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Faculteit Geneeskunde en Gezondheidswetenschappen

CONTRIBUTION OF SOME SURGICAL TECHNIQUES TO LIMIT POSTOPERATIVE SWALLOWING IMPAIRMENT IN HEAD AND NECK SURGERY

DE BIJDRAGE VAN BEPAALDE HEELKUNDIGE TECHNIEKEN OM SLIKSTOORNISSEN TE BEPERKEN NA HOOFD- EN HALSHEELKUNDE

MIEKE MOERMAN

Thesis submitted as partial fulfillment of the requirements for obtaining the degree of
Doctor in de Medische Wetenschappen
(Doctor in Medical Sciences)

Promotores:
Prof. Dr. P.Van Cauwenberge
Prof. Dr. H. Vermeersch

2004

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Ghent University,
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Functional outcome following colon interposition in total pharyngo-esophagectomy with or without laryngectomy.
Dysphagia 18 (2): 78-84

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Head and Neck 25 (9): 772-777

Vermeersch, H., Moerman, M., Fahimi, H., Bonte, K., Van Cauwenberge, P.
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Handboek Stem-, Spraak-, Taalpathologie.
Hoofdstuk Secundaire Slikstoornissen
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AIMS OF THE STUDY

Surgical procedures in the head and neck region can result in oropharyngeal swallowing disorders. These are often predictable as a functional impairment resulting from specific anatomic or neurologic insults, produced by the resection. But these impairments can result in aspiration and pneumonia as a consequence, which eventually ends in a life-threatening situation (1).
The role of caregivers, i.c. surgeons and speech pathologists is of utmost importance: the surgeon tries to protect the patient from aspiration by restoring the anatomical condition. The speech pathologist protects or rehabilitates the patient in such a way that the risk on this life threatening disease occurring is minimal, through exercise and optimal use of the anatomy subsequent surgery (2).

These two caregivers must be considered as co-workers.
The speech therapist may document and even define the physiologic cause of the swallowing disorder, which may lead to therapeutic suggestions, eventually for surgical modifications. But although patient's rehabilitation to the new anatomical condition after surgery is performed through intensive exercise programs or compensatory techniques, speech therapy alone cannot always solve the problem. Therefore, diverse surgical solutions have been considered through history (3,4,5,6,7).
In addition, surgical procedures for closing anatomical defects may result in a variety of swallowing disorders, ranging from mild to severe, depending on the manner in which the surgical defect is reconstructed (8).

Usually, therapeutic modalities for swallowing impairment after head and neck surgery include reeducation and speech therapy (9,10). However, in spite of intensive training, a fair number of patients does not improve or recover. Therefore, we wanted to interfere earlier with these occurring swallowing disorders and investigated the role of prevention.

Primary prevention of dysphagia after head and neck surgery can be defined as "prevention of swallowing disorders through the surgical technique itself, so that swallowing problems would not occur". Secondary prevention of dysphagia after head and neck surgery can be defined as "prevention after developped head and neck surgical related dysphagia, to

prevent worse swallowing problems". This definition does not define the methods by which secondary prevention is provided. These methods can consist of rehabilitation techniques and surgical techniques (e.g. prevention of aspiration pneumonia through laryngeal suspension techniques, or infiltration of the cricopharyngeal muscle which is described below). Therefore, concerning swallowing disorders, secondary prevention can be divided in **secondary prevention by surgery** and **secondary prevention by rehabilitation.** This is in contradistinction to primary prevention, which always consits of surgical techniques, as stated by the definition. **Rehabilitation** of swallowing disorders can be defined as "a non-surgical treatment focused on improving deglutition through reëducational or compensatory techniques". The latter is mostly performed by the speech pathologist.
This paper wants to focus on primary and secondary prevention of swallowing disorders in major head and neck surgery.

The first goal of surgical reconstructive techniques is providing primary healing. However, in head and neck oncology a second goal, restoration of function, becomes more important. There is no doubt that there are surgical techniques available to limit postoperative swallowing impairment in head and nek surgery. But the question remains wether it would be possible to modify existing surgical techniques with an even more functional result. Is it possible that through modification of existing reconstructive techniques a more functional surgery is performed, which advances, facilitates or even expels postoperative rehabilitation and thus limits swallowing impairment?

For this, we focused on the aspects in swallowing physiology that can be influenced by surgery. This implies that neurological swallowing disorders are not the subject of this work.
From the moment the bolus leaves the oral cavity and the swallowing reflex is triggered, two pathophysiologic patterns play a capital role in bolus propulsion: I) the driving forces along the pharynx and at the tongue base, and II) the resistance (of various etiologies) on the bolus' way down. As such we assumed that: I) increasing the propulsion efficiency or II) decreasing the prebolus resistance by surgical means could improve the swallowing physiology.
Neurological disorders also occur in the head and neck patient because of neurological trauma during surgery. These neurological disorders can also influence I) propulsion efficiency or II) prebolus resistance. However, we do not focus on these as it can hardly be influenced by functional surgery. Neurological reconstruction has gained more interest, but results are still not completely satisfactory.
Therefore, we study various surgical procedures in these two aspects and their functional outcome.

