ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΣΠΟΥΔΩΝ:
‘‘ΕΛΑΧΙΣΤΑ ΕΠΕΜΒΑΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ,
ΡΟΜΠΟΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ ΚΑΙ ΤΗΛΕΧΕΙΡΟΥΡΓΙΚΗ’’

ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ΙΑΤΡΙΚΗ ΣΧΟΛΗ

ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

ΘΕΜΑ:
TRANSORAL ROBOTIC SURGERY FOR TONGUE BASE TUMORS

ΜΕΤΑΠΤΥΧΙΑΚΟΣ ΦΟΙΤΗΤΗΣ:

ΧΑΡΑΛΑΜΠΟΣ Δ. ΚΟΥΜΟΥΛΛΗΣ
Α.Μ.:2010777

ΑΘΗΝΑ, ΙΑΝΟΥΑΡΙΟΣ 2014

ΠΡΑΚΤΙΚΟ ΚΡΙΣΕΩΣ
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Του Μεταπτυχιακού Φοιτητή Χαράλαμπου Δ. Κουμουλλή

Εξεταστική Επιτροπή

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- Χρήστος Π. Τσιγκρής, Καθηγητής Χειρουργικής & Επιστημονικός Υπεύθυνος του Π.Μ.Σ.
- Θεόδωρος Διαμαντής, Καθηγητής Χειρουργικής

Η Τριμελής Εξεταστική Επιτροπή η οποία ορίσθηκε από την ΓΣΕΣ της Ιατρικής Σχολής του Παν. Αθηνών Συνεδρίαση της.....ης ..... 20.... για την αξιολόγηση και εξέταση του υποψηφίου κου. Χαράλαμπου Κουμουλλή, συνεδρίασε σήμερα .../.../....

Η Επιτροπή διαπίστωσε ότι η Διπλωματική Εργασία του κου. Χαράλαμπου Κουμουλλή με τίτλο «**Transoral Robotic Surgery for tongue base tumors**», είναι πρωτότυπη, επιστημονικά και τεχνικά άρτια και η βιβλιογραφική πληροφορία ολοκληρωμένη και εμπεριστατωμένη.

Η εξεταστική επιτροπή αφού έλαβε υπ' όψιν το περιεχόμενο της εργασίας και τη συμβολή της στην επιστήμη, με ψήφους ..... προτείνει την απονομή του Μεταπτυχιακού Διπλώματος Ειδίκευσης (Master's Degree), στον παραπάνω Μεταπτυχιακό Φοιτητή.

Στην ψηφοφορία για την βαθμολογία ο υποψήφιος έλαβε για τον βαθμό «ΑΡΙΣΤΑ» ψήφους ....., για τον βαθμό «ΛΙΑΝ ΚΑΛΩΣ» ψήφους ....., και για τον βαθμό «ΚΑΛΩΣ» ψήφους ..... Κατά συνέπεια, απονέμεται ο βαθμός «.....».

Τα Μέλη της Εξεταστικής Επιτροπής

- Ιωάννης Γκρινιάτσος, **Επιβλέπων** (Υπογραφή) _____
- Χρίστος Π. Τσιγκρής, (Υπογραφή) _____
- Θεόδωρος Διαμαντής, (Υπογραφή) _____

Στην υπέροχη σύντροφο μου Σουζάνα
Για την λάμψη που στη ζωή μου έχει φέρει

Στην κόρη μου Ηλέκτρα
Ό,τι πιο σημαντικό και φωτεινό υπάρχει

Ευχαριστώ ιδιαίτερα τον Καθηγητή Χειρουργικής Κύριο Χρήστο Τσιγκρή
Υπεύθυνο του Μεταπτυχιακού Προγράμματος
για την βοήθεια και υποστήριξή που έδειξε στο πρόσωπό μου

Ευχαριστώ τον Επίκουρο Καθηγητή Χειρουργικής και Επιβλέποντα
Κύριο Ιωάννη Γκρινιάτσο
για την υποστήριξή του στην εκπόνηση αυτής της πτυχιακής εργασίας

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1. Introduction

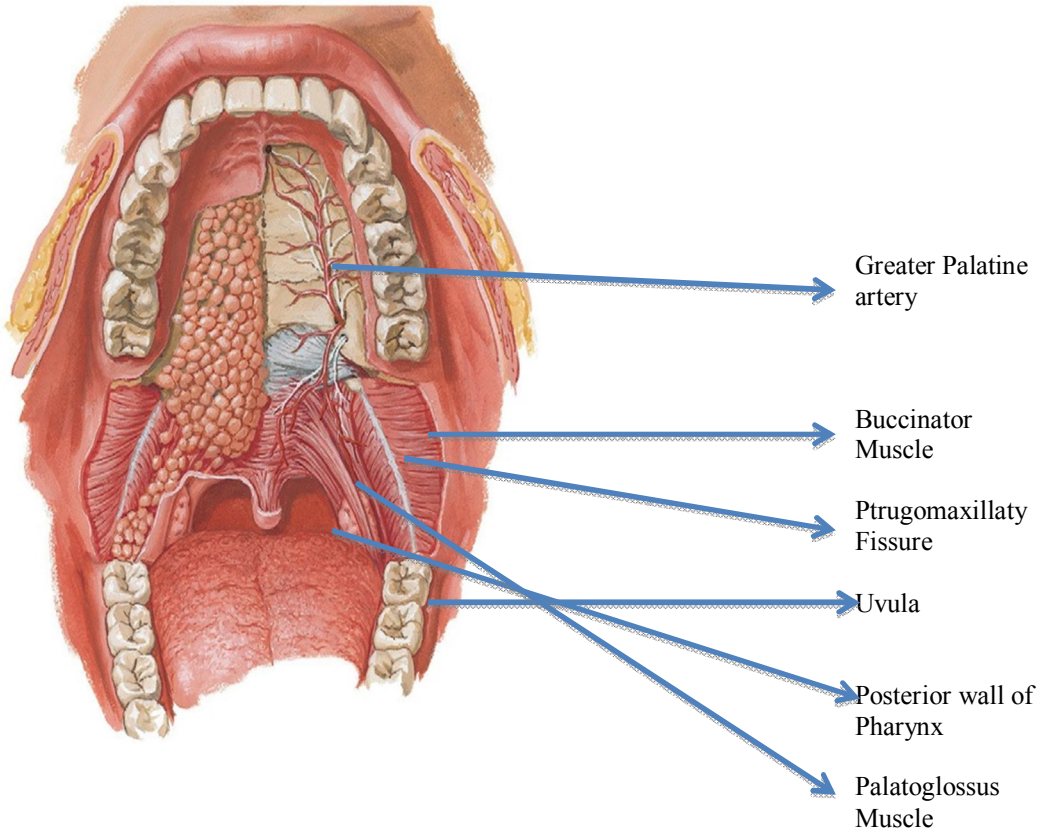
Open surgical approaches to the oropharynx can be associated with morbidities such as cosmetic deformity, malocclusion and dysphagia. Therefore, a trend toward using radiotherapy and concurrent chemotherapy as a primary modality in case of oropharyngeal cancer has been observed in the last few decades. However, evidence of a clear advantage of concurrent chemoradiotherapy over using combined treatment (primary surgery followed by radiotherapy or chemoradiotherapy) is still lacking, while toxicity of intensive chemoradiotherapy causing severe dysphagia with dependence on a gastrostomy tube has been well documented.

In recent years, transoral robotic surgery (TORS) has been used for the removal of pharyngeal and laryngeal cancers with the objective to improve functional and aesthetic out- comes without worsening survival.

Based on reports in transoral laser surgery (TOLS), the benefits of the transoral approach to the pharyngolaryngeal lumen are well known. TORS allows a clearer and wider view of the surgical field and better 3D visualization of structures than TOLS, enabling access to the tumor via a smaller approach than the external one. Another advantage of TORS is the use of miniaturized tools. This allows mimicking standard surgical instruments and arm movements, with tremor filtration. In addition, it permits a frontal view and reaches “blind corners” of the pharyngolaryngeal complex, not-perpendicularly positioned to the visual line due to the possibility to use a 30° telescope. One of the objectives of this study is to evaluate whether acceptable overall functional outcomes in case of tongue base tumors are obtained using TORS. Most reports describe the use of TORS in radical tonsillectomy and partial laryngectomy. Few authors have focused on tongue base neoplasms, most likely due to the difficulty to recruit eligible cases

2. Basic principles of anatomy

2a. The oral cavity



The boundaries of the oral cavity comprise the lips anteriorly, the cheeks laterally, the pillars of fauces posteriorly, the hard and soft palate superiorly, and the floor of mouth inferiorly. The contents of the oral cavity include the alveolar processes, the teeth, the tongue, and the ducts of the major and minor salivary glands. The anatomy of these structures will be discussed in more detail in the following sections. The major functions of the oral cavity are communication (verbal and non-verbal),

nutrition, and respiration. The role of various structures in these major functions will also be discussed in greater detail in the following sections.

The pillars of fauces

The pillars of fauces are musculomucosal folds connecting the soft palate to the root of tongue anteriorly (the palatoglossal fold), and to the wall of the pharynx posteriorly (the palatopharyngeal fold). The palatine tonsils are found in a triangular area (the tonsillar fossa) between the palatoglossal and palatopharyngeal folds. The palatine tonsils contain lymphoid tissue, are part of the lymphatic/immune system, and are thought to be involved in the regulation of infections of the pharynx and upper respiratory tract. The palatine tonsils are often simply referred to as the 'tonsils'.

The palate

The hard palate is formed by the palatine processes of the maxillary bone and the horizontal plates of the palatine bones. It separates the oral cavity from the nasal cavity. The hard palate is involved in speech production. A small bulge of tissue (the incisive papilla) is present in the anterior midline of the hard palate, and represents the site where the nasopalatine nerve exits the base of skull. Either side of the midline are a number of raised projections called rugae, which provide additional areas for grinding of food during mastication.

The soft palate is formed by the tendinous aponeurosis of tensor palati muscle, fibres of the tensor palati/levator palati muscles, and lymphatic tissue. It separates the oral cavity from the nasopharynx. The soft palate is involved in swallowing function (closes off the nasal passages), speech production, and also the 'gag reflex'. The muscular uvula hangs in the midline between left and right pillars of fauces. There are many normal variations in the shape of the vault of the palate.

The soft tissue behind the last molar tooth in the lower alveolar process (the mandibular dental arch) is called the retromolar pad. The upper alveolar process (the maxillary dental arch) expands posteriorly into the maxillary tuberosity. The alveolar processes are called alveolar ridges in edentulous patients. (The alveolar processes start to resorb when permanent teeth are lost/removed.)

The alveolar processes divide the oral cavity into the vestibule/sulcus (located outside the alveolar processes), and the oral cavity proper (located inside the alveolar processes). The vestibule is interrupted by frena/frenula: these are cords of mucous membrane, which sometimes contain muscle fibres, which extend from the lips or cheeks onto the alveolar processes. Frena may cause spacing between teeth (diastema), and are susceptible to trauma (e.g. from overzealous tooth- brushing).

The teeth

There are four different morphological types of tooth in the human dentition: incisors canines premolars and molars. The first two types are used for tearing food, whilst the latter two types are used for grinding food.

