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# Head and Neck Reconstructive Surgery

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## 1. Introduction

### 1.1 Floor-of-the-mouth defects

The oral cavity is the most common location in the head and neck region for primary malignant tumors. In the Western world, primary squamous cell carcinomas of the oral cavity most frequently involve the tongue and the floor of the mouth. In countries in which betel nut and tobacco chewing are common, the buccal mucosa and retromolar trigone are the most frequently encountered primary tumor sites. Initial treatment depends on parameters of the primary tumor, patient factors and factors related to the treatment team (Shah & Patel, 2003; Ariyan, 1997).

Reconstruction of defects in the oral cavity after tumor extirpation and anticipated radiotherapy requires well-vascularized pliable tissues with limited tissue bulk (Gurtner & Evans, 2000). The radial forearm flap has been used conventionally for decades to repair defects of the floor of the mouth and oral sidewalls. Its major disadvantage is significant donor site morbidity when the flap is harvested as a conventional fasciocutaneous flap. Webster described a suprafascial dissection that permits leaving the fascia on top of the forearm tendons and musculature (Webster & Robinson, 1995). The harvest requires meticulous cleavage of the anterior sleeve of the conjoint tendon that stretches between the flexor carpi radialis and the brachioradialis tendons and envelops the radial vascular pedicle (Fig 1). The suprafascial harvest, in combination with a full-sheet skin graft, strongly reduces adhesions, neurotrophic pain and loss in range of motion, and its superiority over the conventional “subfascial” technique has been clearly demonstrated (Chang et al., 1996).

The anterolateral thigh flap (ALT) has been popular for decades in Asia for head and neck reconstructions and offers reliable, pliable tissues for intraoral lining. When a thin flap is needed in more obese patients, a suprafascial dissection towards the perforators allows immediate thinning down to 4 mm. The ALT flap provides a large skin paddle and can be combined with anterolateral thigh fascia and the thick tensor fascia lata. If more bulk is required, a segment of the vastus lateralis can also be incorporated as a monobloc, or each segment based on its perforator can be used as a chimera flap that allows for optimal positioning in the defect (Fig 2).



Fig. 1. Suprafascial harvest of the radial forearm flap. Left: The conjoint tendon of the anterior and posterior fascia wraps the radial vascular pedicle. The anterior sleeve is sectioned at the position of the scissors, leaving the conjoint tendon intact. Right: The donor bed after harvesting a suprafascial radial forearm flap. No tendons are exposed. A fatty layer covers the superficial nerves. There is no tenting between the flexor carpi radialis and brachioradialis tendons.

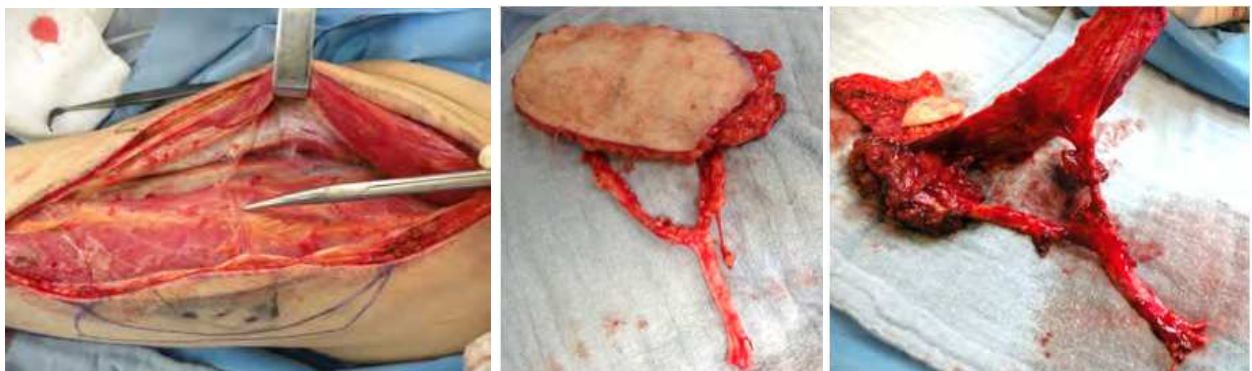


Fig. 2. The anterolateral thigh flap. Left: A septocutaneous perforator is visible between the vastus lateralis and rectus femoris muscles. Middle: The anterolateral thigh flap harvested on 2 perforators. Right: A multi-unit ALT flap is harvested with a large fascia segment on one perforator, and a small muscle cuff on a second perforator and a small skin island are used as monitor.

The vascular pedicle is the descending branch of the lateral circumflex femoral artery (LCFA) system. This pedicle is long and of good caliber. The ALT flap is notorious for its anatomic variations. The skin perforators of the anterolateral thigh can be either musculocutaneous (87%) or septocutaneous (13%), whereas the pedicle of the flap can be either the descending or the oblique branch of the LCFA (Wong et al., 2009). The absence of significant perforators is rare (1%).

The SCIAP flap (superficial circumflex iliac artery perforator-based free groin flap) provides a thin and flexible lining for the reconstruction of the floor of the mouth and an inconspicuous donor site (Fig 3). A disadvantage, however, is the variable vasculature both of the artery and the veins, which often renders the harvest unpredictable in terms of pedicle length.





Fig. 3. A superficial circumflex artery perforator-based flap from the left groin. This flap offers thin pliable tissues ideal for the reconstruction of the floor of the mouth.

Full-thickness cheek-and-floor-of-the-mouth defects in combination require a double skin paddle and a long vascular pedicle that allows for optimal set-in and satisfactory volume to provide adequate lining of the cheek. A folded radial forearm flap is an option; however, its use requires either two skin paddles with one perforator each in the suprafascial dissection technique or use of the traditional harvesting technique with a de-epithelialized zone in between to permit plication and suturing to the sidewalls of the cheek. A folded anterolateral thigh flap can be used with the intervening folded portion de-epithelialized (Fig 4). These full-thickness defects often have a significant volume deficit, which may result in a long-term sunken appearance of the cheek.

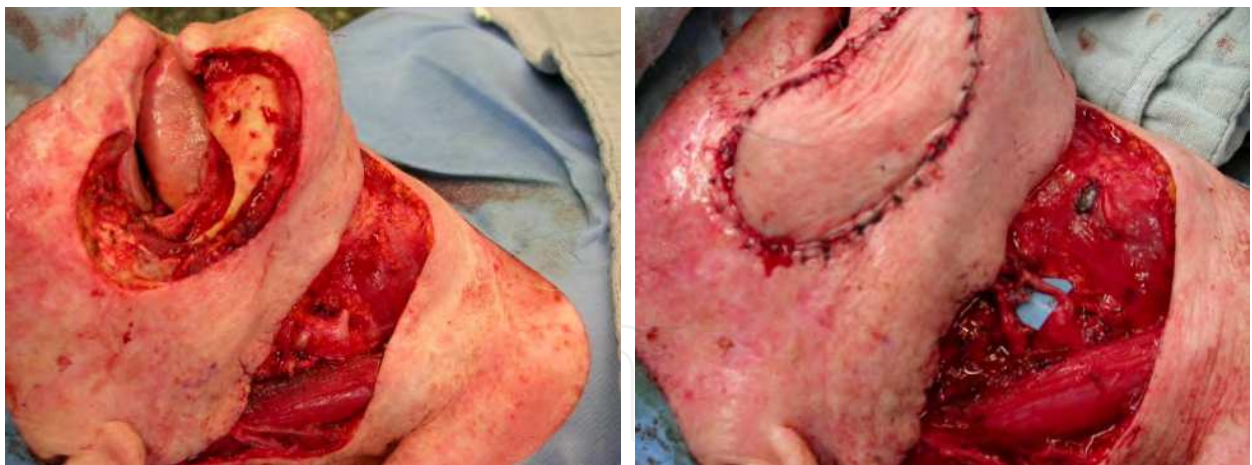


Fig. 4. Left: Full-thickness defect of the floor of the mouth and cheek. Right: A defect restored with an anterolateral thigh flap with 2 skin paddles. Venous anastomosis end-to-side on the IJV and artery end-to-end on the superior thyroid artery.

The anterolateral thigh flap provides more tissue volume than a radial forearm flap; in addition, vascularized fascia or a vastus lateralis muscle segment can be included to provide more tissue volume. If two suitable perforators are present, the skin paddle can be split as a chimeric flap, which allows for a more elegant reconstruction; if the oral commissure is involved in the defect, the fascia lata can be split and sutured into the upper and lower orbicularis oris muscle as a static sling (Huang, 2002).

## 1.2 Defects of the tongue

Hemitongue defects are preferably reconstructed using a thin sensate flap (Kimata et al., 1999, 2003). The suprafascial dissected radial forearm flap is particularly useful if a pliable, flexible, well-vascularized flap is required for lining of the tongue in cases where there is also a significant defect in the floor of the mouth or on the cheek (Fig 5). The anterolateral thigh flap with the lateral femoral cutaneous nerve delivers the required tissues. If the donor thigh is too bulky, a suprafascial dissection allows for immediate thinning of the flap. Also, partial tongue defects that include the floor of the mouth can be restored with an ALT flap; if required, a fascia extension or de-epithelialized segment can be used to drape the floor of the mouth or to fill the dead space in the submandibular zone.

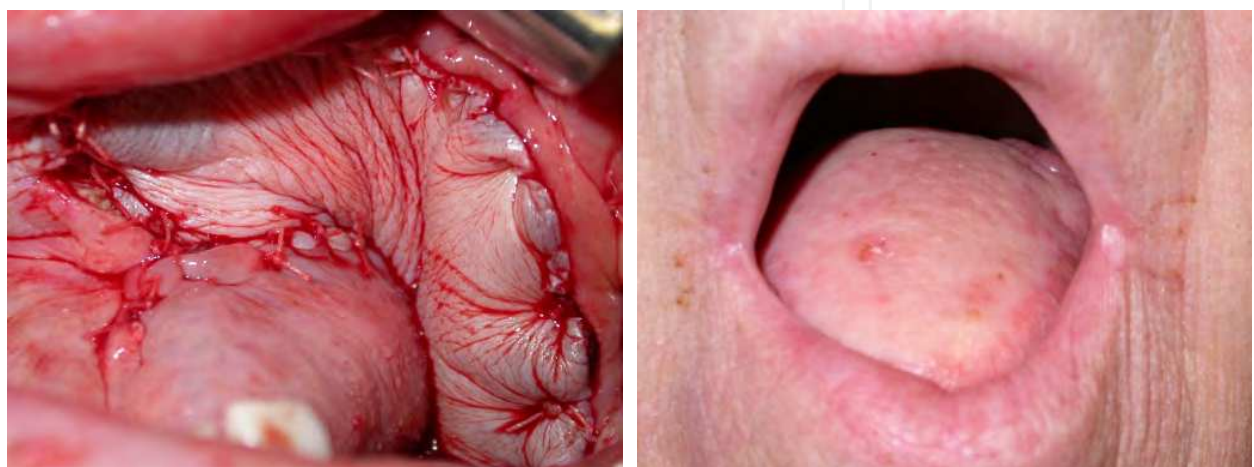


Fig. 5. Left: segmental tongue, floor of the mouth and internal defect of the cheek. Defect restored with a suprafascial radial forearm flap that drapes well over the U-shaped defect. Right: a total tongue reconstruction with an anterolateral thigh flap and small central segment of vastus lateralis muscle.

Total glossectomy defects require significant bulk to restore height and volume to the reconstructed tongue, and a myocutaneous flap is therefore required. Previously, the rectus abdominis myocutaneous flap was popular for the reconstruction of the tongue. However, donor site morbidity may be significant (Lyos et al., 1999 ; Hurvitz et al., 2006). The anterolateral thigh flap can provide as much volume as a rectus abdominis myocutaneous flap with a similar long vascular pedicle but with minimal donor site morbidity. The myocutaneous gracilis flap also allows access to the required tissues with minimal donor site morbidity (Yousif et al., 1999). However, pedicle length is limited, and in obese patients, it is difficult to align the skin portion on top of the gracilis muscle, which may result in shear stress or omission of a skin perforator and subsequent loss of the skin paddle.

## 2. Reconstruction of the mandible

When a primary tumor of the oral cavity extends to the alveolar ridge or infiltrates the mandible, surgical excision becomes mandatory. A marginal mandibulectomy is indicated when a primary tumor of the oral cavity approximates the alveolar process or the lingual site of the mandible. A marginal mandibulectomy preserves the mandibular arch and can be

performed on the symphysis, at the body of the mandible or at the coronoid process and retromolar trigone. Mandibular reconstruction is not required following a marginal resection of the mandible. The defect is restored by primary suture of the mucosa of the floor of the mouth anteriorly to the lower lip or laterally to the cheek mucosa or with a split-thickness skin graft. For suitable patients, osteointegrated implants recreate denture.

