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Reconstruction of the mandible using free fibula flap

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Abstract

Purpose: To review the reconstruction of the mandible through vascularised free fibula flap through anatomical considerations, preoperative evaluation, reconstruction plates, microvascular anastomosis, stereolithographic models and computer assisted mandibular reconstruction. Hence Free fibula flap is being considered as versatile and gold standard flap for mandibular reconstruction.

Keywords: Free fibula flap ,Mandibular reconstruction, Fibula osteoseptocutaneous flap

Introduction

Over the past few decades, in the field of maxillofacial, there have beenmany facial defects in maxilla and mandible. Majority of the defects were caused by cysts, tumors, cancerous lesions, radiations, genetic malformations and posttraumatic deformities. As there were no specific surgical procedure to replace thedefects, reconstruction came into limelight.

Reconstruction of facial bones and restoration of facial contour after extensive resections may require the simultaneous transferof more than one principal tissue in composite flap, which contains skin, muscle and bone[7].

The principal aim of the Maxillofacial reconstruction is to provide anatomical, functional, aesthetic rehabilitation, facial contour, oral competence, continuity of mandibular arch and support to the outer tissue surface[11].

Various treatment modalities are available for managing oromandibular defects. The treatment of primary to advanced lesion had evolved from reconstruction plates, non-vascularised bone grafts, vascularised bone grafts to the recent modality of the use of vascularised free flaps[1].

Taylor et.al first introduced the fibula flap in 1975, but had not become popular for mandibular reconstruction till the year 1989 when Hidalgo utilized this technique to restore 12 mandibular defects. He was first to describe fibular transplantation for reconstruction of mandible and initiated a new field in the.

Maxillofacial reconstruction

Zlotlow and colleagues incorporated secondary osseointegrated dental implants for functional rehabilitation in 1992 .Wei and colleagues described theuse of osteoseptocutaneous fibula flap for reconstructing composite

Discussion

Goals of Mandibular Reconstruction

Accurate Classification of defect and understanding of functional deficits.Restore form and function.Restore bony contour of native mandible.Restoration of mastication.

Greater then loss of tongue volume, greater negative impact on patientprognosis for recovery of oral function.Deglutition. Articulation.Maintenance of adequate airway.

From the point of view of reconstructive surgery the effect of mandible reconstruction depends on the patients age, general health, lifestyle, tumour localization ,stage of disease, infiltration of surrounding tissues and also on the experienne of the surgical team

Reconstructive options

The options available for mandibular reconstruction are:

Alloplasts with or without soft tissue flaps. Non-Vascularised bone grafts.Vascularised osteo-cutaneous flaps.

Using principle of distraction osteogenesis for bone transport.

Factors that must be taken into account in mandibular reconstruction are the following Stabilization of the mandible.

Sufficient soft tissue coverage over whichever device or graft is utilized.Infection and/or contaminated wound as a result of entering the oral cavityor oropharynx.Operating time. Reasonable function. Cosmetically acceptable results.

Cost effectiveness. Complications relative to specific procedures

Alloplasts

Various alloplastic materials such as vitallinium, stainless steel, methylmethacrylate have been largely restricted to restoration of continuity of bonydefect after excision of neoplastic defects.

Kirschner wires and rods were used to secure bone grafts, to stabilize mandibular stumps and to stabilize soft tissues. Stabilization after partial mandibulectomy is by interposing the implant between the bone ends and after hemi mandibulectomy by seating the implant into the glenoid fossae.

They present a problem of telescoping which may be solved by means of threaded pins with flanges or making L-shaped bends in the pins to prevent the further penetration into the marrow cavity. This type of reconstruction lacks functional stability and there is resorption at the rod ends resulting in loosening

and dislodgement. External fixations with transcutaneous pins were used but its use now is limited due to inconvience to the patient and occurrence of chronic inflammation around the pins. Metallic mesh trays have been used along with

bone chips for mandibular reconstruction. Reconstruction plates and screwshave been used for bridging bony defects. It helps to preserve the occlusion and TMJ functions

Alloplastic materials were introduced to prevent collapse of mandibular segments and to provide soft tissue support . The ideal material should be inert ,easy to bend and contour, reliable and strong enough to withstand forces of mastication.