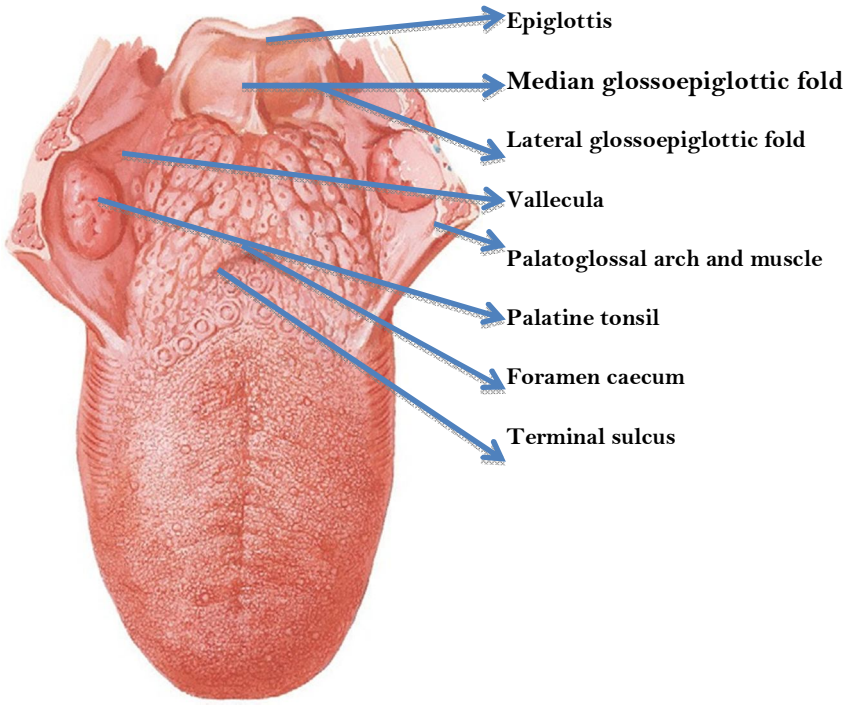
The floor of mouth

In the midline, a prominent frenum (the lingual frenum) extends from the alveolar process to the floor of mouth, and from there to the ventral surface of the tongue (Figure 2.3). The mucosa of the floor of mouth is raised on either side by the sublingual folds, which contain the two sublingual salivary glands, which drain through a series of ducts on the summit of the sublingual fold. Similarly, the mucosa of the floor of mouth is raised on either side of the lingual frenum by the sublingual papillae, which contain the ducts of the submandibular glands (the Wharton ducts). Saliva pools in the floor of mouth, and so the mucosa of the floor of mouth should be moist and glistening (at normal salivary flow rates).

The tongue

The ventral surface of the tongue reveals the deep lingual veins, and more laterally the fimbriated (fringed) folds. The deep lingual veins often develop varicosities with increasing age. The dorsal surface of the tongue is divided into the body or anterior two-thirds, and the base or posterior third. The boundary is seen as a ‘V’- shaped line called the sulcus terminalis. At the apex of the ‘V’ is a depression (the foramen caecum), which is the site of origin of the thyroid gland prior to its descent into the

neck. In a small percentage of people, functional thyroid tissue remains at this site (‘lingual thyroid’). The mucosa of the anterior two-thirds of the tongue is not smooth, but is covered in tiny projections known as papillae. The thread-like (filiform) papillae are scattered widely and provide a ‘rasping’ surface to aid mastication. The other papillae carry taste buds: fungiform papillae – these pale-red, mushroom-shaped papillae are less numerous, and are loosely scattered between the filiform papillae foliate papillae – these leaf-shaped papillae appear as ridges on the posterior edges of the tongue; and circumvallate papillae – these rampart-shaped papillae appear as large circular structures anterior to the sulcus terminalis. The innervation of the tongue is complicated, as it is formed from different embryological structures, each supplied by a different cranial nerve



Nervous innervation of oral cavity

The sensory innervation to the oral mucosa and teeth is provided by branches of the trigeminal (5th cranial) nerve. The trigeminal nerve also innervates the muscles of mastication (e.g. masseter, medial pterygoid). Special sensory innervation, such as

taste sensation, is supplied by the facial (7th cranial) nerve 'hitch-hiking' in branches of the trigeminal nerve.). The parasympathetic innervation comes through the otic submandibular and pterygopalatine ganglia. The is innervated by the following five cranial nerves

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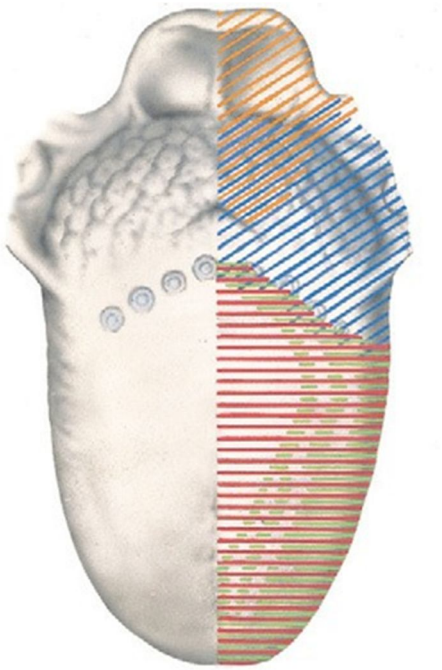


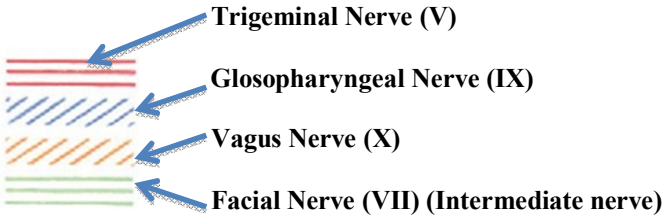
Mandibular: via lingual nerve; for general sensation to the anterior two-thirds of the tongue

Facial: via **chorda tympani nerve**, which joins the lingual; for taste on the anterior two-thirds of the tongue

Glossopharyngeal: general sensation and taste to the posterior one-third of the tongue

Vagus: via the internal branch of the superior laryngeal nerve, for general sensation and taste on the base of the tongue at the epiglottic region

Hypoglossal: motor to the intrinsic and extrinsic tongue muscles



Vasculature/lymphatic drainage of the oral cavity

The arterial system of the oral cavity is via branches of the lingual, facial, and maxillary arteries, which in turn are all branches of the external carotid artery.

Extracellular fluid (ECF) from the superficial tissues passes through the superficial group of lymph nodes, through the deep cervical lymph nodes (deep cervical chain), and then into the systemic circulation via the right and left jugular trunks. ECF from the deep tissues passes directly through the deep cervical lymph nodes, and then into the systemic circulation via the right and left jugular trunks. The posterior-third of the tongue contains raised mounds of lymphatic tissue (the lingual tonsil). This is one of the four lymphatic elements, collectively known as Waldeyer's ring, that encircle the entrance to the oropharynx. The other elements are the palatine tonsils, pharyngeal tonsils (the adenoids), and tubal tonsils found at the entrance of the auditory tube.

Pharynx

The **pharynx** (throat), a fibromuscular tube, connects the nasal and oral cavities of the head with the larynx and esophagus in the neck. The pharynx is subdivided as follows:

Nasopharynx: lies posterior to the nasal cavity above the soft palate

Oropharynx: extends from the soft palate to the superior tip of the epiglottis; lies posterior to the oral cavity

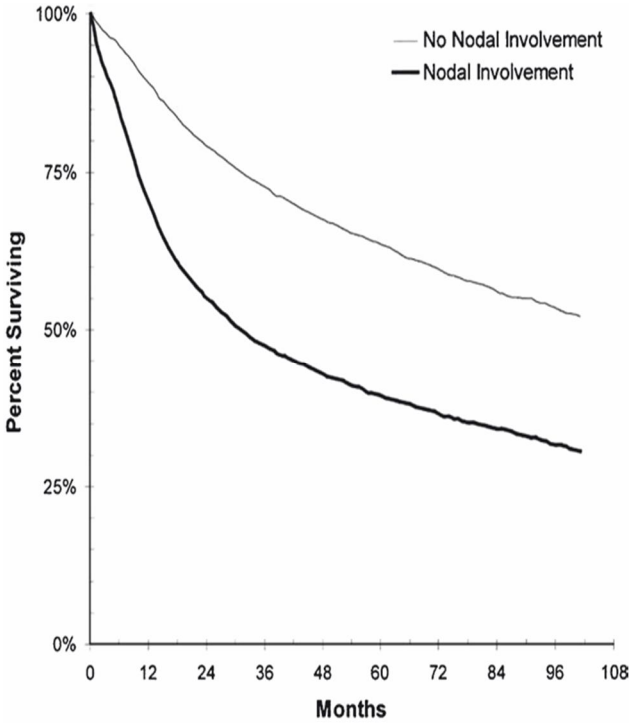
Laryngopharynx: extends from the tip of the epiglottis to the inferior aspect of the cricoid cartilage; also known as the *hypopharynx*. The muscles of the pharynx participate in swallowing (deglutition) and con- tract serially from superior to inferior to move a bolus of food from the oropharynx and laryngopharynx into the proximal esophagus. The blood supply to the pharynx is via branches of the **thyrocervical trunk** (subclavian) and the **external carotid artery** (principally its superior thyroid, facial, ascending pharyngeal and maxillary branches). Venous drainage is via the pharyngeal venous plexus, the pterygoid plexus of veins, and the facial, lingual, and superior thyroid veins, which all drain primarily into the internal jugular vein

3. Oral cancer

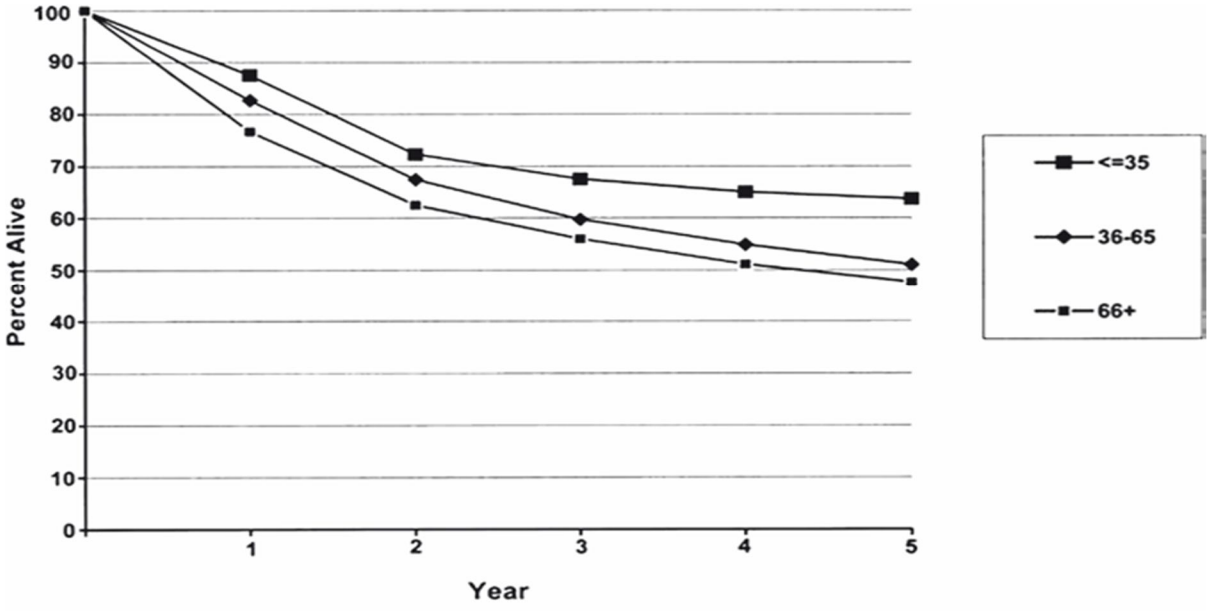
3a. Overview

Squamous cell carcinoma of the oral cavity has a propensity to metastasize to the cervical lymph nodes even in the early stages. The presence of lymph node metastasis is the most significant independent prognostic variable in determining survival of patients with cancer of the head and neck. Therefore, the diagnosis and treatment of cervical lymph node metastasis are the most important responsibilities of the head and neck oncologist.

