Chapter

Pharynx Reconstruction and Quality of Life

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Abstract

Patients who are diagnosed with squamous cell carcinoma of the pharynx have a first delayed presentation, with advanced stages of the disease. Therefore, they frequently require a multimodal approach—by surgery, radio, and chemotherapy. Due to anatomic spatial limits and particularities, therapy can imply large organ resection with difficulties in reconstruction. Nowadays, there is a paradigm shift in the management of this pathology, with significant first referral to oncology departments and initiation as the first line of treatment of radio/radio-chemotherapy. As a consequence, salvage surgery may be mandatory in some selected cases. The proposed chapter will address the oncological particularities of the pharynx, with a focus on the oro- and hypopharynx, ways of reconstruction after oncological ablative surgery of these segments, and impact on quality of life (QoL) index. Speech, respiratory, and deglutition rehabilitation of these patients is essential and will be a distinct topic. This paper will have the structure of a literature review with clinical examples of reconstruction from ENT and Head and Neck Surgery Department of Coltea Clinical Hospital, Bucharest. Reconstruction methods used in our clinic are regional flaps and biocompatible prostheses in advanced stages. QoL index in our clinic is assessed with questionnaires developed by the European Organization for Research and Treatment of Cancer – EORTC QLQ C30.

Keywords: pharynx carcinoma, oncology, deglutition, reconstruction methods, QoL

1. Introduction

The pharynx is the main structure, in addition to the oral cavity, shared by two organ systems. It is funnel-shaped, the upper end being wider and located just below the lower surface of the skull, and the lower end being narrower and located at the level of the sixth cervical vertebra. Its muscular-membranous integrity allows it to mediate several vital functions such as swallowing, air conduction, and voice production [1].

Performing surgical operations in the pharynx require delicate technique in order to preserve the physiology of the organ. Reconstruction of the pharynx is probably the most demanding task of the surgeon. Treatment for advanced *laryngeal and hypopharyngeal cancer* can cause anatomical and functional sequelae. Surgery aims at curing, but also keeping the organ's function. In tumors in which there is the need to remove the entire larynx or in cases of *hypopharyngeal tumors* with the need to remove the larynx, closing the remaining pharynx, in most of the cases done primarily, can be performed in two ways, cross-sectional or T closure. In *pyriform recess* tumors, a part of the pharyngeal wall is resected together with the primary tumor meaning that the pharyngeal remain is smaller, thus one should use the "T closure" technique or the flap [1, 2].

1.1 Oncological disease of the oropharynx - diagnosis

The pharynx, with its anatomical and physiological particularities, is an increasingly common site for head and neck malignancies, as apart from individual genetic characteristics, it is an often offended part of the human body—both infectious diseases and environmental exposure to risk factors (alcohol, tobacco intake) have a well-established cause—effect relation. On the other hand, as we have a better understanding of viral oncogenesis, human papillomavirus (HPV)—associated squamous cell carcinoma (SCC) of the oropharynx (OPSCC)—is nowadays a distinct entity from the traditional tobacco and smoking-related OPSCC [3].

SCC is the most common malignancy of the oropharynx, with a rate of 90% from all malignancies. It is an invasive epithelial neoplasm with degrees of squamous differentiation and with a high lymphophilia, as it may present with early and extensive lymph nodes metastases. Epithelial precursor lesions, especially erythroplakia, severe dysplasia, and carcinoma in situ (CIS) are involved in the development in patients with a history of tobacco and alcohol consumption. These tumors are aggressive, with a high disruption of cellular histology, invasion of lymphovascular space, neurotropism, and infiltration of other tissues such as muscle and cartilage. SCC can be keratinizing to nonkeratinizing and well-differentiated to poorly differentiated. HPV-associated OPSCC has a different histopathology with a lack of keratinization and mature squamous differentiation [3].

Other types of malignant carcinomas, with lower rates of appearance, of the oropharynx may include lymphoepithelial, salivary gland tumors, soft tissue tumors, hematolymphoid tumors, and mucosal malignant melanoma [3].

1.1.1 Clinical

Presentation is often in advanced stages, as the symptoms of early tumors are nonspecific. Mainly, dysphagia, foreign body sensation or pain in the throat, oral bleeding, referred otalgia, or neck mass may be patients' complaints. The presentation may also be as an unknown primary with an isolated nodal mass and no upper aerodigestive tract lesions or radiologic imaging [3].

After a thorough anamnesis, with emphasis on risk factors and social aspects, physical examination should have a great focus on the tongue (appearance and movement), tonsillar, fossae, retromolar trigone, soft palate (appearance and mobility), base of the tongue, vallecular, and pharyngeal walls. Inspection and especially palpation of the tongue base, tonsillar fossa, sensate testing, and an office endoscopy complete the examination. A complete head and neck investigation is mandatory for excluding synchronous cancers and bimanual palpation of the neck to assess lymph nodes [3].

1.1.2 Imaging

Precise evaluation and treatment plans require detailed imaging with a focus on soft tissues, vascular, and bony structures. Consequently, computed tomography (CT) and magnetic resonance imaging (MRI) are both used, either as one or complementary [3].

Positron emission tomography (PET) with CT can be useful for unknown primary, synchronous primary tumors and distant metastases. Limitations of these techniques are influenced by previous surgery or radiotherapy (RT), and it is not usually used for tumor staging [3].

Gray-scale and Doppler ultrasonography (USG) studies of the neck are useful tools for the evaluation of the lymph nodes. Fine-needle aspiration (FNA) can be done simultaneously for the purpose of establishing a histologic diagnosis [3].

Distant metastatic spread may appear in organs such as the lung, liver, skeletal system and brain, and CT of the lung and/or MRI of the abdomen are recommended [3].

1.1.3 Endoscopy

As an in-office procedure, oropharyngeal lesions biopsy can be performed if the site of the tumor is the tonsil or soft palate. FNA with USG of the lymph nodes may assist the diagnosis in selected facilities. On the other hand, when the site involves base of the tongue, inferior tonsillar, or posterior oropharyngeal wall endoscopy, with or without microscopic assistance may be the next step in the diagnosis. Pan endoscopy under general anesthesia is an important tumor evaluation and biopsy tool, and also can be used to rule out secondary malignancy [3].

1.1.4 Biopsy

Although frozen sections are close in accuracy to the final diagnosis up to 90%, the final treatment decision is based on standard histopathologic evaluation [3].

1.1.5 Testing for HPV or p16 and staging

Testing for HPV or its surrogate marker, p16 overexpression delineates tumor diagnosis and prognosis, and nowadays, the new system of staging developed by the American Joint Committee presents some differences between non-HPV-associated (p16 negative) and HPV-associated OSCC. The main ones are regional lymph nodes (N), with differences in pathologic N category, as metastasis in more than 4 lymph nodes stages in N2 disease [3].

1.2 Oncological disease of the hypopharynx - diagnosis

SCC of the hypopharynx and esophagus are head and neck rare afflictions (3–5% of head and neck HN SCC) with the worst prognosis, as they tend to present in late stages, with significant submucosal extension and a hard clinically and radiologically estimation of the disease. Organ-preserving protocols involve a slow rehabilitation, with high rates of complications, like stricture or impossibility of decannulation due to aspiration events. On the other hand, advanced tumors often require reconstructive surgery, with a multidisciplinary approach. Rarely, in 5% of the cases, other types of carcinoma, such as adenocarcinoma, sarcomata, and lymphoma can affect the hypopharynx [3].