The plates used for reconstruction are either titanium or stainless steel. Titanium plates are more expensive than stainless steel, but bending and contouring is easier.

The THORP reconstruction plate system uses a perforated hollow titanium screw that allows bone in growth and osseointegration which increases the stability of bone-screw interface. There are several large series describing the use of reconstruction plates for mandible reconstruction after tumour resection.

The success of these plates is variable and depends on the amount of bone resected and the location of the defect. These plates are successful only if they are used for reconstruction of short lateral segmental defects .Plate extrusion rates increases greatly when soft-tissue /mucosa is resected or if the plate is placed in an anterior position .Mandibular reconstruction plates are indicated only for short lateral segments in patients who have no mucosal or soft tissue resection and who are not likely to undergo radiation.

Mandibular reconstruction plates should be used only in patients with a very poor prognosis or those who are unable to tolerate longer more complicated micro vascular procedures. With the development of biocompatible materials that are inert, capable of withstanding the masticatory forces and increased knowledge of the principle of internal fixation, alloplastic materials such as titanium plates and trays have emerged as alternatives for immediate mandibular reconstruction.

The use of Reconstruction plates for Mandibular reconstruction is often criticized because reported rates of post-operative plate exposure have been extremely high. (WEI ETAL., 2003; OKURA ET AL., 2008) 46.15% reported by

WEI et al . Exposure is the most serious complication of plate reconstruction and necessitates a fundamental review of the therapeutic plan, including plate removal.

Titanium Hollow screw osseointegrating reconstruction plate (THORP) SYSTEM

First reconstruction plate with mechanism for osseointegration at the bone-to-bone screw interface. Locking mechanism at screw- to-plate interface .Found to be superior to solid screw steel and titanium plates. Recent studies comparing THORP to vascularised bone grafts show significant delayed complications of hardware extrusion. Specific Free tissue transfers for head and neck Reconstruction.

Anterior oral cavity defect: Radial forearm flap, lateral arm flap.

Posterior oral cavity defects : Lateral arm flap, Scapular and parascapular flap.

Full-thickness and large defects –Latissimus dorsi muscle /myocutaneous flapRectus muscle/myocutaneous flap, Groin flap.Composite(osteocutaneous)defects-Deep circumflex iliac artery flap, Fibula flap, scapular/parascapular flap, Radial forearm flap.

Free Bone Grafts

The first attempt to bridge defects of the mandible stem from German pioneers at the turn of the 19th century. Sykoff is thought to be the first surgeon to have done a free bone transplant. He used a graft from the horizontal part of the contra lateral mandible 4cm length to bridge a defect. The German surgeons Klapp and Schroder described in detail various ways to bridge mandibular defects in their book on' Gunshot wounds of the Mandible 'also called creeping substitution. Any micro-movement, because of non-rigid fixation, would jeopardize the viability of the graft. Free bone grafts are still a good option for defects that are not bigger than approximately 5cm, provided the soft tissues are in good condition. Gaps greater than 5cm not really suitable for this means ofbridging a defect, while in most cases of malignancy, when a large part of the surrounding soft tissues is lacking, healing cannot be assured.

Pedicled Bone Grafts

The use of pedicled bone grafts goes even further back in history .AgainGerman surgeons were the first to apply this technique .According to theinformation provided by Klapp and Schroder. Bardenheuer (1891) was the firstto transplant a frontal bone graft, pedicled to the soft tissues, to the mandible. Rydygier and Woffler (1892) transplanted a pedicled clavicle to restore continuityof a mandible. Wildt and Diakonow (1896) used the mandible of the same sideand took a partial thickness graft that was pedicled to probably the platysma and the skin. This composite graft then transposed to the defect and fixed with wires. The advantages of these techniques was that they did not require further surgery for a donor site. The disadvantage, however was the possibility of soft tissue dehiscence ,fracture of the implant and plate loosening .Although nonvascularized bone grafts are acceptable for small mandibular defect reconstruction nevertheless have some drawbacks .These tissues are limited inwidth and length, their blood supply is random and therefore its viability is not ensured. Vascularized bone offers significant advantages over conventional ortraditional methods of bone grafting.