There are several important demographic factors that also appear to impact survival. According to the surveillance epidemiology and end results (SEER) data for cancer of the oral cavity, the 5-year relative survival rate for the group of older patients was lower than the corresponding value for the younger group. The 5-year relative survival rates for males were significantly lower than that for females. The 5-year relative survival rate for African- Americans is significantly worse than that of whites.



Survival for patients with (*n* = 9,938) lymph node involvement from the SEER database, computed based on the Kaplan–Meier method (*P* < 0.0001). Reprinted with permission of Wiley-Liss Inc., a subsidiary of John Wiley & Sons, Inc. (Hollenbeak et al. 2001



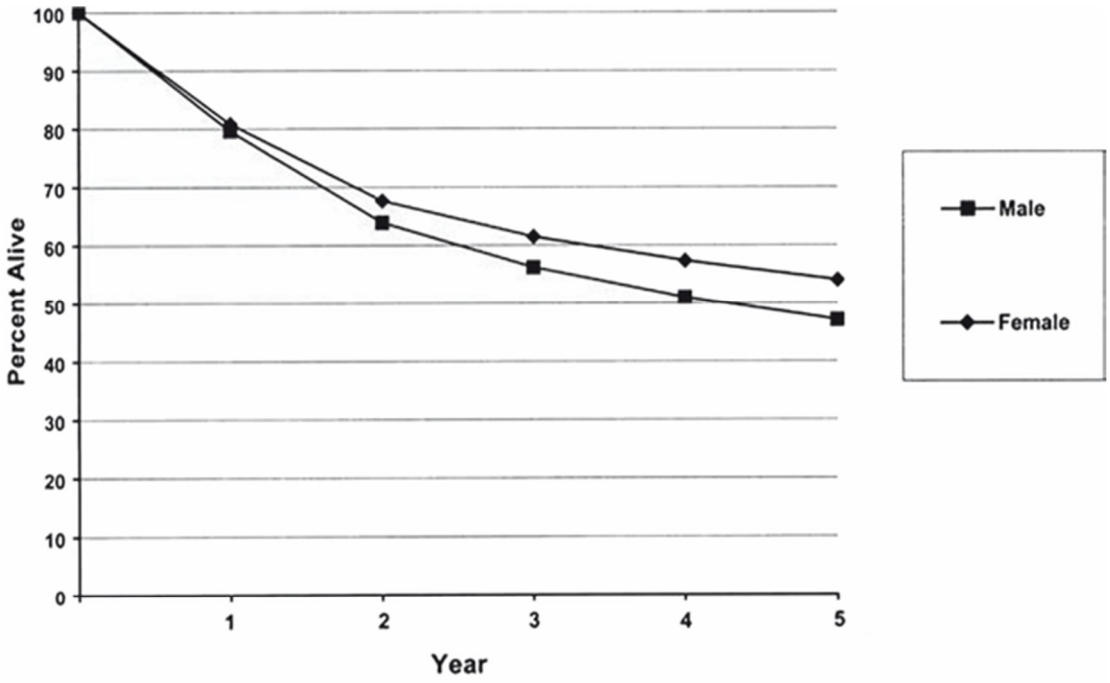
AGE	1	2	3	4	5	95% CIs	CASES
35 or younger	87.5	72.3	67.5	65.0	63.7	59.1 / 68.2	520
36-65	82.7	67.4	59.7	54.9	51.0	50.1 / 52.0	14215
66 or older	76.7	62.5	56.0	51.1	47.6	46.3 / 48.8	12846

Five-year relative survival by age for oral SCC cases, 1985–1991. Five-year survival rates for all age groups were significantly different (95% confidence level) (95% CI: 95% confidence interval for 5-year relative survival). John Wiley & Sons., Inc. (Funk et al. 2002)

A recent study of patients with cancer of the head and neck disclosed that there was a definite decrement in survival for individuals who did not have health care insurance, a difference presumably due to lack of access to health care (Chen et al. 2007). Goodwin et al. in a recent provocative article concluded that "Black Americans clearly bear a greater burden of head and neck cancer. The underlying causes are largely unknown but are most likely due to a complex interplay of differences in access to health care, quality of medical care, biologic/genetic factors, incidence of co morbid conditions, exposure to carcinogens, diet and cultural beliefs" (Goodwin et al. 2008).

Squamous cell carcinoma of the oral cavity is the most frequently encountered malignant tumor of the upper aerodigestive tract and accounts for 3% of all cancers in

the United States (Greenlee et al. 2000). Throughout the world, cancer of the oral cavity is more frequent in regions where the use of tobacco and alcohol is high. The highest worldwide-standardized incidence rate of cancer of the oral cavity is in France and the lowest rate is in Japan. It is estimated that 5,700 people die from cancer of the oral cavity in the United States each year (Chen and Myers 2001).



GENDER	1	2	3	4	5	95% CIs	CASES
Male	79.6	63.9	56.2	51.0	47.1	46.1 / 48.0	16872
Female	80.8	67.6	61.5	57.3	54.0	52.8 / 55.2	10726

Five-year relative survival by sex for oral SCC cases, 1985–1991. Five-year relative survival rate for males was significantly lower than for females (95% confidence level). (95% CI: 95% confidence interval for 5-year relative survival). Reprinted with permission of John Wiley & Sons., Inc. (Funk et al. 2002)

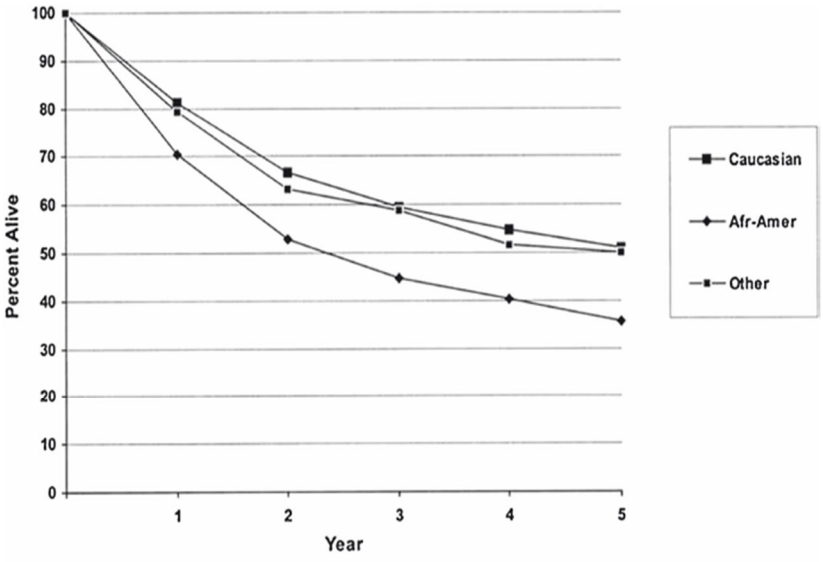
In Western countries, most of the tobacco-related cancers in the aerodigestive tract are related to cigarette smoking, whereas in Southeast Asia, a significant number of cases of squamous cell cancer of the oral cavity result from the use of betel nuts and pan, a mixture of betel nuts, tobacco, and slaked lime wrapped in a leaf.

Cancer of the head and neck was not a very common problem prior to the latter half

of the nineteenth century. The increased incidence of these cancers is linked to the development of the mechanized production of cigarettes in factories. These factories made cigarettes readily available at a low price, which led to widespread addiction and the subsequent increased incidence of cancer of the head and neck (Klein 1996) (Fig. 1.5).

3b. Diagnosis

The diagnostic approach to the mass in the neck depends on a variety of factors including the age of the patient, the time of appearance and the topographic location of the mass, and any associated symptoms. Hayes Martin, the "Father of Modern Head and Neck Surgery" and Chief of the Division of Head and Neck Surgery at the Memorial Sloan-Kettering Cancer Center in New York City stated that in adult patients, the majority of the unilateral masses in the neck are malignant (Martin et al. 1951). By means of a thorough history and physical examination, and with the judicious use of laboratory studies and imaging, an accurate diagnosis can be made in the vast majority of these patients



RACE	1	2	3	4	5	95% CIs	CASES
Caucasians	81	66.6	59.5	54.8	51.1	50.3 / 51.9	24111
African-American	70.5	62.9	44.7	40.1	35.5	33.2 / 37.8	2522
Other	79.4	63.2	58.9	51.5	50.1	44.3 / 56.0	442

Five-year relative survival by race for oral SCC cases, 1985–1991. African-Americans demonstrated significantly lower 5-year relative survival than the other two groups (95% confidence level). (95% CI: 95% confidence interval for 5-year relative survival). (Funk et al. 2002)

3c. History & physical examination

Cancer of the oral cavity does not usually present much of a diagnostic dilemma. It is very important, however, to include the patient's past medical history in order to identify any co morbidities, which might play an important role in determining the management program. The social history is also quite important, because most of the patients with cancer of the oral cavity have been, or currently are, smoking cigarettes and consuming alcohol.

The smoking chorus of cigarette makers, in the 1952 production of Carmen at the Metropolitan Opera, New York (Klein 1996). Reprinted with permission from the University of Nebraska Press

Since surgery is usually the key to successful management of cancer of the oral cavity, it is important for the surgeon to know what quantity of alcohol is being consumed because acute alcohol withdrawal following surgery often leads to delirium

tremens. Prior to the availability of intravenous fluid administration, reliable and easily titrated sedation, and ventilatory support, this condition was often fatal. In the modern era, it is almost always managed successfully but at a very high cost since the patients usually spend 7–10 days on the ventilator in the Intensive Care Unit under sedation until the event has been adequately treated. The dollar cost for such treatment, added onto the costs of the actual surgery and reconstruction, amounts to resources that could have been conserved had the patient undergone a systematic, carefully monitored program of alcohol/withdrawal preoperatively. A subset of patients will develop a similar problem with acute nicotine withdrawal, which is also preventable.

The physical examination remains an important aspect of the initial evaluation. A complete inspection of the oral cavity with palpation of the lesion and surrounding tissues is important and provides a great deal of information as to the surface dimensions of the lesion and the depth of invasion. A tumor map should be created documenting the size and location of the tumor. Examination of the upper aerodigestive tract is vital in determining whether any other primary cancers are present. Palpation of the neck is of vital importance and is fundamental in determining whether the patient's tumor is operable. Fixation of cervical lymph node metastases is a sign of inoperability. Measuring the metastatic lymph nodes is essential for accurate staging. The measurements and location of metastatic nodes should also be documented on the tumor map. It is also very helpful as a baseline in the event the patient is treated non-surgically in order to measure the progress of the treatment program.

