Head and Neck Cancer - Reconstruction

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Overview

History

Head and neck tumors can lead to devastating cosmetic and functional deficits with resultant psychological, physical, and nutritional detriment. Despite recent advances in medicine, the overall survival for patients with head and neck has remained static for the past 35 years.[1, 2] This survival rate has led to the establishment of the principles of tumor excision with maximum tissue sparing (eg, Mohs technique for skin cancer removal) and newer endoscopic laser-assisted techniques for aerodigestive tract cancers aiming at decreasing surgical morbidity without affecting the overall survival.

As the role of adjuvant radiation and chemotherapy increases, plastic and reconstructive surgeons will continue to manage defects in irradiated fields, which may decrease the chance of local flap availability and increase the demand for distant pedicled and free flaps.

Deformities of the head and neck region can have devastating effects on appearance and function of the patient and are among the most disabling and socially isolating defects with significant impact on patient’s quality of life. Reconstruction of such defects continues to be an extremely demanding challenge for plastic surgeons who aim to restore form and function with minimal surgical morbidity.

The desire to alleviate these problems led to the development of plastic surgery as early as 3000 BC.

- In 3000 BC, the Edwin Smith Surgical Papyrus, from ancient Egypt, described the first surgical management of facial trauma, including the treatment of mandibular and nasal fractures. Treatments at that time were simple including reduction of the nasal fracture followed by nasal cleaning, packing, and splinting with linen.[3]
- In the sixth century BC, Sushruta, from northern India, described the first operative procedures for nasal reconstruction by transferring skin from the forehead and the cheek.[4]
- In the 1950s, defects were repaired using a forehead flap or temporal flap combined with split-thickness skin graft, but this lead to a scarred forehead or temporal contour deformity.[5]
- In 1959, Seidenberg et al described the first revascularized flaps to the head and neck, but they only gained popularity when they were re-introduced by Daniel and Taylor in 1973.[6]
In 1965, Bakamjian first described the deltopectoral flap.[7]
In 1973, Daniel and Taylor reported the first free flap, the transplant of an autologous skin flap to the lower extremity using the operating microscope.[6]
In 1976, Panje and Harashina simultaneously described the use of free flaps to reconstruct defects of the oral cavity.[8, 9]
In 1979, Ariyan described the pedicled pectoralis major myocutaneous flap.[10]
In the late 1980s and early 1990s, the use of osteocutaneous free flaps to reconstruct mandibular defects was advanced.

Frequency

In the United States, 2008 estimates are 35,310 new cases of cancer of the oral cavity and pharynx and 12,250 new cases of cancer of the larynx.[11]

General Concepts of Reconstruction

Successful reconstruction requires a team approach, which includes a medical oncologist, ablative surgeon, and reconstructive surgeon, for careful preoperative assessment and development of a treatment plan. Important considerations include tumor stage and prognosis; patient age, sex, body habitus, and functional status; available reconstructive donor sites; and the psychosocial make-up of the patient.

The reconstruction ladder consists of the following steps starting from the simplest to the most complex option:

1. Healing by secondary intention
2. Primary closure
3. Skin grafting (split or full thickness)
4. Composite grafts
5. Local flaps
6. Regional pedicled flaps
7. Free tissue transfer

Alloplastic materials (synthetic compounds), such as porous polyethylene (Medpor), polytetrafluoroethylene (Gore-Tex), silicone, and titanium, are occasionally used for structural or bony reconstruction.[12]

As a general rule, when planning an individual patient’s reconstruction, attempt the least complex and safest option from the reconstructive ladder first, while maintaining form and function. The plastic surgeon should be comfortable with the full armamentarium of reconstructive techniques, and should be able to decide which technique is the best for each particular patient and defect.

The remainder of this article covers the reconstruction of specific anatomical entities of the head and neck.

Reconstruction of Lip Defects

The lower lip is the site of more than 90% of cancers of the lips, as it receives more ultraviolet exposure than the upper lip.