In the etiology of the SCC of the pharynx, the most cited carcinogen is alcohol intake. Although HPV can be detected in hypopharyngeal cancers, there is no strong correlation between the diseases, until up to date [3].

Plummer-Vinson or Patterson-Brown-Kelly syndrome, which affects primarily women (85% of the cases) is a syndrome that is associated with postcricoid and upper esophageal carcinoma. It involves dysphagia, iron deficiency anemia, and the presence of hypopharyngeal and esophageal webs. Chronic irritation may result in hypopharyngeal webs with progression to carcinoma. Improved nutrition and prenatal care may decline the incidence [3].

1.2.1 Clinical

As it is stated before, patients with hypopharyngeal and esophagus usually present in advanced stages of the disease. Clinical examination may reveal dysphagia, neck mass, sore throat, hoarseness, referred otalgia, shortness of breath, hemoptysis, gastroesophageal reflux (GERD), or even asymptomatic. Also, these patients may present with weight loss and malnourishment [3].

The examination should focus on the mucosa of the aerodigestive tract for primary and synchronous cancers evaluation. Flexible endoscopy (**Figures 1** and **2**), as well as neck palpation, is mandatory [3].

Figure 1.
Fiberoptic flexible view of the pharynx with hypopharyngeal carcinoma—note edema and saliva pooling.

Figure 2.
Fiberoptic flexible view of the pharynx with hypopharyngeal carcinomas—note the laryngeal involvement.

Operative endoscopy, with complementary laryngoscopy and esophagoscopy are next steps in work-up. If it is possible, an assessment of second primary of the esophagus should be performed. Biopsy of the tumor is essential for diagnosis and further management. The pathology is usually SCC, but other rare lesions can occur: lymphomas, adenocarcinoma and neuroendocrine tumors, and thyroid malignancies with direct invasion; extremely rare: sarcomas, liposarcomas, angiosarcomas, and synovial sarcomas [3].

1.2.2 Imaging

Hypopharyngeal cancer has a particularity of submucosal spread that may be undetectable on clinical or radiographic examination. It is essential for the examination to focus on submucosal extension, involvement of the thyroid gland and metastasis to paratracheal and upper mediastinal lymph nodes, invasion of the prevertebral fascia, and carotid artery involvement as well. Cross-sectional CT or MRI is used for primary evaluation. CT is preferred as it assesses cartilage invasion. PET-CT is used for the detection of loco-regional recurrence and persistent disease [3].

1.2.3 Staging

Hypopharyngeal carcinoma and cervical esophagus carcinoma have different staging with appropriate treatment management (**Figure 3**). For hypopharyngeal tumors, involvement of the larynx, with fixation, is a sign of local significant spreading. For esophageal primary tumors, the assessment is based on the spreading of the layers of the esophageal wall [3].

Figure 3.
Fiberoptic flexible view of the pharynx after base of the tongue carcinoma surgery and epiglottoplasty.

1.3 Treatment of pharyngeal carcinoma

Squamous cell carcinoma of the pharynx is defined by a late presentation, with the advanced stage that often implies submucosal spreading and early lymphatic metastasis. These characteristics predict a poor prognosis [4].

Figure 4.
Edema and mucositis after radiotherapy for oropharyngeal carcinoma.

In addition, along with scientific discoveries, new staging and ways of treatment appear and oropharyngeal carcinoma now requires tumor human papillomavirus (HPV) testing by p16 immunohistochemistry (IHC). Based on the result, there are clinical stages and consequently therapeutically differences. However, even in advanced stages, there is an indication of concurrent systemic therapy/RT (preferred in p15 HPV + T0–3, N3 or T4, N0–3), surgery (resection of primary with neck dissection), or induction chemotherapy followed by RT or clinical trials (**Figure 4**) [5].

Nowadays, stage-related ways of treatment begin to have a different angle, with organ preservation protocol with chemoradiation therapy and encouragement of conservation surgery that will maintain laryngeal functioning. Regardless, survival and oncological disease-free are mandatory and most patients diagnosed with hypopharyngeal carcinoma still need radical surgery—with total laryngectomy, partial of total pharyngectomy, and even esophagectomy. As a result, these kinds of surgeries are real challenges of reconstruction, especially when treating a circumferential defect [4].

Generally, it is well established that a residual mucosa bigger than 3 cm in width may grant a good primary closure. In other cases, a pedicled or free tissue transfer patch may be inserted. Reconstructive methods may include local flaps, myocutaneous flaps, free fasciocutaneous flaps, free jejunal interposition, gastric pull-up, and use of biocompatible materials—each with advantages and limitations. These are in straight relation with surgical team experience and resources [4].

There is a paradigm shift regarding pharynx carcinoma treatment and patients are discharged to trials of systemic therapy even in advanced stages. At present, advanced cancer requiring/amendable to pharyngectomy with total laryngecotmy (T1–3, N0–3; T1, N+) may have as a choice of treatment: induction chemotherapy, or partial/ total laryngopharyngectomy with neck dissection, thyroidectomy, and pretracheal and ipsilateral paratracheal lymph node dissection, or concurrent systemic therapy/RT, or clinical trials. After induction chemotherapy, complete response with stable or improved disease in the neck, NCCN guidelines recommend to go along with definitive RT or systemic therapy/RT. On the other hand, a partial response, depending on the nodal disease, means that the case may be treated with surgery or systemic therapy/RT. Advanced stages, with clinical T4a, N0–3 has as treatment of choice surgery, induction chemotherapy, concurrent systemic therapy, or admission to

Figure 5.
Recurrent oropharyngeal carcinoma with bleeding—After surgical and RT therapy; note the presence of nasogastric feeding tube and the edema.

clinical trials. At follow-up, clinical changes will demand an adapted treatment [5] (**Figure 5**).

With treatment development, a variety of surgical skills and reconstruction techniques can deliver an adequate QoL for the patients, without certain differences between them. Even if different ways of treatment may seem even in oncological response, it is certain that salvage surgery is associated with additional complications (**Figures 6** and 7) [6]. Finally, patient selection and empowerment are critical in treatment and follow-up.

At the beginning, surgery of the upper aerodigestive tract malignancies presented a high rate of mortality (80%—Billroth's laryngectomies). As follows, surgical techniques advancement was necessary, taking into consideration that this kind of carcinoma affects two main vegetative functions, respiration and alimentation. Some authors elaborated an algorithm with treatment choices of defects of the laryngopharynx, hypopharynx, and cervical esophagus, with emphasis on complications of laryngopharyngectomy and back-up management [7].

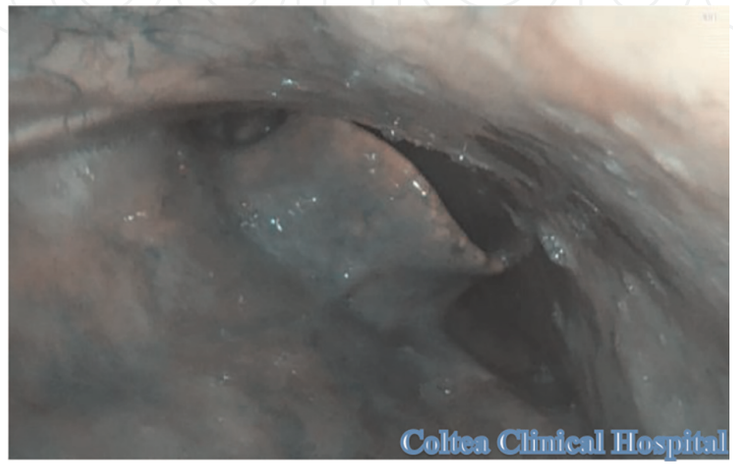

Figure 6.
Fiberoptic flexible view NBI assisted after hypopharyngeal carcinoma surgery with primary reconstruction.