When a primary malignant tumor infiltrates the gingiva over the alveolar process or infiltrates the mandible, a segmental mandibulectomy and stabilization or reconstruction are required. A commando composite operation consists of the resection of the intraoral primary tumor with a mandibular segment and ipsilateral neck dissection 'en bloc' (Shah & Patel, 2005).

Proper flap selection and operative planning is based on the extent and location of the resection, the quality of surrounding tissues, the status of the recipient vessels (ipsilateral versus contralateral) and the availability of donor sites. These variables are often related to the general condition of the patient and the patient's history of previous surgery or irradiation therapy.

Reconstruction of the mandible is accomplished either with the use of soft-tissue free flaps and a reconstruction plate or with the use of osseous free flaps. Despite early enthusiasm for soft-tissue free flaps (radial forearm and rectus abdominis) in conjunction with a reconstruction plate, there is a higher incidence of long-term failure, such as plate fracture and extrusion, of such flaps than with the use of osseous free flaps (Schusterman et al., 1991; Foster et al., 1999; Head C et al., 2003). Although the use of osseous free flaps in mandible reconstruction is more complex, their advantages far outweigh any disadvantages. Vascularized bone allows authentic bone healing, resulting in a stable union between the flap and graft within 2–3 months in the majority of patients, in spite of preoperative or postoperative radiation therapy (Cordeiro & Hidalgo, 1994). Moreover, vascularized bone serves as an excellent recipient substrate for the placement of osteointegrated dental implants. The four osteocutaneous donor sites most commonly used for mandible reconstruction are the fibula, the iliac crest, the radial forearm, and the scapula. Each donor site has its own intrinsic parameters with respect to the quality and quantity of available bone and soft tissue, the quality of the vascular pedicle, the feasibility of a two-team approach, and the potential for osseointegrated dental implants (Disa & Cordeiro, 2000).

**The fibula** has become the flap of choice for reconstruction of most segmental mandibular defects. The bony flap based on the peroneal artery and associated veins can deliver up to 27 cm of triangular-shaped bone, an amount that is ideal for lateral, anterior, or combination defects. Donor site morbidity is minimized by preserving 7 cm of distal fibula at the ankle and 6 cm at the knee. Blood supply to the fibula is both intraosseous and segmental; therefore, multiple osteotomies can be performed without risk of devascularizing the bone (Wei, 1994, 2003). The flap can be harvested as an osteocutaneous or osteomyocutaneous flap with a skin island based on perforators that travel within the posterolateral crural septum (Fig 6). Musculocutaneous perforators to the skin are often encountered proximally, while more septocutaneous perforators are present in the middle and distal third of the lower leg. The flexor hallucis longus muscle or segments of the soleus muscle can be integrated in the harvest to provide extra soft-tissue bulk.



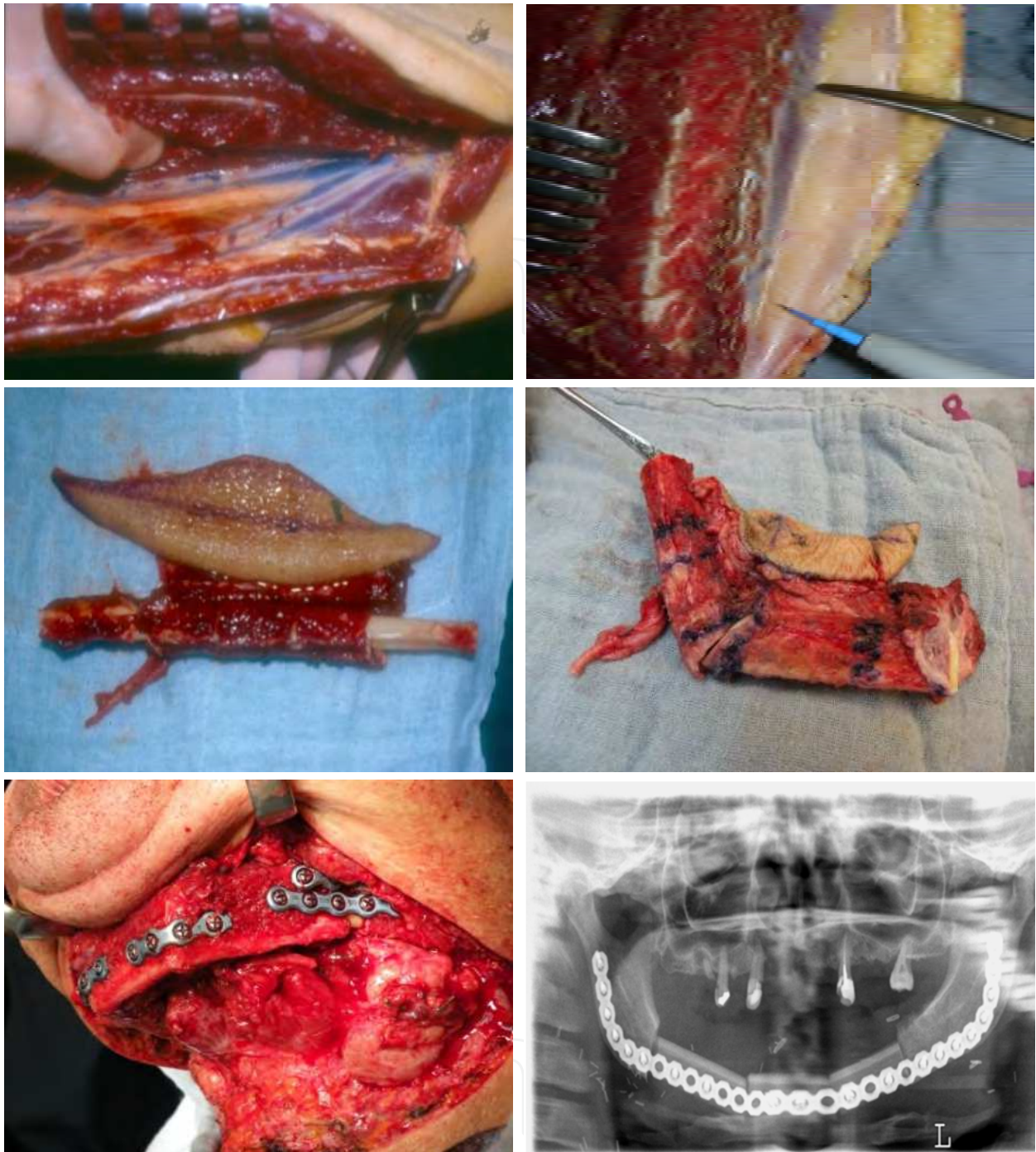


Fig. 6. Upper left: Harvest of osteocutaneous fibula (OCF). The transition zone between the peroneal and tibial pedicle in between the tibial nerve. Upper right: Two septocutaneous perforators in the posterolateral septum. Middle left: Harvest of the OCF with a minimal muscle cuff. Middle right: Restoration of the lateral ramus of the mandible with the OCF. One osteotomy required. Skin island covers the floor of the mouth and cheek. Lower left and right: Anterior ramus reconstructed with OCF. Four osteotomies required.

One advantage of the use of a fibular flap is the possibility of carrying out a simultaneous unimpeded dissection in a 2-team approach while the ablative procedure is being performed. After harvest, the flap can be left perfused on its vascular pedicle while the

osteotomies are performed in order to minimize ischemia time. A disadvantage of the fibula is the straightness of the bone; this makes the fibula particularly suitable for anterior defects, but osteotomies are required for curvature. The fibula also has a low profile relative to the height of the native mandible in dentulous patients. In patients in whom osseointegrated implants are planned as either a primary or a secondary procedure, the fibula should be placed about 0.5 to 1 cm above the inferior border of the native mandible, closer to the superior alveolar edge, to facilitate the placement of implants; alternatively, a double-barrel fibula can be used (Chang et al., 1998; Urken ML et al., 1989 ; Sclaroff A, 1994). However, this requires an adequate skin paddle because more soft tissue is often needed to accommodate the extra bony volume. Another disadvantage of the fibula osteocutaneous flap is the unreliability of the skin island, which has been reported to be not useful in up to 10% of cases. The incorporation of flexor hallucis longus muscle or segments of soleus muscle with the skin paddle may result in a greater reliability of the skin island.

**The iliac crest** was the main method of mandible reconstruction in the 1980s. Its major advantages are its natural curvature, which is anatomically contoured for ipsilateral reconstruction, and the abundance of vertical and horizontal height of the bone for mandibular contour and osseointegration (Jewer et al., 1989). The flap has a large overlying skin island. It has a good cosmetic appearance of the donor site compared with the other free flaps that are used for mandibular reconstruction. The disadvantages of this flap include a short vascular pedicle and a lack of segmental perforating vessels, which limit the ability to perform osteotomies for graft shaping. In obese patients, the skin paddle can be thick and relatively nonmobile. In obese patients there may also be excess adipose tissue, and the harvest of the flap may become unreliable. This limits its utility for intraoral reconstruction. An additional limitation of the iliac crest flap is the donor site morbidity associated with its use. This includes numbness in the hip region and, especially, bulging as well as hernia formation due to the fact that all attaching muscles must be dissected from their origins. A modification of this flap leaves the superior anterior iliac spine intact with its muscle insertions. Also, only the inner table of the iliac crest can be used; this reduces donor site morbidity but also reduces the quantity of bone available for osseointegration. The versatility of the fibula has superseded the iliac crest in most situations.

**The radial forearm flap** has long and large donor site vessels. The skin paddle is thin, pliable and long and can perfectly drape over intraoral defects. The major disadvantage of the forearm osteocutaneous flap is the quality of the available bone, which is thin and not reliably osteotomized. Additional bulk can be added by harvesting a segment of the brachioradialis muscle. However, this adds to the already notorious donor site morbidity. Harvest of a unicortical segment of radius may destabilize the bone, resulting in fracture. The forearm osteocutaneous free flap is best suited to ramus defects requiring minimal bone but needing a large amount of skin. The available bone stock of the radius is usually unsuitable for osseointegration.

**The scapula** flap is versatile because the long circumflex scapular artery and vein can supply a large quantity of soft tissue with the bone. An axial parascapular and/or transverse scapular flap skin island can be based on this vascular pedicle in combination with a segment of the serratus anterior or latissimus dorsi muscles. The major drawback of the scapula flap is the marginal quality of the bone, which is not reliable for osteotomies or osseointegration. The location of the donor site prohibits simultaneous harvest of the flap



and tumor ablation, thus drastically lengthening the time required for the procedure. The major indication for the use of the scapula flap in mandibular reconstruction is a posterior defect that does not require osteotomy of the bone but does require a large amount of external skin and soft-tissue reconstruction.

### 3. Reconstruction of the maxilla

If a primary tumor involves the hard palate, upper gum, or the upper gingivobuccal sulcus, or if the tumor is in direct continuity with the maxilla, maxillar resection is mandatory. The resection may consist of an alveolectomy, palatal fenestration or partial maxillectomy. Multiple classifications describe the maxillectomy and midface defects in terms of the vertical and horizontal aspect of the maxillary loss (Brown JS et al., Cordeiro P et al., Santamaria et al.). Classes I-IV describe the increasing extent of the maxillary defect in the vertical dimension as follows: class I—maxillectomy without oronasal fistula; class II—maxillectomy not involving the orbit; class III—involving the orbital adnexae with orbital retention; class IV—with orbital enucleation or exenteration; class V—orbitomaxillary defect; class VI—nasomaxillary defect (Fig 7). Horizontal classification is based on the increasing complexity of the dentoalveolar and palatal defect and describes the vertical

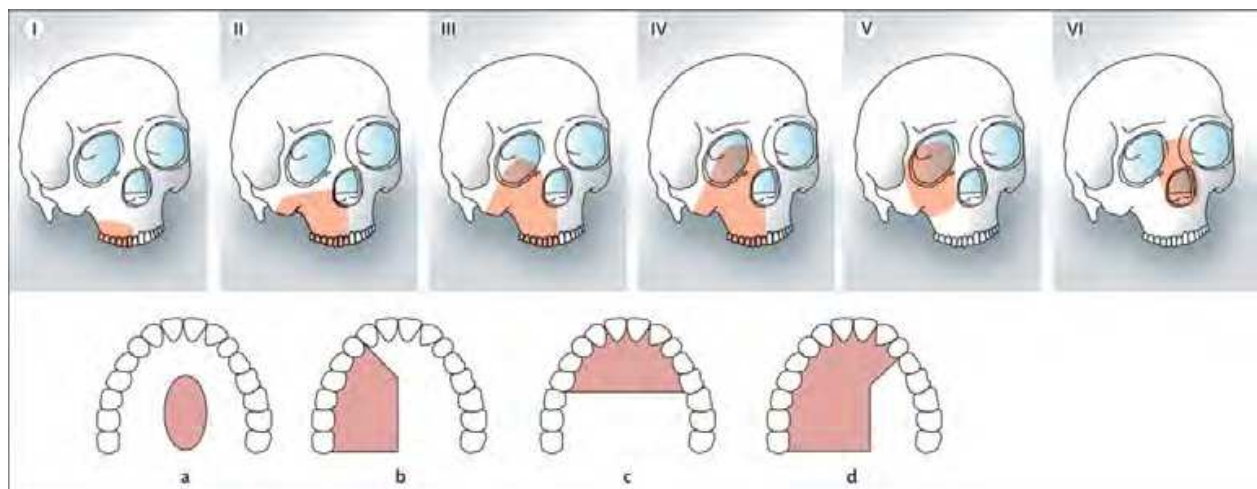


Fig. 7. Classification of vertical and horizontal maxillectomy and midface defects. Vertical classification: I—maxillectomy not causing an oronasal fistula; II—not involving the orbit; III—involving the orbital adnexae with orbital retention; IV—with orbital enucleation or exenteration; V—orbitomaxillary defect; VI—nasomaxillary defect. Horizontal classification: a—palatal defect only, not involving the dental alveolus; b—less than or equal to 1/2 unilateral; c—less than or equal to 1/2 bilateral or transverse anterior; d—greater than 1/2 maxillectomy. Letters refer to the increasing complexity of the dentoalveolar and palatal defect and qualify the vertical dimension. From Brown JS and Shaw RJ., *The Lancet Oncol.* 2010; 1001-08.