Anatomy

The lips are formed of 3 layers: skin, muscle (orbicularis oris), and mucosa. The vermilion (“red lip”), which is formed of modified mucosa, is the myocutaneous junction; it includes the “white line” where the skin meets the vermilion. Alignment of this zone is the initial step in lip skin closure, as minute defects are easily noticeable.

The superior and inferior labial arteries (branches of the facial artery) provide the blood supply to the lips. They course deep to the mucosal surface of the lip.

The motor nerve supply of the lips is from the facial nerve, through the buccal and mandibular branches. The sensory enervation is from the trigeminal nerve, through the infraorbital branch (upper lip) and mental branch (lower
Reconstruction of the Lower Lip

Lower lip reconstruction depends on the defect size.

- Defects smaller than one third of the lip can be repaired with a V or W resection, followed by primary 3-layer closure. To avoid crossing the mentolabial groove, select V resection for smaller defects and W for larger defects.
- Defects between one third and two thirds of the lip can be repaired with the staircase technique, which entails progressive horizontal distances that involve half of the defect width.
- Defects that cover more than 60% of the lip usually require rotational flaps to be closed (eg, Abbe, Estlander, Bernard, Gillies, McHugh, Karapandzic).

Abbe (Sabattini) transoral cross-lip flap

- Described by Sabattini in 1836 and by Abbe in 1968, this flap involves the transfer of full-thickness V-, W-, or rectangular-shaped lip tissue from one lip to the other.[13, 14]
- To keep the size of the 2 lips equal, the width of the flap should be half of the defect and the height of the flap should equal that of the defect.
- The flap blood supply is based on the labial artery and small veins that parallel the artery.
- The flap is pivoted approximately 180° on its pedicle and is sutured in the defect.
- Three weeks later, the flap is divided, and the donor site is closed primary.

Estlander flap

- This is a cross-lip flap that involves rotating tissues from the upper lip, with point of rotation at the commissure, to correct defects involving the oral commissure.
- It is based on the labial artery.
- It requires commissuroplasty at 3 months.
- The flap length is 1-2 mm longer than defect size and is half the defect width.
- The incision is placed in the ipsilateral melolabial crease.
- This flap maintains motor and sensory competence of lip.

Karapandzic flap

- The Karapandzic flap is described for central lower lip defects. A complete lip is formed by rotating the upper lip and perioral tissue by bilateral advancement-rotation flaps.
- Semicircular incisions can be created from the defect, but the nasolabial folds are a better location at which to start the incisions.[15]
- Partial-thickness incisions should be made through the skin and muscle. Muscle fibers should be mobilized by blunt dissection, and neurovascular structures should be identified and preserved bilaterally. The incision is carried inferior into the mental crease at the midline. Advancement results in closure of the lip defect. Burrows triangles are removed at the lateral portion of the incision.

Gillies fan flap

- This is a rotational advancement flap that advances the remaining lip segment with a portion of the other ipsilateral lip to close a lip defect.
- It uses bigger tissues and results in less microstomia.

Bernard-Burow flap

- This flap uses cheek tissue to replace defects.
- Horizontal incisions are carried through the skin from the commissure to the melolabial fold. Subcutaneous tissue and a skin triangle are created adjacent to the melolabial fold.
- Intraoral mucosal advancement flaps are created from labium.
- Flaps are advanced into the lower lip defect with mucosal advancement to create new lower lip vermilion.
Burrows triangle tissue is excised and the remaining defect closed. This technique may reconstruct a total lip defect.

