Complications of Head and Neck Reconstruction and Their Treatment

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ABSTRACT

Head and neck reconstruction is an intensive multistep process that requires attention to detail to achieve a successful result. The knowledge and prevention of complications as well as their management is an essential part of the training of the surgeon participating in head and neck reconstruction. This article explores the general complications, including free flap failure, carotid artery blowout, hardware exposure, and ectropion, as well as regional complications relating to operations of the scalp, cranium, base of skull, midface, mandible, and pharyngoesophagus.

KEYWORDS: Free flap failure, carotid blowout, hardware exposure, ectropion, scalp, cranium, base of skull, midface, mandible, pharyngoesophagus

Head and neck reconstruction is mainly performed after extirpative oncologic surgery, as well as for trauma, congenital defects, and infection. Head and neck reconstruction can be subdivided into several regions of interest; namely, the scalp and cranium, the base of the skull, the midface, the mandible, and the pharyngoesophagus.

The goals of head and neck reconstruction are to restore form, function, and aesthetics by the selection and use of safe techniques. To achieve this, good wound healing has to be accomplished in frequently hostile environments. Use of the reconstructive ladder as a guide for reconstruction is appropriate, especially as most small defects can be closed with local flaps or grafts. However, when there is a large composite

defect, free flaps are frequently required to achieve these goals.¹

The importance of a free flap is highlighted by the fact that a failed free flap in head and neck reconstruction may necessitate reconstruction with a second or even third free flap.^{2,3} Success rates for free flaps in the head and neck and upper extremities are high, at around 97 to 98%.^{3,4} These success rates can be maintained even in the elderly population at 96% as reported by Coskunfirat et al⁵ and at 95% as reported by Malata et al.⁶

This article will explore the general complications, including free flap failure, carotid artery blowout, hardware exposure, and ectropion, as well as regional complications relating to operations of the scalp,

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cranium, base of skull, midface, mandible, and pharyngoesophagus.

GENERAL COMPLICATIONS

Free Flap Failure

Common causes of free flap failure include arterial and venous thrombosis, infection, anatomic variations, and flap dissection errors (e.g., vascular pedicle anomalies and flap elevation problems).^{3,7,8}

In this section, we discuss the reasons for, the prevention of, and the treatment of anastomotic failure.

ARTERIAL FAILURE

In the head and neck region, the common causes of thrombosis resulting in flap failure are:

- Bleeding.
- Extrinsic compression and kinking of the vessel.
- Avulsion of the anastomosis due to uncontrolled physical movement or coughing bouts.

Arterial spasm is an uncommon cause, unlike in the extremities, where the recipient arteries are more muscular and prone to spasm.

Bleeding can occur at any point along the anastomosis where vessel apposition is poor, which could be due to vessel mismatch or a faulty suturing technique. Platelets aggregate at the gap in an attempt to seal the leak, and this serves as a nidus for thrombosis. Aside from the anastomotic line, bleeding may originate from small arterial branches because of slipped ligatures or hemoclips. A hematoma that accumulates around the pedicle is a potent stimulus of vessel spasm.

Potential bleeding points may not be immediately apparent because of the hypotensive state the patient is in during anesthesia. Thus, bleeding usually manifests during reversal from anesthesia or in the intensive care unit when blood pressure has normalized. Hemodilution is yet another factor that creates a bleeding tendency; this is easily avoided by using blood products instead of crystalloids to correct for hypovolemia.

Bleeding is an indication for reexploration, and this should be done under general anesthesia. A leaking point at the anastomosis can be sealed by placing additional sutures. Sometimes an adventitial stitch is all that is necessary to avoid new needle punctures. If a thrombus is seen, it should be extracted and the anastomosis revised, as the segment of vessel has become thrombogenic. If the vessel has been joined to the carotid artery and is leaking, additional sutures would be necessary to stem the bleed. Pledged sutures using bits of muscle or fascia may prevent stitch "cut-through." If possible, avoid end-to-side anastomosis to the carotid artery, but if there is no

choice, 8-0 sutures should be used to give strength to the repair.

Kinking of the pedicle happens when there is vessel redundancy. The sandbag propping up the shoulders should be removed before the end of the operation to neutralize the head position. The lay of the vessels is checked before closing the wound, and adjustments are made by anchoring sutures to create a smooth curve if there is redundancy. Alternatively, the redundant segment may be shortened.