3e. Imaging

Imaging plays a vital role in the diagnosis and staging of metastatic cancer in the neck. The most commonly used imaging studies have been computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound (US). A newer modality, positron emission tomography (PET)–(CT), has an expanded

role in the evaluation of the patients with cancer of the head and neck, particularly in identifying cancer elsewhere, both related and unrelated to the cancer of the oral cavity. The role of sentinel node biopsy (SNB), using radioactive imaging techniques, has received a great deal of attention in recent years, and its utility is being evaluated. CT scanning is the imaging modality most frequently used in the evaluation of the cervical lymph nodes. It has been shown to be more sensitive and more specific than physical examination alone (Gavilan et al. 2003). MRI is used somewhat less but remains valuable because it is the best method for evaluation of perineural invasion associated with the primary cancer and gives very good definition to study the extent of cancer invasion into the tongue musculature. Squamous cell carcinoma metastatic in the lymph nodes tends to undergo necrosis, leading to filling defects within otherwise enhancing lymph nodes. Necrosis is more often evaluated with CT rather than MR and should be considered a suspicious finding for metastatic cancer even when the node is smaller than 10 mm (Bennett et al. 2007). Extracapsular spread of cancer may be appreciated on CT scan as a blurring of the margin of the lymph node. Infiltration of the surrounding tissues may also be identified.

Ultrasound is a fast, safe, and inexpensive study that helps in the differentiation of benign from malignant tumors. This is highly operator dependent, but combined with fine-needle aspiration biopsy, the sensitivity and specificity of this test are increased (Gavilan et al. 2003).

Another interesting but not commonly used technique for indications for surgery of the neck is the measurement of tumor thickness of carcinoma of the oral tongue. Yuen et al. concluded that oral sonography has a satisfactory accuracy in the measurement of tumor thickness and is a useful adjunct in assisting pretreatment staging for prognosis and evaluation of carcinoma of the oral tongue (Yuen et al. 2008). Many studies have demonstrated that tumor thickness, rather than the surface diameter, is a more significant factor in predicting subclinical nodal metastasis, local recurrence, and survival in carcinoma of the oral tongue (Yuen et al. 2000, 2002; Kurokawa et al. 2002; Ocharoenrat et al. 2003; Lim et al. 2004; Sparano et al. 2004).

The role of SNB for oral and oral pharyngeal squamous cell carcinoma of the head and neck is still being defined Hart et al. 2007 (Rigual et al. 2005). Stoeckli (2007) studied 79 patients and concluded that SNB is technically feasible and reproducible with the highest sentinel node detection rate. Validation against selective neck dissection revealed a negative predictive value of 100%. Application of the SNB concept in clinical practice was very successful; the recurrence rate within the neck was very low, and the morbidity caused by elective neck dissection could be spared in 60% of the patients.

Ross et al. (2004) also concluded that SNB can be successfully applied to T1 and T2 cancers of the oral cavity and oral pharynx in a standardized fashion by centers worldwide. For the majority of these tumors, SNB technique can be used as a staging tool. At the Second International Conference on the Sentinel Node Biopsy for the Head and Neck Cancer, the delegates from 20 countries discussed technical and clinical aspects and clinical results. Their report confirmed the high accuracy and reliability of SNB for early oral and oral pharyngeal squamous cell carcinoma

3f. Tumor staging of oropharyngeal cancer, stage description

Tis Carcinoma in situ

T1 Tumor < 2 cm in greatest dimension

T2 Tumor > 2 cm but < 4 cm in greatest dimension

T3 Tumor > 4 cm in greatest dimension

T4a Tumor invades any of the following: larynx, deep/extrinsic muscle of the tongue (genioglossus, hyoglossus, palatoglossus and styloglossus), medial pterygoid, hard palate or mandible

T4b Tumor invades any of the following: lateral pterygoid muscle, pterygoid plates, lateral nasopharynx or skull base, or encases the carotid artery

Nodal Staging

The most commonly accepted nodal staging classification for squamous cell carcinoma of the oral cavity is as follows:

Nx: nodes cannot be assessed

N0: no lymph nodes with evidence of metastasis

N1: a single ipsilateral node with evidence of metastasis 3 cm or less

N2a- a single ipsilateral lymph node with evidence of metastasis greater than 3 cm, but not greater than 6 cm in greatest dimension.

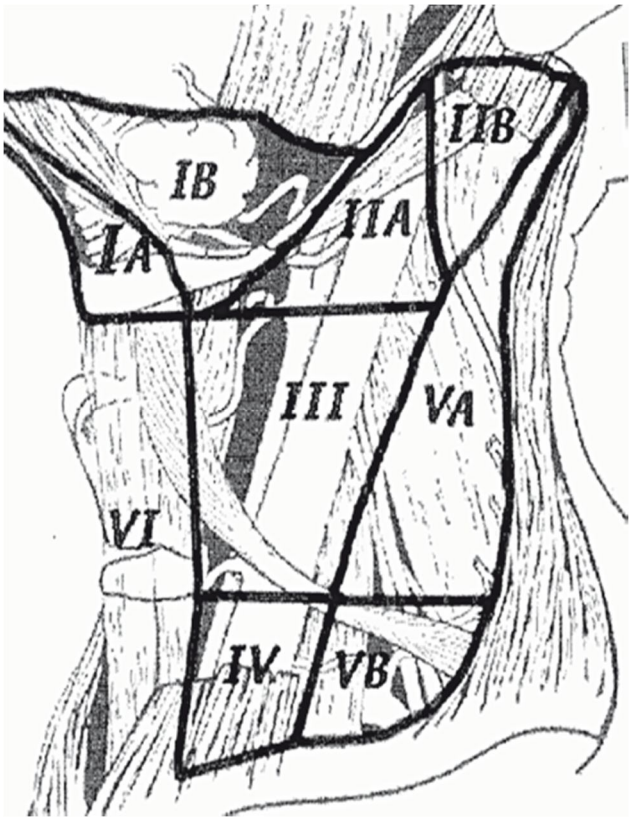
N2b- multiple ipsilateral lymph nodes with evidence of metastasis, none greater than 6 cm in greatest dimension.

N2c- bilateral or contralateral lymph nodes with evidence of metastasis, none greater than 6 cm in greatest dimension. N3- a lymph node with evidence of metastasis greater than 6 cm in greatest dimension.

3g. Nodal drainage patterns

The vast majority of nodal metastases in oral cavity cancer involve levels I, II, and III. For oral tongue cancer, the likelihood of nodal disease is the highest among the oral cavity primary sites. Cancers of the oral tongue that are anteriorly situated tend to spread to nodes in levels I or II. Tumors more laterally or posteriorly situated tend to spread to nodes in levels II and III. Nodal disease from other oral cavity primary sites is less common than from tongue carcinoma but follows a similar pattern. Primary sites that are more anteriorly situated, such as anterior floor of mouth or gingiva, tend to spread to level I or II; primary cancers more posteriorly located tend to spread to levels II and III. In general, there is an orderly downhill, superior-to-inferior spread,

whereby once levels I and II are involved, the tendency to spread then occurs more inferiorly into level IV and so forth. The posterior triangle or level V of the neck is relatively uninvolved in the nodal spread of oral cavity malignancy. Primary lesions that involve or approach the midline (e.g., floor of mouth or oral tongue) are more likely to access the lymphatics bilaterally. While larger lesions and higher N status are generally associated with a greater likelihood and degree of adenopathy, some early-stage, small primary cancers may give rise to a fairly extensive degree of nodal disease



IA Submental

IB Submandibular (outside gland only)

IIA Upper internal jugular

IIB Upper spinal accessory (nodes are separated from the posterior aspect of the vein by a fat plane. For RT planning, the upper level is at the caudal edge of lateral process of C1)

III Mid internal jugular

IV Lower internal jugular

VA Upper level V (posterior triangle around lower portion of spinal accessory chain)

VB Lower level V (posterior triangle around lower portion of spinal accessory and transverse cervical chain)

VI Visceral nodes

4. Surgical techniques for oral & oropharyngeal cancer

4a. Oral cavity cancer

The oral cavity extends posteriorly to the circumvallate papillae of the tongue, the junction of the hard and soft palates, and the anterior faucial arch. The tongue and floor of the mouth are the most common sites of origin for primary squamous cell carcinomas in the oral cavity. Squamous cell carcinoma may be ulcerative and invasive, fungating and exophytic, or both. The diagnostic evaluation consists of the history and the physical examination, histopathological tissue diagnosis and imaging. Evaluation of the deep extent of the primary tumor and of the neck nodes requires the use of imaging.

The mainstay of treatment of early oral cancer is surgery. Radiation therapy alone can be effective for early superficial lesions but side effects such as xerostomia, as well as potential complications at the level of the mandible, make radiation therapy a poor choice. Usually, surgical resection of the primary tumor is preferred, including a neck dissection to remove the neck nodes at risk.

Advanced T3 and T4 lesions are best treated with a combination of surgery and radiation therapy. Improvement in loco regional control of advanced oral cancer is attributable to the addition of postoperative radiation [15,16].

The defect after resection of small tumors can be closed primarily, healing by secondary intention, or a skin graft can be applied over the defect. Larger defects require a free flap reconstruction to separate the oral cavity from the neck dissection and to preserve a maximal amount of function. The forearm free flap is a fasciocutaneous free flap, based on the radial artery and venae comitantes. It consists of thin, pliable skin and a very long pedicle with large diameter. These characteristics have made it a very useful flap for intraoral and pharyngeal defects [17,18].

Surgical resection of the mandible becomes necessary when a primary malignant tumor of the oral cavity directly extends to the gingiva over the alveolar process, or infiltrates into the mandible. If a primary tumor of the oral cavity approximates the alveolar process, then resection of a part of the mandible (“marginal

mandibulectomy"), preserving its arch, is adequate to obtain satisfactory margins around the primary tumor. Mandible reconstruction is not necessary following marginal mandibulectomy.

When resection of an invaded segment of the mandible is indicated, immediate reconstruction of the resected mandible should be considered. The fibula can be transferred as a free osseous or free osseocutaneous flap. The fibula has become the flap of choice for reconstruction of most segmental mandibular defects. The flap is based on the peroneal artery and vein. Because it receives both a segmental and intraosseous blood supply, multiple osteotomies can be made with- out devascularizing the bone [19–22].

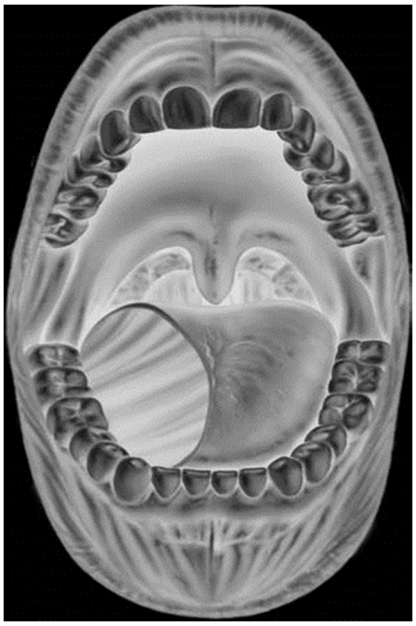
4b. Tumors of the oropharynx

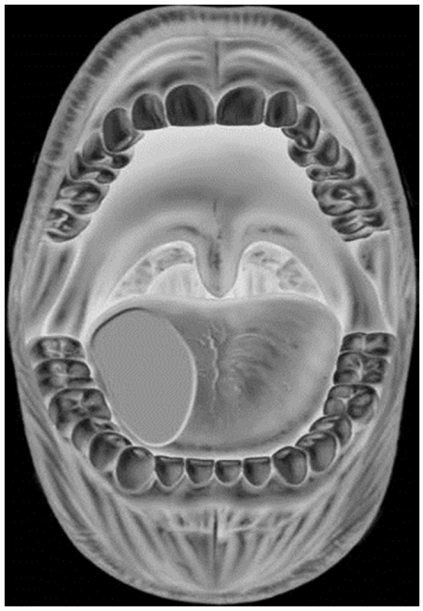
The oropharynx is that part of the pharynx which extends from the level of the hard palate above to the hyoid bone below. Carcinoma of the oropharynx most commonly occurs in the slit between tonsil and base of tongue, at the level of the anterior tonsillar pillar. The initial symptoms of oropharyngeal cancer are often vague and non-specific, leading to a delay in diagnosis. Consequently, the over- whelming majority of patients presents with locally advanced tumors.