**Combined flaps**

- Combined multistage flaps can be used for larger defects.
- The bilobed and Karapandzic flaps may be used to reconstruct an 80% defect of the lower lip.[15]
- Two Abbe flaps can be used in combination.
- Extended Karapandzic flaps followed by cross-lip flaps can restore symmetry and balance between the lips.[16]

**Free flap for total lip reconstruction**

- The lower lip and chin can be reconstructed with a composite radial forearm-palmaris longus free flap.[17]

**Table. Flaps for Lower Lip Reconstruction (Open Table in a new window)**

<table>
<thead>
<tr>
<th>Flap</th>
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<th>Disadvantages</th>
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<td>Trap-door deformity as scar appears thickened</td>
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<td>1/2-1/3 lip defects involving oral commissure</td>
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<td>One stage</td>
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<td>No mouth closure</td>
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Reconstruction of the Upper Lip

- For defects that cover up to 50% of the upper lip, primary closure as described for the lower lip is performed.
- For defects that involve between one third and two thirds of the upper lip, the Abbe and Estlander flaps are preferred.
- For defects that involve at least two thirds of the upper lip, use a modified Burow technique, which uses perialar crescentic excisions and laterally based advancement flaps.
- Reverse Karapandzic flap can be performed.

Reconstruction of Floor of Mouth and Alveolar Ridge Tumors

History

Cancers of the floor of mouth (FOM) predominate in men in their fifth and sixth decades of life. Multifocal carcinomas are more common in patients with tumors of the floor of the mouth. Most tumors are composed of a squamous cell histologic type. The most common gross morphology is a superficial exophytic tumor of well or moderately well differentiated grade. Ulceration follows continued tumor growth with subsequent extension into adjacent soft tissue structures such as the oral tongue, submandibular space, and alveolar ridge. Bony involvement is heralded by tumor fixation, and restricted tongue mobility signifies invasion of intrinsic tongue musculature.

Squamous cell carcinoma originating in the alveolar ridge is less common when compared to other sites in the oral
cavity. Women are more commonly affected than men, and it occurs during the sixth decade of life. Of gingival cancers, 70% occur on the lower gum in the posterior third of the molar area. Most of these tumors spread to adjacent areas of the oral cavity and frequently are associated with bone destruction due to the tight mucosal adherence of the gingiva to the mandibular periosteam.

**Anatomy**

The floor of the mouth consists of the semilunar space of the mylohyoid and hyoglossus muscles extending from the inner aspect of the lower alveolar ridge to the undersurface of the tongue. This region extends to the anterior tonsillar pillar posteriorly. The ductal openings of the paired sublingual and submandibular glands are situated in the mucosal floor, separated by the midline frenulum of the tongue.

The lower alveolar ridge consists of the alveolar process of the mandible and its lining mucosa. The area extends from the line of insertion of the mucosa in the buccal gutter to the line of the free edge of the FOM mucosa. The posterior extent is defined by the ascending ramus of the mandible. The upper alveolar ridge extends from the upper gingival buccal gutter to the junction of the hard palate. It includes the alveolar ridge of the maxilla and its lingual mucosa. The posterior extent is defined by the superior end of the pterygopalatine arch.

**Reconstruction of small intraoral defects**

- Primary closure can be done in buccal region and tongue, but tethering can lead to poor tongue mobility, interfering with speech and deglutition.\(^{[18]}\)
- Grafting has the disadvantage of scar contracture.
- Closure by secondary intention can be used in the alveolar arches or hard palate defects, where scar contracture is not significant.

**Reconstruction of large intraoral defects**

- Free flaps are the ideal mode of reconstruction for large defects of the upper aerodigestive tract.
- The radial forearm and anterolateral thigh free flaps are the major workhorses. They are thin and pliable, and they can be folded or tubed to compensate for palatal and pharyngeal defects.\(^{[19, 20]}\)
- The radial forearm flap is considerably thinner than the anterolateral thigh flap. The anterolateral thigh flap donor site can usually be closed primarily with minimal morbidity, yet it is more technically demanding to elevate.\(^{[21]}\)