Reconstruction with the free radial forearm flap is a well-known technique in oropharyngeal surgery. However, in large resections at the tonsillar and palatal region, covering the defect with this non-dynamic tissue often results in postoperative nasal regurgitation and hypernasality (11,12). We modified this standard reconstructive procedure by suturing the free radial formarm flap to the palatal defect, combined with a caudally based velopharyngeal flap. Thus improving the propulsion efficiency by excluding nasal leakage and directing the propulsion forces towards the pharynx. We performed this procedure in 4 patients and analysed the functional outcome regarding swallowing and speech. This study aims at improving primary prevention.

The effect of botulinum toxin (temporal paralysis) is well known in plastic surgery, ophtalmology etc. Injecting the cricopharyngeal muscle with botulinum toxin is a new technique. We used it according to our philosophy: reducing the prebolus resistance. We hypothesized that, wathever the cause of diminished propulsion efficiency should be, lowering the prebolus resistance would benefit swallowing. We applied this in cases of diminished pharyngeal propulsion efficiency and we lowered the prebolus resistance at the cricopharyngeal level. We started this procedure in one non-head and neck patient with success and enlarged the indication to 3 head and neck oncologic patients. One patient had received standard total laryngectomy and radiotherapy, one was operated on the dorsal pharyngeal wall and irradiated and one had received chemo-radiotherapy. We can thus assume that (most likely) due to the radiotherapy the propulsion efficiency was diminished and -consequently- the (relative) prebolus resistance at the cricopharyngeal muscle had increased. Botulinum injection results in a temporal paralysis and therefore we supposed that it could reduce the cricopharyngeal resistance with decrease of swallowing impairment as a consequence. This study aims at secondary prevention.

In large hypopharyngeal lesions with extension to the esophagus, restoration of the digestive tract is necessary. In literature, various reconstructive procedures are described such as gastric pull up and jejeunal interposition. However, for high oropharyngeal lesions, gastric pull up is too short and jejeunal interposition is known for its adverse effect on swallowing

(13-16). These two drawbacks made us prefer colonic interposition. Firstly because of the technical advantage of its greater length and secondly because of the larger diameter compared to jejeunum. We then investigated wether a colonic interposition could provide a good functional outcome. We studied 10 patients who received this kind of reconstruction because we wanted to know if colon interposition meets the conditions of a low prebolus resistance and thus of primary prevention.

In total laryngectomy, pharyngeal closure is standardly performed by I) first suturing the mucosa in two layers and II) then suturing the cricopharyngeal muscles together at the midline. The use of voice prostheses has lead to the origin of unilateral myotomy for obtaining better voice quality (17,18). However, from a surgical point of view it is not logical to I) suture a muscle and II) then cut that muscle again. This results in an avascular and thus fibrotic bar, inducing scar tissue. For this, we reasoned that, instead of performing the standard procedure with unilateral myotomy, suturing of the constrictor muscle aside is much more logical and provides less tissue trauma. Horowitz et al. stated that "unilateral myotomy reduces the cricopharyngeal pressure, thereby diminishing forces against the pharyngeal suture line with minimizing postoperative fistulisation, eliminating dysphagia of cricopharyngeal spasm and improving the alaryngeal voice quality" (19). Thus, we studied the effect on swallowing where the constrictor muscles were left unsutured and compared this to the classical surgical technique using a unilateral myotomy. We also investigated wether it would be possible to reduce the naso-gastric tube feeding period and consequently the hospital stay. Providing an equal or improved functional outcome with a surgically simpler technique and reducing the hospital stay in these cases, favours a better quality of life.

Permanent closure of tracheo-esophageal fistulae has always been a challenge because of high failure rates and consequently the need for complicated reconstructive techniques. Often extensive surgical procedures such as pedicled or free flaps are mandatory for providing a definite solution (20-22). We looked for a simpler surgical technique with a good functional outcome. A three-layer closure without the need for additional tissue is proposed and analysed in surgical success rate and functional outcome. Focusing on swallowing, we can apply the theory "lowering prebolus resistance". When analysing the results, we investigated wether this modified surgical technique provides for a good swallowing function and thus matches primary prevention of swallowing disorders.

We divided the causes of the swallowing disorders into two subtypes (see below): decrease of propulsion efficiency and increase of prebolus resistance. By restoring or rehabilitating these two types of disorders, through surgery or through speech therapy, the goal of preventing aspiration is reached. We believe that it is essential to have the two skills, i.e. reconstructive surgery and specific speech pathology, available in the same centre.

This work starts with a description of several swallowing disabilities, typical for "the head and neck patient" based on literature findings combined with personal experience in every day practice. The second chapter also, reviewing the various existing assessment methods, is mainly based on literature review. The preferred assessment method is then illustrated in a series of 8 total laryngectomy patients.
From chapter III on, we describe our experience concerning prevention of swallowing disorders by modifying existing head and neck surgical techniques.
The first chapter describes dysphagia in standard head and neck surgery. The pathophysiology is explained and possible therapeutic modalities are proposed. Knowledge of the normal deglutition physiology and the most frequently occurring patho-physiology is essential for putting the statements made further down in this work in their perspective.