Compression of the pedicle can be a consequence of tunneling. A tunnel that is too narrow gives no allowance for swelling. An adequate tunnel is one that allows the easy passage of a 10- or 20-cc syringe. During reexploration for a case of tight tunneling, rerouting the pedicle should ideally be done, and this may entail use of vein grafts if the pedicle is short. If this is not possible, a simple measure is to lay the subcutaneous tunnel open with a skin flap incision. The pedicle remains covered by the skin flap, and the secondary defect is skin grafted. Naturally, the aesthetic outcome is far from ideal, but its expense is justified if the flap is salvaged. Subsequently, the scars may require revision at a later date.

Occasionally, the pedicle may be compressed against bone, such as the osteotomized edges of the mandible, maxilla, or cranium. If the vessel is abutting against bone, one should ensure that the point of contact is smoothened or, better still, recessed and soft tissue introduced to cushion the pedicle.

Accidental avulsion of the pedicle can happen with forceful neck movements, which occurs with violent coughing or poorly supervised transfer of the patient by medical personnel. If pedicle disruption occurs within 2 weeks of surgery, immediate exploration is undertaken to reestablish blood flow. However, to maximize flap survival, exploration should be limited to the pedicle^{9,10} and, if necessary, through a separate incision directly over the vascular pedicle. The flap should not be lifted from its bed or separated from the cervical skin flaps to avoid disrupting newly formed vascular connections. If loss of blood supply occurs after 3 weeks, a more conservative approach is advocated.¹⁰ Barring infection, the flap is best left undisturbed as revascularization from the recipient bed is critical for flap survival. Flap viability is monitored by its color and presence of bleeding. Sepsis is a manifestation of flap necrosis, which, if present, requires excision.

VENOUS FAILURE

Veins, being low-pressure systems, are more susceptible to compression, twisting, and kinking. Spasm is uncommon. The same measures for preventing and rectifying vessel occlusion in the previous section apply, with one additional measure, which is to anastomose an extra vessel. Most pedicles have paired veins. In the radial forearm flap, for example, the venae comitantes and cephalic vein can be joined to the internal jugular and

external jugular veins, respectively. An extra outflow channel means that venous drainage is safeguarded even when one system is obstructed.

In the event of venous congestion, reexploration should be undertaken with greater urgency than in a case of arterial insufficiency as retrograde propagation of clots within the fine radicals of the venous network make it virtually impossible to salvage the flap. Any clot formed in the vessel lumen is expelled by gently squeezing the vessels and manually extracting the clots with a jeweler's forceps. Flushing saline into the vessel should be avoided as this propels the clots deeper into the vessel.

USE OF A SECOND FLAP IN TOTAL FLAP FAILURE

When faced with total flap failure, one salvage option is to use a pedicled flap such as the pectoralis major myocutaneous flap or the lower trapezius flap. Recent literature,³ however, advocates a second free flap for the following reasons:

1. To cover exposed critical structures such as the brain and neck vessels that are out of the reach of pedicled flaps.
2. To facilitate early adjuvant treatment as free flaps have better vascularity and heal more quickly.
3. To obtain specialized tissue such as bone for mandible reconstruction.
4. To reduce complications related to delayed wound healing.

The only contraindication is a deteriorating and unfit patient. Severe infection is a relative contraindication, which can be treated with adequate debridement.

Virgin recipient vessels should be used for revascularization of the second free flap because the original recipient vessels may be inflamed. The most common primary arterial recipient vessels are the facial and superior thyroid arteries. Therefore, in the event of flap failure, alternative vessels include the ipsilateral superficial temporal vessels, the transverse cervical vessels, or the contralateral superior thyroid artery. Regarding venous drainage, if the ipsilateral neck is to be reused, then the cephalic vein can be transposed up to the neck when the external or internal jugular veins are not available.¹¹ Alternatively, one may use contralateral neck vessels, but this would entail use of vein grafts.

Carotid Blowout

Sudden catastrophic bleeding in a previously irradiated neck suggests a blowout of the carotid artery. This condition can occur as a complication of head and neck surgery where the carotid arteries have been stripped bare, manipulated, or used as a recipient vessel for free flaps.

Urgent repair of the blowout often involves use of a vein patch or an interpositional vessel graft. The entire

vessel must be covered with well-vascularized soft tissue to prevent further blowouts. A second free flap or the pedicled pectoralis major muscle flap is ideal for this purpose.