**Reconstruction of large advanced-stage defects**

- Late-stage cancers of the FOM include tumors that invade the mandible, intrinsic musculature of the tongue, and anterior tonsillar fossa. Management of these advanced tumors requires wide local resection that may include cortical or segmental mandibulectomy, en bloc FOM musculature resection, and partial or hemiglossectomy.
- Tumors with extensive anterior growth from the FOM may invade the lip or skin of the lower face.
- Total or partial loss of the mandible incurs serious functional, aesthetic, and psychological morbidity for patients. Prior to the development of advanced reconstruction options for mandibular defects, patients were left with terrible cosmetic deformities and poor function, as observed in the so-called "Andy Gump" deformity, with anterior mandibular arch defects. While en bloc resection of advanced oral cavity tumors can be reconstructed with regional tissue transfer, such as the pectoralis major musculocutaneous flap or free flaps, bony defects are best managed with an osteocutaneous free flap or in combination with regional tissue transfer.

**Mandibular Reconstruction**

**Fibula flap**

- The fibula flap consists of the fibula bone and associated soft tissue paddle. Its blood supply comes from the endosteal and periosteal branches of the peroneal artery.\(^{[22]}\)
- Advantages
  - As much as 25 cm of fibula bone can be harvested in an adult.
  - Extensive periosteal vascular support allows multiple osteotomies for aesthetic and functional
reconstruction of the mandible.
- This flap can reconstruct angle-to-angle mandibular defects.
- The bicortical bone of the fibula accepts plates and screws for fixation and osseointegrated dental implants.
- This flap provides potential sensory reinnervation via the lateral sural nerve.
- This flap allows simultaneous flap harvest and single-stage reconstruction with a two-team approach.

**Disadvantages**
- The soft tissue component of the flap is limited.
- The poor arc of rotation of the skin island relative to the bone and its unpredictable vascularity are factors in this limitation.
- Patients with severe peripheral vascular disease may not be candidates for flap harvest if the lower limb vasculature is involved.

**Potential donor site morbidity**
- Pain (60%)
- Dysesthesia (50%)
- Feeling of ankle instability (30%)
- Inability to run (20%)\(^{[23]}\)
- Fibular flap failure (In the event of fibular flap failure, the necrotic soft tissue can be excised, leaving the bone component in place until the end of radiotherapy; then, a new fibula flap procedure can be performed. This avoids delay in radiotherapy and retraction at the site of bone flap.\(^{[24]}\)

**Iliac crest flap**

- The iliac crest flap is a source of large bone volume for mandible reconstruction after obliterative head and neck surgery. Its blood supply comes from the deep circumflex iliac artery.
- **Advantages**
  - Thick bicortical bone in the iliac crest can accept osseointegrated implants.
  - After harvest, the scar site is hidden.
  - The distance of the harvest site from the head allows simultaneous harvest and single-stage reconstruction.
  - This flap provides a large cutaneous island for composite defects.
  - A total of 14-16 cm of iliac crest can be harvested, and osteotomies that conform to most mandible defects can be made.
  - This flap can supply additional thin, pliable tissue for oral cavity and pharyngeal mucosal defects.
  - The internal oblique muscle may be incorporated into the flap with dissection of the ascending branch of the deep circumflex iliac artery, which supplies this muscle.
- **Disadvantages**
  - Skin island harvest requires a large surface area to incorporate sufficient musculocutaneous perforators.
  - The bulk of the skin island and subcutaneous tissue limits the ability to reconstruct the contour of oral cavity defects, especially in patients who are obese.
  - Harvest of the iliac crest flap produces donor site pain.
  - The risk of retroperitoneal hematoma is a disadvantage.
  - The risk of abdominal wall herniation is a disadvantage.

**Scapular flap**

The blood supply of this flap is the subscapular artery.