Chapter II gives a survey of the existing assessment methods: QOL protocols, clinical examination and technical investigations. Comparing these various methods gives an overview of the advantages and drawbacks of the existing methods and leads to a selection of preferred methods. Thus, a refined method for assessing swallowing disorders is proposed. Namely, we are convinced that a to the point questionnaire must be combined with a thorough clinical examination and videofluoroscopy to obtain an accurate idea of the pathophysiology. As such, a questionnaire, refined to the clinical relevance, is used in a pilot study involving total laryngectomees.

In chapter III the functional outcome in several surgical techniques is evaluated. Using the combination of three assessment methods described in chapter II, this study wants to evaluate the functional outcome regarding deglutition after various head and neck surgical techniques. The impact of surgery on swallowing physiology is stressed and eventually, surgical modifications for improving the postoperative functional outcome are suggested. This study describes various surgical techniques and modifications to improve postoperative functional outcome regarding swallowing function.

On grounds of the subdivision of the causality of swallowing disorders, namely, **decrease of propulsion efficiency** and **increase of the prebolus resistance**, the surgical techniques described in this work are divided into I) surgery aiming at an increase of propulsion efficiency and II) surgery aiming at a lowering of the prebolus resistance. In addition, III) a surgical technique for restoration of the continuity of the digestive tract and IV) modification of standard surgical techniques are evaluated in their **functional outcome.**

For this, reconstruction with the free radial forearm flap at various sites, a refined reconstructive technique in wide oropharyngeal defects, botulinum injection for cricopharyngeal dysfunction and restoration of the upper digestive tract with colon interposition are studied in relation to deglutition. In addition, early oral food resumption is evaluated in total laryngectomy whilst the surgical pharyngeal closure technique is modified. Early oral food resumption is also studied in a simple surgical closure technique for tracheo-esophageal fistulae, albeit from aside.

In conclusion, the theoretical model and hypotheses are reviewed. By systematically listing the results we give an answer on the question: "is it possible that through modification of existing reconstructive techniques a more functional surgery limits swallowing impairment through advancing, facilitating or even expelling postoperative rehabilitation?" In other words: "is it possible to establish primary or secondary prevention in swallowing disorders caused by head and neck surgery?"

The importance of diagnostic procedure and the surgical points of interest are listed.

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CHAPTER I

GENERAL INTRODUCTION

Moerman, M., Poncelet, G., Vermeersch, H.
Handboek Stem-, Spraak-, Taalpathologie.
Hoofdstuk Secundaire Slikstoornissen
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This chapter gives a brief overview of dysphagia in most frequently occurring head and neck surgical procedures. The pathophysiology is explained and possible therapeutic modalities are proposed. We do not focus on swallowing disorders with a neurological cause such as dysphagia after stroke, neuro-muscular diseases etc., because this is not the goal of this work.
Knowledge of the normal deglutition physiology and the most frequently occurring pathophysiology is essential for putting the statements made further down in this work in their perspective.

I.1 Impaired swallowing caused by treatment in the head and neck region

We describe swallowing disorders after standard head and neck surgery procedures and after radiotherapy.
The pathophysiology is explained and possible therapeutic strategies are proposed (3).
In this thesis, the subject of which is limiting swallowing impairment after head and neck surgery, neurological causes of dysphagia are not mentioned. For those who are interested, we refer to Logemann's book "Evaluation and treatment of swallowing disorders" and others (4, 5, 6, 7).

I.1.1 Dysphagia caused by radiotherapy

The forms of dysphagia that may arise in connection with radiation therapy can be divided into two categories:

a) Acute swallowing disorders occurring during or immediately after radiotherapy; and
b) Late swallowing disorders, which may occur up until 2 years after radiotherapy.

Classical external radiotherapy is performed in the head and neck region up to a maximum dose of 65 Gray. The oral cavity and neck are exposed to the maximum dose. As side effects are substantial, if possible, Intensity Modulated Radiotherapy (IMRT) or Three Dimensional Radiotherapy or Brachytherapy should be administered when possible to reduce the radiation field and consequently the side effects.

I.1.1.1 Acute swallowing disorders

Irradiation eliminates rapidly dividing cells by destroying of the genetic material (DNA). Tumour cells have a short cell cycle but glandular tissue cells and cells also possess this feature. This causes the acute side effects including:

a) Pain caused by mucosal ulcers; and
b) Mouth dryness caused by diminished salivary secretions.

Pain prevents the patient from transporting the bolus around the oral cavity and lack of salivary secretions alters the bolus' consistency.