Hardware Exposure

Plates, screws, and titanium meshes used in head and neck reconstruction may become exposed in an early or late setting. Causes of early exposure include wound dehiscence due to tension, infection, or flap necrosis. If the exposed area is small and located over a noncritical area such as the external surface of the mandible, then the wound can be dressed and allowed to granulate before secondary closure is considered. New implant materials such as titanium are inert and seldom incite a foreign body response even in the presence of infection. Nevertheless, one needs to plan for closure expeditiously as the implant might loosen and allow the underlying skeletal fixation to lose its rigidity. The wound could be closed secondarily by skin advancement or by a flap such as the deltopectoral flap if skin is deficient.

Intraorally, exposed plates above the salivary line can often be left in situ until the bone has healed. This is sometimes the case for a fibula-reconstructed upper alveolus in which skin is not included because of excessive bulk. Exposed miniplates will gradually become overgrown with granulation tissue and mucosa over 6 to 9 months, as long as the bone is well vascularized. Below the salivary line, a wound with an exposed plate heals poorly because it is constantly bathed in saliva. A common scenario is one in which a patient with mandibular reconstruction suffers a suture line breakdown at the lower buccal or labial sulcus and develops a salivary fistula. In such situations, one has to import fresh soft tissue to close the defect. A tongue flap can be employed for this purpose. Secondary sutures will fail if there is wound tension.

Over critical areas such as the cranium and base of skull, an exposed implant may become a portal of infection to the brain and meninges. For example, in a case of craniectomy reconstruction, a titanium mesh may become exposed because of wound tension over the scalp. Due to the risk of meningitis, the problem should be rectified with urgency. A scalp rotation flap can be used to ease the tension at the area of breakdown and the resultant secondary defect skin grafted. If the scalp has become "battle-scarred" by numerous previous neurosurgical incisions, any attempt at raising a scalp flap might devitalize it. Thus, free flap coverage, for example using an anterolateral thigh flap, would be required for such circumstances (Fig. 1). However, if microsurgical expertise is not available, then the mesh should be removed and a repeat elective cranioplasty planned.

Late exposure of implant is usually due to thinning-out of skin over the implant, which may occur as a result of radiation therapy. This can be avoided by interposing a layer of soft tissue between the skin and

Figure 1 This 35-year-old man sustained a severe head injury in a motor-vehicle accident. Left temporal craniectomy was performed for evacuation of subarachnoid hemorrhage and decompression of brain swelling. The bone was subsequently replaced with titanium mesh. (A) Oblique view of the patient 2 years after the initial trauma. Note that the mesh is exposed and infected (arrow). (B) Side view of the patient showing the extent of the thinned-out scalp that had to be excised. (C) Preoperative CT scan showing the titanium mesh cranioplasty. (D, E) Intraoperative pictures of scalp reconstruction using the anterolateral thigh musculocutaneous flap. A dural defect (arrow) was repaired with artificial dura and sealed with fibrin glue. Muscle was used to reinforce the repair. The mesh was sterilized and re-used. The flap was suspended to the mesh with sutures. (F) Oblique view of patient 1 year postoperatively showing good healing and a well-restored head contour.

the implant. In fibula flaps used for mandibular reconstruction, a de-epithelialized portion of the intraoral skin paddle is routinely used to provide an extra soft tissue layer over the reconstruction plate (see Fig. 2D, E). Initially, the added bulk may appear excessive, but this eventually subsides with radiotherapy.

An exposed implant is simply removed if the bone has united, and the existing wound will usually heal spontaneously. If there is nonunion, it should be bone grafted, refixed, and covered with a flap. For exposure of the brain and meninges, immediate coverage, as mentioned earlier, is necessary.

Ectropion

Ectropion is defined as eversion of the lid margin from the globe. The condition is graded as:

- Mild when there is slight eversion of the cilia inferiorly, with or without scleral show.
- Moderate when the eyelid margin is everted with lower eyelid descent and scleral show.
- Severe when frank ectropion is present.

Chronic ectropion results in exposure keratitis of the conjunctiva, which contributes to ocular irritation and may lead to blindness.¹²

In head and neck reconstruction, three situations in which ectropion is commonly seen are the following:

1. After flap reconstruction of through-and-through maxillectomy defects.
2. After resection of skin tumors in the cheek and periorbital region.
3. After facial nerve resection.