- **Advantages**
  - This flap offers bone from the scapula and 2 thin skin paddles based on the scapular and parascapular flaps, respectively. Harvesting the tissue at the level of the circumflex scapular artery supports both skin paddles and the bone.
  - This permits reconstruction of modest mandibular resections and provides intraoral lining and soft tissue coverage for the cheek and neck.
- **Disadvantages**
  - When this flap is used, the patient needs to be repositioned intraoperatively.
  - The skin paddle and the bone component have different blood supplies, which come together to form
the scapular circumflex artery. Therefore, the vascularization of the skin paddle and the bone component can sometimes be completely dissociated.[24]

**Soft Tissue Reconstruction of Oral Cavity**

Regional pedicled flaps and free flaps are used to reconstruct oral cavity defects caused by tumor ablation.

Regional pedicled flaps are based on axial pattern blood supply. Pedicle location and length define the limits of regional flaps in head and neck reconstruction. Primarily, branches of the subclavian or axillary arteries supply the regional flaps used in reconstruction of the head and neck. The right subclavian artery arises from the right innominate artery while the left subclavian artery arises directly from the aortic arch. The axillary artery begins at the lateral border of the first rib as a continuation of the subclavian artery. The axillary artery is divided into 3 parts by its relation to the pectoralis minor muscle. The axillary artery has 3 main branches: the superior thoracic artery, thoracoacromial trunk, and subscapular trunk. The 2 primary branches of the subclavian artery are the thyrocervical and costocervical trunks.

Regional flaps can be classified as fasciocutaneous (eg, deltopectoral flap) or as myocutaneous (eg, pectoralis major, latissimus dorsi, trapezius flaps). Selection of a certain regional flap depends on the size and location of the defect and the limitations of the regional flap choices. The pectoralis major myocutaneous pedicled flap (PMMPF) is described below as it is considered the workhorse of pedicled flaps for head and neck reconstruction. [25]

### Regional flaps

- **Pectoralis major flap**
  - The blood supply of the pectoralis major flap is the pectoral branches of the thoracoacromial artery.
  - To spare skin for a later deltopectoral flap option, extend the lateral skin incision toward the anterior axillary fold.
  - The motor nerve supply should be identified and cut to prevent muscle contraction.
  - **Advantages**
    - This flap offers one-stage reconstruction.
    - The patient's position need not be changed intraoperatively.
    - This flap provides a large cutaneous island that can be used for defects involving 2 epithelial surfaces.
    - The muscular part covers neck structures protecting the carotid artery, especially in patients who have undergone radiation therapy.
  - **Disadvantages**
    - The flap can conceal recurrences, making follow-up in the neck area more complicated.
    - In women, the flap might include breast tissue, which may lead to breast asymmetry.
    - In males, hirsute chest skin is placed intraorally.
    - This flap causes loss of pectoralis muscle function in arm adduction and/or rotation.
    - In patients who are overweight, the flap is bulky, which leads to postoperative contour deformities.[26]

- **Submental island flap**
  - The blood supply of the submental island flap is the submental artery.
  - This flap can be used for the reconstruction of the following structures:
    - Lip
    - Tongue
    - Buccal mucosa
    - Floor of the mouth
    - Lower gingiva
    - Oropharynx
    - The palate
    - Facial skin
  - Care should be taken during elevation of this flap in identifying and preserving the marginal mandibular branch of the facial nerve.[27]
  - Limitations of the regional pedicled flap, together with the advancements in microvascular free tissue
transfer, has led to the broad application of free tissue transfer in head and neck reconstruction.

Free flaps

The characteristics of an ideal free flap for head and neck reconstruction include the following:

- Pliable so as not to impair movement in head and neck
- Consistent, large and long pedicle
- Possibility of variable size and thickness
- Harvesting the flap can be consistent and can be done by reconstructive surgeon in the same time of tumor excision
- Minimal donor site morbidity

The 2 main choices of free flaps are the radial forearm free flap and the anterolateral thigh free flap. Perforator flaps are also described below.