dimension: a—palatal defect only, not involving the dental alveolus; b—less than or equal to 1/2 unilateral; c—less than or equal to 1/2 bilateral or transverse anterior; d—greater than 1/2 maxillectomy. This classification provides a framework to explain the complexity of each defect and describes the rationale for the reconstructive options. Traditionally, the majority of midfacial defects were lined with split-thickness skin grafts, and obturators were

used to fill the defect. Obturation is simple and provides the patient with immediate new dentition. However, the cavity behind the obturator may contract during the healing process, and the obturator should be repetitively adapted to the changing contour. In addition, radiotherapy may cause severe problems. Soiling from the oral and nasal cavity may occur, and the interface between a rigid non-flexible obturator and soft tissues may cause problems of skin irritation, maceration and poor hygiene.

For some defects, obturation may offer a simple non-invasive solution preventing oronasal communication and improving speech. For larger defects, however, there may be problems with stabilization of the obturator (McCarthy et al. 2010). Reconstruction with tissues obliterates the defect using vascularized tissues that are more resilient to irradiation and provide preservation of volume, flexibility and shape, allowing for more easy integration of dentures in the second stage. Moreno et al. reported on the largest comparative series between obturation and reconstruction of the maxillary defects. They found that reconstruction gave the better outcome for swallowing and speech, especially in larger defects in the horizontal component (class IId). In general, one could conclude that for larger alveolar class IId and class III-VI defects, a reconstruction with a composite free flap is preferred.

Brown et al. analyzed the literature from 1998-2009 and summarized the reconstructive options selected for each of the classes. For class I and class IIa midline hard palate defects, most authors report the use of the radial forearm free flap. For class IIb defects that consist of less than half of the lateral alveolus and palate, zygomatic implants have been reported to give good results. The temporoparietalis fascia flap can close the oroantral and nasal fistulae but provides no bulk. The most frequently reported soft tissue flap used for reconstruction of class II defects is a radial forearm fascia flap. However, the anterolateral thigh flap provides well-vascularized tissues and can be easily modified in terms of bulk and lining with fascia in addition to the skin paddle. A segment of bone can also be included based on the ascending branch of the lateral circumflex vascular pedicle. The most frequently reported composite flap is the fibula osteocutaneous flap, which provides easily maniable bone segments rooted on a large vascular pedicle and a skin paddle on fine septocutaneous perforators. The fibula also provides good bone stock for osteointegrated implants.

In class III defects, support of the orbital, cheek and dental arch must be provided in addition to a facial skin paddle and closure of the oral and nasal defects. The rectus abdominis myocutaneous flap provides a voluminous, well-vascularized paddle. The dissection is straightforward, and the vascular pedicle is predictable and long. However, long-term donor site morbidity may be cumbersome (Browne et al., 1999). Moreover, the rectus flap only provides soft tissue bulk without bone for support of the bony walls. Because postoperative irradiation is inevitable, the combination of a rectus abdominis flap with non-vascularized bone to restore the orbital rim and floor may result in wound breakdown and collapse due to bone loss (Cordeiro & Santamaria, 2000). For class IIIb defects, the most recent literature supports the use of a DCIA iliac crest flap with a segment of internal oblique muscle. The bony segment can be shaped into the defect with the curvature required for the orbital rim and the piriform aperture, and it provides sufficient bone for the restoration of the alveolar rim even for dental implants (Fig 8). The internal oblique muscle provides the lining of the nasal wall and the separation between the nasal and oral cavities (Brown et al., 2002).

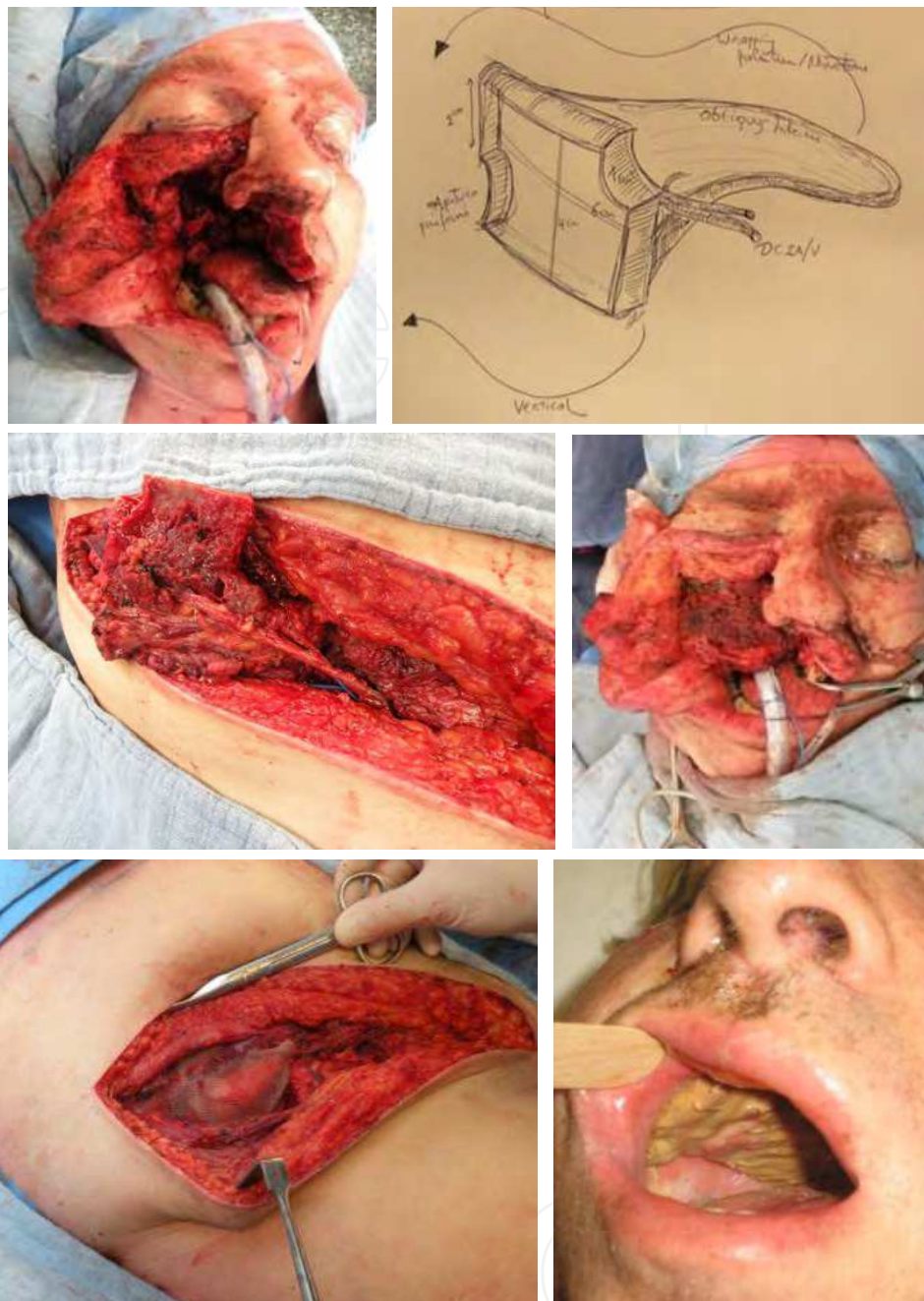


Fig. 8. Upper left: class IIIb defect involving maxilla and orbita at right side. Upper right: pre-op sketch of required iliac crest flap with internal obliquus muscle. Middle left: harvest of the iliac crest flap based on the DCIA. Middle right: flap fixed into the defect with mini plate and screws. Lower left: donor site carefully closed with a mesh graft and muscular approximation of abdominal wall and gluteal thigh layers. Lower right: the internal vestibular lining with obliquus internus muscle reepithelialises spontaneously.

The scapular angle osteomyocutaneous flap, a scapula flap with a latissimus dorsi segment, was proposed for class II and IV defects (Uglesic, 2000; Bidros, 2005). This chimera flap, which is based on the thoracodorsal angular artery, provides all required tissues for class II and IV defects. The advantage in comparison to the DCIA flap is the long thoracodorsal vascular pedicle, which facilitates flap set in. The angular scapula segment has also been



described in combination with the serratus anterior or teres major muscle (Ugurlu et al., 2007; Clark et al., 2008). The osteocutaneous fibula flap can also be used for these defects. However, the challenge lies in aligning the skin paddles and the required bony osteotomies for the perfect fit (Futran et al., 2002; Peng et al., 2005). The advantage of using either of these composite vascularized bone flaps is that the intrinsic height of the bone allows good bony adaptation, which promotes union at the alveolus and zygomatic remnant, although the scapular bone is significantly thinner than the iliac crest. In addition, both flaps provide adequate muscle to obturate the oral, nasal, and orbital defects. The subsequent epithelialization produces a natural result. Harvest of the iliac crest flap with internal oblique muscle is more difficult than the scapular angle osteocutaneous flap. However, the patient does not need turning or tilting, and a two-team approach is possible, which significantly reduces operation time (Brown & Shaw, 2010).

Class V orbitomaxillary defects are usually restored with soft-tissue flaps because exenteration of the orbit is required, but the palate remains intact. No bone is required. The orbit should be lined to receive an orbital prosthesis. The pedicled temporoparietal fascia flap delivers excellent lining in unilateral cases. When the defect is larger, a suprafascial harvested anterolateral thigh flap or suprafascial radial forearm flap are appropriate options. The suprafascial dissection of the ALT facilitates flap thinning. The suprafascial dissection of the radial forearm flap significantly reduces donor site morbidity at the forearm and should be performed for all forearm flaps that require a skin paddle.

Class VI nasomaxillary defects that involve the nasal bone require a reconstruction with thin vascularized tissues such as a radial forearm flap. A split radius can be included to provide structural support of the flap. A rib cartilage or bone strut can support a suprafascial radial forearm flap as well. However, after radiotherapy there is a significant risk of graft loss.

#### **4. Reconstruction of the hemilarynx after hemilaryngectomy**

The accepted treatment modalities for laryngeal cancer are radio(chemo)therapy and surgery. A unilateral advanced tumor on one vocal fold can only be treated surgically by total laryngectomy because the reconstruction of a hemilarynx for sparing one vocal cord is so complex (Pearson et al., 1990). However, every attempt must be made to avoid total laryngectomy because the loss of speech and the need for a permanent tracheostome dramatically change the quality of life of these patients.

The technique for extended hemilaryngectomy is designed to allow for functional treatment of lateralized glottic cancer with subglottic extension (T2, T3) and of lateralized chondrosarcomas of the cricoid cartilage (Fig 9). The aim of the reconstruction is to restore the extended hemilaryngectomy defect and to obtain a morphology after reconstruction that is comparable to the vocal fold paralysis in the paramedial position.