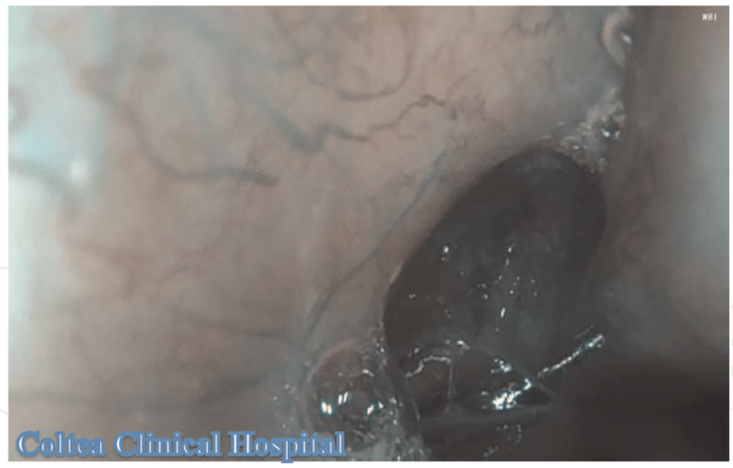

Figure 7.
Fiberoptic flexible view NBI assisted after hypopharyngeal carcinoma surgery with primary reconstruction. Close-up on the right reconstructed pharyngeal wall.

2. Reconstruction of the pharynx

Oropharyngeal reconstruction is a complex and difficult process that should perform a combined evaluation of the size, location of the defect, patient's age and comorbid status, and the use of the simplest reconstruction with the highest level of function. For small defects healing by secondary intention is the simplest way of approach; but with extensive lesions, the next steps in the reconstruction ladder should be primary closure, skin grafts, local and regional flaps, or free flaps (**Figure 8**) [3].

Hypopharyngeal defects often require a multidisciplinary approach and are associated with a high risk of mortality and morbidity—fistula development and vascular offense are the main concerns in this kind of surgery. Thus, the goals of reconstruction are the protection of the great vessels, restoration of the pharyngeal conduit, protection of the airway, and rehabilitation of the voice. Options for reconstruction are local and regional cervical skin flaps and deltopectoral, pectoralis, and latissimus flaps; gastric and colonic interpositions; and revascularized fascial and gastroomental autogenous transplants. Literature reviews conclude that vascularized tissue use has a reduced fistula rate, even when patient history includes RT. The decision must also be made in a ladder fashion and consider if the defect is partial or circumferential [3].

Certain milestones should be reached for an ideal hypopharyngeal reconstruction: single-stage procedure, high success rate for tissue transfer, low donor-site morbidity, low fistula and stenosis rates, restoration of the ability to speak and swallow, able to achieve a successful reconstruction in heavily radiated areas, and tolerance of postoperative radiotherapy [8].

In general practice, it is well established that a residual mucosa bigger than 3 cm in width grants primary closure. On contrary, a pedicled or free tissue transfer patch may be inserted [3].

In straight correlation with surgeon's experience, reconstructive methods may include local flaps, myocutaneous flaps, free fasciocutaneous flaps, free jejunal interposition, gastric pull-up, colon interposition, or even use of biocompatible materials—each with advantages and throwbacks, with a brief review in **Table 1**.

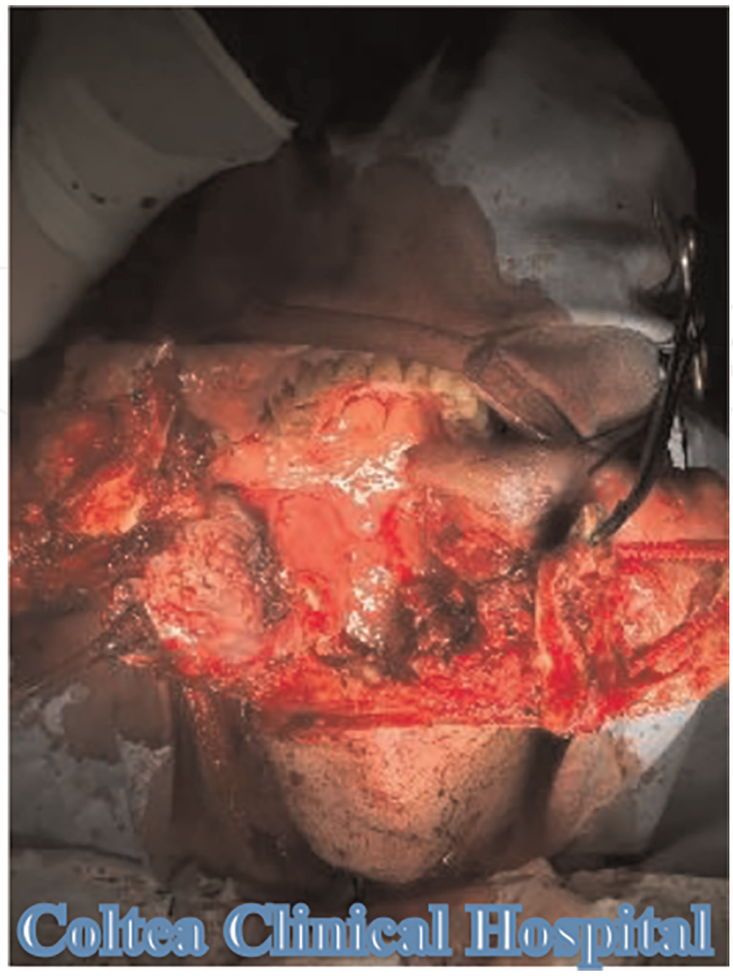

Figure 8.
Advanced oropharyngeal carcinoma—Trans mandibular approach.

Reconstruction	Advantages	Disadvantages
Primary closure, when possible	Decreased pain after surgery Less chance of secondary bleeding Superior speech and swallowing rehabilitation	Tension and contracture of the tissue Difficult surveillance over profound margins (than healing by secondary intention)
Local flaps	Optimal time management	Can be used for limited defects
Regional flaps	Single-stage reconstruction They can fill large defects—muscular bulks Do not require multidisciplinary teams Low donor site morbidity Fit for salvage surgery and patients with severe comorbidities—good time management	They can be too bulky, with high complication rates especially after oropharyngeal reconstruction They may require pedicle monitoring
Free muscular flaps	Low donor site morbidity Can be done in one stage surgery Tolerates well postoperative RT Superior speech rehabilitation	Multidisciplinary approach High complications rate: strictures or fistulas

Reconstruction	Advantages	Disadvantages
Free digestive flap interposition	Anatomical advantages Good vascularization Earlier deglutition rehabilitation	Dysphagia—uncoordinated peristalsis, dumping syndrome Difficulties in swallowing and voice rehabilitation Multidisciplinary approach Abdominal surgery complications
Biocompatible materials	One stage surgery and do not require multidisciplinary teams Optimal time management	Biofilms development High complication rates: fistula

Table 1.
Means of reconstruction after oncological surgery of the pharynx.