Figure 2 This 55-year-old man sustained panfacial fractures in a motor-vehicle accident. The mandible was severely comminuted. Primary open reduction and internal fixation with bone grafting were performed. (A) Frontal view of the patient 5 years after the initial trauma. Note his jaw asymmetry and malocclusion. (B) CT scan shows a cross-bite and an anterior open bite because of right mandibular bone loss. (C–F) Intraoperative pictures of mandibular reconstruction using a fibula flap. Surgical planning included use of dental models to define the number of osteotomies required on the existing mandible. An occlusal splint was used to aid in the restoration of occlusion. A sagittal split osteotomy was performed on the left side to correct the cross-bite. The right condyle and ramus were excised because of ankylosis of the temporomandibular joint. A pseudoarthrosis was created with a piece of conchal cartilage applied over the proximal end of the fibula. The fibula flap was fixed with a 2.7-mm unlock plate and covered with a de-epithelialized portion of the skin paddle to prevent plate exposure. (G) Frontal view of patient 6 months postoperatively shows improvement of jaw symmetry and occlusion. (H) CT scan shows restoration of the vertical height of the mandible and normalization of occlusal relationships.

AFTER FLAP RECONSTRUCTION OF THROUGH-AND-THROUGH MAXILLECTOMY DEFECTS

Resection of maxillary tumors may result in the loss of cheek skin, oronasal lining, and the underlying maxilla and zygoma. Such defects with requirements for skin, bone, and mucosa are reconstructed using composite osteocutaneous free flaps such as the scapular flap or fibular flap or with bone grafts in combination with a myocutaneous free flap such as an anterolateral thigh flap. Ectropion may develop because of the pull exerted by the flap on the lower eyelid. Osteotomized osteocutaneous flaps afford less free play between bone and skin, and it is harder to achieve the dual goal of eyelid support and contour restoration. In the authors' experience, calvarial bone grafts and free myocutaneous flap are preferred for complex defects, particularly those

that involve the orbital floor and orbital walls.¹³ An accurately reconstructed orbitozygomatic framework is critical for correct ocular and eyelid positioning as the rigid framework provides anchor points for soft tissue. First, the medial and lateral orbital walls, lateral orbital rim, orbital floor, infraorbital rim, and zygomatic arch are reconstructed with bone grafts secured with miniplates to the remnants of the orbit and skull base. The infraorbital rim is positioned 3 to 4 mm higher than the normal side for lower eyelid support. The globe position is checked and adjusted by layering the grafts. Medial and lateral canthopexies are performed by attaching the respective canthal ligaments to the newly created framework with nonresorbable sutures. This tightens the lower eyelid. Next, the flap is inset, and its muscle, fascia, and dermis are individually suspended

by sutures to drilled holes on the reconstructed infraorbital rim. Before apposing the flap to the lower eyelid, the patient's head is elevated to check for sagging of the flap. If present, additional sutures are placed to suspend its dermis to bone. A fascial sling may be necessary if such measures fail. Regarding the choice of flaps, those with thick dermis such as the scapular flap are less likely to sag than fatty flaps such as the transverse rectus abdominis myocutaneous (TRAM) flap.

AFTER RESECTION OF SKIN TUMORS IN THE CHEEK AND PERIORBITAL REGION

Ectropion is one of the known complications of cheek reconstruction with local flaps. Small skin defects ($<1 \text{ cm}^2$) are amenable to closure with transposition flaps, advancement flaps, or even full-thickness skin grafts. However, for larger defects ($>3 \text{ cm}^2$), we believe cervicofacial rotation flaps are the most reliable, for two main reasons. First, there is a large expanse of skin made available by the design; and second, the resulting scars are hidden as they correspond with relaxed skin tension lines. Historically, cervicofacial rotation flaps have been designed as medially and inferiorly based flaps (Mustarde flap).¹⁴ Recently, Kroll¹⁵ and Roth et al¹⁶ have described laterally based advancement flaps that incorporate the principles of deep-plane dissection (according to Hamra)¹⁷ and are secured to precise points of fixation along the temporal fascia and zygomatic region. Such flaps provide a superior aesthetic outcome compared with the medially based ones as the advancing border of the flap corresponds with the borders of the facial aesthetic units.¹⁸

The key to prevention and management of ectropion is to use dermal sutures to suspend the flap onto maxillary periosteum or drilled holes so that there is no tension in closure. These hitching sutures will counteract gravitational effects on the flap. Around the eyelid, the vectors of the rotation design should be as parallel as possible to the eyelid margin to avoid downward traction.