In order to restore the cartilaginous framework after extended hemilaryngectomy, donor tissues should be used that mimic the resected tissues. The trachea represents good donor tissue: it has a similar cartilaginous structure and is internally lined with respiratory mucosa. When opened at the posterior membrane, a 4-ring horseshoe-shaped configuration can be obtained that mimics the hemilaryngeal convex shape. Because of the proximity of the cervical trachea to the larynx, a possible one-stage reconstruction of the hemilarynx would consist of a simple advancement of 4 cm of trachea with preservation of the tracheal continuity. To allow this upward mobilization, the trachea must be dissected from the surrounding tissues over

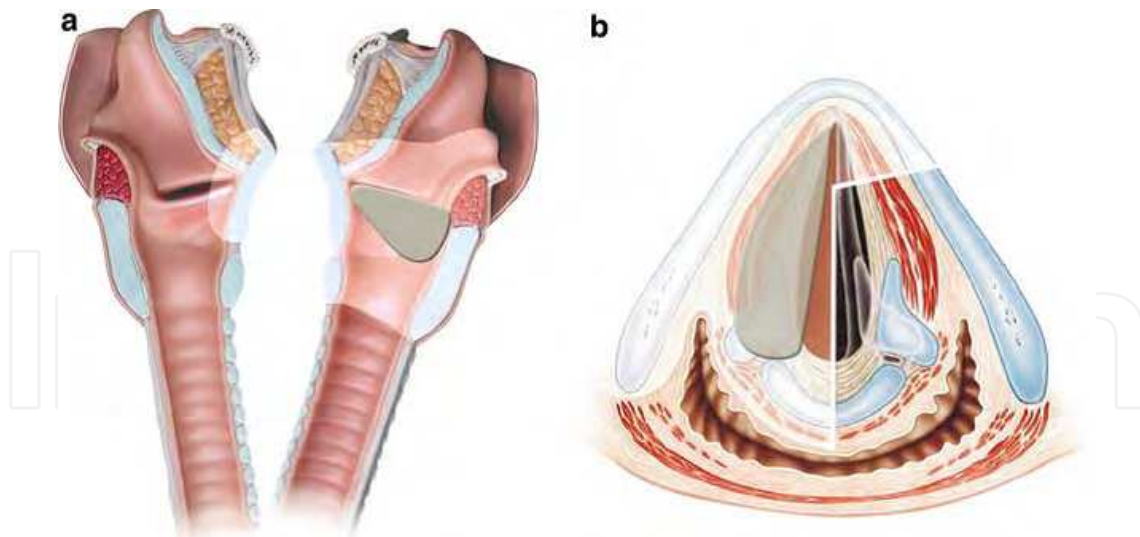


Fig. 9. Extended hemilaryngectomy defect. a: Internal view of the larynx after midline sagittal section. b: Axial section at the glottic level. The tumor (gray) is visible on one vocal fold. The bright area shows the amount of larynx resection necessary to remove the tumor. The resection includes one side of the thyroid cartilage and the full amount of the arytenoid and the cricoid cartilage at the tumor side. From Delaere P., Vander Poorten V, Vranckx J, Hierner R. *Eur. Arch. Otorhinolaryngol.* 2005 Nov; 262(11):910-6

about 8 cm, which means that this segment will have its extrinsic blood supply interrupted. Vascularity will further diminish after modification of the upper 4 cm of membranous trachea to create the convex patch and placement of a temporary tracheostomy at the anterior wall. Even in non-irradiated cases, advancement of a tracheal patch would inevitably lead to patch necrosis. Zur and Urken (2003) transferred the trachea pedicled on the thyroid artery and vein with the adjacent thyroid gland in a single stage. However, the thyrotracheal flap is not well suited for primary reconstruction of defects caused by epithelial-based neoplasms. There is an inherent risk of occult metastases to the thyroid gland and the paratracheal lymph nodes, and such metastases are commonly seen when there is significant subglottic extension. Therefore, a 2-stage prefabrication procedure is required to generate a revascularized autologous trachea segment. Delaere et al. reported a modification of the operative sequence compared to their initial procedure. In the first series of patients, the prefabrication of a 4-ring trachea segment was carried out by wrapping it with a radial forearm fascia flap, and a microvascular anastomosis was performed to head and neck blood vessels. The prefabrication step took 2 weeks. In a second stage, the tumor was resected and the hemilarynx restored with the prefabricated trachea construct. However, the prefabrication step used in the 1<sup>st</sup> stage before tumor resection in the second stage could manipulate tumor cells and elicit spreading. The conversion of sequence proved to be difficult; when the tumor is resected primarily, a hemilaryngeal defect exists at the time prefabrication of the trachea must begin. The hemilaryngeal defect must therefore be temporarily closed to permit breathing and swallowing during the time that the prefabrication step takes place. Experience after reconstruction of 50 cases allowed the authors to modify the sequence and to define an 'optimal reconstructive design' for extended hemilaryngectomy repair leading to optimal functional results without diminishing oncologic safety.

In the first stage of this design, an extended hemilaryngectomy is performed. For T3 glottic cancer, the tumor is resected with inclusion of the anterior commissure and with inclusion

of half of the cricoid cartilage. The ipsilateral thyroid lobe and tracheoesophageal lymph nodes are removed, as well as the lymph nodes at levels II, III, and IV. Only tumors without extension to the supraglottic area are included<sup>2</sup>. Subsequently, a radial forearm flap comprising a proximal fasciocutaneous segment and a distal fascial component is harvested from the non-dominant arm (Fig 10). The fascial paddle is wrapped around the upper 4 cm of the cervical trachea. The fasciocutaneous paddle is used to temporarily close the extended



Fig. 10. Stage 1. Upper row, left: Hemilaryngectomy. The trachea segment that will be prefabricated by wrapping it with a radial forearm flap is shown in white. Upper row, right: tumor resection indicated in white. White dots locate the sutures used to close the aryepiglottic area to recreate the sphincter. Middle row, left: Hemilaryngeal defect to be restored with the free flap. Middle row, right: A radial forearm flap is harvested with a fascia (F) segment distally and fasciocutaneous (FC) segment proximally. Lower row, left: The FC segment restores temporarily the hemilaryngeal defect. The F segment wraps 4 trachea rings. After microsurgical anastomosis, this revascularised fascia flap will prefabricate the trachea segment introducing an intrinsic axial blood supply.



hemilaryngectomy defect. After microsurgical anastomosis of the radial vascular pedicle to the neck vessels, the flap and the pedicle are covered with an ePTFE membrane to prevent adhesion formation. An inferolateral corner of the fasciocutaneous segment is sutured in the skin of the neck as a monitor flap to control vascularization of the buried tissues after microsurgical anastomosis. It also serves as the roofing for the temporary tracheostome and can be used in the second stage to close the skin defect after removal of the tracheostome.

After 4 months, a second look at the section margins is performed. If histology confirms the absence of tumor recurrence, the definitive reconstruction is initiated (fig 11). The ePTFE membrane is removed, and the skin paddle of the radial forearm flap is dislodged from the laryngeal defect. The skin paddle is de-epithelialized to serve as posterior bulk at the end of reconstruction. The fascia-enwrapped segment of revascularized trachea is isolated, remodeled and transferred upward into the laryngeal defect. The mediastinal tracheal stump is mobilized and sutured to the reconstructed larynx. During the second stage, the microvascular pedicle of the radial forearm flap in which the trachea segment was wrapped remains unharmed. A tracheostomy is maintained in the suture line between the reconstructed larynx and the mediastinal trachea. That tracheostomy is closed after restoration of all laryngeal functions, usually 1 to 2 months after the second operation. The tracheostomy is closed by inverting the skin around the tracheostomy, a small procedure performed under local anesthesia.

Tracheal autotransplantation leads to optimal reconstruction of extended hemilaryngectomy defects. Swallowing function recovers within a week after the first and second interventions, and laryngeal respiratory function is fully regained after closure of the tracheostomy.

After the first operation, the radial fasciocutaneous forearm flap restores the sphincter function of the larynx<sup>1</sup>. Swallowing of solids and liquids is possible after 1 week, and speaking is possible during finger occlusion of the temporary tracheostomy. After the second operation, the tracheal patch and the vascularized forearm flap produce successful restoration of sphincteric and respiratory function.

Hand-free speech is possible after closure of the tracheostome 6 weeks after the definitive reconstruction. The voice sounds natural and moderately hoarse. Some aspiration of saliva can be seen during the first days after operation, and most patients resume oral feeding after 1 week. When the patient does not succeed in swallowing without aspiration, a conversion towards total laryngectomy is performed. The tracheostomy closure may be delayed because of swallowing problems caused by postirradiation pharyngeal hypocontractility.

At the subglottic level, the luminal concavity should be restored to preserve function. The revascularized tracheal patch graft meets these subglottic reconstructive requirements (Pearson, 1990 ; Delaere , 2007). At the glottic level, the reconstructive tissue should follow the midline posteriorly, and a luminal concavity should be preserved anteriorly (Fig 12). Two sutures placed at the lateral site of the defect between the epiglottis and the aryepiglottic fold bring the aryepiglottic fold into a midline position posteriorly. Such a configuration leads to optimal sphincter and respiratory function.

Complete posterior closure is important for obtaining a good voice and swallowing function; therefore, the reconstruction must be placed in the posterior midline. Complete glottic closure is less critical anteriorly; therefore, a paramedian position of the graft will allow good respiratory function.

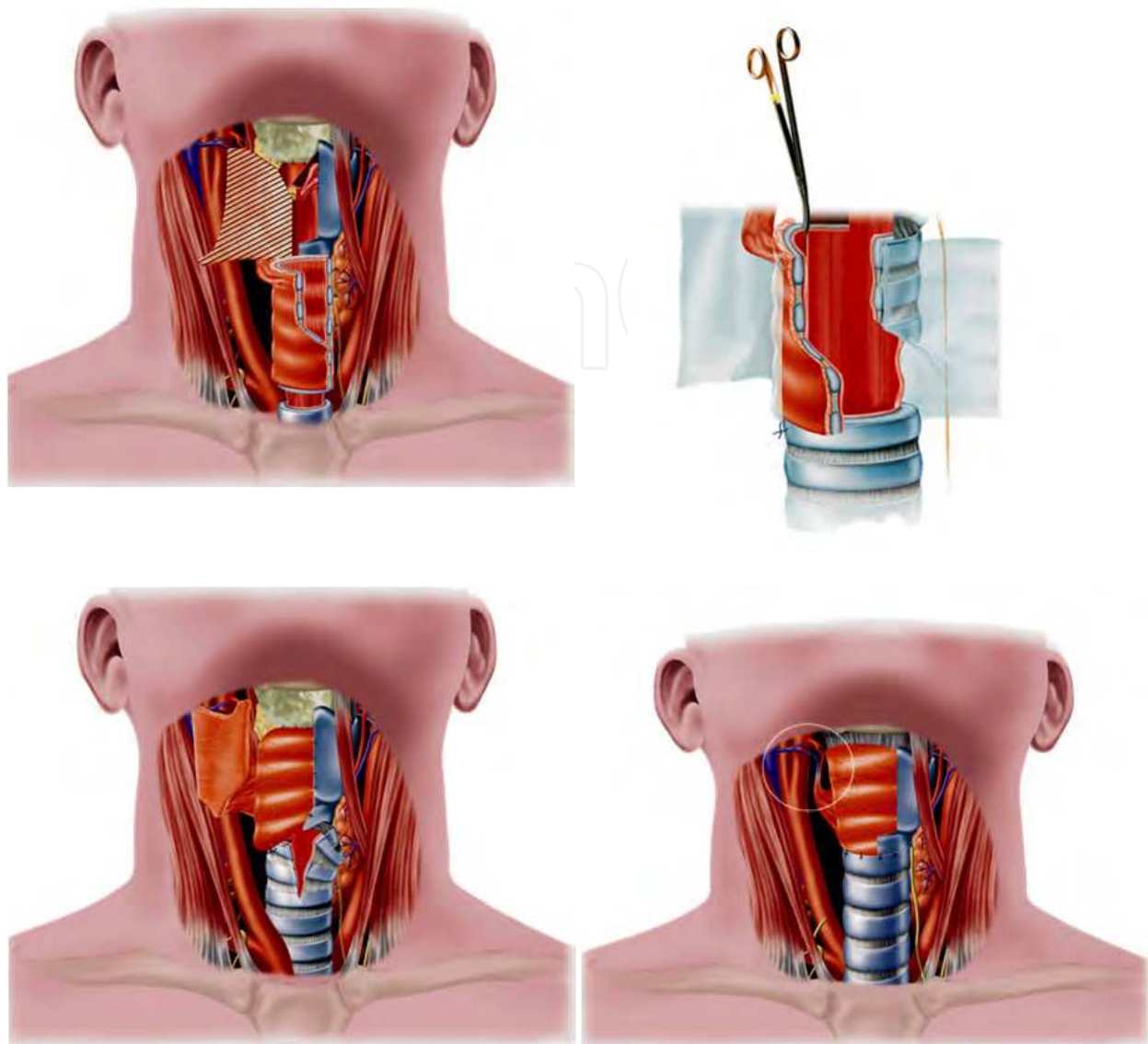


Fig. 11. Stage 2. Upper left: The FC segment is de-epithelialized while the vascular anastomosis remains intact. Right: The opened prefabricated trachea. Lower left: The hemilarynx defect is restored with a horseshoe-shaped prefabricated trachea segment. Lower right: The final state.