Consequently, the irregular bolus is too sticky to be fluently transported. Irradiation of soft tissues often causes oedema. In edentulous patients the dental prosthesis may no longer fit and as a result chewing becomes problematic. From the moment this oedema disappears (often after a period of 6 months or more) a new dental prosthesis can be fitted.
It is not particularly easy to resolve these swallowing problems. Luckily, these problems dissolve themselves (albeit in some cases only partially) after a period of time. At the acute moment the patient's comfort may be improved by symptomatic therapy.

I.1.1.2 Late swallowing disorders

The rapidly dividing cells destroyed by the radiation therapy are replaced by fibrous tissue. As a result, rigidity in the oral cavity and the pharyngeal region occurs over a longer period of time (between 1 or 2 years after radiotherapy). Fibrous tissue is less sensitive, thus causing deglutition disorders by lack of sensation and diminished peristalsis. As lack of sensation demands a more intensive trigger, the pharyngeal phase is delayed. Because of this delay in the pharyngeal phase, but also because of the diminished peristalsis, the prebolus resistance at the pharyngo-esophageal sphincter is too high. This results in food remnants stagnating in the pyriform sinus, wich eventually causes aspiration in the lower respiratory tract.
The therapy depends on the etiology: the speech therapist provokes the sensation by presenting strong flavors, fluctuations in temperature, etc. If the swallowing impairment is mainly caused by diminished motility or suppleness, possible solutions include dilations, injections with botulinum toxin, myotomy, etc. If possible, a surgical procedure should be avoided given the higher rate of complications and wound healing problems after radiation therapy.

I.1.2 Dysphagia caused by standard surgical procedures in Head and Neck Surgery

Surgical procedures in head and neck in which large resections are performed, result in anatomical changes and physiological alterations. Even if the removal of soft tissue, muscle and bone can be restored perfectly, tissue fibrosis and lack of sensitive or motor innervation may remain responsible for swallowing impairment. Nowadays neurological reconstruction has gained more interest, but results are not completely satisfying.
Here below, the role and the effect of surgery in the physiology and pathophysiology of swallowing is reviewed for several head and neck regions. Suggestions for therapy and rehabilitation are proposed and summarized in table 1. At the end of paragraph I.1.2.3, table 2 gives an overview of the preferred type of reconstruction, according to our own experience.

I.1.2.1 Dysphagia after oropharyngeal surgery

The oral cavity is a very important anatomical region for the preparatory phase and the transport of the bolus. The pharynx consists of the velopharynx, oropharynx and hypopharynx. This region is very important for bolus propulsion towards the esophagus. This requires a very specific muscular activity, which results in peristalsis. Surgery in the oropharyngeal region often has (temporal) impact on deglution (8).

I.1.2.1.1 Dysphagia after surgery in the oral cavity

The oral cavity can be compared to a closed box in which the food is prepared for swallowing (preparatory phase). The food forms a bolus, which is transported backwards. When the bolus reaches the tonsillar pillars, information about the bolus' consistency is sent out (i.e. triggering). Surgery in this area influences these functions or parts of these functions.

I.1.2.1.1.1 Lip resection

The lips are component parts of the anterior oral sphincter, which provides the oral cavity's anterior seal and prevents leakage and anterior spillage. Total or partial lip resection interrupts this. Raising the intra-oral pressure is disturbed and leakage, especially of fluids, occurs. Lesions of

Table 1

Therapy Techniques for Swallowing Problems

Swallowing disturbance – Physiologic	
Oral stage of the swallow	**Therapy**
Reduction in lip closure	Lip exercises
Reduction in cheek tension	Posture (tilt toward stronger side)
	Pressure on weaker side
Reduction in tongue elevation	Tongue exercises
	Position food more posterior
	Prosthesis Posture (tilt head backward)
Reflex	
Delayed or absent reflex	Thermal stimulation
	Posture (tilt head forward)
Pharyngeal stage of the swallow	
Reduced pharyngeal peristalsis	Alternate liquid/solid swallows
Pharyngeal hemiparesis	Posture (tilt head toward stronger side, turn toward weaker side)
	Supraglottic swallow
Reduced laryngeal elevation	Supraglottic swallow
	Reduced laryngeal closure
	Adduction exercises
Cricopharyngeal hypertonicity	Myotomy

Swallowing disturbance – Anatomic	
Tongue scarring	Surgical release
	Position of food
Cervical osteophyte	Surgical removal
	Diet change
Scar tissue on pharyngeal wall	Posture
Scar tissue at base of tongue	Surgical removal
Tracheo-esophageal fistula	Surgical closure
Zenker's diverticulum	Surgical removal

Adapted from Logemann, JA (1983). Evaluation and treatment of swallowing disorders (pro.ed.) Austin, Texas, USA

the mental nerve, branch of the trigeminal nerve, cause sensitivity disorders, which increases the symptoms. The appropriate therapy is determined by the extension of the resection. If up to one third of the lip is removed, it is often possible to achieve primary closure of the defect. Postoperative speech therapy can be very useful. If necessary, the opening of the mouth will be gradually extended using (dental) prosthesis, progressively enlarging. The speech pathologist's goal is to improve tissue suppleness and muscular tension. Lip tension and precise articulation (diadochokinesis) are the most important exercises after the manual support of lip closure during deglutition.
Following more extensive surgery (i.e. removal of more than one third of the lip), it is not possible to achieve primary closure and so reconstruction with rotation or advancement flaps is required. In this type of surgery more tissues are manipulated and fibrous tissue and scare tissue is formed. Therapeutic strategies are similar, but more time consuming. Again, achieving mobility and tissue flexibility are the main goals.