AFTER FACIAL NERVE RESECTION

Paralytic ectropion is caused by facial nerve palsy, resulting in denervation of the orbicularis oculi muscle. Laxity of the tarsocanth structures results, which is more pronounced in elderly patients. In younger individuals, the eversion of the lid may not be so obvious because of sufficient rigidity of the tarsal and canthal tissues. The simplest way of correcting lower eyelid laxity is a lateral canthoplasty.¹² Using a nonresorbable suture, the lateral canthus is fixed to the lateral orbital periosteum at a level 3 or 4 mm higher than its original position, resulting in a 1- to 2-mm elevation of the lid margin. A horizontal lid-shortening procedure may be included in difficult cases.

REGIONAL COMPLICATIONS

Scalp and Cranium

Complications of scalp reconstruction are related to wound breakdown leading to cerebrospinal fluid leak and exposure of hardware. Management of wound breakdown depends on the size and location of the defect. Small defects can be covered with rotation flaps and other local flaps. Secondary reconstruction can be performed with tissue expansion where up to 50% of the scalp can be reconstructed. Large, subtotal or total scalp defects have to be reconstructed with free flaps.^{19,20}

Cranial vault reconstruction is preferably performed with autologous bone grafts harvested from split cranial grafts or rib grafts. Alloplastic materials have been reported as alternatives, but these are foreign materials, which may not integrate in the long term and may result in foreign body reactions, infection, and ultimately extrusion. Alloplastic material is contraindicated in pediatric patients. When infection occurs, debridement, complete removal, and vascularized tissue reconstruction is required. Another alternative is demineralized bone, which are allografts. When compared with autografts, demineralized bone was found to be safe and had a similar incidence of complications.²¹

Base of Skull

Complications of base of skull reconstructions can be divided into early and late. Early complications include, most commonly, cerebrospinal fluid leak caused by incomplete dural closure²² and infection caused by communication with the aerodigestive tract. Late complications include diplopia caused by a lack of bony support for the globe, facial deformity secondary to soft tissue atrophy, and trismus due to postoperative radiotherapy fibrosis.

To lower the incidence of complications, the intracranial cavity must be isolated from the extracranial space and the upper aerodigestive tract.²³ Principles to follow include:

1. Obliteration of dead space with a well-vascularized flap to achieve uncomplicated primary healing and to prevent collection of fluid. To obtain a good seal over bare bone, bone fasteners can be used to enable direct and secure suture of the muscle flap to the skull base.²⁴
2. Cranialization of the frontal sinuses and plugging of the nasofrontal ducts with bone graft to prevent communication between the intracranial and extracranial spaces.
3. Reconstruction of bony defects of the facial skeleton with split calvarial bone grafts to prevent contour deformities. Importantly, defects of the anterior cranial

fossa should be repaired to prevent pulsatile exophthalmos in addition to restoring contour.

4. Rigid fixation of bone fragments to achieve stability of the craniofacial skeleton.
5. Obliteration and seal of cavities using fibrin glue.
6. Prevention of infection with prophylactic antibiotics (cefuroxime and metronidazole for 5 days, initially intravenously for 2 to 3 days and orally thereafter).^{25,26}

When a cerebrospinal fluid leak occurs, spinal drainage and head-up nursing are indicated; the leak should resolve within a week if it is minor. If the leak is persistent, an aggressive approach using a suitable free flap was found to have good results.²⁶ The free flap is used to obliterate dead space as well as provide vascularity to the wound. Intracranial infection is treated with drainage and washout, closure of dural defects, as well as antibiotics.

Occasionally, extradural hematomas can pose a problem in the early postoperative period and will require early drainage to prevent infection. Pulsatile enophthalmos can also develop if there is resorption of the bone graft. This can be corrected after adequate assessment and reconstruction with another bone graft.

Prevention of anterior cranial fossa prolapse can be achieved with bulky free flaps without bony reconstruction. Dural tuck-up sutures can reduce the intracranial pressure at the inferior surface of the exposed dura. Additional support is provided by inseting the anterior lamina of the rectus abdominis muscle such that it directly abuts the dura. Additionally, the muscle is secured to the edges of the bony defect to maintain its position.²⁷

Despite its rarity, free flap failure usually requires reconstruction with a second free flap as local flaps are unreliable.^{3,22} Salvage surgery using free flaps is performed using the same rigorous approach as in the primary surgery, but more safety measures are taken to ensure a successful outcome. Chepeha et al²² used the free radial forearm flap because it had low donor site morbidity, a long vascular pedicle that could reach the upper neck, and an anatomically remote donor site that permitted two teams to operate simultaneously. An alternative flap is the anterolateral thigh flap.