The most challenging part of the reconstruction is repair of the airway lumen at the subglottic level. Experimental research has shown that only revascularized tracheal autografts succeed in creating a luminal convexity (Delaere et al., 1998, 2005, 2007). Tracheal autografts have the combined characteristics of a respiratory mucosal lining, a cartilage support and a vascular supply, which are tissue characteristics that are necessary for restoration of a luminal convexity. The normal larynx was studied morphologically by Hirano et al. (1987), who concluded that, in the normal larynx, the anterior glottis plays the most important role in phonation while the posterior glottis plays an equally important role in respiration. Diseases of the anterior glottis usually cause voice problems. They disturb respiration only when they present a large obstruction to the airway. Diseases of the posterior glottis result in respiratory distress. They do not affect phonation until they

become extensive and inhibit vocal fold closure. In the normal situation, the posterior glottis is a respiratory glottis, while the anterior glottis is a phonatory glottis. Closure of the posterior larynx is important for swallowing without aspiration. After extended hemilaryngectomy, the posterior larynx becomes a sphincteric larynx. After reconstruction, the phonatory glottis is moved from anterior to posterior while the respiratory glottis is moved from posterior to anterior. With the tracheal patch in a paramedial position, the amount of airway lumen that is lost in the posterior larynx will be gained anteriorly.

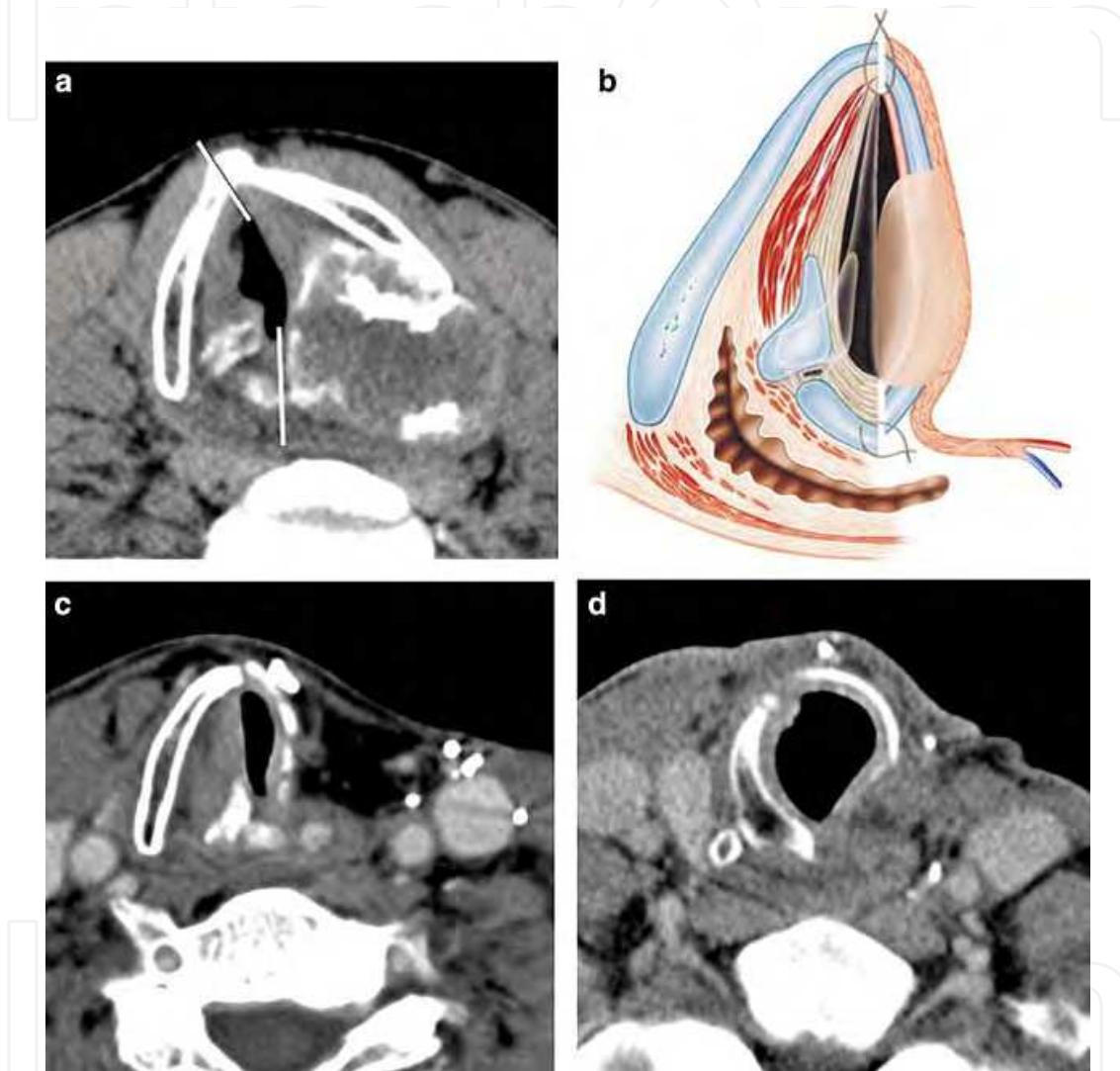


Fig. 12. Upper left: A preoperative CT scan at the glottic level showing a lateralized chondrosarcoma of the subglottic area at the left side with involvement of the vocal fold. The tumor was resected by performing an extended hemilaryngectomy (white lines indicate resection). Upper right: Schematic presentation of reconstruction at the glottic level. A combination of radial forearm skin and tracheal autotransplant gives a reconstruction against the midline posteriorly at the level of the vocal fold, while a small convexity is provided anteriorly by the tracheal autotransplant. Lower left: A postoperative CT scan, glottic level; the same situation as in b. Lower right: A postoperative CT scan, subglottic level. A tracheal autotransplant restores the airway lumen. From Delaere P., Vander Poorten V, Vranckx J, Hierner R., *Eur. Arch. Otorhinolaryngol.* 2005 Nov; 262(11):910-6



The extended hemilaryngectomy allows for complete removal of a suitable tumor, for neck dissection, for hemithyroidectomy and for removal of the ipsilateral tracheoesophageal lymph nodes. The reconstruction is a combination of immediate reconstruction with a fasciocutaneous free flap and flap prefabrication with the help of the fascial part of the same fasciocutaneous free flap. The 4-month prefabrication period allows laryngeal repair with a well-vascularized tracheal patch in combination with a strip of forearm skin. During the second operation, the small piece of forearm skin is detached from the radial vascular pedicle, but it shows a sufficient marginal perfusion from the laryngeal remnant. The delay between tumor resection and definitive reconstruction permits a second look with control of the resection margins. In cases of local recurrence, a total laryngectomy can be performed during the second procedure.

## **5. Reconstruction of the trachea**

### **5.1 Reconstruction of short-segment stenosis of the trachea**

Segmental tracheal resection with end-to-end anastomosis is the treatment of choice for a stenosis encompassing less than 50% of the tracheal length. The advantage of a tracheal resection is that no graft is necessary, and there is no need for prolonged endotracheal intubation (Grillo, 1990). A requirement is that a direct end-to-end suture does not exert traction on the suture line, which may lead to local necrosis, leakage and fistulization. Scarring due to previous interventions may limit a tensionless suture (Delorimier, 1990; Idriss, 1984).

### **5.2 Reconstruction of recurrent short-segment stenosis of the trachea**

Augmentation of the tracheal lumen by inserting local, regional, or distant tissue is necessary when a tracheal resection is not possible as, for example, in long-segment stenosis or in cases of restenosis after tracheal resection (Eliachar et al., 1989). Tracheal reconstruction using repair tissue is a second-choice solution because autologous donor tissues that resemble the mucosa-lined elastic cartilaginous framework of the trachea are not available. The most frequently used reconstructive tissues consist of cartilage grafts, pericardium, and muscle flaps, which are used as a carrier for skin, periosteum, or bone (Wright et al., 2004). Because these donor tissues all lack one or more features for optimal tracheal repair, the outcome is not constant. Experimental evaluation showed that for optimal laryngotracheal repair, the donor tissue should resemble the native tracheal tissue as closely as possible and be composed of a cartilaginous support, an internal lining consisting of respiratory mucosa, and a reliable blood supply (Fig 13).

Composite tissue consisting of vascularized fascia for blood supply, buccal mucosa for internal lining, and elastic cartilage for support are generally suitable as vascularized tracheal transplants.<sup>5</sup> However, bare cartilage undergoes necrosis when directly exposed to the airway lumen <sup>6</sup> and therefore should be vascularized. This can be done using a 'prefabrication' procedure <sup>6,7</sup>. The cartilage is sutured on a vascularized fascia layer, such as the radial forearm fascia and its intrinsic blood supply, which consists of the radial artery and comitant veins. After 2 weeks, the orthotopic transfer can be performed (Fig 14).

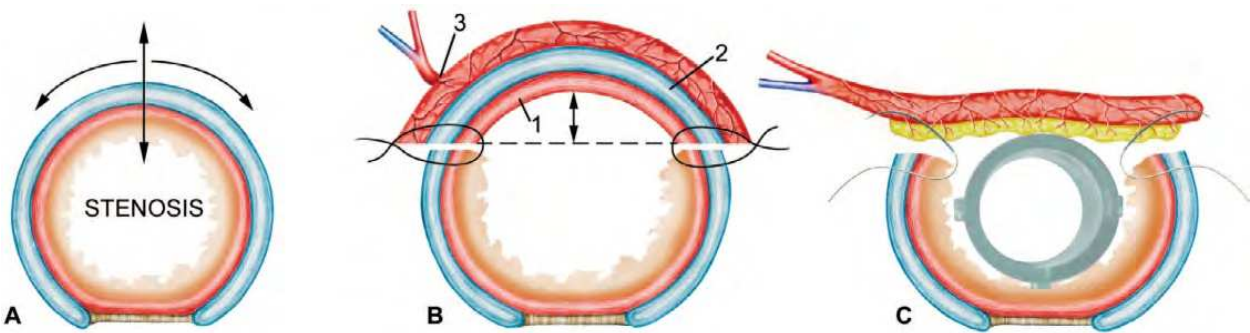


Fig. 13. Optimal reconstruction of anterior airway defect. (A) Axial section through tracheal stenosis. The stenotic airway is incised longitudinally (double arrow) and expanded (arrows). (B) Optimal reconstruction. The anterior tracheal defect is reconstructed with a revascularized tracheal allotransplant. The optimal tissue consists of a respiratory mucosal lining (1) and an elastic type of cartilage support (2). Vascularized fascia wrapped around the allotransplant will keep the reconstruction viable (3). The elastic nature of the cartilage component allows augmentation of the airway lumen (double arrow). (C) Reconstruction with vascularized mucosa. The airway defect is reconstructed with vascularized fascia and buccal mucosa. A laryngeal stent will prevent recollapse during the healing phase.

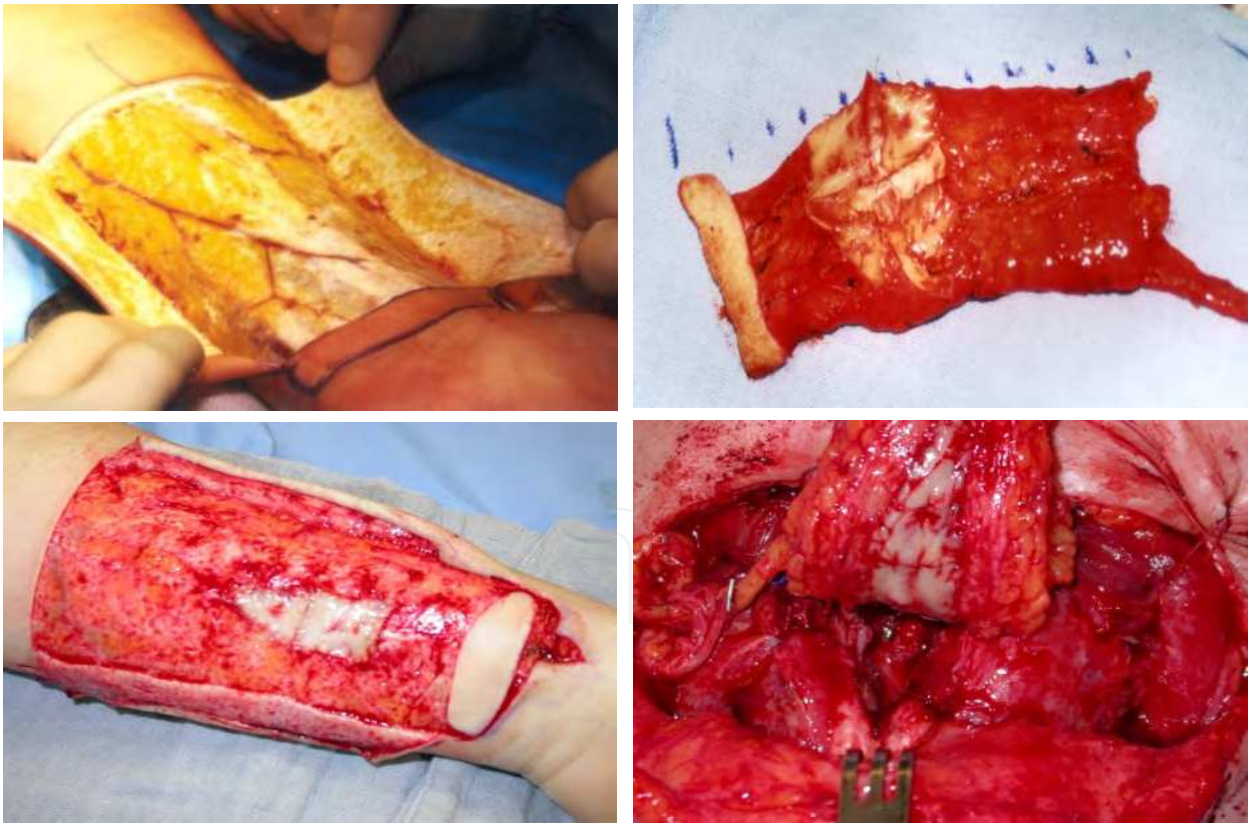


Fig. 14. Upper row. Left: Radial forearm fascia flap used as a vascular carrier. The skin is opened in an H-shaped pattern. After suturing the cartilage grafts on the fascia, the skin is closed until the 2<sup>nd</sup> stage 2 weeks later. Right: Auricular cartilage sutured on the radial forearm fascia flap. After the prefabrication step to vascularize the cartilage grafts, the transfer to the trachea defect is performed in a 2<sup>nd</sup> stage after 2 weeks.