- Radial forearm free flap
  - Since it was first described by Song et al in 1982, the radial forearm free flap has become a workhorse flap in head and neck reconstruction.[28]
  - Advantages
    - The radial forearm flap has most of the desired characteristics of the ideal free flap.
    - It provides a skin paddle that is thin, reliable, pliable, and predominantly hairless.
    - Its harvest is safe and consistent.[29]
  - Potential donor site complications
    - Donor site not hidden
    - Donor site closure consists of skin grafting
    - Partial skin graft loss
    - Tendon exposure
    - Fracture of the radius at bone harvest site
    - Sensory loss in distribution of the superficial radial nerve
    - Restricted forearm function
    - Vascular compromise of the hand (This is the most devastating complication related to harvest of the radial forearm free flap. This occurs when insufficient collateral circulation via the ulnar artery exists. Use of the preoperative Allen test, in which the distal perfusion of the hand is ensured while occlusion of the radial artery is performed, eliminates the risk for postoperative vascular insufficiency.)
  - Potential donor site complications have led some centers to shift toward the anterolateral thigh flap in recent years.[30]

- Perforator flaps
  - Perforator flaps are skin or subcutaneous tissue flaps based on the dissection of a perforating vessel.[31]
  - Advantages
    - Reducing muscle harvest minimizes donor site morbidity.
    - The long-term bulk of free tissue transfer is more predictable, as it avoids transfer of denervated muscles.
  - Disadvantages
    - The dissection of small perforating vessels may be tedious and challenging.
    - Variable position and size of the perforator vessels can be a disadvantage (Doppler ultrasonography is routinely used to locate the perforator arteries).
  - Contraindications
    - Small perforator size
    - Scarring at the donor site

- Anterolateral thigh free flaps
  - The anterolateral thigh flap is likely the most widely used perforator flap for head and neck reconstruction. It is based on the descending branch of the lateral circumflex femoral artery.
  - Advantages
    - This flap provides a long, large vascular pedicle.
- This flap can provide a huge amount of skin, muscle, and fascia with little donor site morbidity.
- It can be used as a sensate or a flow-through flap.\[32\]
- The anterolateral thigh free flap can technically be combined with iliac bone.\[33\]
- This flap can be harvested simultaneously during tumor excision.

- Disadvantages and potential complications
  - Sometimes requiring second-stage thinning, the thigh flap can be thinned principally. This concept was proposed by Kimura under the operating microscope (microdissection).\[34\] This technique is accompanied by an unacceptably high rate of flap failure.\[35\]
  - Patients may experience fatigue and weakness when climbing and descending stairs.
  - Use of split-thickness skin graft (STSG) at the donor site may be complicated by decreased range of motion at the hip and knee joints as a result of adhesion between the skin graft and the underlying muscle.\[36\]
  - Hypesthesia, anesthesia, numbness, and decreased tolerance to cold may occur in the distribution of the medial branch of the lateral cutaneous nerve of the thigh that is usually sacrificed to protect the perforator.\[37, 38\]

- Repair of free flap failure
  - Second free flap
  - Regional pedicle flap
  - Conservative management with debridement; wound care followed by closure by secondary intention

-Reconstruction of Tumors of the Oropharynx

Primary closure, skin grafts, local pedicled flaps, and microvascular free flaps are all in the reconstructive armamentarium for the pharyngeal defects. In the past, the goals of oral and oropharyngeal reconstruction were to close the defects and to avoid local postoperative complications. However, the goals of reconstruction are now to regain function (swallowing, speech, and breathing) and to improve the patient's quality of life.

Resection of the intrinsic and extrinsic musculature of the tongue affects speech and swallowing functions. Reconstruction should aim at restoring mucosal surface, muscle bulk, and movement and sensation, whenever possible.