Midface

Complications occur when the function and anatomy of the resected maxilla are unrestored. The goals of reconstruction are

1. To support the orbital contents.
 2. To separate the sinus and nasal cavities from the orbit and obliterate the sinus cavity.
 3. To reconstruct the shape of the anterior cheek wall.²⁸
- Failure to achieve such goals may result in complications that manifest, respectively, as enophthalmos

and diplopia, speech, swallowing and occlusal derangements, and facial asymmetry and deformity.

Diplopia can frequently be corrected by correction of enophthalmos. Fine-cut computed tomography (CT) scans and volumetric three-dimensional reconstruction are essential to delineate and calculate the abnormality in orbital volume. This information is useful for the surgeon during reconstruction, to predict the size of the bone graft to use, as well as to determine the best location to place it intraorbitally. A triangular-shaped bone graft is usually harvested from split calvarial grafts because of its favorable curve, which fits on the orbital floor. The graft is placed with its concave surface facing up and its apex directed toward the cone of the orbit. A very slight overcorrection is necessary to offset the volume loss from bone graft resorption.

Soft tissue complications secondary to lack of support of orbital contents have been addressed in the earlier section "Ectropion."

Oronasal fistulas occurring in the hard and soft palates are common. The complications associated with fistulas include passage of food into the nasal cavity and hypernasal speech. Closure of these fistulas is frequently made more difficult by trismus and postirradiation fibrosis. Small fistulas can be closed by using a tongue flap, a well-vascularized muscle that can be designed as either a proximally or a distally based flap. The facial artery musculomucosal flap described by Pribaz is also a useful flap for fistulas. Large defects are closed with a free radial forearm flap. A dental obturator worn as a denture is an alternative option.

To correct facial asymmetry, it is necessary to evaluate the deformity using a CT scan. This will aid the surgeon in deciding the relative extents of hard and soft tissue correction necessary. Autologous bone is the preferred method of repairing bony deformities. Choices for soft tissue augmentation include dermal fat grafts in conjunction with fat injections for minor defects and vascularized soft tissue flaps for major defects.

Mandible

COMPLICATIONS OF MANDIBULAR RECONSTRUCTION WITH VASCULARIZED BONE GRAFTS

Radical resection of oral cancers frequently results in major defects of the mandible. The goals of mandibular reconstruction include functional restoration of the bony and dental arches, as well as good aesthetics. Functional restoration requires the close cooperation of the plastic, oral, and oncologic surgeons as well as the prosthodontist. Careful presurgical planning is critical for a successful result. Common complications of mandibular reconstruction with bone flaps include malocclusion, jaw asymmetry, and nonunion.

MALOCCLUSION AND JAW ASYMMETRY

Malocclusion and jaw asymmetry are potential problems when the surgical effort is focused solely on "filling" a defect without regard for dentition and occlusal relationships. Such problems may be avoided by the early involvement of the dental and maxillofacial surgeons as they will be able to aid in planning, the surgery itself, and postoperative rehabilitation.

The classical approach is to place the patient in maxillomandibular fixation (MMF) prior to mandibular resection, thus maintaining normal occlusion of the residual dentition. After resection and reconstruction, the MMF is released.

In a patient who has full dentition and class 1 occlusion, minimal dental preparation is required. MMF is applied, without the need for a dental splint. A dental splint would be useful in individuals who have malocclusion or partial dentition, as it may be difficult to determine the correct occlusion intraoperatively. Such splints are fabricated with dental models, and this process is aided by studying the patient's photographs, plain radiographs, and orthopantomogram (Fig. 2). In the edentulous patient, dentures are used to establish the correct anterior-posterior and vertical occlusal relationships. Intraoperatively, the upper denture is secured by screws to the palate, and the lower one by circum-mandibular wiring. The patient is placed in MMF once the dentures are in place.

In the authors' experience, reconstruction plating is preferred for fixation of the bone flap. The advantages include strength; speed, as a less-than-perfect fit between bone segments is acceptable; and better preservation of the periosteum as fewer screws than miniplating are needed. The plate is preadapted once the mandible is exposed, before the tumor is resected. This is accomplished by a template, which is contoured by pressing it against the outer surface of the mandible. The plate is then shaped according to the template and applied to the mandible. The plate should span the diseased portion and overlap normal bone by at least three screw holes at each end. The plate is then removed and resection continued. This technique ensures that the proximal and distal bone ends of the mandible retain their original spatial relationship. In the final assembly of the plate and bone flap, the condyle is checked to ensure that it is seated correctly in the glenoid fossa.