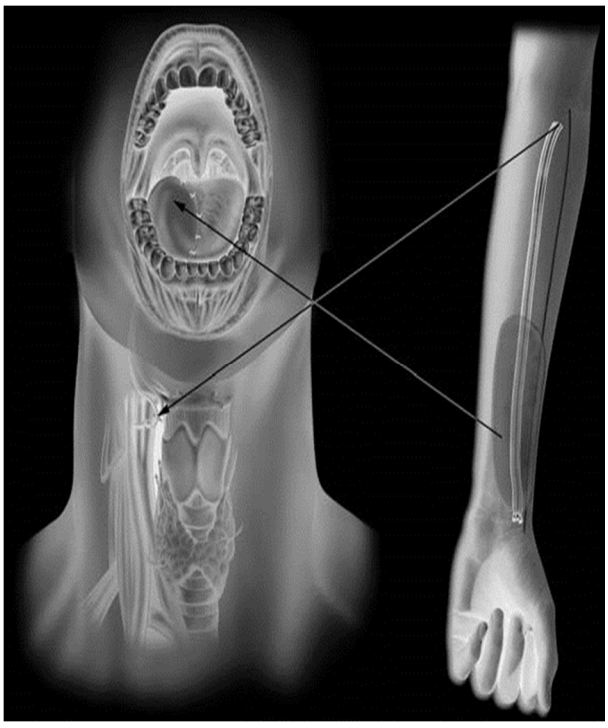
Surgery or radiation therapy, alone or in combination, are currently accepted as standard treatment of oropharyngeal cancer. For most patients, the primary treatment consists of (chemo)-radiation [23–25].

Surgery is usually reserved for residual or recurrent tumor. The surgical approach must afford good exposure, both for accurate and complete resection of the lesion but also for reconstruction of the defect. Mandibulotomy or mandibular osteotomy is an excellent mandible-sparing surgical approach to gain access to tumors of the oropharynx [26,27]. The two halves of the mandible are secured in place using miniplates at the end of the procedure.

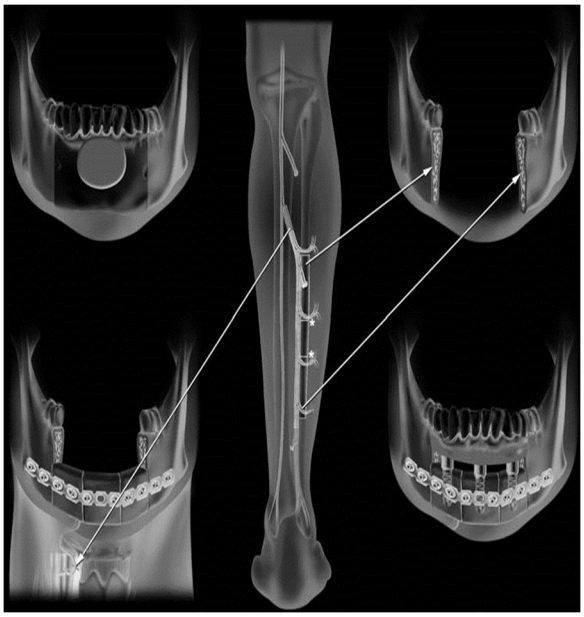
Patients who have had significant surgical resection and reconstruction require a temporary tracheostomy to protect the airway in the postoperative period.



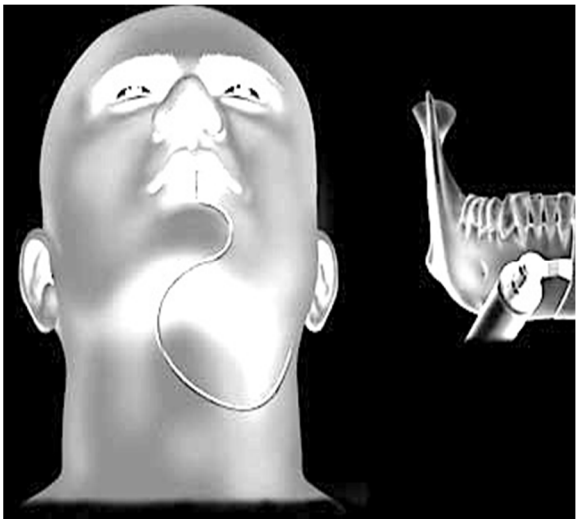


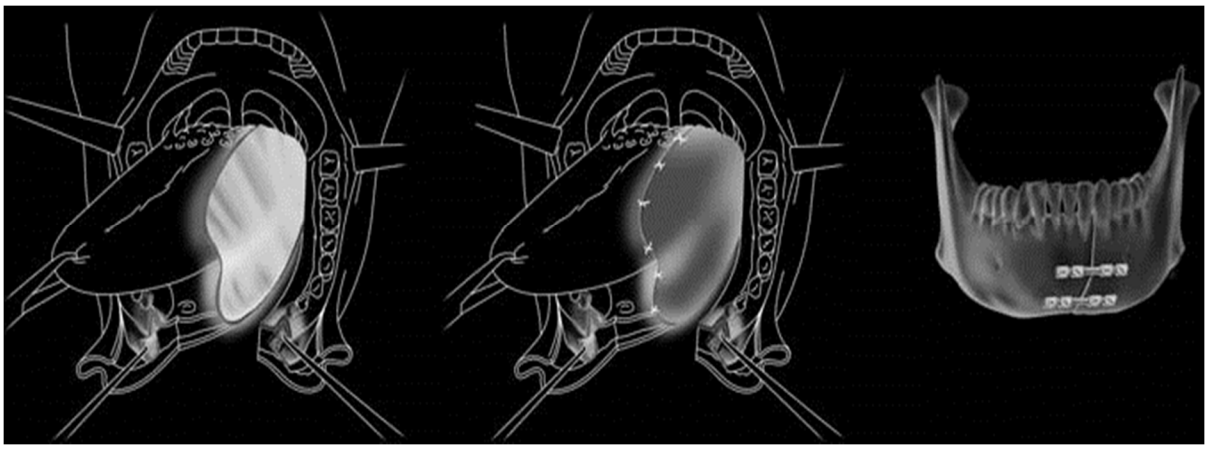


Hemiglossectomy with radial forearm flap reconstruction. (a) The tumor of the oral tongue that requires surgical treatment. (b) The situation after hemiglossectomy. (c) The radial forearm skin (1) is used to reconstruct the hemiglossectomy defect. The radial forearm blood vessels (2) are sutured to the neck vessels to reestablish the blood supply for the radial forearm flap.



Mandible resection with fibular reconstruction. (a) Schematic presentation of resection of the mandibular symphysis for an extended floor of the mouth tumor with extension into the mandibular bone. (b) Fibular bone is harvested with the peroneal artery and vein. It is osteomized (asterisks) to make the bone into the shape of the mandibular symphysis and placed into the anterior mandibular defect (1); the peroneal blood vessels are sutured to the neck vessels (2). (c) Titanium implants can be placed in the reconstructed mandible to restore the dentition.



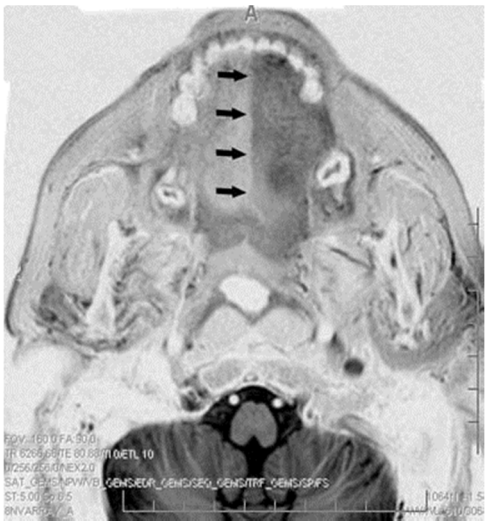


The mandibulotomy approach to tumors of the oropharynx. (a) A paramedian osteotomy (1, 2) can be safely sited between the lateral incisor and the canine teeth to avoid damage or exposure of the dental roots. Incision of the floor of the mouth allows the mandible to be swung out laterally (3) to gain access to the tumor in the oropharynx. (b) Free radial flap reconstruction of the surgical (1, 2) defect after partial resection of the base of the tongue and tonsil. The mandibular osteotomy is fixed using miniplates (3), which provide accurate dental occlusion and stability. Color version in plate section.

4c. Base of tongue

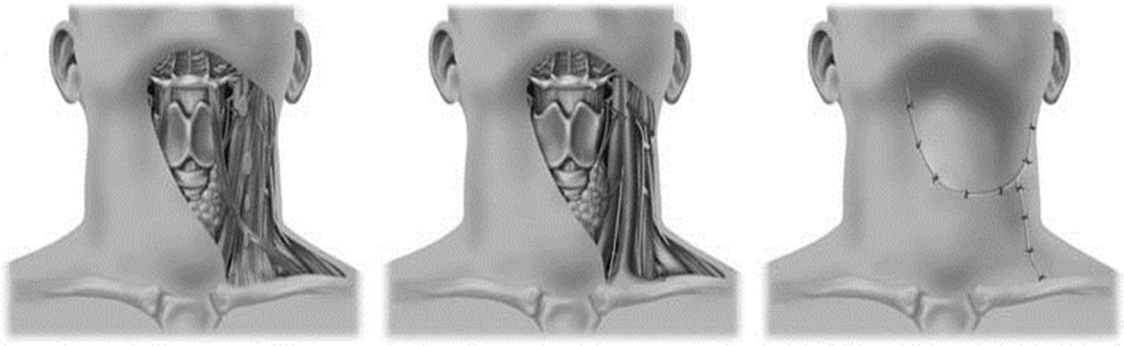
The tongue base that area of tongue posterior to the circumvallate papillae and down to the vallecula, bounded laterally by the glossopharyngeal sulcus is also a very common site of malignancy. As with tonsil cancers, these may be very subtle or massive and invasive. They may be superficial/exophytic or extend submucosally. Sites of adjacent spread include anteriorly into the deep oral tongue and floor of mouth), laterally via the glossopharyngeal sulcus into the pharyngeal sidewall and inferiorly into the supraglottic structures (epiglottis and aryepiglottic folds). The glossopharyngeal sulcus, the junction of the lateral tongue base and pharyngeal wall, deserves special mention

A 39-year-old woman with oral tongue carcinoma and a suggestion of extension to the floor of mouth. (a) Axial post-contrast CT shows an obvious enhancing mass in the left lateral oral tongue (arrows). (b) At a more inferior level, imaging shows the suggestion of extension to the left floor of mouth (arrows), but the floor of mouth was uninvolved clinically and at surgery. This was probably a tumor along the lateral and perhaps ventral tongue surface, but radiographically was inseparable from the floor of mouth



Advanced base of tongue carcinoma in a 46-year-old man presenting with otalgia and dysphagia, followed by left-sided tongue weakness. (a) Axial T_2-weighted MRI shows a hyperintense mass in the tongue base (arrows). Bilateral upper internal jugular nodal metastases are visible. (b) The same sequence at a slightly more superior level demonstrates deep anterior submucosal extension into the sublingual space (asterisk), resulting in hypoglossal paralysis. (c) The T_2-weighted MRI shows signal hyperintensity in the left hemitongue, indicating subacute denervation. Note how this respects the midline (arrows)

5. Surgical Neck Dissection



Modified radical neck dissection. The spinal accessory nerve is preserved.