I.1.2.1.1.2 Floor of mouth resection

The floor of mouth consists of muscles and has an anatomical link with the base of the tongue via the genioglossal muscle. The mouth's floor supports the tongue's muscular activity and assists the bolus transport and the intra-oral pressure raise. Surgical interventions disturb the preparatory or transport phase.
Surgery at the anterior part of the mouth's floor has little or no influence on the swallowing function if the defect can be easily closed, ideally by using local tissues (other than tissue from the tongue!) or by free tissue transfer. If the defect is situated at the back of the mouth's floor, a mandibular split approach can be required. This results in an increase in swallowing disorders. The principal cause for these swallowing disorders is a section of the mylohyoid muscle. This muscle indirectly assists in a normal tongue motility and preserves the muscular tonicity (a comparison can be made with the pelvic floor and muscles). Although at the end of the procedure osteosynthesis of the mandibular bone is performed, mandibular split can badly influence deglutition (mainly chewing), albeit temporarily.
Speech therapy involves stimulation of the oral muscle activity to improve the transport of the bolus and achieve accurate intraoral tension. Movements of the jaw during chewing are manually guided by the speech pathologist, whilst estimating muscular tension and force. Adjusted poise aims to use the force of gravity to guide the food towards the anatomically intact part. Therefore the head is tilted towards the non-operated side. For the anterior floor of mouth, the head is tilted backwards and the food is positioned more posteriorly. Food consistency can be adapted. For the lateral floor of mouth resections, improvement of tongue mobility, reflex triggering and voluntary laryngeal control can help in airway protection and pharyngeal clearance.

I.1.2.1.1.3 Tongue resection

The tongue is a very important organ in the swallowing process. It moves the bolus around the oral cavity. Once an accurate bolus consistency is obtained, the food is transported backwards in order to trigger the pharyngeal phase. The tongue's sensitivity plays an important role in registering the bolus' volume. The bolus' volume forms an impression on the dorsal surface of the tongue, which determines the movement of the hyoid bone in antero-cranial direction (9). The larger the bolus, the larger I) the tongue impression and II) the antero-cranial movement of the hyoid with III) subsequent elevation of the larynx and IV) passive opening of the upper esophageal sphincter.
The extent of swallowing impairment is effected by I) the extent of the defect, II) the location of the defect and III) the type of reconstruction. If more than 50 percent of tongue tissue is removed, severe dysphagia occurs. Surgical reconstruction aims to close the defect whilst preserving tongue motility. Free flaps are often used, particularly the free radial forearm flap, as the soft tissues of the forearm are pliable and have little bulk.

Three specific locations of resection are discussed below:

Tongue tip
The tip of the tongue plays an important role in cleansing the bucco-alveolar sulci. Meanwhile the bolus is moved backwards. After surgery, bolus transport is impaired and stagnation may occur at the bucco-alveolar sulci. Sometimes taste perception may also be affected. A meticulous reconstruction reduces the swallowing disorders, but speech therapy is always recommended to refine motility. Sometimes a palatal reshaping prosthesis may be considered.

Tongue border
This structure is extremely important to retain the food in the oral cavity. Functional impairment leads to early rear spillage and early aspiration. In addition to swallowing disorders, there may be a partial loss of taste. The

aim of therapy is to ensure that food is always presented at the non-operated side. This then ensures that it is possible for the bolus to be properly transported by preserving sensitivity and motility. Also, the head should be tilted towards the non-operated side.

Valleculla
The base of the tongue acts as a driving force. After the onset of the pharyngeal phase, this structure puts a downwards pressure on the bolus. Together with the contractions of the constrictor muscles, the activity of the base of the tongue forms the propulsion force. Surgery impairs this driving force. This may lead to a discrepancy between the opening of the upper esophageal sphincter and the bolus propulsion. This results in "late aspiration". Adjustment of posture and the supraglottic swallowing maneuver are therapeutic options.

1.1.2.1.1.4 Palatal surgery

Under normal conditions the palate closes the oral cavity from the nasal cavity. As a consequence, the intra-oral pressure is increased and the bolus is directed towards the pharynx. In surgical defects, nasal regurgitation occurs. The most important way of resolving this problem is by closing the anatomical defect with an obturator prosthesis or through surgical reconstruction.

Soft palate
The soft palate blocks the nasopharynx. If there is a partial or complete resection, depending on the size of the defect and the contraction pattern of the velopharyngeal port, nasal regurgitation may occur. Closure of the velopharynx is determined not only by the soft palate elevation but also by the adduction of the lateral and dorsal pharyngeal walls. Speech therapy is only worthwhile in smaller defects. Attention is drawn to both sensitivity and motility. Forward head posture is extremely important. In larger defects a prosthesis with posterior extension may be helpful.