Site and location of mandibular and soft tissue defects

Mandibular segmental defects involving the symphsis and parasymphysisare the most significant in terms of aesthetic and functional morbidity. Failure toreconstruct this part of the mandible results in the Andy Gump deformity and loss of tongue-anchoring and masticatory platform functions of the anterior arch .Theanterior arch also serves to anchor the hyomandibular muscle complex involved in laryngeal elevation and deglutition. Two common issues with regard to microvascular mandibular replacement are the type of fixation needed to securethe bone graft in place and the method used to size and shape the bone graft accurately to match the resected segment closely.

In some cases, a template-driven method for sizing and shaping the bonegraft is lacking and stereolithographic model may be of use. Using computed tomography data (CT) data, a three dimensional model is created using computer-aided design software. This model is then used to create custom reconstruction plates that can be used as a template for the bone graft and to secure graft into place. Stereolithographic models allow pre-bending of plate sand pre-plating technique as described recently by Pellini etal[11].

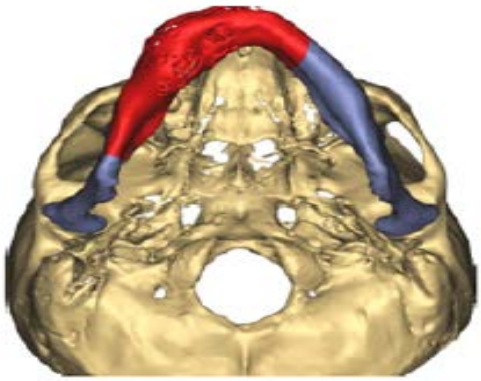

Figure 1: 3 D Reconstruction of patients craniofacial skeleton

Figure 2: Right fibula cutting guides fixed on patients fibula

Central segmental mandibular defects

Isolated anterior arch defects can be reconstructed using any of the available favoured donor sites; however the associated soft tissue defects may require more

discernment in choice of the most appropriate flap. Common associated soft tissue defects include those involving the floor of the mouth ,lower lip, chin and neck, and tongue.The scapula, iliac crest, and fibula each possess unique attached soft tissue components .The Fibula possess a closely attached thin skin paddle that may be made sensate. Although the scapular system has the least substantial bone of the three flaps .Most anterior segmental mandibular defects will have an associated defect of the anterior floor of the mouth. Therefore, atleast a portion of the soft tissue component of the free flap must be used to resurface the anterior floor of the mouth and close the through hand–through defect in this area.

The Fibular flap often proves inadequate to reconstruct the intra and extraoral soft tissue deficits. However, the iliac crest is suitable with its muscular component for the intra oral defect and its skin component for the chin and neck defect .The Fibular flap could be used and the extra oral defect resurfaced with a regional flap (lower island trapezius or pectoralis flap).

The free fibula flap described by Hidalgo is the most common composite vascularised free tissue used for reconstruction of complex oromandibular defects .The techniques in flap design, harvest and osteotomy have undergone changes over the years5. The osteotomy of the fibula and the alignment of the osteotomised segments is a significant step in the challenging task ofmandibular reconstruction .In order to simply this step, a variety of mandibulartemplates6 are being used.The templates are important because they help inthe normal contour of the mandible especially the lower margin ,help inplanning the number of osteotomies thereby minimizing the periosteal strippingand reducing the vascular compromise.

Sterolithographic model used to adapt a reconstruction plate andbone graft accurately into a segmental mandibular defectLateral segmental mandibular defects

Lateral segmental mandibular defects (posterior to the mental foramen)tend to be less morbid than anterior arch defects in terms of aesthetics and function. Failure to reconstruct this part of the mandible results in a mild to moderate contour deficiency, mandibular drift toward the side of the defect, and malocclusion. The functional deficits with regard to speech and swallowing are

often are related more to associated soft tissue deficits and radiation therapy.The primary reconstruction of lateral segmental defects include pedicled vascularised bone, MRPS, and micro vascular bone transfers. Pedicled vascularised bone tends to undergo avascular necrosis .The iliac crest composite flap is useful for lateral mandibular defects.