There are many excellent descriptions of techniques for neck dissections that are available. However, there are two areas of controversy as to what levels should be included in the selective neck dissection. These include the dissection of sublevel IIB (submuscular recess) and the dissection of level IV. Paleri et al. studied a series of 903 patients identified in 14 articles with 903 necks suitable for inclusion (Paleri et al. 2008). The overall incidence of metastatic disease at sublevel IIB in patients with cancer of the oral cavity is 3.9% (11 of 279). Contralateral positive nodes and isolated metastasis to this level were rare. Their conclusion was that there was no advantage in performing submuscular dissection (of sublevel IIB) in the contralateral neck or in cancer of the larynx. The primary concern in dissecting sublevel IIB is the potential for injury to the spinal accessory nerve, with associated pain, and shoulder dysfunction. Since oral cavity and oropharyngeal primary cancers have an incidence rate of metastasis to sublevel IIB of 4–5%, Paleri's recommendation is that this sublevel should be dissected in the setting of oral cavity and oropharyngeal primaries. An alternative suggestion based on the observation that "if it is evident that the patient will need postoperative radiation on the basis of the primary cancer, dissection of sublevel IIB can be avoided and subclinical metastasis can be treated adequately with radiation therapy."

Another controversial site is level IV. Byers, in 1997, reported finding "skip metastasis" to lymph nodes in level III and or level IV in 15.8% of the patients with cancer of the oral tongue (Byers et al. 1997). As a result of this study, the authors recommended removal of the lymph nodes of level IV whenever an SND is performed on any patient with cancer of the oral tongue. Medina (Khafif et al. 2001), however, recently published the results of a study undertaken to determine the incidence of occult metastasis to lymph nodes in level IV in patients with cancer of the oral tongue with N_0 neck to determine the efficacy of a clinical practice in which these lymph nodes were not routinely removed during elective dissection for cancer of the tongue. The authors concluded that occult nodal metastasis to level IV for patients T1–T3 N_0 cancer of the oral tongue was 4%. Dissection of these nodes only when there is intraoperative suspicion of metastasis to level II or III does not increase the risk of recurrent tumor in the neck.

Shah et al. studied RND specimens performed electively for cancer of the oral cavity and found metastasis in level IV lymph nodes in 3% of the patients (Shah 1990). Medina argued that extending a supraomohyoid neck dissection to include the lymph nodes at level IV is a relatively simple maneuver that prolongs the operation by only a short period of time. However, exposure to that region through a high cervical incision, which they use for their SNDs, is awkward and increases the risk of a chylous fistula. The majority of surgeons favor the elective neck dissection rather than the wait-and-see policy by observation. This should include levels I, II, III, and IV in all cases of oral cavity cancer, particularly with cancer of the oral tongue. The idea of only doing a neck dissection in cases with 15–20% possibility of metastasis is a form of gambling with the patient by playing the odds. After all, for the surgeon, the percentage of positive nodes may be small, but for the patient who is one of Medina's, 4% is actually 100%. Because there is an incidence of metastasis to level IIb and IV, albeit a small one, not removing the lymph nodes in that area is similar to the obsolete method of "watch and wait," which it is cited over and over again in this chapter, being inadequate treatment instead of doing an elective neck dissection. As long as there is any incidence of metastasis to the sub- site, the subsite should be dissected carefully and the potential lymph node metastasis removed, particularly since so little extra time and effort is necessary. Naturally, caution must be exercised to avoid injury to the spinal accessory nerve and thoracic duct.

6. Robotic Surgery

6a. Historical data, an overview

Following their creation in fiction, robots have invaded the industrial and military worlds. The Czech writer Karel Capek in a science fiction play called Rossum's Universal Robots (RUR) used the word robot for the first time. Capek is recognized as having created science fiction well before it became a literary genre in its own right. In RUR, the author imagined a future in which all workers are automats that only revolt once they have acquired a soul and become ''human''.

After being developed on industrial assembly lines, robots such as drones now play an essential role in war zones. In the medical field, the first robots were developed in rehabilitation medicine to help disabled patients. Robotic surgery was initially developed in the field of neurosurgery because of the rigid structure of the skull providing stable anatomical landmarks. Stereotactic surgery has been extensively developed since the beginning of the 1990s. Otological surgery also constitutes a field of robotic experimentation especially for stapedectomy.

Robotic surgery was first developed by the American armed forces. In the 1980s, in order to perform remote- controlled surgery on soldiers, the American armed forces, in partnership with Stanford University, California, developed a research programme that gave birth, in particular, to a start-up called Intuitive Surgical Inc. During the 1990s, three main types of robots were developed: Aesop and Zeus by Computer Motion Inc. and Da Vinci by Intuitive Surgical Inc. Intuitive Surgical Inc. subsequently acquired Computer Motion and currently has exclusive worldwide marketing rights.

The first surgical operation assisted by the Da Vinci robot, laparoscopic splenectomy, was performed in 1997. This procedure was followed by other applications: gas-trectomy, splenectomy, and oesophagectomy. Clinical studies demonstrated the feasibility of using a robot in these surgical procedures, but with no real benefit in terms of operating time, length of hospital stay, quality of surgical resection and quality of life for the patient compared to conventional laparoscopic surgery. Various

disadvantages were reported: the cost of robotic surgery and the absence of tactile feedback preventing tactile control by the surgeon. The advantages were excellent vision in three dimensions and manipulation of instruments in three dimensions. The Food and Drug Administration approved the use of the Da Vinci robot for use in laparoscopy in 2000. Robotic surgery was progressively developed in urology, gynaecology, and thoracic surgery. Robotic surgery has occupied an important place in urology since the first prostatectomy performed in France by Professor Abbou's team at Mondor University Hospital in 2000 [36]. A study showed that robotic surgery allowed a more favorable postoperative course with decreased bleeding, decreased pain and a shorter length of hospital stay. Almost 65% of radical prostatectomies in the United States are now performed with the Da Vinci robot.

6b. The Da Vinci robot

Use of a robot allows the surgeon to perform more complex operations than would be possible by conventional laparoscopic surgery. Robotic surgery has several advantages: a) three-dimensional vision versus two-dimensional vision in conventional laparoscopic surgery; b) stable vision, as the camera is maintained and mobilized by one of the articulated arms of the robot c) more precise and finer instrument control with greater freedom of motion in all three dimensions d) suppression of physiological tremor e) finally, the surgeon is seated in the axis of the console, ensuring more favorable ergonomic conditions. In practice, the surgical robot is used to control endoscopic instruments during surgical procedures. The robot is composed of three elements: a surgeon console with an integrated three-dimensional stereoscopic viewer, a patient-side cart comprising robotic arms and a vision system. The surgeon is seated in front of the console and operates instruments by means of the two master controls. The surgeon's head rests between infrared sensors on either side of the viewer providing a magnified three-dimensional stereoscopic view of the operative field. The extremities of the instruments are aligned on the display screen by the master controls to ensure natural and predictable movements of the instruments.

The surgical robot allows real-time and direct control of instrument movements by the surgeon. It uses a kinematic system (based on the principles of articulated movements) allowing the surgeon to use open surgery techniques via the console.

These open surgical techniques are instantaneously converted into minimally invasive surgical techniques at the surgical field. The robot provides the surgeon with access to the surgical field via small incisions without compromising dexterity, precision and the natural movements required for open surgery. The electronic components of the robot allow scaled reduction of movements of the surgeon's hand, reducing hand movements to proportionally smaller movements of the extremity of the instrument in the surgical field. Robotic instruments have a total of six degrees of freedom. Various adjustments allow the surgeon to optimize scaled reduction according to various clinical applications. Physiological tremor of the surgeon's hand is eliminated by an electronic filtering system ensuring stable and predictable instrument control.

However, the main disadvantages of the Da Vinci robot are its cost and the absence of tactile feedback, i.e. the surgeon has no tactile sensation and cannot distinguish a flexible structure from a firm or hard structure. However, the excellent quality of vision (×10) compensates for the absence of tactile feedback. The second disadvantage is the cost, which comprises several variables: purchase of the robot, maintenance and the purchase of specific material for limited use.

6c. Use of the Da Vinci robot in Head & Neck Cancer

Transoral Robotic Surgery is a novel group of techniques first developed at the University of Pennsylvania. It is defined as a surgical approach for benign and malignant lesions of the oral cavity and laryngopharynx. It involves placing a minimum of three arms of the Da Vinci surgical robot system into the oral cavity with oral retractors. The TORS en-block surgical approach is not only a primary modality of therapy but it also provides important information regarding pathologic tumor attributes that is useful to determine the need for subsequent adjuvant therapy. To date the main oncologic indication for TORS has been the minimally invasive transoral resection of Oropharyngeal Squamous Cell Carcinomas (OSCCs). Local control has been exceptionally high as 98% in a recent report of patients with advanced OSCC treated with TORS.

Before being used in head and neck cancer, the Stanford team demonstrated that the Da Vinci robot could be used in animal models (pigs) to perform resection of the sub-mandibular gland, thyroid gland and for neck dissections [37]. The only complication was postoperative subcutaneous emphysema.

Initially developed in the United States essentially by the University of Pennsylvania team and then by other teams, Da Vinci robotic surgery has been shown to be an efficient tool for exposure and resection of tumors situated in head and neck anatomical sites with difficult endoscopic access. The first studies performed in animals, dummies and human cadavers were published in 2005 [28—32]. They validated application of robotic surgery to the head and neck in terms of feasibility (sharing of the airway with anesthetists), exposure, haemostasis, resection, and transoral sutures. For example, the University of Pennsylvania team showed that the use of 5 mm instruments compared to 8 mm instruments allowed improved vision, greater ease of use and a shorter operating time [32]. Animal models were also used to perform anatomical studies for skull base surgical incisions (anterior and midline). However, the transoral route could not be used to resect the following regions: nasopharynx, clivus, sphenoid and the pituitary region [38], but provided good access to the parapharyngeal space in animals [39]. In human cadavers, the same authors demonstrated the feasibility of access to the skull base by a combination of cervical and transoral routes [38]. In another cadaver study, Hanna et al. described an approach to the skull base via antrotomy and resection of the posterior part of the nasal septum allowing control of the cribriform plate of the ethmoid, sella turcica, nasopharynx and clivus [40]. In 2008, Ozer and Waltonen proposed an incision through the soft palate for resection of nasopharyngeal lesions [41].

