PEER-REVIEWED ARTICLE

Review of methods used in the reconstruction and rehabilitation of the maxillofacial region

Précis

Modern methods in the reconstruction and rehabilitation of the maxillofacial region.

Abstract

Maxillofacial and dental defects often have detrimental effects on 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, 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.

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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. Reconstruction of jaw and mouth defects represents a challenge to the surgeon[1-5] and is most commonly indicated in patients with oral squamous cell carcinoma (SCC). It is also employed 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 has heralded a new era of success in maxillofacial reconstruction.[1,2,4,6] In the past 20 years, the development of bone technology,[8-12] osseointegration,[13-17] microsurgery[7,18,19] and improved dental prosthetics has 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, prosthodontics 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 its 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 vascularised flap less severely compared to the non-vascularised flap. A number of different donor sites are used for VFTT, the selection of which depends on the recipient site location and the type of tissue being replaced.[5,6,7,13,18,20-30] The principal types of flaps used in reconstruction are discussed below.

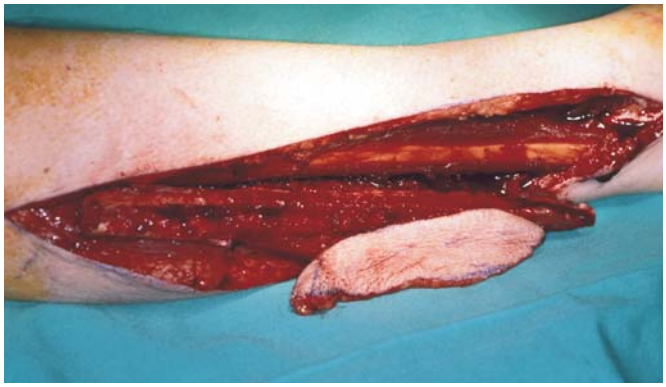

FIGURE 1: Fibula free flap at harvest site. (Image courtesy of Mr Gerard Smith.)

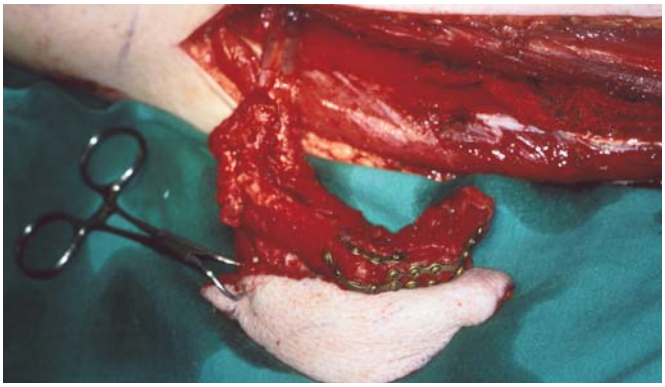

FIGURE 2: Free flap prepared for transfer to mandible. Note blood vessel still attached. (Image courtesy of Mr Gerard Smith.)

FIGURE 3: Free flap placed at recipient site with fixation plates. (Image courtesy of Mr Gerard Smith.)

FIGURE 4: Skin marked out for radial forearm free flap procedure. (Image courtesy of Mr Gerard Smith.)

Fibula free flap

The 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 (**Figures 1**, **2** and **3**).[32]

Radial forearm flap

The radial forearm flap is used mainly to restore lateral edentulous defects (**Figures 4**, **5** and **6**). 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] 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

A scapular free flap is an osteocutaneous flap and is a recommended choice for complex defects involving skin, bone and mucosa.[25] This flap, in general, accepts osseointegrated dental implants well,[19] and a study of 55 patients over 12 years showed a success rate of 89%.[26]

Iliac crest free flap

The iliac crest free flap offers the best bone stock for dental implants (**Figures 7** and **8**).[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 success rate in a recent review averaged 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

Prosthodontic treatments depend on the degree of edentulousness or the type of defect present (**Figures 9**, **10** and **11**). Fixed prostheses

