19). The risk of radial fracture is estimated to be 17% (23) and this flap is now regarded as less popular for mandibular reconstruction. However, it is useful when restoring the anterior maxilla and non-tooth bearing areas of the mandible (24) and when soft tissues need to be reconstructed.

Scapular free flap is an osteocutaneous flap and is a recommended choice for complex defects involving facial skin, bone and mucosa (25). This flap, in general, accepts osseointegrated dental implants well (19)and a study of 55 patients over twelve years showed a success rate of 89% (26).

Iliac crest free flap offers the best bone stock for dental implants (19). The natural contours of the bone are helpful for reconstructing lateral and hemimandiblectomy defects and studies show no significant differences in terms of orthopaedic or quality of life outcomes (27). The iliac crest has remained the reconstructive flap of choice in dentate patients (23) and the success rate in a recent review was found to average 96% (29).

REHABILITATION

Maxillofacial rehabilitation is the second important step in the management of patients with orofacial defects as it restores the function of the region. Several important modern methods are discussed below.

Prosthodontics

Prosthodontics (the replacement of missing teeth with artificial materials, such as a bridge or denture) is a treatment modality that depends on the degree of dentulousness (presence of teeth) or the type of defect present. A fixed prosthesis is a device, such as a bridge or denture, which is securely retained by natural teeth, teeth roots and/or dental implants. Fixed prostheses avoids pressure on the mucosa which may be tender, dry and friable in irradiated patients (32). Reports have shown that bone loss in the edentulous maxilla is greater when fixed prostheses are used in place of overdentures (33). A study by Watson et al. showed that overdentures involved more postoperative treatment than fixed prostheses for adjustments and mechanical problems (33). A recent consensus report stated that the implant-supported overdenture is the gold standard in restoring the edentulous mandible (34). In patients with dry mouth, secondary to radiotheraphy for oral SCC, serious concerns regarding ability to maintain oral hygiene must influence treatment options. Teeth with a poor prognosis should be extracted before radiotherapy to avoid osteoradionecrosis (30).

Dental Implants

Osseointegration, which is the basis of dental implants, has revolutionised the restoration of the oral cavity. The technique involves the direct attachment of osseous tissue to an inert, alloplastic material without intervening upon connective tissue. It has allowed increased denture retention and fixed placement of restorations in otherwise edentulous spaces but studies have shown that up to 6-7mm height of bone is required in order to carry out this technique (16). A study looking at the success rate of implants into 6mm of bone height showed that 10.7% failed (14), while the overall mean survival rate in fourteen trials with follow-up periods of 2-16 years involving 10,000 implants was found to be 94.4%, with a success rate 86.8% for grafted bone (15).

Implants placed in reconstructed bone perform identically to those placed in native bone and the quality of bone was found to be the greatest determinant of fixture loss (35). Patient satisfaction with this technique is high. In a study carried out on twenty-eight patients, 85% reported satisfaction with the implants in reconstructed jaws and had no social problems (17).

The use of implants in irradiated bone has been controversial. There is a risk of developing osteoradionecrosis of the mandibular bone when carrying out surgical procedures such as implant placement. In patients about to receive radiation post-operatively, implants should not be loaded for six months (7). The overall success rate for endosteal dental implants was 92%. The implant success rate was 86% when the bone, in which the fixtures were placed, was irradiated postoperatively. In the fourteen fixtures that were placed into previously irradiated bone the success rate was 64% (7). The greater success of native bone and vascularised bone flap osseointegration compared to free bone grafts has been noted (31).

Several factors need to be considered in implant placement in patients treated with radiation therapy for oral malignancies. The use of hyperbaric oxygen has been show to prevent osteoradionecrosis in patients undergoing post-radiation mandibular surgical procedures (30). The risk of osteoradionecrosis is dependant on the dose of radiation (30). Zygomatic implants are a useful treatment modality, where insufficient bone exists for maxillary implant placement. These factors are discussed in detail below.

Hyperbaric Oxygen Therapy (HBO): The vascular vessels in the field of irradiation are narrowed causing a decreased blood flow to the region. Irradiated host bone had been regarded as a contraindication to implant placement (28). HBO is used by some as a precaution before implant placement in irradiated bone to reduce the likelihood of osteonecrosis (36). However, studies have shown acceptable results in irradiated bone without HBO (37).

Radiation Dose: There has been some discussion in the literature as to the importance of radiation dose on implant survival, suggesting that an upper limit of 55 Gy (30) should not be breached without the use of HBO. Disagreement as to when implants should be placed in irradiated bone still remains (31).

Zygomatic Implants: Introduced by Brånemark in 1998, this long implant is used to restore atrophic posterior maxilla in maxillectomy patients and has a success rate of between 82 and 97% in oncology patients (8,38). Zygomatic implants may be an alternative procedure to bone augmentation and sinus lifts (8) but failure is more problematic than dental implants.