Cadaver studies demonstrated the feasibility of robotic surgery in various anatomical sites. They also allowed surgeons to acquire the various skills required for exposure, resection and transoral suture. Several Da Vinci robotic surgery training courses are now available in France and other countries.

These experimental studies were rapidly followed by studies in patients with head and neck cancers in various sites, essentially the oropharynx and larynx [33—35]. These studies showed that the three-arm robot was perfectly adapted to resection of head and neck cancers.

The first procedure using the Da Vinci robot in man, consisting of transoral resection of a vallecular cyst was published in 2005 by McLeod and Melder [42]. Installation of the robot took 75 minutes and the surgical operation lasted 30minutes. The postoperative course was uneventful. In 2006, O'Malley et al. reported a prospective clinical trial evaluating use of the Da Vinci robot in three patients with a tumor of the base of the tongue [6]. The authors stressed the value of the FK retractor for exposure and the ease of use of the instruments ensuring negative surgical margins in all three patients. No intraoperative or post- operative complications were observed. In 2007, the same team published the preliminary results of two prospective trials of supraglottic laryngectomy and radical tonsillectomy [33,35]. Weinstein et al. reported the results observed in three patients with supraglottic laryngeal cancer treated by transoral robotic surgery using the Da Vinci robot [35]. Solares et al., also in 2007, reported a series of three patients, in whom transoral robotic surgery was possible for only one patient [43], with inadequate exposure for the other two patients. The limitations of TORS related to inadequate transoral exposure were also emphasized by Rahbar et al. in a series of five children with laryngeal cleft. Adequate exposure could not be achieved in three patients. No post- operative complications were observed in the two children operated successfully [44].

Two recent publications reported free flap reconstruction after resection of head and neck cancer. Robotic surgery avoided the need to resect the mandible [45,46]. Use of the CO_2 Laser on one of the robotic arms has been described, especially for supraglottic laryngeal tumors [43,47]. The contribution of an imaging-guided system (resembling neuronavigation) for tumors of the parapharyngeal space was reported by a New York team [48].

In practice, in head and neck cancer, the surgical robot is positioned to the right or to the left of the patient, in a strictly supine position on the operating table. The axis of the robot is at an angle of 30° to the operating table. The patient is intubated according to usual modalities with a standard endotracheal tube. The first stage of the operation consists of exposure. A Mersuture® 0 or 1 (Ethicon®) suture is systematically inserted in the midline of the mobile tongue to retract the tongue out from the oral cavity. Exposure of the lesion requires the use of various types of retractors. Exposure of lesions of the oral cavity requires a simple mouth gag and the

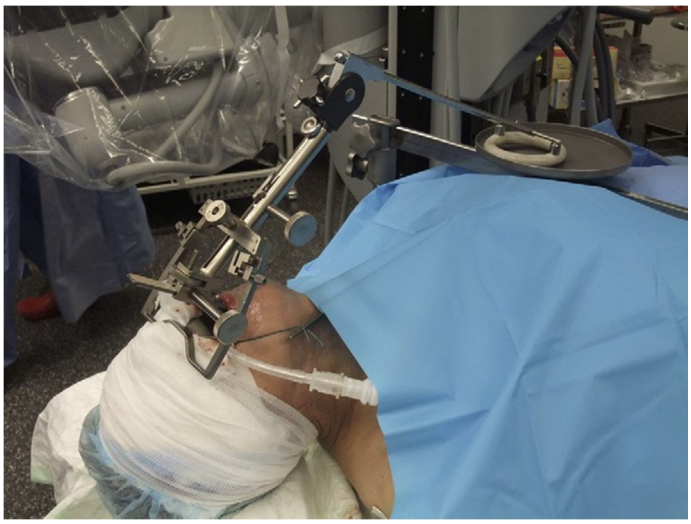
FK-Retractor® is always used for lesions of the larynx and hypopharynx, while a Boyle-Davis® retractor can be used for certain oropharyngeal tumors. The 30° video-endoscope is always used to visualize the larynx and/or hypopharynx, and we also generally use the 30° video-endoscope, rather than the 0° video-endoscope, for the oropharynx. Like other authors, we use 5 mm instruments. For all TORS procedures, the right robotic arm is equipped with 5 mm monopolar electrocoagulation and the left robotic arm is equipped with Maryland dissector® forceps; the camera is fitted on the central arm. Robotic arms are usually inserted transorally. The lesion is exposed.

Correct positioning of the robotic arms is essential; zones of least constraint must be located allowing free, unobstructed movement of the robotic arms. The surgeon operates from the surgeon console according to the modalities of robotic surgery. A second surgeon is systematically placed at the patient's head to aspirate smoke, blood and to facilitate exposure of certain anatomical structures. A clip forceps (Ethicon®) is always prepared. Patients are systematically monitored in the recovery ward for the first 24 hours.

Surgeon console

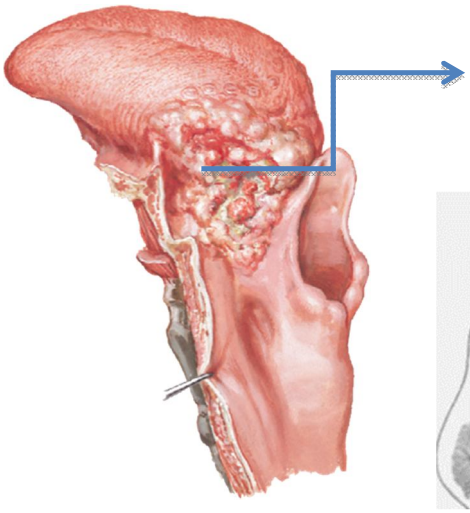
Patient-side cart with robotic arms. Surgical instruments and the camera are fitted onto robotic arms and are then introduced transorally. An assistant is always placed at the patient's head as a safety measure and to aspirate smoke and blood.

The vision system allows operating room personnel to visualize the surgical procedure

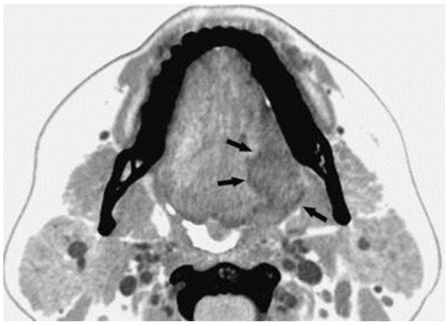


Endotracheal intubation according to the usual modalities. The FK-retractor allows exposure of laryngeal and pharyngeal lesions. Instruments fitted onto robotic arms are then introduced transorally

7. Transoral Robotic Surgery for Base Tongue Tumors



SCC of base of the tongue



7a. Set Up & Basic Surgical Steps

The general anaesthesia required for the procedure follows the same principles as for any other that is not performed through robotic surgery.

For induction to anaesthesia propophol is used and/or midazolam and endotracheal intubation is performed. An inhalational agent such as isoflurane is used for maintenance of the anaesthesia effect.

It is essential to remark that the neck dissection whenever that is necessary is performed and then follows the set up of the robotic system and the resection en block of the tumor.

The set up follows the same principles as for the other surgical procedures that are performed through the robotic system. Generally it is preferred the endoscopic three dimensional camera that is 30 degrees angulated than that one of 0 degrees and that is because of the fact that the base of the tongue and the glossoepiglottic lacunae and valleculae are better visualized with that of 30 degrees.

The camera is passed through the retractors and it is forwarded till the posterior pharyngeal area pushing the posterior pharyngeal wall for better access and evaluation of base of the tongue and the surrounding structures. There are many kind of retractors that are available for use. Dingman, Crowe Davis and Feyh-Kastenbauer (FK) retractor are the most commonly used. Each one has its advantages and disadvantages.

The Crowe Davis is commonly used in tonsil surgery, is easy and quick to apply and has either an open left or right instrument border that allows greater lateral excursion of the robotic instruments. Unlike the Dingman or the FK retractor the Crowe Davis does not have a spring or articulating mechanism on its lateral ends that allows either sutures to be attached or lateral cheek or tongue retractors to be applied. The Dingman retractor has springs located on each side that allows various positioning of sutures for palate or tongue retraction. However the working space defined by the circumferential rectangular metal frame is somewhat limited for broad robotic instrument movement.

The FK has a wider rectangular opening and is thus less limiting than the Dingman and it has two small articulating clamps that allow various tongue or cheek retractors to be attached and manipulated. Furthermore the FK has a broad range of anterior and dorsal tongue blades including blades that facilitate exposure and right or left base of tongue retraction. The primary robotic instruments that are used either 8mm or 5mm in width (Endowrist, Intuitive Surgical) and they are consisted of a forceps , a bipolar cautery in conjunction with the permanent cautery spatula.

The assistant surgeon is located next to the patient holding a suction for smoke , blood and saliva maintaining always clear the surgical field.

As the procedure of en block resection of the tumor starts and goes on it is worth of mentioning that there are plenty of ways to resect the lesion. The surgical team of the University of Pennsylvania is proposing developed a technique that involves exposing the junction of epiglottis and base of tongue initially using the open laryngeal blade and then making the vallecular cuts at the first component of the surgery. Then the retractor is readjusted by using the adjustment mechanisms built into the FK retractor or the cutout tongue blades are switched to make the superior and lateral cuts and then the operation is completed. The advantage in this technique is that as the inferior limits are defined and are cut this is believed that aides in both maintaining appropriate depth of resection and adequate margin resection while the risk of inadvertent injury to the epiglottis such as transaction or mucosal stripping is reduced. The en block resection with clear deep margins is achieved by connecting the superior cuts to the inferior cuts at the depth defined by these initial tissue incisions and using the excellent three dimensional visualization offered by the robotic optics. Important anatomic landmarks that the surgeon should always bear in mind are the lingual artery that is identified approximately 1 cm medial to the posterior lateral base of tongue border and 1,5-2 cm deep into the musculature , the glossopharyngeal nerve that is also identified medial to the lingual artery and the hypoglossal nerve that is almost 1 cm deep to the lingual artery.

At the end of operation a tracheostomy is usually performed especially in cases where an edema of the tongue or of the larynx is suspected or mentioned during or at the end of the operation.

So far after completion of the surgery no inadvertent trauma or injury to the lips, teeth, gums or cheeks has reported and effectively haemostasis has performed whenever necessary through the cautery/bipolar cautery reducing the risk of post operative hemorrhage approximately to zero. All the patients are followed for 24 hours at the postoperative anesthetic unit.

The average hospital stay is almost 3,6 days (range 1-7 days) and the average intraoperative blood loss is almost 88ml (range 10-500ml). So far no operation of that kind has converted to open resection and the average surgical time was ranged from 31 to 152 minutes [50].

7b. Post-Operative follow up

It is recommended that patients continue using their Percutaneous Endoscopic Gastrostomy tube (PEG) to provide efficient nutritional intake until full solid foods could be reintroduced into the diet. All patients are able to eat a full solid diet by way of mouth without any PEG supplement within approximately 6 weeks after the surgery. It is reported only one case of postoperative bleeding at the time of appointment (12 days post-op) during the time of indirect laryngoscopy that underwent successful transoral coagulation of the bleeding with no sequelae.