Lower row. Left: The buccal mucosa is sutured on the radial forearm fascia flap, which serves as vascular carrier. A skin patch will serve as a monitor flap and will be sutured to the skin of the neck. Right: The prelaminated flap sutured into the defect on the trachea, mucosa patch downwards.

Because buccal mucosa is thinner than cartilage, composite tissue consisting of vascularized fascia and mucosa could be used in a one-stage procedure without a prefabrication step. Vascularized mucosa can repair airway defects with primary healing of the reconstructed site (Fig 14). A disadvantage of the mucosa-lined fascia is the absence of supportive tissue. The convexity of the airway lumen will be less because the cartilaginous supportive component is not available. When using a mucosa-lined fascia flap to repair an airway defect, it is essential that the mucosal patch and the defect be of similar size. Simultaneous use of the Dumon silicone stent will prevent prolapse of the mucosa-lined fascia and will prevent collapse of the incised and expanded airway. A short-term stenting period of 4 to 6 weeks is sufficient to anticipate collapse of the reconstructed airway during healing. This reconstruction technique is indicated for restenoses after segmental tracheal resection (Fig 15). Anastomotic stricture is usually related to excessive tension at the suture line and occurs in approximately 10% of patients undergoing tracheal resection (Delaere et al., 2005). Mucosa-lined fascia is currently the preferred tissue combination for the treatment of an airway stenosis in which segmental resection is difficult or impossible. The mucosa-lined reconstruction shows primary healing with a complete take of the oral mucosa on the fascial vascular carrier. The vascular supply and the epithelial lining guarantee a primary healing. No re-epithelialization is necessary during healing; this may be advantageous in the clinical situation of a restenosis where a scarred wound bed is encountered. Wound healing with mucosa-lined fascia is comparable to the wound healing seen when using skin-lined flaps.

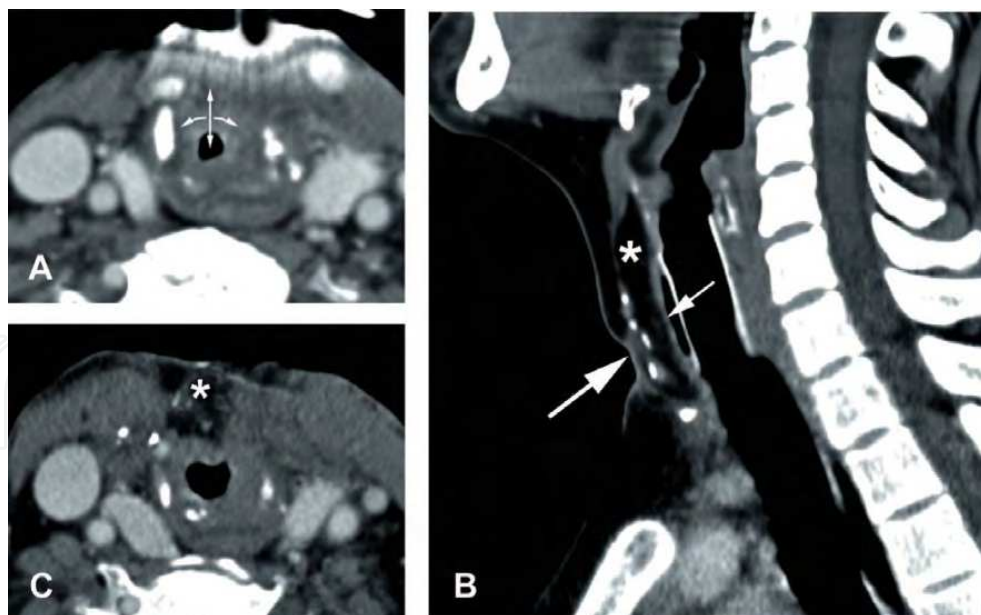


Fig. 15. Computed tomography (CT) scan of restenosis and tracheoplasty. (A) An axial CT scan at the stenotic site. The stenosis is incised longitudinally (double arrow) and expanded (arrows). (B) A sagittal reformatted CT scan. The silicone stent is visible. The buccal mucosa graft is visible as an internal lining (small arrow). Forearm fascia flap (asterisk); monitor skin flap (thick arrow). (C) An axial CT scan after reconstruction (same level as in A). Fascia flap (asterisk). The surface area after reconstruction is expanded by a factor of 2.



A mucosal lining is preferable, however, for airway lining to prevent the crusting and desquamation seen when using skin grafts. Another advantage of the mucosa-lined fascia is that the donor defect at the forearm site can be closed primarily, resulting in a less visible scar compared with the defect after dissection of a fasciocutaneous flap.

### 5.3 Reconstruction of long-segment stenosis of the trachea

For long airway defects, there are no autologous donor tissues available to use in restoring the mucosa-lined elastic cartilaginous framework. One option is a tissue engineering protocol in which a 3-dimensional vascularized tubular trachea is cultivated. Recently, successful restoration of a main-stem bronchus was reported in which a tissue-engineered transplant colonized by the recipient's epithelial and chondrogenic mesenchymal cells was used without the use of immunosuppressive therapy. The main drawback of this procedure was the lack of an intrinsic blood supply. An avascular tissue-engineered trachea would be unsuitable for use inside a major tracheal defect where the graft would be exposed to the airway lumen and to continuous movements during respiration, swallowing, and coughing. Without intrinsic vascularization techniques, scar tissue will be generated and healing becomes unpredictable. Ad hoc tissue engineering protocols do not allow us to generate a vascularized hollow tubular trachea that remains stable over time (Ott et al. 2011). The only other option is an allogenic trachea transplant. An allogenic trachea from a tissue bank could be used to bridge the gap in a manner similar to stored bone grafts. However, although the vascular requirements of the cartilaginous framework are limited and cartilage elicits limited immunologic rejection, the inner mucosal lining requires a significant vascular supply and, like regular skin, its immunologic response is strong. Because the blood supply to the trachea makes it unsuitable for direct revascularization, most previous attempts at tracheal transplantation have been performed after indirect revascularization. Rose et al. reported the first allogeneic tracheal transplantation in a human (Rose et al., 1979). The donor trachea was implanted heterotopically in the sternocleidomastoid muscle of the recipient and was transferred to the orthotopic position 3 weeks later. The recipient was not given immunosuppressive therapy; the report did not document the viability of the allograft or the long-term outcome. Klepetko et al. reported preserved viability of a heterotopically revascularized allograft by wrapping it in the omentum of a patient who received a lung transplant from the same donor. Its viability was documented after 60 days (Klepetko et al., 2004).

As with other composite-tissue allografts, restoration of arterial inflow and venous outflow is essential for the survival of the tracheal allograft. Indirect revascularization of a donor trachea is perfectly feasible, as demonstrated by the successful outcome of tracheal allografts and of autografts using vascularized fascia flaps in laboratory animals and humans (Buckwalter, 1998, Delaere et al., 1995). When this recipient tissue is perfused by an identifiable vascular pedicle, a microvascular transfer can be performed after the prefabrication step (Delaere et al. 2007).

Experiments in immunosuppressed rabbits showed complete revascularization and restoration of the mucosal lining in tracheal allografts after 2 to 4 weeks of heterotopic revascularization in the lateral thoracic area. Delaere et al. (2010) reconstructed a long-segment tracheal defect in a patient using an allograft that was revascularized in the first stage by heterotopic wrapping in vascularized radial forearm fascia. Immunosuppressive

therapy during the prefabrication step was necessary for establishing connections between the donor's capillary network around the trachea and the recipient's fascial blood vessels.

This occurred quickly enough to maintain viability of the cartilaginous trachea. Nonetheless, unlike in the animal model, the posterior membranous trachea underwent avascular necrosis, and the necrotic segments were debrided and replaced with buccal mucosa (Fig 16).

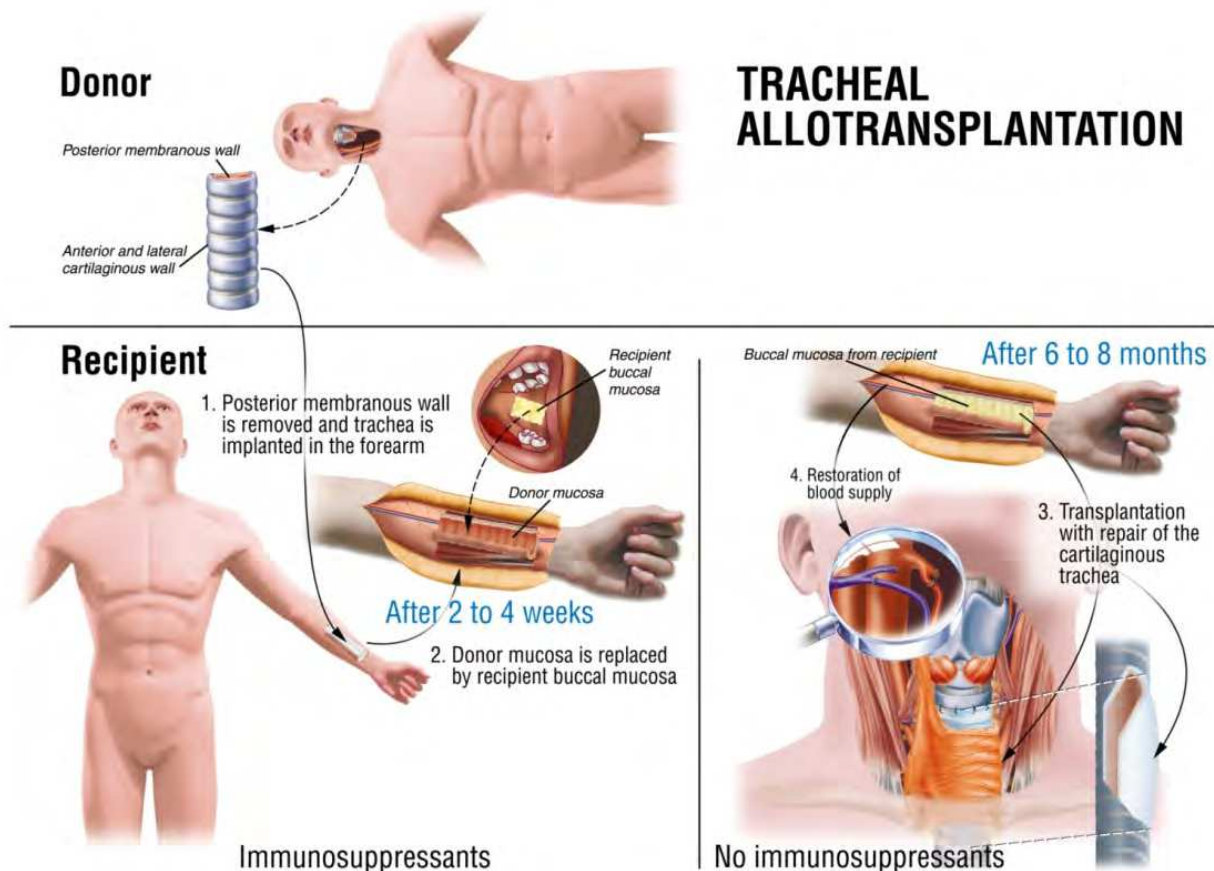


Fig. 16. Overview of trachea allotransplantation. A donor trachea is wrapped by radial forearm fascia in the forearm in a heterotopic position. The buccal recipient mucosa is sutured at the posterior membrane. After prefabrication, the vascularized trachea is transferred orthotopically to the neck. Immunosuppression is stopped when the trachea is in place. From Delaere P., Vranckx JJ., Verleden G., De Leyn P, Van Raemdonck D. N.Engl.J.Med. 2010; 14, 362: 138-145.