Hard palate
If the alveolar ridge is removed, albeit only partially, resection of the hard palate causes chewing impairment. A defect of hard palate will always cause nasal regurgitation. This can be resolved by an obturator prosthesis; speech therapy gives little benefit.

1.1.2.1.1.5 Mandibular resection

The jaw is essential to the chewing process: the dental status, dental occlusion and resistance against chewing forces are determined by this bony structure. The degree of postoperative swallowing disorders is defined by maintenance of these three items.
Removing the horizontal part of the jaw leads to loss of dental elements. Dental status may be restored by using simple bridge prosthesis if this can be fixed to remaining dental elements (ideally the eye-teeth). If the patient is toothless, dental implants can be used if the mandibular bone is sufficiently thick. Two implants positioned at the eye-teeth can be used as fixation points for bridge prosthesis.
An osteosynthesis, which is matched before sectioning the bone, preserves the occlusion. If there is no bony continuity, chewing forces must be supported by the osteosynthesis. This means there is a risk that the osteosynthesis may break. This usually occurs after a period of 1 to 1.5 years. Therefore autologous bone is often used for reconstruction (for example, a free fibular graft, iliac crest, etc.).
In resections of the vertical part of the jaw, restoration of the bone continuity is difficult because there is insufficient bone available to ensure an adequate cranial fixture. An accurate point of fixture requires three to four boreholes. In case of a hemimandibulectomy or high resection of the vertical part of the mandibula this is not possible. As a consequence the occlusion is impaired and chewing forces are reduced.
Soft tissue loss diminishes the muscular tonicity and reduces the intra-oral pressure.
A thorough reconstruction aims to restore I) the dental status (chewing), II) the bony continuity (chewing forces), and III) preserving the occlusion. Speech therapy is useful for increasing the jaw's mobility and the soft tissues' suppleness. Occasionally the speech pathologist may manually assist the jaw movements by placing external pressure. Compensation exercises are taught to guide the food towards the not operated side. A guide plane prosthesis, which guides the mandible into proper occlusion, can be helpful.

I.1.2.1.2 Dysphagia after pharyngeal surgery

I.1.2.1.2.1 Velopharyngeal resections

The velopharyngeal closure mechanism prevents food and fluids from entering the nasal cavity. This combines a velar elevation, medial movement of the lateral pharyngeal walls and posterior pharyngeal wall vaulting. Soft palate resections, wether complete or partial, may give rise to nasal reflux. Meanwhile bolus propulsion caudally may be impaired. Speech therapy improves the velopharyngeal closure mechanism by stimulating the muscular activity of the constrictor muscles. For larger defects, a prosthesis with a posterior extension can be used. In certain cases, a pharyngeal flap (cranially or caudally) may be considered. The aim of this procedure is to mechanically reduce the gap according the nasal reflux.

I.1.2.1.2.2 Oropharyngeal resections

Tonsil
This region is the triggering zone for the pharyngeal phase. The muscular activity helps to close the fauces when the bolus leaves the back of the oral cavity. After surgical interventions i) early aspiration due to early spillage, ii) late aspiration due to decreased sensitivity and iii) delayed triggering may occur. Postoperative sensitivity must be rehabilitated by thermal stimulation and tactile stimulation. The transport of the bolus is guided by adapting poise namely: tilting the head towards the non-operated side and rotation towards the operated side. This is the rule for rehabilitating the swallowing function after surgery in the oropharyngeal and hypopharyngeal region.

Base of the tongue
The base of the tongue's most important function is the caudal propulsion of the bolus. The base of the tongue pumps the food into the open upper esophageal sphincter. Surgery causes severe swallowing disorders, in particular: due to a decreased driving force, the food cannot enter the upper esophageal sphincter and so stagnation occurs at the pyriform sinuses. This causes late aspiration. Speech therapy involves poise adaption (see above) and reinforcement of the laryngeal closure. For this, the supraglottic swallow or the Mendelsohn's maneuver is required.

I.1.2.1.2.3 Hypopharyngeal resections

In these procedures part of the constrictor muscles are removed, which causes impairment of the peristaltic muscular activity. Late aspiration can occur, which may eventually result in aspiration pneumonia. Rehabilitation aims to achieve a good laryngeal closure by using the supraglottic swallow or the Mendelsohn's maneuver and poise adaption to guide the food towards the non-operated side. In larger resections, a tracheotomy is required temporarily to protect the lungs. In the case of recurrent pneumonia and severe dysphagia, a total laryngectomy may be necessary.

I.1.2.2 Dysphagia after partial laryngectomy

In a partial laryngectomy, the laryngeal functions in deglutition are altered and may be impaired by varying degrees, either permanently or temporarily. This affects both phonation and deglutition. The larynx's most important role is its 'sphincteric' role of protecting the lower respiratory tract. Three levels of closure maintain the laryngeal seal: i) the epiglottis and arytenoids, ii) the false vocal folds and iii) the true vocal folds.