A scapular composite flap for reconstruction of a lateral mandibular defect.The skin component is used to cover the neoalveolus and close the through-and–through defect of the lateral floor of the mouth.

Timing of Reconstruction

The ideal timing of mandibular reconstruction has been widely debated, especially in patients with malignant disease. Historically, proponents of a delayed or staged approach advocated a period of observation to monitor the patient for development of recurrent disease or to establish histologically clear bony margins prior to reconstruction. Today, however, it is widely accepted that immediate reconstruction may be performed without risk for a delayed diagnosis or recurrent disease. Prior to microsurgical techniques, delayed reconstruction was critical to allow maturation of the wound bed for nonvascular bone grafting.

Surgeon Training/Preference:

The choice of any surgical procedure is affected by the training and skill level of the surgeon. A thorough

understanding of the available literature regarding techniques, complication rates, indications should guide the surgeon through the choice of available procedures .Although every surgeon may not be comfortable or adapt with every technique, it is theresponsibility of every surgeon to be familiar with the most current therapies and seek consultation or referral when in the best interest of the patient.Location of defect and mandibular reconstruction plates (MRPs): This is most important when consideringreconstruction with a MRP with or without a soft tissue flap or a delayed, nonvascularized osseus reconstruction when thepatient will require temporary stabilization with a MRP .In these situations, reconstruction of defects of the anterior region demonstrates high complicationrates. Spiessel in 1976 was the first to report bridging a tumor defect with are construction plate. However, Schmoker was the first to propose reconstructionof mandibular defects with a reconstruction plate without osseous reconstruction. Vascularized Bone Flaps vs Nonvascular Bone grfafts/importance of defect length of the bony defect.

Marx has stated that micro vascular bone –periosteal flaps do not represent a true advance in jaw reconstruction. He has proposed that nonvascular bone grafts provide more adequate bone volume, improved continuity, better arch form, better alveolar bone height, and endosseous implant success .Success rates for nonvascularized bone grafts have been reported from 38-100%,and similarly failure rates have been reported from 20-81%, affecting the outcome of mandibular reconstruction including length of themandibular defect, timing of reconstruction, radiotherapy, postoperative recipient site complications, malignant diagnosis, and intraoral communication. Pogrel etal. Compared vascularised bone flaps to non vascular bone grafts. Foster performed an outcome analysis for vascularised bone flaps and nonvascularbone grafts comparing primary bone union and endosseous implant success.

Radiotherapy is another important consideration when selecting the typeof osse demonstrates higher failure rates in an irradiated wound bed. Regional muscle flaps have been proposed to provide a vascular wound bed to support nonvascular bone grafting and to help prevent MRP extrusion in patients with extensive tissue loss or requiring radiotherapy. Although regional muscle flaps represented an important advance in mandibular reconstruction to improve the success of nonvascular grafts prior to predictable free tissue transfer techniques. If regional muscle transfer is performed prior to radiotherapy, the wound bed is subject to the same hypovascular effects of radiation. This leads to potential graft failure in two ways. First and most obvious is the risk for great failure, or resorption in the hypo vascular wound bed resulting in inadequate volume of the graft. Second, wound healing complications are increased in the radiated wound, which can lead to wound dehiscence and graft exposure with failure

Quality /Vascularity of the wound bed

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Bone Grafts and Flaps

Currently available techniques for bone replacement include nonvascularisedbone grafts, bone flaps and micro vascular osseous andosteocutaneous flaps.

Foremost is the quality of the soft tissue environment into which the bone reconstruction is to be performed. A history of previous radiation, scaringfrom previous graft failures or previous infection lessens the probabilitythat vascularisation of non-vascularised bone graft will occur.

Another consideration is whether adequate soft tissues cover both internal and external is present for the reconstructed bone. Adequate soft tissuemust always be provided at a previous operation if a non-vascularisedbone transfer is used. Whereas the bone flaps are able to provide boneand soft tissue is a one stage procedure, which makes them preferableand soft, when bone and soft tissue reconstructions are required.