2.1 Local flaps

Healing by secondary intention can be used for defects less than 5 to 6 cm and it is not advisable when the pharynx communicates with the neck and after open procedures. When it is possible, this procedure is preferred from primary closure, as it can give oncological surveillance over profound margins and gives less tension and contracture. Primary closure has the benefits of decreased pain after surgery, less chance of secondary bleeding, and superior results in speech and swallowing rehabilitation [3].

For oropharyngeal reconstruction, local flaps may be used after open procedures. The palatal island, uvulopalatal, inferior and superior pharyngeal, the superior-constrictor advancement-rotation (SCARF), facial artery myomucosal (FAMM), and the buccinators myomucosal flaps can be considered as the main local flaps for oropharyngeal defects. These flaps can be used for limited defects [3].

2.2 Regional flaps

2.2.1 The pectoralis major flap reconstruction technique

The pectoralis major miocutaneous (PMMC) flap is an often used flap, with an excellent blood supply—from the pectoral branch of the thoracoacromial artery [4]. Its main advantages are single-stage reconstruction with muscle bulk, which is important in filling large defects; it can be rapidly raised from the anterior chest wall and it does not require multidisciplinary teams, with additional expertise in microvascular or abdominal surgery, the morbidity of the donor site is low, and with high importance, it comes from a nonirradiated area in salvage surgery. However, this flap seems to be too bulky, and after reconstruction some authors report high fistula and stricture rates. Still, it is a helpful choice for salvage surgery, for elderly patients and for patients with severe comorbidities—when time management needs to be optimal [4].

The pectoralis major muscle is a thick, fan-shaped muscle, that lies underneath the breast tissue. It has three parts of origin, a clavicular one, at the anterior surface of the medial half of the clavicle, a sternocostal one on the anterior surface of the sternum and the first seventh costal cartilages, and one abdominal at the level of the right abdominal muscle sheath. The insertion is made through a common tendon formed by the three parts of origin at the intertubercular sulcus of the humerus [9].

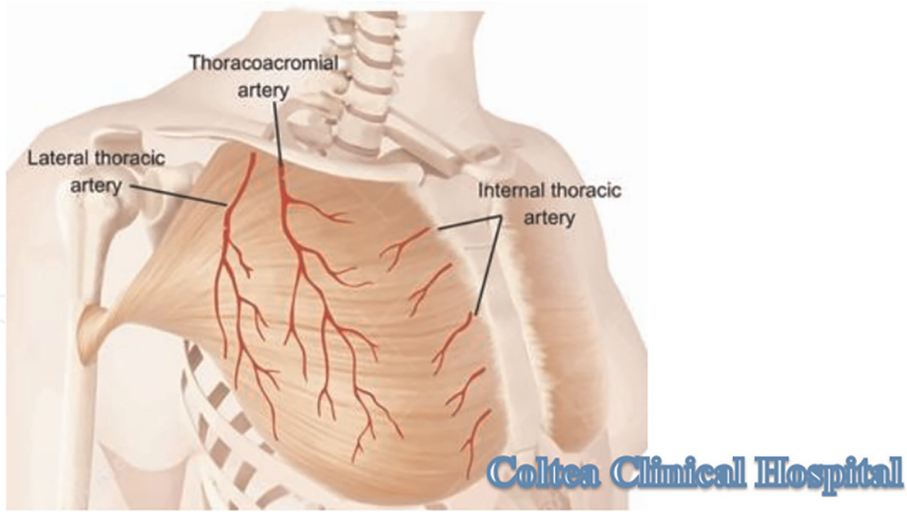

Figure 9.
Arterial supply of the pectoralis major muscle.

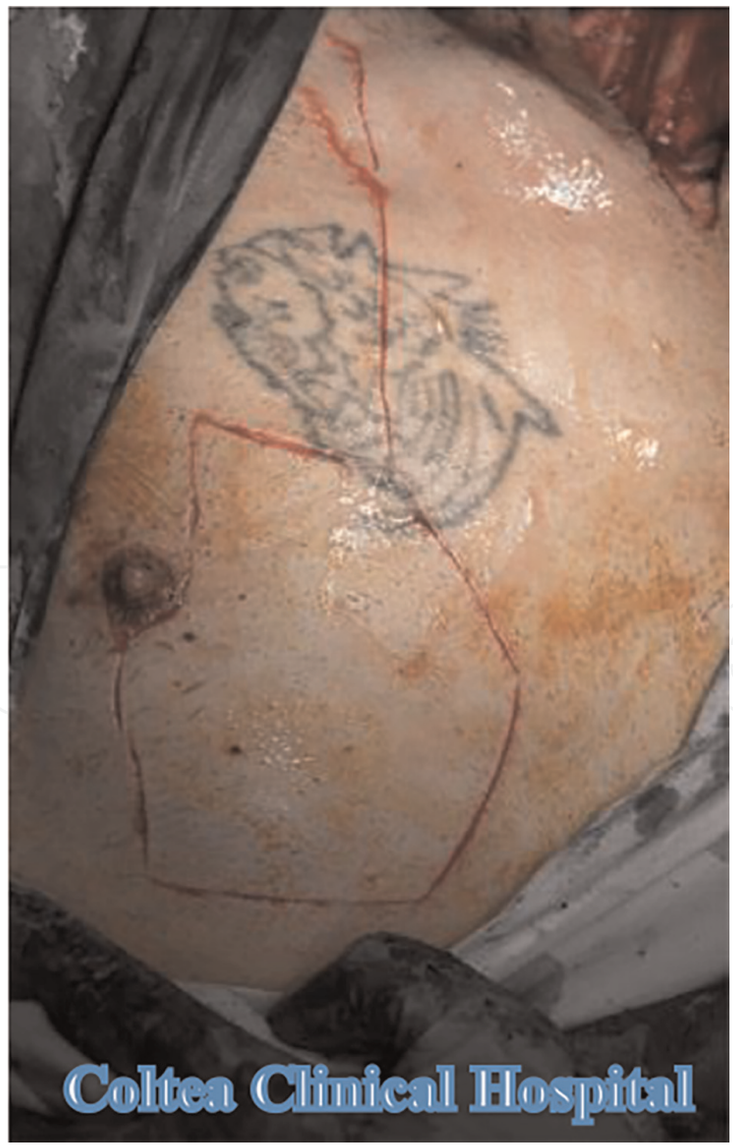

Figure 10.
Skin island and vascular pedicle of the PMMC.

Figure 11.
Skin island and vascular pedicle of the PMMC.

It is a superficial muscle, being covered by skin, subcutaneous connective tissue, the medial and intermediate supraclavicular nerves, and the mammary gland. It covers the small pectoralis, anterior serratus, subclavius muscles, ribs, and intercostal spaces. The close relationship with the pleura must be taken into account when harvesting the flap.

The arterial supply of the pectoralis major is provided by the pectoral branches of the thoracoacromial artery, the perforating branches of the internal thoracic artery, and the perforating branches of the lateral thoracic artery (**Figure 9**). Its venous drainage is through the pectoral vein, which drains into the subclavian vein [10, 11].

The first step when using a chest flap for reconstruction is to determine the length of the flap required. A dry gauze is used to perform the measurement. This is placed on the middle of the collarbone, this being the place where the pectoral flap will be rotated. The upper limit of the flap is measured, and then the gauze is pivoted lower to establish the lower edge of the flap. The boundaries of the skin tissue island are achieved by drawing a line from the acromion to the xiphoid process. A second line is drawn perpendicular to the clavicle at the intersection of the lateral third with 2/3 medial of the clavicle. The intersection of the two lines represents the upper limit of the skin islet. The lower limit of the skin island is represented by the 7th rib, the lateral one is the extremity of the pectoralis major muscle, and the medial one is the middle sternum (**Figure 10**). Preferably, the island should have an elliptical shape to facilitate closure [12].