I.1.2.2.1 Dysphagia after partial laryngectomy in the horizontal horizontal plane

I.1.2.2.1.1 Supraglottic laryngectomy

As surgery during this procedure occurs at some distance of the true vocal folds, the glottal closure remains undamaged after surgery. Postoperatively, aspiration may eventually occur because the epiglottis has been removed. After some time (usually between 4 or 5 weeks) the swallowing function will adapt and normal oral feeding can resume.

I.1.2.2.1.2 Supra-cricoïdal laryngectomy with crico-hyoïdopexy

In this procedure the epiglottis, the false vocal folds and the true vocal folds are removed. The larynx is reconstructed by impaction of the cricoid against the hyoid. Laccourreye obtained an average decanulation time of 7 days and a normal postoperative deglutition in 75 % of his patients within the first postoperative month. The voice quality of almost all patients was fair (10).

I.1.2.2.2 Dysphagia after partial laryngectomy in the vertical plane

I.1.2.2.2.1 Fronto-lateral partial laryngectomy

During this procedure, parts of the true and false vocal folds are removed, but both cricoarytenoid joints are preserved. Therefore, provided the glottal closure is adequate (i.e. enough tissue bulk fills the defect) a good voice quality is retained. Aspiration is limited and of temporary effect as the glottal seal and the tilting of the epiglottis is preserved.

I.1.2.2.2.2 Anterior frontal vertical partial laryngectomy

The front two thirds of the glottis is removed. Almost all endolaryngeal tissues are removed, with exception of the two arytenoids. Resolving the defect by a reconstruction using muscular tissue results in too much tissue bulk and the laryngeal inlet is too narrow for respiration. For this, secondary healing is justified and completed after 6 to 8 weeks. This of course, induces fibrosis in the front half of the larynx. As fibrous tissue is immobile, closure at the glottal level can only be obtained by mobility of both arytenoids. In most cases this is sufficient to prevent aspiration. Phonatory function corresponds to a raw vibration, without modulation.

I.1.2.2.2.3 Supra-cricoïdal laryngectomy with crico-hyoïdo-epiglottopexy

In this procedure the true and false vocal folds are removed, sometimes with one arytenoid. The epiglottis is sectioned at the petiolus. Piquet demonstrated that out of 104 patients with T2 or T3 lesions, 102 had an unimpaired swallowing function. In 85 patients, the trachea canula could be removed within 28 days. All patients had an acceptable phonatory function that did not impact on their social activities (11).

I.1.2.3 Dysphagia after reconstructive procedures

The most important goal of reconstructive surgical techniques is healing wounds primarily. This is achieved by surgical closure of the wound or by covering the defect with other tissues. Generally, skin grafts, pedicled tissue (preserved vascularity) or free tissue transfer (the vessels are sectioned and reanastomosed onto an acceptor vessel) can be applied. Pedicled flaps or free tissue transfer may consist of I) skin, II) fascia or III) muscle, or IV) composite flaps (skin/fascia/muscle/bone). In the case of malignancy, knowledge of reconstructive procedures gives the possibility of carrying out large resections with high success rates. A meticulous reconstruction leads to a better quality of life by restoring function and aesthetics.
In the upper aero-digestive tract, free tissue transfer is often used. Matching the characteristics of the donor and acceptor area adds to a better quality of life, and particularly improves the swallowing function.

I.1.2.3.1 Acceptor area

The location of the defect, the extent of the defect, and eventual bone loss, are the three most important features in determining the selection of the donor material. In the mobile region of the tongue, the palate and the hypopharynx the free radial forearm flap is often used. In partial defects of the floor of mouth, the free radial forearm flap is again the preferred donor material. In the case of larger defects, for example a complete loss of the floor of mouth, a free rectus abdominis or lateral thigh is usually the preferred choice. In case of (partial) defects of the jaw, a free fibular graft or iliac crest is preferred. In selected cases where the jaw's bony continuity is not restored and only an osteosynthesis is applied, the plate is covered with soft tissue such as, a free radial forearm flap or a pedicled major pectoral muscle.

I.1.2.3.2 Donor area

Matching the donor material to the acceptor area, depends primarily on the characteristics of the acceptor area. The suppleness, the tissue bulk and the morbidity of the donor area are the main features which need to be considered. The location of tissue prelevation depends on individual qualities. For example, in a thin person having little tissue bulk in the region of the major pectoral muscle because of small amount of subcutaneous fat tissue, this flap may be used at the pharyngeal or tonsillar area,

but not for reconstructing the base of the tongue. Equally if a patient depends on crutches due to mobility problems at the lower limbs, the major pectoral muscle prelevation will be avoided.

I.1.2.3.3 Motor function

It is impossible to preserve the muscular activity by adapting the contraction pattern of the donor area to the contaction pattern of the acceptor area. Sometimes a certain degree of motor function can be obtained (e.g. pedicled major pectoral muscle). More often the preferred approach is to section the nerves because of the unreliable contraction pattern.