Methods of fixation

A wide variety of methods of fixation of the fragments of the mandible areavailable to provide immobilisation during the period of healing of bone grafts.Depending on the size of defect these vary from relatively simple techniquessuch as intermaxillary fixation, monomaxillary fixation with a splint and a rigidskeletal fixation by specially constructed external fixation appliance.

Dental Restoration

The final stage of mandibular reconstruction is the provision of dentures.These can be done by use of removable dentures or fixed dentures toosteointegrated implants. The use of removable dentures is a problematic due tolack of buccal and lingual sulcus around the reconstructed mandible. This requires secondary surgical procedures as vestibuloplasties. The use of osteointegrated implants helps in functional dental restoration. Dental rehabilitation with osseointegrated implants is an integral part of mandibular reconstruction following ablative surgery .Dental rehabilitation supported with endosteal implants helps restore functional mastication, facial aesthetics and support for the lower lip. Planning for implantation begins prior to surgical resection .Patients being considered for implants should demonstrate good oral hygiene, have are sonable inter incisal opening, a favourable prognosis for survival and anticipated favourable post-operative swallowing function.

Implant placement is done in two stages: fixture placement followed by exposure of the implant and placement of the transmucosal attachment.Following placement, the implant is allowed to integrate for 4 months in the mandible and 6months for maxillary implants. The trans –mucosal attachment isthen placed and two weeks later the denture is attached and load bearing follows.

Complications

An MRP alone was used to reconstruct an anterior and posterior archdefect. The complications are plate breakage a) and Exposure b) approximately2 years postoperatively.

Plate exposure

Ling and Peng reported that the most common problem was delayedwound healing and the early donor-site dysfunction rate was only 2.2% and therewas only 1 complication i.e Hematoma.

The most common late complication was numbness of the lateral side ofthe lower leg and dorsum of the foot5,15.

The other complications such as muscle weakness, edema, pain, abdominal gait and ankle instability.

inspite of using all the above materials like alloplasts, reconstruction plates, bonegrafs, various disadvantages has been encountered .so, as to overcome their disadvantages free fibula flap came into picture for reconstruction of mandibular defects.

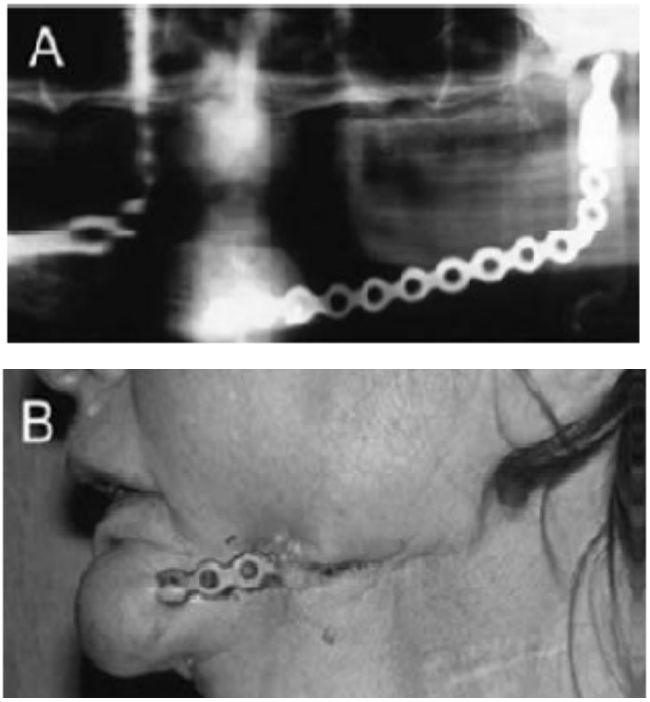

Figure 3: plate exposure

Conclusion

From the time of evolution to the present era, different treatment modalities have evolved for the reconstruction of the mandible .Fibular free flapprovides sufficient amount of bone and soft tissue for mandibular reconstruction which improves the chewing and swallowing efficiency by dental rehabilitation with minimal risk of donor-site morbidity. Hence free fibula flap has is being considered as versatile and gold standard flap for mandibular reconstruction

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