Figure 12.
Transposition of the flap and compression dressing with 2 catgut.

The next step is to expose the large pectoralis muscle. The dissection is performed from medial to lateral. After exposing the pectoralis major muscle, its edge is sutured to the subcutaneous connective tissue of the skin island. An incision is then made from the medioclavicular level to the myocutaneous island. Lifting of the flap is done by digital dissection, deep to the pectoralis major muscle.

Dissection of the vascular pedicle must be done carefully so as not to damage it and compromise the flap. It is recommended to leave an equal thickness of tissue around the flap (**Figure 11**).

A subcutaneous tunnel is made at the level of the clavicle through which the flap is transposed at the level of the defect (**Figure 12**). A drain is placed at the level of the pectoral defect, at a distance from the vascular pedicle. The suture is made in 2 planes. A compression dressing is held in place for 2 days (**Figure 13**).

Most often, reconstruction of the hypopharynx with the PMMC is performed after total laryngectomy. Because the posterior wall of the larynx is attached to the anterior wall of the pharynx, a significant part of the pharyngeal wall may be excised during total laryngectomy. If it is necessary to reconstruct the entire circumference of the pharynx, it is recommended to use a free flap (tubularized anterolateral tight, radial

Figure 13.
Transposition of the flap and compression dressing with 2 catgut.

Figure 14.
Gigant oropharyngeal and cervical defect which needed PMMC reconstruction.

forearm fasciocutaneous free flap or jejunum). Defects of the pharynx extending below the clavicle are most commonly reconstructed with a gastric pull-up or colon interposition flap.

After harvesting and lifting the flap at the neck level using the technique described above, the flap is rotated 180 degrees to bring the skin side in. The closure of the defect begins at the caudal extremity of the pharynx. The right edge of the remaining pharynx is sutured to the left edge of the flap with 2–0 catgut sutures. Reconstruction of the pharyngoesophageal defect is done in the form of a racquet. A nasogastric feeding tube is inserted and passed into the distal esophagus before complete closure of the pharyngeal defect [13].

When an anterior cervical soft tissue defect is also present, a prelaminated pectoralis major pedicled flap can be used for reconstruction. This flap can provide two epithelial surfaces. This is a two-step procedure that involves first implanting a skin graft under the pectoralis major muscle. After maturation of the added tissue, the myocutaneous flap is transferred onto the neck, where the grafted surface is used for pharyngeal lining [14].

PMMC is also used for the reconstruction of defects of the oropharynx (**Figures 14** and **15**), but with a rather high complication rate. Complications include partial necrosis and less often total necrosis and fistula development. Due to the gravitational force, as it is a heavy flap, has a tendency to pull away, causing separation of the suture line, especially at the superior edge.

Figure 15.
Appearance of the patient 2 days after PMMC reconstruction for extensive pharyngeal resection and cervical region defect.

2.2.2 The sternocleidomastoid (SCM) flap

The sternocleidomastoid (SCM) is used as a pedicled flap in head and neck reconstruction since 1908, and although it has been previously associated with high complication rates, recent reviews state that preservation of the vascular pedicles and techniques improvements make it an adequate choice, especially when free flap surgery is inappropriate [15].

The muscle originates from the upper edge of the sternal manubrium, from the medial quarter of the upper face of the clavicle; the two muscle heads merge into a single muscle belly that is directed upwards and laterally. Insertions arrive at the mastoid process of the temporal bone and at the anterior portion of the superior nuchal line. SCM has fibers arranged in parallel; it is not a pennate muscle. The sternomastoid portion is the muscle area that develops a greater percentage of contractile strength than the other portions [16].

The arterial supply is given by branches of the external carotid artery (occipital artery and superior thyroid artery), which can be palpated, feeling the heartbeat in the medial-anterior portion of the muscle. The external jugular vein passes inferiorly and posteriorly the SCM, from which it drains venous blood (external posterior jugular vein and anterior jugular vein) [16]. Superior and middle pedicles are the most important to be preserved, as they give the major blood supply to the muscle. The inferior pedicle is the most controversial, with variations of origin—suprascapular artery, thyroid artery, or transverse cervical artery, and it cannot be relied on to perfuse the entire muscle. Some studies conclude that preserving the superior thyroid arteriovenous system is critical for the survival of the flap. Also, care to be taken to external jugular vein, as venous limitations may also affect flap viability [15].

Anatomic studies suggest that only one pedicle may not be not enough, as ischemic complications may appear due to a low vascularization in the distal end of

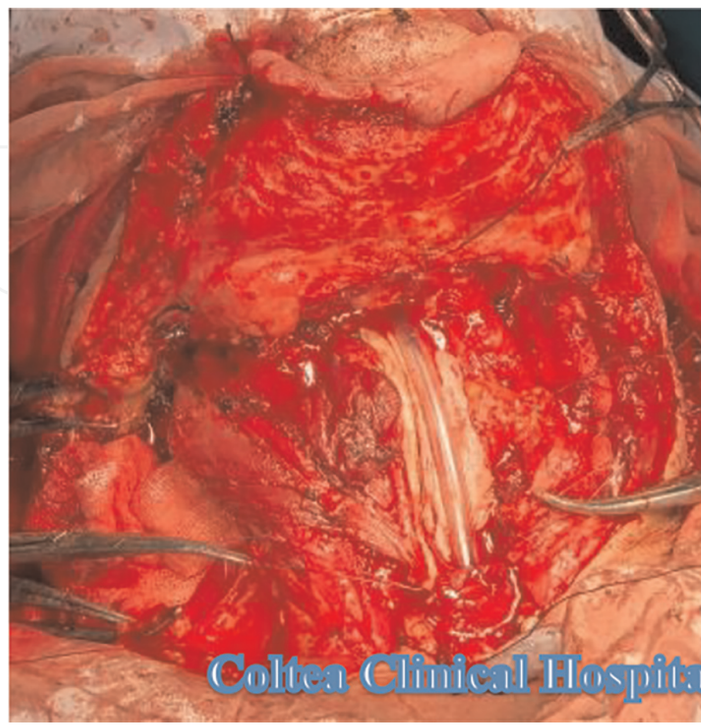

Figure 16.
SCM flap used to enforce posterior wall of the new digestive way after total circular pharyngolaryngectomy.

the muscle and some authors advocate the use of superior and middle pedicle, with dissection at the highest length to allow flap rotation. Single-headed SCM flaps can repair soft tissue defects up to 8 cm × 6 cm, and if a bone is needed an SCM flap with a clavicular bone graft can fix mandibular defects up to 6 cm long. The skin incision should be parallel to the muscle from the angle of the mandible, and with a clear view of the occipital and superior thyroid arteries. Skin platysma flaps are raised anterior to posterior to the SCM and muscle should be raid with its investing fascia. Separation from its superior or inferior bony attachments is done with a combination of blunt and sharp dissection. After flap harvesting, selective functional neck dissection can be performed. Suturing the skin on the muscle may be favorable for skin perfusion as it decreases tension and avoids tearing of the delicate perforators to the skin [17].