-Anatomy

The oropharynx is bounded by the following structures:
- Anteriorly - The oral cavity separated is from it by the anterior tonsillar pillar, consisting of the palatoglossus along with the soft palate and circumvallate papillae at the tongue base
- Inferiorly - The hypopharynx at the at the level of the hyoid bone
- Superiorly - The nasopharynx at the horizontal plane of the soft palate
- Posteriorly - The posterior pharyngeal wall

-Reconstruction of soft palate defects

Defects of the soft plate result in velopharyngeal incompetency (ie, inability to seal the oropharyngeal and nasopharyngeal cavities in speech and deglutition). Primary closure of the smallest of soft palate defects can lead to rhinolalia aperta, leading to a noticeable change in voice resonance due to air escape behind an incompetent velum. Swallowing problems are most noticeable after ingesting liquids, with a resulting nasal regurgitation.

Following the surgical ablation of lateral soft palate and tonsillar fossa defects, the radial forearm free flap can be used for reconstruction. However, small defects can be effectively closed primarily or with split-thickness skin graft (STSG).

Extensive palatomaxillary defects that need repair after surgical ablation can be reconstructed with a prosthesis (though this provides suboptimal functional results) or with vascularized bone-containing free flaps (eg, fibula or
iliac crest internal oblique osteomusculocutaneous free flap).\[40\]

**Reconstruction of base of tongue**

Tongue base cancers account for approximately 40% of all oropharyngeal carcinomas and are associated with significant degrees of functional morbidity, as the tongue is among the areas most difficult to reconstruct.\[41\] This led to the historical rationale of initially treating most primary tumors of the base of tongue with combined chemotherapy and radiation therapy protocols. In recent years, surgical reconstructive techniques have continued to advance, improving functional outcome so that the consideration of surgery as the primary treatment is now being revised.\[42\]

Small defects of the base of the tongue can be repaired with primary closure. Large defects can be repaired with myocutaneous flaps, such as rectus or pectoralis major flaps, and with fasciocutaneous flaps, such as the radial forearm free flap.

Recent reports reveal the improvement of functional outcome with the use of the radial forearm flap.\[41\] Yagi et al described a new design for free flap reconstruction of tongue base consisting of 4 lobes on a single pedicle.\[43\] The first reconstructs the tongue, the second the tongue base, the third the oral floor, and the fourth the lateral wall. They reported excellent functional results in 23 patients.\[43\]

**Reconstruction of posterior pharyngeal wall**

Small defects can be closed primarily closure or with STSG. Larger defects usually require free flap reconstruction. In this case, the radial forearm or lateral arm flaps are preferred to thicker flaps.

**Reconstruction of Pharyngoesophageal Defects**

Hypopharyngeal carcinomas are associated with poor prognosis because of a combination of late diagnosis, aggressive tumor behavior with tendency for submucosal spread, skip lesions, and spread into the surrounding structures of the neck.

Advances in chemoradiation and altered fractionated radiotherapy protocols have enabled laryngeal preservation in many patients with marginal improvements in survival over conventional radiotherapy. Yet, surgical salvage after definitive radiation therapy is not rare. Other patients are not suitable candidates for chemoradiation and their carcinomas are best managed with primary surgery. However, following laryngopharyngectomy, the reconstructive surgeon is faced with a challenging condition. He or she should aim at adequate functional restoration regarding swallowing and voice, together with minimizing morbidity in such high-risk vulnerable patients.\[44\]

**Anatomy**

The hypopharynx extends from the level of the hyoid bone superiorly to the lower border of the cricoid inferiorly. It is a cone-shaped structure in continuity with the oropharynx above and the cervical esophagus below. The hypopharynx is divided into the following regions: paired pyriform sinuses, postcricoid, and posterior pharyngeal wall.

Pyriform sinus cancer is the most common. The sinuses extend from the pharyngoepiglottic folds superiorly to an apex inferiorly lying at the level of the glottis. Laterally, it is bounded by the overlying thyroid cartilage and thyrohyoid membrane. Medially, the pyriform sinus is closely related to the laryngeal structures. The posterior pharyngeal wall is separated from the vertebral bodies posteriorly by the prevertebral fascia and the retropharyngeal space. Tumors arising de novo here are rare.