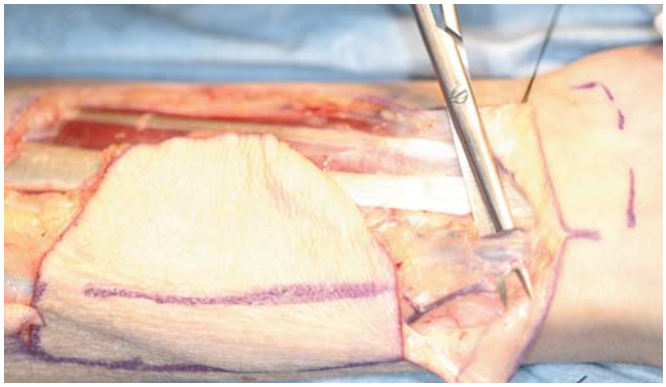

FIGURE 5: Preparation of free flap. Note dissection of vessel. (Image courtesy of Mr Dermot Pierse.)

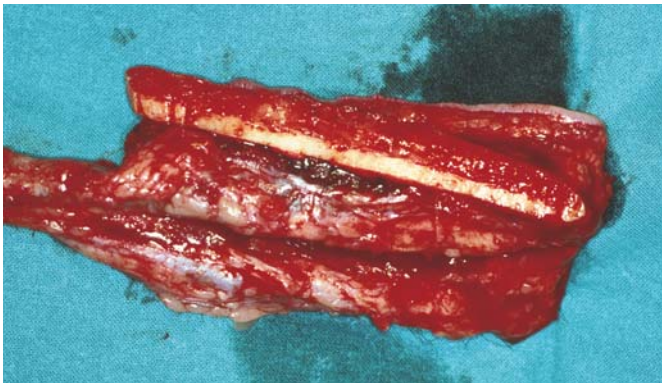

FIGURE 6: Radial free flap prepared for recipient site. (Image courtesy of Mr Gerard Smith.)

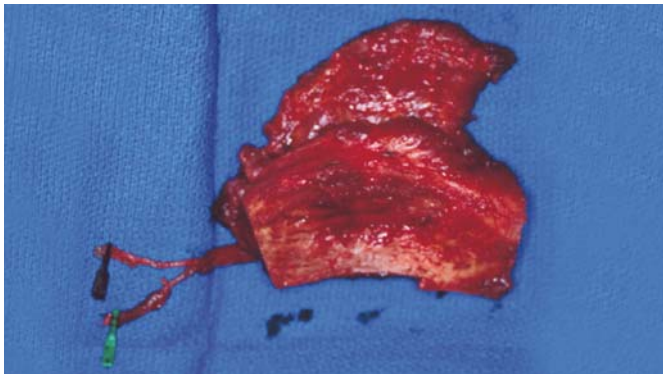

FIGURE 7: Iliac crest free flap prepared for recipient site. (Image courtesy of Mr Gerard Smith.)

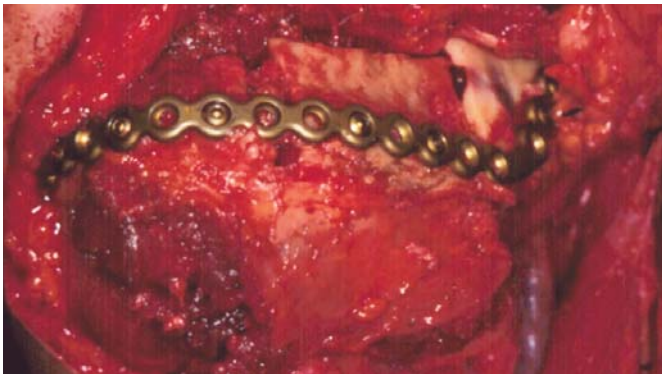

FIGURE 8: Iliac crest free flap at recipient site, with internal fixation. (Image courtesy of Mr Gerard Smith.)