With a high versatility in head and neck reconstruction, this regional pedicled flap can be used as a myocutaneous, myofascial, myoperiosteal, or osteaomuscular flap. This flap is best used for defects below the level of the zygomatic arch. It is not advisable to use this flap if the tumor directly invades the muscle or if the neck dissection cannot be done adequately in order to preserve the pedicles, as oncological safety is the priority. The history of radiation is not an absolute contraindication [18] (**Figure 16**).

2.2.3 The supraclavicular (SC) flap

The supraclavicular flap is a versatile fasciocutaneous flap designed along the axis from the supraclavicular fossa extending over the shoulder. It is useful in the reconstruction of a variety of head and neck defects and can be ideal for pharyngeal and esophageal reconstruction [19].

Key anatomic landmarks are the SC triangle with identification of the cutaneous perforator of the supraclavicular artery. The supraclavicular flap is an elongated ellipse over the supraclavicular region with an inferior extension to the deltoid tip. It

Figure 17.
Supraclavicular flap for oral cavity reconstruction.

can cover up to 8 cm of the defect. Flap elevation is done from distal to proximal, in a subfascial plane, and care should be taken to avoid injury of the cephalic vein on the ventral surface. Donor site can be closed primarily and drain placement is recommended (**Figure 17**) [18].

2.3 Multidisciplinary approach: Free flaps and other types of reconstruction

This kind of approach requires a multidisciplinary team, and the head and neck team must determine the approximate size of each tissue needed for reconstruction, thus communication is vital. Time management, especially when using tourniquets and gentle dissection of an intact vascular pedicle, is also of great importance. In addition, topical measures can assure viability: copious micro-irrigation with saline or heparinized lidocaine (2% lidocaine, 100 U/ml heparin) and papaverine irrigation (30 mg/mL). The free flap paddle should be manipulated while having a native supply. A delicate microsurgical technique and good pedicle geometry are the most important factors in microvascular anastomosis. The end-to-end anastomotic technique is the most commonly used. Postoperative monitoring is essential and visible flap inspection with pinprick can be supplemented by digital palpation and Doppler monitoring [3].

2.3.1 Radial forearm free flap

Radial forearm-free flap is considered the best choice for near-total laryngopharyngectomy defects, with high advantages, especially in tailoring options. Likewise, it has low donor site morbidity and can be harvested in one-stage surgery. It tolerates well postoperative radio-therapy and has seemed to have superior speech rehabilitation. As disadvantages, some authors report high complications rate, with stricture or fistula but which are manageable with conservative measures [20].

2.3.2 The free jejunal flap

In esophageal involvement, the free jejunal flap is a reliable way of reconstruction, with certain anatomical advantages. It is stated that up to 20 cm of jejunum can be harvested and as it comes along with the vascular mesentery, that allows obliteration of possible defects and protect the vascular structures of the neck. Deglutition rehabilitation seems to be earlier, but it may present with dysphagia because of uncoordinated peristalsis. Flaws of this flap are the quality of voice rehabilitation with excessive mucus production, the need for a microvascular reconstructive team, and in addition, abdominal surgical complications [21].

2.3.3 Gastric pull-up reconstruction

Gastric pull-up reconstruction is a surgical technique in which the stomach is brought, through the mediastinum to the neck along with the entire esophagus. The main indication for this procedure is esophageal carcinoma, with thoracic segment involvement. The main advantages are a great vascularization, with pedicle on the right gastric and gastroepiploic vessels, only one anastomosis is needed, one-step procedure, and the lowest stricture rate of all flaps. On the other hand, it presents high morbidity and mortality, with an overall incidence of complications of between 26% and 55%. Mediastinitis, difficulties in swallowing and voice rehabilitation, dumping syndrome are the main concerns postoperatively [4].

2.4 Transoral surgery techniques

As transoral surgery evolved, with even robotic-assisted (TORS), reconstructive ways for oropharyngeal defects should take into consideration structural features, such as creating an anatomic barrier between the neck and the pharynx and to ensure adequate coverage of the carotid artery. Functional considerations are restoring swallowing function, preserving speech and articulation, preventing aspiration, and maintaining velopharyngeal competence. Some authors created an algorithm that submits the factors determining more advanced reconstructions: number of subsides involved, exposure of the great vessels, communication with the neck, size of the defect (palate, tongue base), and radiation history. In defects with >50% of palatal defect, pharyngocervical communication and exposed carotid artery, after transoral robotic surgery, the authors recommend considering regional or free flaps [22].

Other authors found ingenious ways in TORS reconstruction, direct transposition of the ipsilateral naso-septal flap into the oropharynx via a trans palatal tunnel at the hard-soft palate junction [23].

As most centers and surgeons use more than one technique in reconstruction for hypopharyngeal carcinoma, multiple factors play in flap choice. Risk and benefit analysis is extremely important, especially for patients with circumferential loss of the pharyngoesophagus. Skin flaps have less donor morbidity than visceral flaps but are limited in obese patients. Free flaps need longer operative time but provide larger and more adaptable paddles for reconstruction [19] (**Figure 18**).

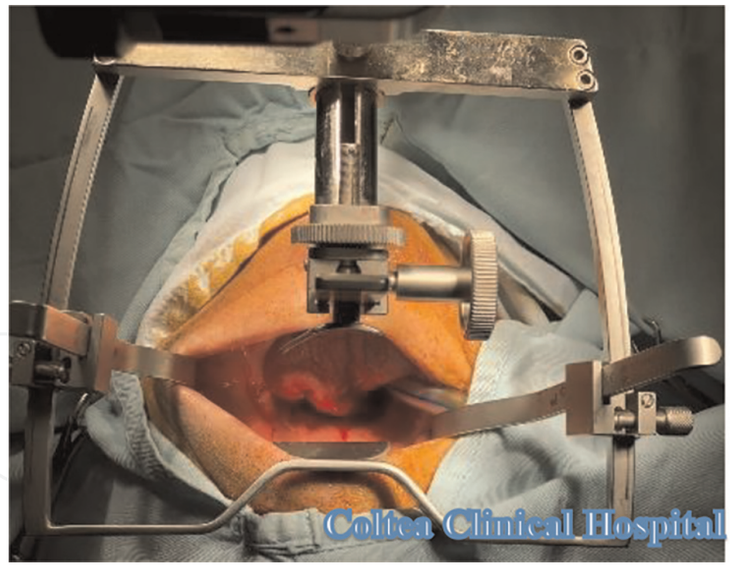

Figure 18.
Transoral surgery setup for base of the tongue carcinoma.

2.5 Biocompatible materials

A possible alternative in reconstruction for esophageal defects can be Montgomery salivary bypass tube. Precisely, this tube has two spherical zones which enable better stability and optimal saliva leaking along of tube, regardless of the head and neck position. Silicon rubbers used in prosthesis construction are the most appropriate solution in terms of morbidity, biocompatibility, functionality, and bacterial and fungal biofilm formation. A study conducted in "Coltea" Clinical Hospital, ENT

department, Bucharest, concluded that insertion of a bacteriostatic agent, such as silver nanoparticles, decreases the fatigue strength, increases flexibility, and offers an optimal local protection solution against fungi development [6] (**Figures 19** and **20**).