Early presentation of malocclusion and jaw asymmetry usually relate to errors in estimating graft length. Such errors can result in retrognathia, prognathism, or a midline shift.²⁹ However, there are instances in which it is not possible to achieve an accurate reproduction of the bony arch because of constraints of graft length (resulting in retrognathia) or space constraints due to floor of mouth swelling (resulting in prognathism).

Corrective osteotomies may be performed to rectify malocclusion or jaw asymmetry, but this should

be done after bone healing has taken place, as there is a risk of devitalizing the flap. The use of dental casts, simulation surgery, and orthodontics are critical for a successful outcome. One should ensure that both intraoral and extraoral soft tissue is sufficiently pliable for osteotomies and movement of the underlying bone. If present, soft tissue deficiencies or contractures should be addressed first.

Late presentation of the above complications usually relates to radiotherapy, which causes fibrosis. Thus any minor displacement of the reconstructed jaw will become more pronounced with time as soft tissue contracture worsens. The best way to counteract this process is to mobilize the jaw, maintain mastication, and preserve occlusion. If good dentition is present, continued use of the patient's jaw will maintain occlusion. In partially edentulous patients, dentures, orthodontic appliances, and guiding elastics are used to preserve occlusion.

NONUNION

Nonunion is defined as failure of consolidation after 4 months, with clinical and radiologic evidence of impaired healing. If the jaw has been irradiated, healing takes longer, and the bone may take up to a year to consolidate. Nonunion may occur between the osteotomized segments of the bone flap, or at the junction between the bone flap and the mandible. These typically manifest as pain, instability, or plate fractures. Causes of impaired healing include devascularization of graft by periosteal stripping and functionally unstable fixation with miniplates.

Osteotomized bone segments lack endosteal blood supply and are dependent on periosteal blood supply for survival. Consequently, bone flaps should never be stripped of periosteum during miniplate fixation as removing the periosteum will devitalize the grafts. The plates are placed directly over muscle and periosteum without regard for exposing bone.²⁹

To ensure adequate fixation with miniplates, Hidalgo advocates placement of plates in two perpendicular planes at each osteotomy site (i.e., on the buccal surface and along the inferior border of the graft and mandible).²⁹ When a reconstruction plate is used, a minimum of three screws should be used at each end of the plate for adequate stability. As it is a "load-bearing" construct, only one or two screws are needed for each bone segment.

Nonunion can be managed by reconstruction plating, which provides greater stability than miniplates. First, the plate is applied without tightening the screws, and the nonunited bone ends are freshened. A block of corticocancellous bone graft is then wedged tightly between the bone stumps. The screws are driven home, compressing the bone graft between the bone ends.³⁰ Some caveats for successful outcome include well-vascularized soft tissue

enveloping the graft and sufficient soft tissue to afford tensionless closure over the construct, without which the graft will be exposed and resorbed rapidly.

A free vascularized corticoperiosteal bone graft can also be used to treat nonunion, particularly if it is radiation-induced.^{31,32} To achieve this, the bone ends are first freshened and stabilized with strong plating. The bone-periosteal flap is then harvested from the medial femoral condyle, based on the descending genicular arteriovenous pedicle. It is subsequently wrapped around the defect and revascularized by microvascular anastomoses to suitable recipient vessels. Nonvascularized cancellous bone grafts may also be used in conjunction with this technique.

Pharyngoesophagus

VASCULAR THROMBOSIS

Most large series report flap survival rates of greater than or equal to 95%.³³ The main problem encountered is that of monitoring a buried flap. Thus, identifying a failing flap requires a high degree of clinical suspicion. Techniques of monitoring such flaps include:

- Observing an exteriorized monitoring segment of the free jejunum or a secondary skin paddle of the free radial forearm.
- Direct observation of the buried flap through a small incision over the midline of the cervical skin flap.
- Use of an implantable Doppler probe to detect flow disturbances in the draining vein of the flap.³⁴

Despite such techniques, flap loss rates of buried flaps remain higher than those of nonburied flaps (6.5% vs. 1.8%).³⁵ The higher failure rate in buried flaps was attributed to failed jejunal flaps that tolerate ischemia poorly and are generally unsalvageable at the time of reexploration. Only cases that were recognized and handled immediately were saved. If a flap is unsalvageable, the general practice is to perform a second free flap using tubed flaps such as an antero-lateral thigh flap or a radial forearm flap. The tubed pectoralis major myocutaneous flap, gastric pull-up, and colonic interposition are alternative means of reconstructing the hypopharynx.