avoid 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. 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 radiotherapy 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 connective tissue. It has allowed increased denture retention and fixed placement of restorations in otherwise edentulous spaces, but studies have shown that up to a 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 14 trials with follow-up periods of two to 16 years involving 10,000 implants was found to be 94.4%, with a success rate of 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 28 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 mandible 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 post-operatively. In the 14 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 placing implants in patients

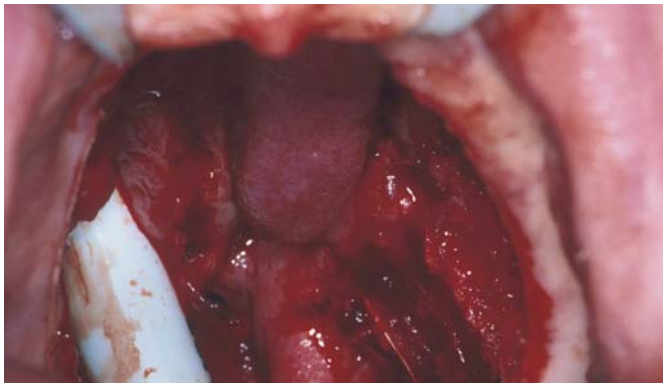

FIGURE 9: Palatal defect following excision of mucoepidermoid carcinoma. (Image courtesy of Mr Gerard Smith.)

FIGURE 10: Obturator with gutta percha. (Image courtesy of Mr Gerard Smith.)

treated with radiation therapy for oral malignancies. The use of hyperbaric oxygen therapy has been shown to prevent osteoradionecrosis in patients undergoing post-radiation mandibular surgical procedures.[30] The risk of osteoradionecrosis is dependent upon the dose of radiation. 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 osteoradionecrosis.[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 55Gy30 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 Branemark in 1998, this long implant is used to restore the 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 with dental implants.

Future advances in rehabilitation

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 bone. Ceramics, such as hydroxyapatite and β-tricalcium phosphate, are strong enough 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] Current 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] There is unreliable evidence supporting the efficacy of agents such as platelet-rich plasma in conjunction with dental implant therapy[3] or wound healing.[9] However, the use of BMPs has been hampered by the lack of suitable carrier agents for the BMP.

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 one another. In a study on the reconstructed mandible, an average gain of 11mm of bone length was achieved using DO.[40] The procedure works well in oncology patients who experience poor functional outcomes after surgery due to scar formation or inadequate bone length, but comes with a higher risk of failure and complications. 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

FIGURE 11: Obturator in situ *restoring palatal defect. (Image courtesy of Mr Gerard Smith.)*

FIGURE 12: Internal fixation plate used to place iliac crest free flap. (Image courtesy of Mr Gerard Smith.)

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 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 (**Figure 12**). Recently, biodegradable, self-reinforcing polylactide and polyglycolic plates/screws have been used for internal fixation of mandibular fractures with excellent success.[2,9] This technique allows accurate correction of fractures but the main drawback is the invasive nature of this system.

Discussion

Reconstructive maxillofacial surgery can now draw upon many techniques in the reconstruction and rehabilitation of the orofacial region and reliable osseous reconstruction. Many institutions boast successful bony union rates of 95%.[4,41] 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 superseded 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] Because of advances, patient quality of life has improved significantly in post-SCC reconstruction; however, the survival rate has not improved.

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 expressed caution about their use in irradiated patients.[36,37] They are employed not only to restore the dentition, but also to restore other structures such as the eye.

Advances in grafting and biomaterials have led to much success, not only in maxillofacial surgery but also 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 and barrier membranes show a higher position of the gingival margin compared to sites treated with barrier membrane alone.[3] DO and the use of growth factors such as BMPs have shown promise, but further research needs to be undertaken before these modalities can be recommended. 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 surgical reconstruction, prosthetic reconstruction 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 is bright, as a wide range of techniques is being developed to improve upon the advances of the past few decades.

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