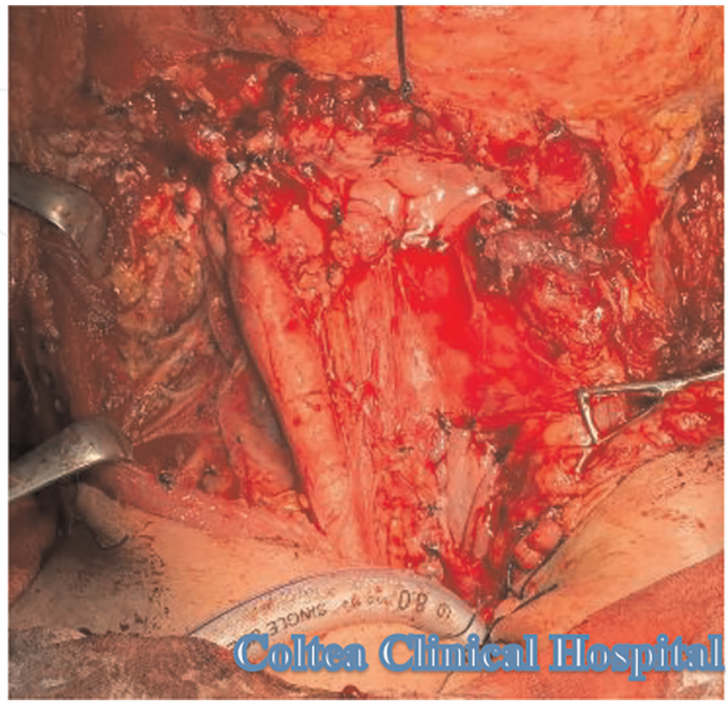

Figure 19.
Total circular pharyngolaryngectomy with radical neck dissection (note the carotid artery) and reconstruction with Montgomery salivary tube.

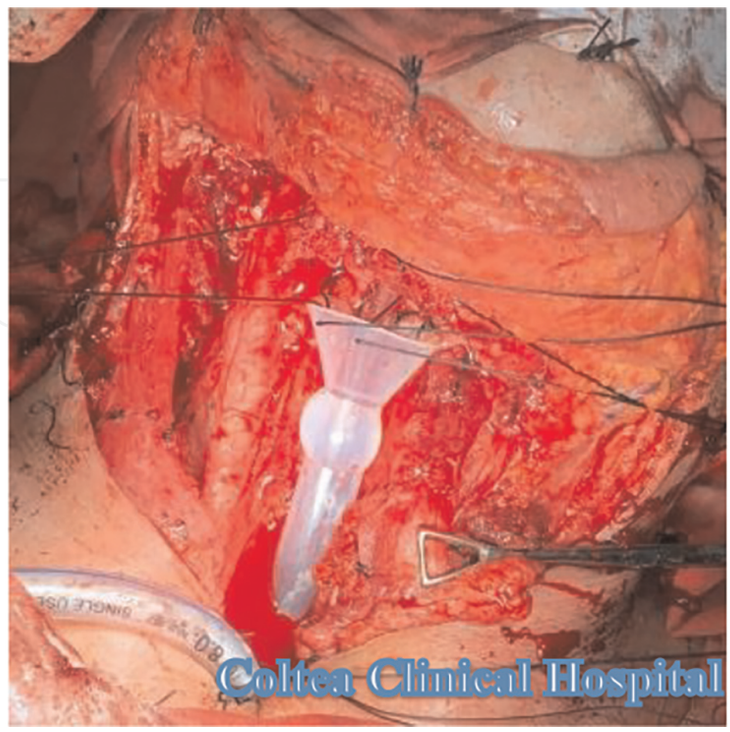

Figure 20.
Total circular pharyngolaryngectomy with radical neck dissection (note the carotid artery) and reconstruction with Montgomery salivary tube.

3. Improving QoL and rehabilitation

3.1 QoL after reconstructive surgery

The European Organization of Research and Treatment of Cancer (EORTC) QoL questionnaire (QLQ) is an integrated system for assessing the health-related QoL (HRQoL) of cancer patients participating in international clinical trials. The core questionnaire, QLQ-C30, is composed of both multi-item scales and single-item measures. These include five functional scales, three symptom scales, a global health status/QoL scale, and six single items. Each of the multi-item scales includes a different set of items—no item occurs in more than one scale. All of the scales and single-item measures range in score from 0 to 100. A high scale score represents a higher response level. The scaling technique described above is based upon the widely applied Likert method of summated scales, in which the constituent items within each scale are simply summed. This makes several assumptions about the nature of the items, the most important of which are (a) that it is appropriate to give equal weight to each item, and (b) that each item is graded on a linear or equal-interval scale. The raw QLQ-C30 scores can be transformed into scores ranging from 0 to 100 [24].

Swallowing, mastication, and speaking are major factors that affect the HRQoL of patients one year after operation for pharyngeal cancer. Some authors advocate that flap reconstruction after oropharyngeal cancer surgery can improve patients' QoL postoperatively [25]. Furthermore, there are studies that conclude that still surgery should be considered as a first-line therapy for oropharyngeal cancer because the surgery-based group achieved equivalent treatment outcomes and slightly better QOL scores than the RT-based group [26].

If the cancer is diagnosed in the late stages, disfigurement, chewing, speech, and shoulder function can be significantly below the preoperative level throughout the follow-up. Sociodemographic factors, heavy drinking, and unemployment may be predictive factors of QoL. Still, there is data that claims that surgical treatment, even with free flaps reconstruction, can improve QoL, with direct influence on pain and improvement of diet [27].

In terms of HRQoL, more prospective and multicenter clinical trials should be performed.

3.2 Deglutition rehabilitation

After surgery, the visualization of pharynx is an essential part of a complete examination. Indirect view of the pharynx can be performed with either a mirror or a flexible fiberoptic endoscope. The procedure can be performed when patients are awake, and it is usually well-tolerated. The remaining pharynx can be seen with the mirror and inspected for asymmetry and any potential mucosal abnormalities [28].

Flexible fiberoptic endoscopy can be used for the simple evaluation of the pharynx and also for the assessment of the degree of dysphagia. Dysphagia is a common problem after neck surgery, with an incidence up to 70%, and contributes to compromised nutrition, weight loss which can both lead to diminished quality of life and decreased psychological well-being. Swallowing is a very complex physiological action that is rapid from the beginning to the end [28].

Fiberoptic endoscopic assessment of swallowing (FEES) is a portable procedure that may be completed in outpatient clinic space or at the bedside. FEES involves passing a

flexible endoscope through the nose and toward the pharynx to observe swallowing in real-time. FEES is a reliable and sensitive tool for assessing dysphagia [29].

American Speech-Language-Hearing Association (ASHA) states that a clinical-instrumental evaluation of swallowing should reveal: organic and functional alterations in the structures involved, the degree of efficacy of swallowing in its various stages, adequate protection of the lower airways, and coordination between breathing and swallowing. Moreover, it should detect and possibly quantify any penetration of the bolus in the tracheal-bronchial tree. The diagnostic tools used for studying swallowing disorders should be able to assess the various movements that take place during all stages of swallowing in relationship to the type of bolus administered, as well as evaluate the efficacy of the rehabilitation procedures [30, 31].

In spite of the fact that FEES supplies limited information compared to video-fluoroscopy because it only investigates the pharyngeal stage followed by a moment of "white-out" in the swallow, it is now employed as a routine procedure. Video-endoscopy permits a static and dynamic evaluation of the structures in the upper airways and upper digestive tract [30, 31].