The recipient buccal mucosa grew progressively over the lumen of the cartilaginous tracheal transplant, creating a chimeric patchwork of donor epithelium and recipient buccal mucosa; when this had occurred, immunosuppressive therapy was tapered and stopped. The authors report that FISH analysis of biopsies showed that endothelial and respiratory cells originating from the donor disappeared shortly after the withdrawal of immunosuppressive therapy. They presumed that the immunologic rejection occurred silently because of repopulation by the recipient's surrounding vascular network and buccal mucosal cells, and they speculated that the cartilaginous framework was not recognized by the immune system because adult cartilage lacks blood vessels. The viability of the tracheal cartilage was maintained after all immunosuppressive drugs had been discontinued. There is a

meticulous balance between the speed of formation of neovascular connections and the oxygen requirements of the allogenic trachea. The metabolic demands of the cartilaginous framework may be low, while the oxygen requirements for the mucosal lining are rather high. The stealth activity of the highly differentiated chondrocytes may be based on their encasement in a dense matrix. This procedure confirmed the hypothesis that intact cartilage allografts are resistant to rejection and that the cartilaginous framework preserves its features when surrounded by well-vascularized recipient tissues. So far, 5 patients have been treated with allogenic trachea transplants with variable outcomes. The limiting factor remains the speed of the revascularization process of the inner mucosal lining of the trachea transplant. Further studies should indicate which strategies are useful in enhancing the neovascularization process in a clinical setting.

## **6. Reconstruction of the hypopharynx**

The hypopharynx is an elementary component of the upper aerodigestive tract. Its boundaries consist of the pyriform sinuses bilaterally, the posterior pharyngeal wall and the post-cricoid zone. The hypopharynx ends at the lower border of the cricoid cartilage where the aerodigestive tract continues into the cervical esophagus. Surgical resection of any tumor in the hypopharynx results in disturbance of swallowing with aspiration in the respiratory tract due to the contiguity of the hypopharynx with the supraglottic larynx. Cancer of the cervical esophagus may result in resection of the larynx, post cricoid and proximal trachea. The most frequently encountered malignancies in this zone are squamous cell carcinomas. Adenocarcinomas of minor salivary glands and melanomas occur infrequently.

Cancer control is the primary goal of treatment of tumors of the hypopharynx. However, preservation of speech, avoidance of a tracheostome and preservation of normal swallowing are important aims if they are feasible. In cases where the larynx is uninvolved but the pharyngeal resection is extensive, careful judgment in the treatment plan is essential because postoperative aspiration is a major problem due to loss of sensation and muscular activity on the pharyngeal wall.

When the resection leaves a full-thickness defect of the pharyngeal wall, an immediate reconstruction is required. This can be performed with a pedicled flap such as the pectoralis major myocutaneous flap. However, this flap is bulky and may lessen the patient's ability to swallow. Microvascular free flaps with refined lining, such as a radial forearm flap, are better options for reconstructions of the posterior pharyngeal wall.

Advanced cancer of the pyriform sinus or the pharyngeal wall and primary post-cricoid tumors require a pharyngectomy with a total laryngectomy. If the cervical esophagus is involved, a pharyngolaryngoesophagectomy must be performed with immediate reconstruction. Immediate one-stage procedures that include reconstruction after the cancer extirpation are mandatory.

### **6.1 Reconstruction after tumor removal without laryngectomy**

The funnel-shaped configuration of the hypopharynx is important for resection and reconstruction. The gradual transition in shape is maintained by the u-shaped hyoid bone and the spreading wings of the thyroid lamina. The posterior pharyngeal wall can be



resected and reconstructed in selected tumors. The postcricoid area is a functionally important subunit that is not reparable with the larynx in situ. The main postoperative risk is from aspiration because of loss of sensation and muscular activity on the posterior pharyngeal wall.

## 6.2 Partial pharyngectomy

A partial laryngopharyngectomy can be performed only when the primary tumor is confined to the anatomical boundaries within the hypopharynx, signifying the ipsilateral pharyngeal wall and pyriform sinus, and the tumor may not extend up to the apex of the pyriform sinus nor to the base of the tongue. In addition, the ipsilateral hemilarynx must be mobile, and the tumor may not involve the larynx in a transglottic plane. Reconstructive options include the use of a vascularized skin island such as the anterolateral thigh perforator flap or the rectus abdominis flap. The ALT flap has the advantage of minimal donor site morbidity (Fig 17). A free jejunal flap can also be used as a jejunal patch sutured to the semicircular defect.

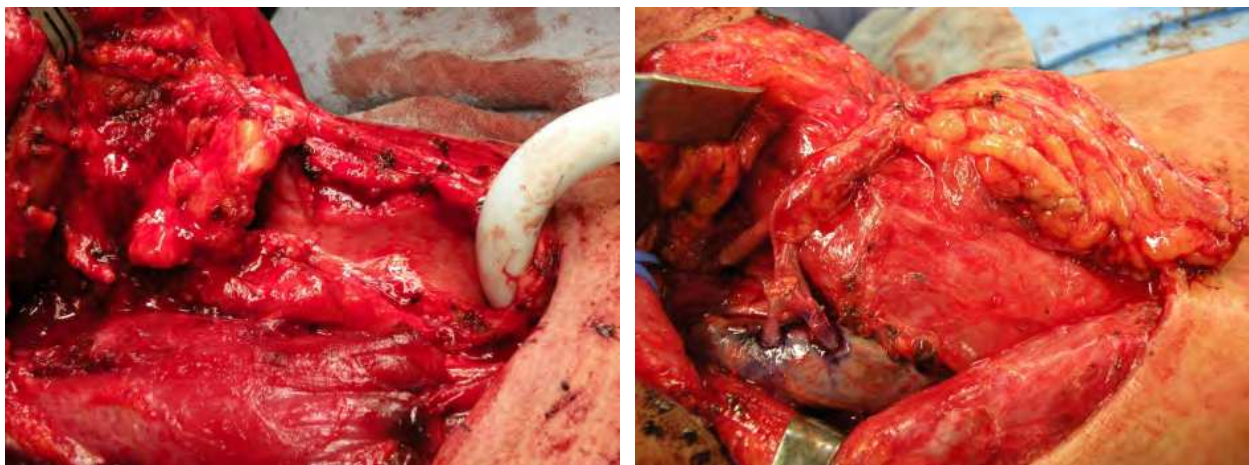


Fig. 17. Left: Semicircular defect of the pharynx. Right: Reconstruction with an anterolateral thigh flap. Two end-to-side anastomoses on the IJV and end-to-end to the facial artery.

## 6.3 Total pharyngectomy and circumferential pharyngeal defects

After pharyngolaryngectomy in advanced cancer, restoration of the continuity of the alimentary tract and the ability to swallow by mouth are important. If the resection is circular, restoration of the continuity is an integral part of the initial treatment strategy.

A total laryngo-pharyngectomy may be necessary in lower piriform fossa lesions and in lesions with extension to the posterior pharyngeal wall. The resultant defect is typically a circumferential defect and must be restored with gastric transposition (pharyngogastrostomy) or microvascular tubed flaps such as the radial forearm flap, anterolateral thigh flap, vertical rectus abdominis flap or jejunum free flap.

The choice of reconstructive technique for restoration of the continuity of the alimentary tract following pharyngeal resection must take into consideration the time required for

restoration of the patient's ability to eat by mouth. Multi-staged operations that require long hospitalization and parenteral feeding until the last stage are not desired. Immediate reconstruction in a single-stage procedure is the goal (Shah & Patel, 2005). The time required to achieve normal swallowing after reconstruction of circular defects is the shortest after a free jejunum transfer (Fig 18) and gastric transposition. The jejunum is ideal for end-to-end anastomosis with the esophagus. It should be beveled at its proximal anastomosis with the oropharynx. A gastric transposition is employed for circumferential pharyngeal defects when a free jejunum vascularized transfer is not available.

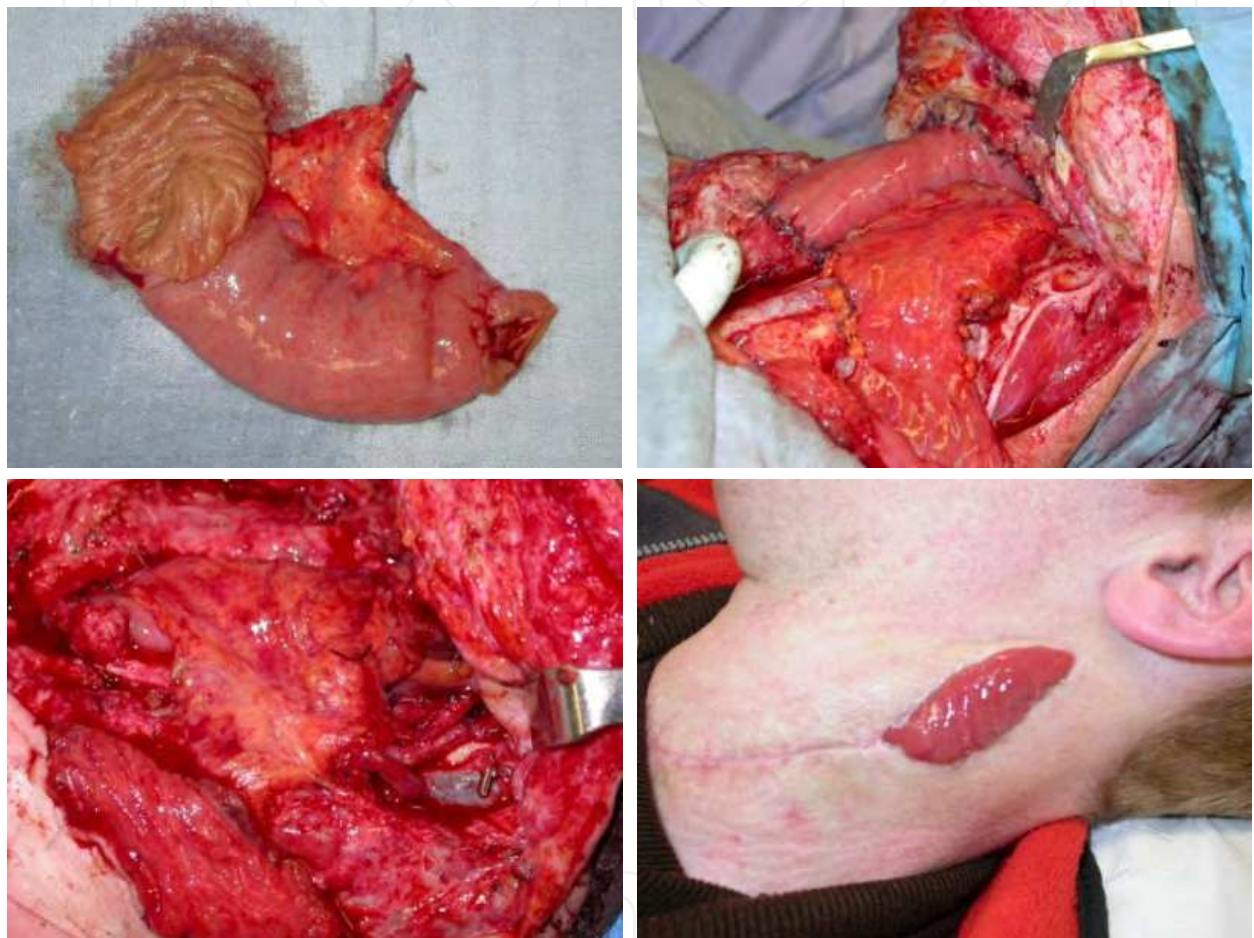


Fig. 18. Upper left: Harvest of a free jejunum flap. Upper right: Reconstruction of the circular hypopharynx defect with a free jejunum flap. Lower left: venous anastomosis end-to-side on the internal jugular vein and arterial anastomosis end-to-end to the facial artery. Lower right: a segment of the jejunum flap is isolated on a mesenterial vascular pedicle and sutured to the neck to serve as a monitor flap. After a few weeks, this monitor island is removed under local anesthesia.