THE FUTURE ADVANCES OF REHABILITATION OF THE OROFACIAL REGION

Several advances that may in time have significant applications in the field of orofacial reconstruction are currently under investigation and are discussed below.

Scaffold Materials

In maxillofacial rehabilitation procedures, scaffold materials such as proceramics and polymers are becoming more commonplace to help rebuild the bone. Ceramics, such as hydroxyapatite and β-tricalcium phosphate, are strong enough scaffolds to provide mechanical strength when replacing load bearing skeletal structures (12). Polymers, such as polyglycolic and polylactic acid, are also used but lack mechanical strength and may cause uncontrolled shrinkage of bone (11). Currently available scaffold materials have a number of drawbacks such as insufficient penetration of cells and bone throughout the scaffold, inadequate degradation properties, or inadequate mechanical stiffness (11).

Growth Factors

Bone morphogenic proteins (BMPs) are growth factors and cytokines known for their ability to induce the formation of bone and cartilage (39). Basic fibroblast growth factor is considered to enhance angiogenesis and to support bone formation in the presence of vital bone cells (10). However, there is no reliable evidence supporting the efficacy of agents such as platelet-rich plasma in conjunction with dental implant therapy (3) or wound healing (40).

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Distraction Osteogenesis

Distraction osteogenesis (DO) has been used in correcting craniofacial deformities of the mandible allowing gradual deposition of bone where two segments of bone are moved apart from each other. In a study on the reconstructed mandible, an average gain of 11mm of bone length was achieved using DO (41). The procedure works well in oncology patients who experience poor functional outcomes after surgery due to scar formation or inadequate bone length (4), but comes with a higher risk of failure and complications (41). There is insufficient evidence as to whether DO is the best method available for vertical bone regeneration (3).

Alloplastic Materials

Alloplastic materials have been used successfully in the treatment of defects in conjunction with VFTT reconstruction (39). Titanium hollow screw osseointegrating reconstruction plates (THORP), which are rigid locking plates with osteosynthetic capacity, are used and they have a recorded hardware-related reconstructive failure incidence of only 7% when used with VFTT free flaps (6). Locking miniplates and double-threaded screws are the latest innovation, which allow the locking to both bone and plates to increase stability.

Rigid Fixation

The development of osteosynthesis plate technology has allowed biocompatible materials to internally fix fractures and unionise bone grafts with great success. Recently, biodegradable, self-reinforcing polylactide and polyglycolide plates/screws have been used for internal fixation of mandibular fractures with excellent success (2, 9). This technique allows accurate correction of fractures but being part of an invasive procedure is it's main drawback.

DISCUSSION

Reconstructive maxillofacial surgery can now draw upon many techniques in the reconstruction and rehabilitation of the orofacial region and reliable osseous reconstruction. Major institutions boast successful bony union rates of 95% (4, 42). In reconstruction, the choice of flap depends on the tissue type being replaced and the choice of donor site. It seems that non-vascularised tissue transfer is no longer the accepted first line treatment in orofacial defects and it is now superceded by vascularised tissue transfer. In the past, non-distant pedicles were used to restore maxillofacial defects, giving way in recent years to free flaps. Initial research has reported high levels of success with free flaps but data from randomised or comparative trials are needed to support this research (23).

From the review of the literature it seems that osseointegrated implants offer the best functional and aesthetic outcomes, achieving success rates up to 94%. However some papers have expressed caution about their use in irradiated patients (36,37). They are employed, not only to restore the dentition, but also to restore other anatomy such as the eye.

Advances in grafting and biomaterials have led to much success, not only in maxillofacial surgery but in periodontics and restorative dentistry. Sinus augmentation procedures allow implants to be placed in areas of bony atrophy. Bone substitutes may prove to be as effective as autogenous grafts for augmenting extremely atrophic maxillary sinuses. Upon healing, sites treated with xenografts (Bio-Oss) and barrier membranes show a higher position of the gingival margin compared to sites treated with barrier membranes alone (3).

Distraction osteogenesis and the use of growth factors such as BMPs have shown promise but further research needs to be undertaken before these modalities are recommendable. Much research is being carried out in the field of muscular and neural tissue regeneration and this may play a role in orofacial reconstruction in the future.

CONCLUSION

Orofacial defects can have detrimental functional and psychological effects on the patient. However, in the modern maxillofacial world, the surgeon has a wealth of techniques to draw upon to manage such defects. The management involves either surgical reconstruction or prosthetic rehabilitation or a combination of both. Microsurgery, osseointegration and bone technology have become the keystones in orofacial reconstruction and major advances in recent years have resulted in more treatment modalities and increased success. The future for maxillofacial reconstruction is bright as a wide range of techniques are being developed to improve upon the advances of the past few decades.

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