After the static evaluation of the morphology and function of the upper airways and upper digestive tract, we can also perform a dynamic evaluation of swallowing. For that we administer a bolus to the patient. During the examination, compensatory positions may be kept to improve swallowing efficacy, and also therapeutic maneuvers can be applied in order to establish the appropriate rehabilitation approach for managing, feeding, and swallowing techniques. So, FEES offers the possibility to study the physiology of swallowing, the evaluation of the presence, degree, and type of dysphagia, and is also a good method for establishing the best means of feeding, for advising diets, and for planning any other diagnostic investigation [32].

During FEES we can also use narrow-band imaging (NBI). The optical NBI filter allows a narrow band light with two wavelengths (415 nm blue light and 540 nm green light) to penetrate the tissue to different depths, corresponding to the peaks of absorption of hemoglobin. NBI light is absorbed by vessels but reflected by mucosa, and thus, maximum contrast of vessels and the surrounding mucosa is achieved. Using filtered narrow banded light, pathological epithelial changes are better observed which improves the early detection of dysplasia and carcinoma and allows a better demarcation of benign lesions. Moreover, NBI also helps the assessment of swallowing. It allows better visualization of the bolus and generally leads to much sharper optical contrasts, especially under difficult examination conditions. Consequently, detection of smaller bolus quantities is enhanced and distinction of the bolus from surrounding structures is facilitated [33].

After the assessment of the dysphagia, the rehabilitation plan is determined firstly using postures. The chin-down posture pushes the anterior pharyngeal wall posteriorly, and the tongue base closer to the posterior pharyngeal wall, thus narrowing the airway entrance and reducing aspiration. The head-back posture uses gravity to clear the bolus from the oral cavity and is useful in patients who have difficulty with oral transit of the bolus. Head rotation toward the damaged side of the pharynx closes the damaged side so that the bolus flows down the more-nearly normal side. The lateral head tilt posture may be used for patients who have both unilateral oral and pharyngeal impairment on the same side [34].

In addition to the use of postures, swallow maneuvers may be added. Swallow maneuvers are designed to place specific aspects of the oropharyngeal swallow under voluntary control in order to improve the process. Moreover, some patients may benefit from the modification of bolus size and consistency which may also be

effective in eliminating aspiration in patients treated for head and neck cancer. For some patients, a larger volume bolus may be effective at eliciting a more rapid pharyngeal swallow by increasing the sensory input for the patient and so increasing

Figure 21.
Free flap reconstruction after fistula complication with vocal prosthesis slightly migrated but with good functional outcome.

Figure 22.
PMMC reconstruction for fistula complication with vocal prosthesis in place.

awareness of the bolus in the oral cavity. However, patients who require multiple swallows to clear a single bolus will probably benefit from smaller bolus sizes in order to reduce residue and the risk of aspiration [34].

3.3 Voice rehabilitation

Voice rehabilitation is the result of some techniques in which a patient can reach a good functional outcome, with optimal social reinsertion. Voice handicap index, swallowing problems, stoma-related issues, and pain are the most important aspects that can influence QoL index after extensive pharyngeal and laryngeal surgery. Speech therapy, additional nursing care, and patient empowerment may influence the final result after surgery.

After oropharyngeal surgery with primary closure, voice and swallowing may be affected, and the use of radial forearm graft seems to allow a good function. On the other hand, regardless of the way of reconstruction, if the larynx is preserved, the persistence of aspiration/ penetration and consequently the need for a tracheostomy are factors that influence the voice.

After total laryngectomy, with a total separation of the aero-digestive system, air cannot reach higher structures involved in speech, but even though, the neopharynx that is sutured with different techniques can become a neoglottis with sound-producing capacity. Voice rehabilitation after total laryngectomy can be achieved by

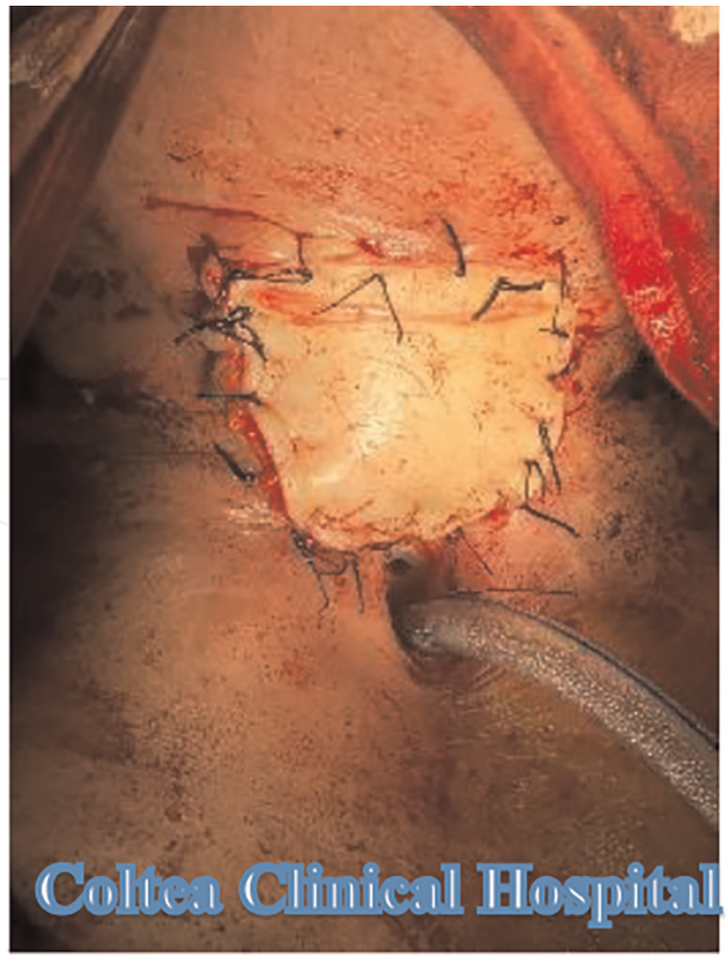

Figure 23.
PMMC reconstruction for fistula complication with vocal prosthesis in place.

esophageal speech (EP), use of an electrolarynx, or tracheoesophageal fistula with a vocal prosthesis (VP).

Tracheoesophageal speech (TES) with VP is the gold standard of voice rehabilitation after total laryngectomy. The main principle of the VP, as a unilateral valve, is that it redirects the exhaled air when the stoma is occluded. As a result, speech is possible as the air reaches the neopharynx, with secondary vibrations, and also the oral cavity. It is a relatively easy to learn technique, with primary placement possibility and low morbidity rates. On the other hand, ES is a difficult-to-learn technique, in which the air is injected with the tongue toward the pharynx and esophagus to make them vibrate. The electrolarynx is a device that produces vibrations and after placing it near the oral cavity, a robotic speech may be achieved.

Hypopharyngeal cancer surgical treatment, even in circular defects and with the need for total reconstruction can now benefit from voice rehabilitation with the use of vocal prosthesis. TES seems to be with good outcome after myofasciocutaneous free flaps and with a lower quality ("wet" or "gurgle" character) after free intestinal flaps. Although some authors claim that after PMMC flap reconstruction a successful TES can be hardly achieved, it has remained a critical reconstructive tool [4, 8] (**Figures 21–23**).

4. Conclusion

The pharynx, as a rendez-vous place of basic physiological and social needs—food intake, breathing, and social interactions, requires a stepped fashion cancer treatment, with a high focus on QoL. Reconstruction is probably one of the most demanding tasks for a head and neck surgeon and often implies a multidisciplinary approach for better outcomes. Keystones after surgery are speech, swallowing, and pulmonary rehabilitation.

Conflict of interest

The authors declare no conflict of interest.

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