Postcricoid cancer tends to spread superficially, extending into the cervical esophagus and pyriform sinuses. The postcricoid area extends inferiorly from the posterior surfaces of the arytenoids and the intervening mucosal fold to the inferior margin of the cricoid cartilage. The upper cervical esophagus originates at the lower border of the cricoid.
Reconstruction of the pharynx and cervical esophagus after resection for tumor involvement is most commonly attained with the use of free tissue transfer. The main factor affecting choice of reconstruction is the extent of pharyngoesophageal defects.

- Partial defects can be reconstructed with the following flaps:
  - Pectoralis major flap
  - Anterolateral thigh flap
  - Cutaneous deltopectoral flap
- Circumferential defects can be reconstructed with the following flaps:
  - A tubed radial forearm or anterolateral thigh flap can be used.
  - The jejunal flap was the workhorse for pharyngeal reconstruction. However, recent concerns have arisen about bad voice quality and intermittent dysphagia due to uncoordinated peristalsis during deglutition. Also, this flap harvest requires laparotomy.
  - Preliminary reports reveal that gastro-omental flaps provide vascularized omentum that can be draped around the pharyngeal anastomoses.\[45\]
  - If the cervical esophagus is involved, gastric transposition is the best management.\[44\]

**Cutaneous and Soft Tissue Defects**

- Skin defects can be reconstructed using the reconstruction ladder mentioned above.
- Ideally, skin defects should be closed while maintaining the color, thickness, and texture of the skin.
- Small defects
  - Small defects can be repaired with primary closure.
  - Local tissue flaps (eg, bilobed, rhomboid, rotational) provide the best aesthetic and functional results.
  - Skin graft use is limited because of color mismatch, contour irregularity, and graft contracture.
- Moderate defects: Larger local flaps (eg, nasolabial, paramedian forehead, dorsonasal) can be used to repair moderate defects.
- Large defects
  - Free flaps: The radial forearm and anterolateral thigh flaps are good for this region, as they are thin and pliable and allow for contouring over the facial skeleton.\[46, 47\]
  - Distant pedicled flaps such as pectoralis major, latissimus dorsi, and trapezius may be used as salvages for free flap failures or in neck defects, but they are less than ideal for facial defects.

**The Horizon**

- Conservative surgical options, including the Mohs technique for skin cancer removal, newer endoscopic laser-assisted techniques for aerodigestive tract cancers, and endoscopic skull base tumor resection continue to pave the way toward more organ-sparing treatment plans. These conservative endoscopic techniques require new limited endoscopic reconstruction techniques.
- Transoral robotic surgery (TORS) for base of tongue neoplasms is a new emerging modality of surgery that may pave the road to more conservative surgeries. Reconstructive surgeons should be aware of the new technological and surgical advances.\[48\]
- Research is now progressing in the field of stem cell and osteosynthesis. The potential that this research can provide rapid de novo bone growth may eliminate the need for vascularized bone flaps.
- Gene therapy and immune system targeting are newer treatment modalities entering the battle against head and neck cancer. Through a combination of viral and nonviral vectors, immune stimulation, and monoclonal antibodies, researchers are working to attack cancer at the cellular and molecular levels. As this technology progresses, it will determine what role surgery, traditional chemotherapy, and radiation will play in the treatment options.\[49, 50\]

**Conclusion**

Head and neck reconstruction is an extremely demanding process that needs continues improvements and refinements. Patients' cases should be managed with a team approach, including oncologists, ablative surgeons,
and reconstructive surgeons. Despite the progress achieved in this field, frustration of head and neck reconstruction remains because of the inability to attain complete functional and cosmetic recovery with current techniques.

In recent years, free flaps have become the workhorse in head and neck reconstruction; most centers are reporting success results higher than 96%, with the possibility of free flap salvage for failures. A competent reconstructive surgeon should be familiar with the armamentarium available for reconstruction, understanding the advantages and limitation of each technique and knowing when and where to adopt each one.

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