FISTULA

The incidence of fistula formation is between 13% and 50%.³³ Predisposing factors of fistula formation include:

1. Slow skin-to-mucosa union if skin flaps are used for esophageal reconstruction.
2. Chronic coughing and gagging, as violent throat movements can tear the suture line.
3. Old age and debilitation.

In the authors' experience, jejunal flaps enjoy lower leak rates as mucosa-to-mucosa healing promotes better union at the suture lines.³⁶ Measures employed to reduce leaks include:

1. Adequate intraluminal drainage by means of a Jackson-Pratt drain to prevent excessive pooling of secretions and saliva.
2. Two-layered suturing technique at the proximal and distal anastomoses.
3. Delaying surgery if the patient has a cough.

Typically, a fistula presents as erythema of the cervical skin flap that develops into a draining abscess. Treatment consists of drainage, dressings, and antibiotics. Most fistulas will heal with conservative management, provided the flap is viable and there is no distal obstruction. Per oral intake is withheld to allow healing. Nutrition is maintained by nasogastric tube feeding or jejunostomy feeding. If such means of feeding are temporarily unavailable, the patient is given total parenteral nutrition.

A fistula that worsens will warrant repair with a flap. Persistent leakage can lead to carotid artery exposure and blowout. In addition, a leak at the distal suture line can cause aspiration pneumonia because of its proximity to the tracheotomy. Local flaps such as the deltopectoral flap or the pectoralis major myocutaneous flap are used to seal such fistulas. The pectoralis major flap is ideal, as the skin island can be turned inwards to form the pharyngeal lining and the muscle portion used to cover the neck vessels. If neck skin is deficient, a skin graft is applied over the muscle.

A radiation-induced fistula usually occurs when a radial forearm flap is used to reconstruct the cervical esophagus. Despite delaying radiotherapy to allow the flap to heal adequately, it is still susceptible to breakdown due to its thinness. Such fistulas will not heal spontaneously and are closed with patch-repair techniques described earlier.

STRICTURE

Strictures usually occur at the distal suture line because of the inherently smaller caliber of the distal anastomosis. Causes of stricture include ischemia of the proximal esophagus or the distal end of the flap and a faulty anastomotic technique.³³ In the context of jejunal flaps, the risk of stricture formation is related to the poor tolerance of the bowel to ischemia.³⁶ The jejunum has a high metabolic demand, and the release of enzymes in response to ischemia leads to autolysis and subsequently fibrosis. Thus, although the jejunum is known to have an ischemia time of 3 hours, in the authors' experience a more favorable functional outcome (such as preserved peristalsis and luminal patency) is obtained if ischemia time is under 2 hours. Some measures employed to reduce ischemia time include:

1. Flap revascularization before flap inset. The artery is anastomosed first and the flap perfused for a few seconds. The artery is then clamped and the venous anastomosis performed. If the venous anastomosis is slow, the flap is oxygenated by intermittently releasing the arterial clamp.
2. Widening the proximal anastomotic diameter by incising the antimesenteric border of the jejunum to match the diameter of the hypopharynx, and widening the distal anastomosis by incising the upper end of the esophagus anteriorly to match the distal end of the jejunal flap. This prevents cicatrization.
3. Stenting the anastomosis with two tubes (i.e., a nasogastric tube and a Jackson-Pratt drain). This reduces the incidence of stricturing by decompressing the bowel and allowing the suture lines to heal.

If a stricture develops, mechanical dilation may be attempted if the stricture is localized, easily accessible, and not severe. A longer-lasting solution is surgical release and patch repair with a skin or myocutaneous flap.

ASPIRATION

One of the complications of conservational laryngectomy is aspiration, especially in patients who have had horizontal partial laryngectomies. Patients who have had severe scarring of the hypopharyngeal area and epiglottitis because of ingestion of corrosives also experience aspiration. When the problem persists, one solution is to create an alternative food passage that is separate from the airway.³⁶ This is accomplished by a free jejunal flap connecting the lower buccogingival sulcus with the cervical esophagus. Patients can learn to redirect food into the opening at the lower buccal sulcus with the tongue. Individuals who are well trained report complete relief of symptoms.

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