### Postcricoid hypopharyngeal stenosis

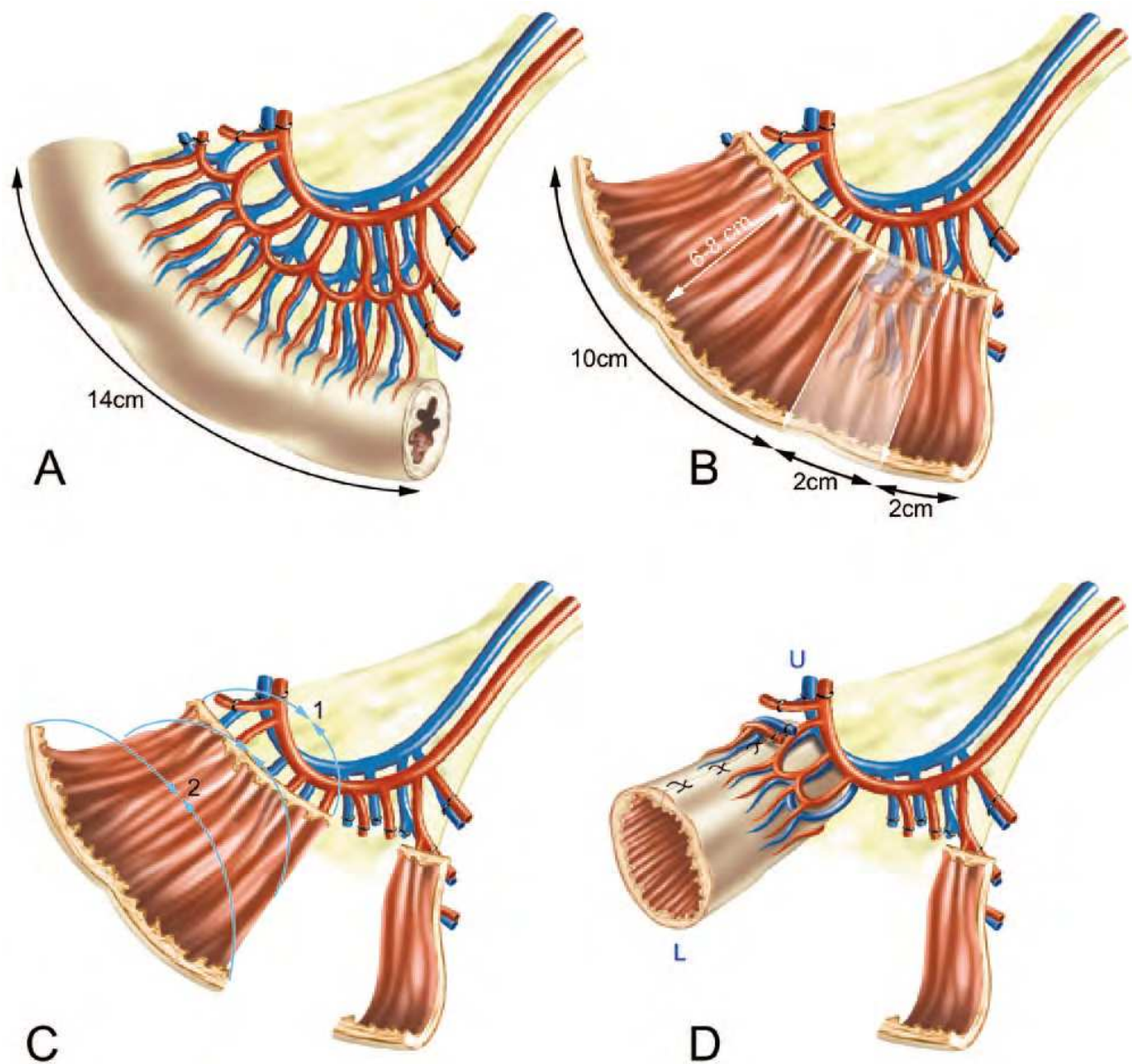
Although tremendous progress has been made in curing head and neck cancer with chemoradiation therapy, the toxicity of therapy may limit the number of patients who can

achieve the ultimate goal of organ preservation, that is, normal speech and swallowing function, in hypopharynx cancer treatment. Postcricoid hypopharyngeal stenosis is a devastating complication of organ-sparing chemoradiation therapy for head and neck cancer. The radiosensitization effect of chemotherapy may lead to chemoradiation-induced mucositis, which may result in ulceration of opposing surfaces of redundant postcricoid mucosa. This may lead to circumferential scar formation and subsequent postcricoid stenosis (Lawrence et al., 2003), a rare complication that may occur short-or long-term after the termination of radiation therapy. A possible cause is progressive obliterative endarteritis and ischemia (Nguyen et al., 2000).

Postchemoradiation hypopharyngeal stenosis is a rare complication, but it is expected that it will become more frequent because the addition of chemotherapy, hyperfractionated, and concomitant boost radiation will result in higher toxicity and higher risk of stenosis (Silvain et al., 2003). Partial or complete stenosis of the postcricoid hypopharynx leads to an inability to swallow, resulting in aspiration and gastrostomy tube dependence. Patients with partial stenosis can be managed successfully with antegrade dilatation (Sullivan et al., 2004). Patients with complete postcricoid hypopharyngeal stenosis have previously remained gastric tube dependent. Complete postcricoid hypopharyngeal stenosis requires reconstruction with preservation of the larynx whenever possible. Bypassing of the postcricoid area using reconstructive tissue with the larynx in situ is technically challenging.

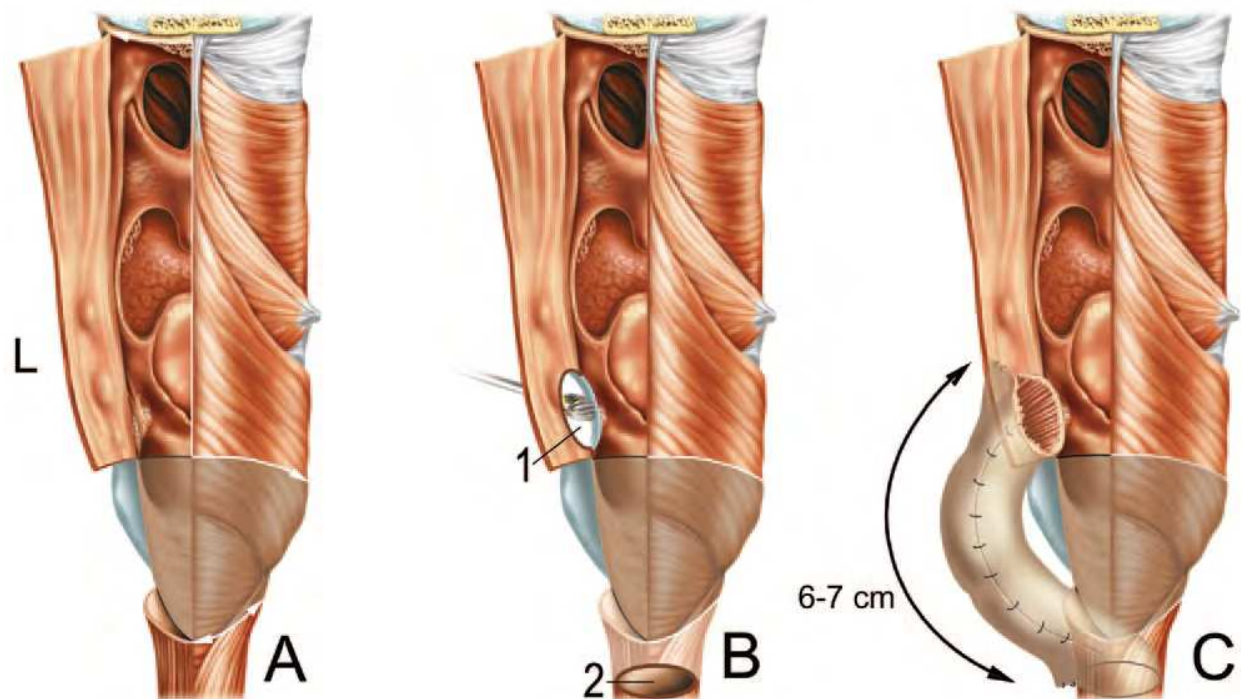
To bypass the short stenosis, a tubed fasciocutaneous free flap, a free gastro-omental flap, or a free jejunum flap could be considered. A tubed fasciocutaneous free flap has a high prevalence of stenosis of the skin mucosa at the circular anastomosis. The majority of authors using fasciocutaneous flaps after total laryngopharyngectomy have described higher rates of distal anastomotic stricture than after enteric reconstructions (Genden et al. 2001, Varvares et al., 2000). The free gastro-omental flap delivers a large vascularized tissue bulk that protects the entire wound. While this may be advantageous for the total laryngopharyngectomy defect, the volume provided by the omentum cannot be accommodated in cases of larynx preservation; hence, it is less well indicated for the correction of post-chemoradiation hypopharyngeal stenosis. The free jejunal tube transfer is currently the most popular flap for reconstruction of the alimentary tract after total laryngopharyngectomy. A tube of about 12 cm is sutured between the base of the tongue and the distal cervical esophagus. The major shortcoming of this approach is that the transplanted jejunal segment maintains an intrinsic motor activity (Reese et al., 1994, 1995). This activity is autonomous and continues long after surgery. In addition, the transplanted segment remains temporally independent of the normal swallow reflex (Delaere et al., 2006, McConnel et al., 1988) and may create a functional obstruction of the jejunal conduit when the jejunum is contracting at the time of bolus delivery. Another shortcoming is that strictures may develop at the distal suture line resulting from kinking due to redundancy of the flap; this will be more pronounced when a short segment of 6 cm is used with the larynx in situ, as in hypopharyngeal stenosis. Delaere et al. (2006) used the jejunum as a patch with reorientation of the tube to avoid these complications. The jejunal tube was transformed into a short mucosal conduit with a large diameter and longitudinally oriented mucosal plicae, thus providing a tube without autonomous muscular activity (Fig 19 and 20).





From Delaere et al., *Laryngoscope*, 2006 Mar; 116(3):502-4.

Fig. 19. Free jejunum used to bypass the postcricoid stenosis. (A) A 14-cm tube of jejunum is harvested on its vascular pedicle. (B) Patch of jejunum. The jejunum is divided longitudinally along its antimesenteric border. Circular mucosal folds are visible. The patch is divided (white double arrows) into a segment of 10 cm and two segments of 2 cm. The width of the patch measures 6 to 8 cm. (C) Formation of tube (arrows) with longitudinally oriented mucosal folds. First, the upper side of the patch is tabulated, and this side is sutured to the pharyngeal opening (1). The patch is progressively sutured into a tube; the reconstruction is completed by suturing the lower end (2) to the stump of the cervical esophagus. The circumference of the newly formed tube measures 10 cm, and its length is between 6 and 8 cm (the width of the jejunum patch). A 2-cm segment of jejunal mucosa is removed; the distal 2 cm of the jejunal patch will serve as the monitor flap. (D) Jejunum after tubulation (U, upper end of tube; L, lower end of tube). The vascularized jejunal patch monitor flap will be placed in the neck incision to allow direct observation. It is removed under local anesthesia at a later stage.



From Delaere et al., *Laryngoscope*, 2006 Mar; 116(3):502-4

Fig. 20. Postchemoradiation hypopharyngeal stenosis. (A) Schematic presentation of postcricoid stenosis from the posterior. The left side (L) of the pharynx is shown after opening; the postcricoid area shows a complete stenosis. (B) During the operation, an opening is made in the left lateral hypopharynx at the upper site of the stenosis. At the site of the hypopharyngeal opening (1), the lamina of the thyroid cartilage is removed with a burr. The cervical esophagus is incised at the lower site of the stenosis (2). (C) A loop is constructed between the upper pharyngeal opening and the lower esophageal stump. To bypass the postcricoid stenosis, the loop must be 6 to 7 cm in length. The width (6-7 cm) of an incised segment of jejunum is used to bridge the length of the stenosis.

After microvascular anastomosis of the jejunal tube with the local vasculature, a monitor flap is essential because the location of the tube within the hypopharynx buries the flap and essentially eliminates direct observation as a method of flap monitoring. Conventional hand-held Doppler ultrasonography is unreliable because it is difficult to discern whether the Doppler signal is emanating from the flap or from a surrounding vessel. More involved methods of monitoring include leaving a window over the jejunum for direct monitoring. However, the resulting skin defect may be a port of entry for infection or may create a chronic wound due to the fact that these tissues often become rigid for a longer period due to edema and inflammation. Based on one of the blood vessels of the mesenteric arcade, a vascularized jejunal monitoring patch can be sutured externally for direct observation.

Before operation, it is important to confirm that only the hypopharynx is involved. Jejunal reconstruction is no longer indicated when dealing with multiples sites of

stenosis. A pedicled colon transfer may be considered for constructing the bridge between the hypopharynx and the stomach if the cervical esophagus is also involved (Maish et al., 2005).

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Plastic Surgery is a fast evolving surgical specialty. Although best known for cosmetic procedures, plastic surgery also involves reconstructive and aesthetic procedures, which very often overlap, aiming to restore functionality and normal appearance of organs damaged due to trauma, neoplasm, ageing tissue or iatrogenesis. First reconstructive procedures were described more than 3000 years ago by Indian surgeons that reconstructed nasal deformities caused by nose amputation as a form of punishment. Nowadays, many ancient procedures are still used like the Indian forehead flap for nasal reconstruction, but as with all fields of medicine, the advances in technology and research have dramatically affected reconstructive surgery.

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