8. Reconstruction & functional aspects of the oropharynx

Intact neuromuscular anatomy of the oropharynx is pivotal for normal speech and swallowing. Alteration of oropharyngeal anatomy following surgical resection of tumors may affect both functions. Neurological damage to cranial nerves as a consequence of surgery or radiation, as well as scarring and fibrosis from surgery and adjuvant therapies can have devastating functional sequelae. A good reconstructive paradigm should anticipate these potential consequences and minimize morbidities surrounding treatment.

During the oropharyngeal phase of swallowing, the bulk of the base of tongue combined with a relaxed upper esophageal sphincter allows propulsion of food into

the esophagus. A competent velopharyngeal sphincter prevents reflux of food boluses and liquid into the nasopharynx. The velopharyngeal sphincter is complex and has variable closure patterns.

During speech, an intact velopharynx prevents escape of phonatory efforts into the nasal cavity resulting in rhinolalia aperta. Similarly, bulk of the tongue base as well as the vibratory properties of oropharyngeal mucosa are important in articulation and maintaining the resonance of speech.

One advantage of the transoral robotic approach to oropharyngeal tumors is that it obviates damage to the extrinsic laryngeal muscles required for laryngeal elevation. The digastric, geniohyoid, and mylohyoid muscles are often disturbed during mandibular swing approaches. This has implications both for speech and for swallowing. However, without appropriate reconstruction, many of the physiologic disturbances following TORS are similar to more invasive approaches. Resection of tonsillar, pharyngeal, and palatal tumors can affect velopharyngeal function. Resection of tongue base neoplasms may affect swallowing function. Deeply invasive pharyngeal tumors, which require aggressive resection, can compromise the barrier between the pharynx and the neck. Simultaneous neck dissections can result in iatrogenic fistulae, which need to be addressed surgically.

9. Reconstructive classification systems for oropharyngeal defects

Currently, there are several reconstructive classification systems that categorize defects in the oropharynx. These are all based on defects created from open approaches. The limitation with these classification systems is that they are not used to guide treatment. The salient feature in all of these classification systems is size-based and subsite-based reconstruction. However, there are other considerations that are important when deciding on reconstruction

9a. Reconstructive algorithm for transoral robotic surgery oropharyngeal defects

In deciding how to reconstruct oropharyngeal defects following TORS, the reconstructive goals include both structural and functional considerations.

Structural considerations are

(a) creating an anatomic barrier between the neck and the pharynx

(b) ensuring adequate coverage of the carotid artery.

Functional considerations are

(a) restoring swallowing function

(b) preserving speech and articulation

(c) preventing aspiration

(d) maintaining velopharyngeal competence.

In order to achieve these goals, the choice of reconstruction varies by the type of defect. The Classification for Oropharyngeal Robotic Defects (CORD) system is developed for that purpose and it is guided by the above functional and structural goals, and guides treatment. Using the CORD system, defects are divided into one of four classes with increasing complexity and increasing need for more advanced reconstructive procedures. The features considered within this classification system include number of oropharyngeal subsites involved, location of the defect, size of the defect, exposure of carotid artery, and pharyngocervical communication.

Class I defects

Class I defects include any one subsite of the oropharynx without any complicating

features such as carotid artery exposure, pharyngocervical communication, or extensive palatal defect (>50%). Given the relative simplicity of these defects, the majority of these defects are typically left to heal secondarily. These defects typically remucosalize with minimal functional morbidity. For tongue base defects, exposed deep intrinsic tongue muscles serve as the substrate for remucosalization. For posterior pharyngeal defects, the prevertebral fascia is the substrate over which mucosa may grow. After pharyngectomy, fat from the parapharyngeal space provides good vessel coverage and also a surface for epithelialization. Small defects of the palate, how- ever, may require a simple suture to close the free edge of the remaining palate to the posterior pharyngeal wall, thus closing the enlarged nasopharyngeal aperture. The goals of this closure are to minimize nasal regurgitation of food as well as rhinolalia aperta.

Class II defects

Class II defects are similar to class I defects in that they have no complicating features; however, they are more advanced in that more than one subsite is involved. This usually involves two adjacent sub- sites of the oropharynx. The principles of management of these defects are similar to that of class I defects. Rarely do class II defects require a regional or free flap for reconstruction. Defects involving the tongue base extending into the tonsil are often left to heal secondarily. For defects of the tonsillar– palatal complex, a local musculomucosal flap may be used to seal the nasopharyngeal port. This flap is typically based on the mucosa and the superior constrictor muscle of the posterior pharyngeal wall. A monopolar cautery or contact laser is typically mounted in one of the robotic arms and used to raise this flap in the submuscular plane carefully to avoid potential injury to the internal carotid artery. This flap can then be rotated toward the posterior edge of the palate and sutured in order to reduce the size of the nasopharyngeal port. The advantage of this local flap is that it is theoretically a neurotized flap and can preserve the dynamic function of the constrictor muscles during swallowing

Class III – IV defects

Class III and IV defects are differentiated from class I and II defects by the presence of (1) >50% of palate defect, or (2) intraoperative communication of the pharynx and neck, or (3) exposure of the carotid artery in the pharynx. Class III defects are similar to class I defects in that only one subsite is involved. And class IV defects are similar to class II defects in that more than one subsite is involved.

9b. Large volume base of tongue defects

Aspiration following treatment of oropharyngeal cancer is a consequence of several predisposing factors. The degree of tongue base resection, the type of reconstruction, and a history of radiation may all predispose an individual to impaired swallowing It is stated that the degree of tongue base resection, use of mandibular osteotomy for exposure, history of radiation therapy, and sacrifice of hypoglossal nerve were all risk factors for aspiration in univariate analysis. In multivariate analysis, only radiation therapy and volume of tongue base resection were independent risk factors for aspiration.

Preventing aspiration is a delicate balance between oropharyngeal sensation and tongue base volume. In a case – control study of oral cavity and oropharyngeal defects treated with either primary closure or free flap reconstruction, one group showed that patients with primary closure had better swallowing parameters than those undergoing free tissue transfer. This was a small study, however, with only nine matched pairs. Finally, placing a free flap to resurface an isolated tongue base lesion requires an additional pharyngotomy to deliver vessels into the neck. This pharyngotomy requires coverage to prevent an iatrogenic fistula and further injures swallowing musculature. For these reasons, many surgeons prefer not to reconstruct large volume tongue base defects [49].

10. Discussion

Over the past 10 years there have been increasing reports of use of primary radiation or combined chemotherapy and radiation for tongue base neoplasms.. The key factor driving this movement away from primary surgery was the reported morbidity of such surgical procedures. Cervical incisions and dissections with mandibulotomy or pharyngotomy were typically required to remove base of tongue neoplasms even in the early stages. These approaches left the patient with various levels of significant speech and swallowing dysfunction as well as cosmetic deformity depending on the size and location of the tumor and extend of resection. Nonetheless combined chemotherapy and radiation is also associated with significant to severe speech and swallowing dysfunction along with varying degrees of chronic pain and xerostomia.

The introduction of endoscopic laser microsurgery for tongue base cancer has been very promising but the its very demanding technique its steep learning curve and the limited operating field of view as it is performed through laryngoscope filled the scientific world with concerns and doubts for its efficacy.

TORS technique for tongue base tumors appears to have more advantages over the open surgical technique and endoscopic CO2 Laser microsurgery. TORS eliminates the need for mandibulotomy with lip split or visor flap or transpharyngeal approaches that adversely affect swallowing, mastication increasing the incidence of aspiration pneumonia and dysphonia.. Furthermore the open procedures have increased incidence of fistulas and infections as they are creating communication from the oral cavity through the neck. Additionally it seems finally that tracheostomy is not needed especially for T1-T2 base tongue tumors as even some that were performed prophylactically were decannulated after the first two postoperative days [50].

The limited intraoperative blood loss and hospital stay and the early feeding for liquids and solid food render TORS as the most promising technique for base of tongue neoplasms rather than laser endoscopic microsurgery. Though that there are still limited data regarding the learning curve it appears that TORS is more easy to be taught than the other techniques. The fact that TORS is two-handed technique with three-dimensional stereotactic view contrary to Laser microsurgery that is one handed technique and there is not stereotactic view explains easily the efficacy of TORS

rather than that of Laser microsurgery pharynx and base of the tongue.

Performed TORS in T1 and T2 base tongue tumors has so far achieved an overall 98% of free margins in all en block resections as it is reported from the majority of the surgical teams that appear to be Centers of reference for this procedure. In December of 2009 the FDA approved the use of the Da Vinci surgical system to perform TORS for selected malignant lesions of the throat and voice box as well as all benign disease.

In conclusion TORS holds promise for human clinical application and may prove valuable as a minimally invasive and low morbidity primary therapy for base of tongue neoplasms.

11. Abstract

Head and neck surgical science has developed dramatically during the past 20 years with a major focus on organ preservation surgery. Among these organ preserving surgeries are the selective neck dissections, supracricoid partial laryngectomies, transoral laser surgeries, and now a newcomer, transoral robotic surgery utilizing the Da Vinci surgical system. Transoral robotic surgery is a relatively new technique that provides several unique advantages, which include a 3-dimensional magnified view, ability to see and work around curves or angles, and the availability of 2 or 3 robotic arms that can be used to reconstruct extensive defects using either local, regional, or free flaps. Preliminary data suggest that transoral robotic surgery may provide a technique for ablation and reconstruction of pharyngeal defects that may be superior to other transoral techniques TORS decreases the number of tracheotomies, and allows more rapid swallowing rehabilitation and a shorter length of hospital stay. Technical improvements are expected. Smaller, more ergonomic, new generation robots, therefore more adapted to the head and neck, will probably be available in the future

Περίληψη

Η χειρουργική της Κεφαλής και Τραχήλου τα τελευταία 20 χρόνια έχει γνωρίσει ιδιαίτερη ανάπτυξη με κυριότερο σημείο-χαρακτηριστικό την όσο το δυνατόν περισσότερη διατήρηση ανατομικών δομών στα πλαίσια των αρχών που διέπουν την ελάχιστα επεμβατική χειρουργική. Μεταξύ αυτών των τεχνικών είναι ο τραχηλικός λεμφαδενικός καθαρισμός μερικές υπερκρικοειδικές λαρυγγεκτομές, δια του στόματος χειρουργική με laser και πρόσφατα η ρομποτικά υποβοηθούμενη δια του στόματος εκτομή νεοπλασιών βάσης γλώσσας. Είναι μια νέα τεχνική η οποία συνδυάζει αρκετά θετικά στοιχεία όπως την τρισδιάστατη αίσθηση της όρασης, την χρήση 2 ή και 3 ρομποτικών βραχιόνων, τα οποία είναι σε θέση να εξαιρέσουν σε υγιή όρια αλλοιώσεων χάρη στην δυνατότητα των 6 βαθμών ελευθερίας κίνησης που διαθέτουν. Ο μειωμένος αριθμός τραχειοτομιών, η μικρή πλέον ενδονοσοκομειακή νοσηλεία, η μειωμένη διεγχειριτική απώλεια αίματος και ο γρήγορος χρόνος αποκατάστασης και διατροφής την καθιστούν πλέον μια πολλή ιδιαίτερη και πολλά υποσχόμενη τεχνική.. Όλο και περισσότερες καινοτομίες και βελτιώσεις μας επιφυλάσσει αυτή η τεχνική και είναι πλέον εφικτή η δημιουργία όλο και νεότερης γενιάς ρομποτικών συστημάτων προσαρμοζόμενα περισσότερο στις ανάγκες της χειρουργικής Κεφαλής & Τραχήλου.

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