I.1.2.3.4 Sensitivity

Sensitivity can be restored, albeit often only partially. In the case of reconstruction with a free radial forearm flap, the cutaneous antebrachial nerve can be sutured onto the pharyngeal plexus. Restoring sensitivity could be important in reconstructions at the trigger zone, the tonsillar area.

I.1.2.4 Dysphagia after esophageal surgery

I.1.2.4.1 Nature of surgery

A partial esophagectomy means the cervical esophagus (or enough tissue) is preserved to perform a cervical anastomosis. Tubuled stomach is often used as neo-esophagus.
A total esophagectomy means it is impossible to perform a cervical anastomosis. In these cases the distance from the diaphragm to the pharynx has to be bridged. Tubuled stomach is often too short so preference is given to colon or jejunum. Jejunal grafts are free grafts with vascular anastomosis in the neck; colon is a pedicled flap from the right or left hemicolon.

I.1.2.4.2 Nature of reconstruction

Whenever possible, the graft is pulled through the posterior mediastinum, which is the physiological course. The posterior mediastinum allows for more space and increases the success rate of fluent postopera-

TABLE 2

Schematical survey of the different types of reconstruction

	Regional tissues	Advancement or rotation	Pedicled tissue flap (skin, deltopec)	Pedicled muscular flap (pec maior/lat dorsi)	FRFF	Rect Abd	Fibula	DCIA
LIP	•	•	•					
FLOOR OF MOUTH					•	•		
EDGE OF TONGUE					•			
BASE OF TONGUE					•	•		
SOFT PALATE					•			
HARD PALATE					•			
TONSIL					•			
LOWER JAW					•		•	•
HYPOPHARYNX			(•)	•	•			

Key: Deltopec — fascio-cutaneous deltopectoral flap,
Pec maior — musculus pectoralis maior muscle(skin)flap,
Lat dorsi — musculus latissimus dorsi muscle(skin)flap,
FRFF — free radial forearm flap,
Rect abd — musculus rectus abdominis free flap,
Fibula — free fibular graft, osteocutaneous,
DCIA — free crista iliaca graft, osteocutaneous.

tive swallowing. In exception, the anterior mediastinum can be chosen. The immediate retrosternal position of the graft means a significant space reduction. This may induce obstructive swallowing.
An important consideration in high esophageal resections is the ultimate preservation of the larynx. In malignancies, a total laryngectomy can be necessary to obtain tumor free resection marges. Aspiration is not possible in these types of surgery. Swallowing problems are merely due to motor disorders of the graft. In benign lesions (caustic lesions, stenotic

lesions), the larynx must be preserved. In these cases the rehabilitation of the swallowing function is started preoperatively with the supraglottic swallowing maneuver, Mendelsohn's maneuver and adduction of the vocal folds (12). A temporarily tracheotomy protects the lower respiratory tract.

I.1.2.4.2.1 Gastric pull up

After stripping of the esophagus, the tubuled stomach is pulled cranially in the posterior mediastinum and sutured to the cervical esophageal rest. In oral feeding, food enters the stomach immediately after the preparatory phase. This may cause hyperperistalsis and dumping which is the immediate filling and rapid emptying of the tubuled stomach. This means the hypertonic food is presented at the bowel very quickly. Hypertonicity is followed by water shifts. The patient perspires, feels uncomfortable and even vomits. This can be resolved by taking smaller amounts, more frequently throughout the day, for example up to 8 meals a day.
Also, narrowing of the proximal anstomosis can occur. The latter can be treated with repetitive dilations or – eventually- revision surgery. Less frequently a total obstruction can occur. This is due to a rotation of the stomach at the level of the diaphragm. The only solution here is surgery, namely thoraco-abdominal exploration, repositioning and reanastomosis.
Section of the vagal nerve results in gastroparesis with food residu and regurgitation as a consequence. In midthoracic anastomosis acid reflux can occur.

I.1.2.4.2.2 Jejunal free graft

Part of the jejunum can be easily used without causing problems. The vascular pedicle of the graft is a branch of the mesenteric blood supply. This procedure involves a free graft and carries a supplementary risk of disturbed blood flow and eventual necrosis of the jejunal segment. It is positioned in the posterior mediastinum and anastomosed to the stomach caudally and at the pharynx cranially. Unlike a tubuled stomach, the diameter never causes a problem. However, the segmental length can cause some swallowing disorders. If the segment is too long, it may kink and cause stagnation or obstruction. Sometimes stenosis of the proximal anastomosis can occur and result in dysphagia. The treatment consists of repetitive dilations from 4 weeks after surgery.

I.1.2.4.2.3 Colonic graft

The colon has enough length and blood supply for esophageal replacement. Both left and right colon can be used. The left side has a somewhat more constant vascularisation. The right colon has the advantage of greater length, ideal for very high anastomosis when the segment encloses the caecum.
Stenosis at the proximal anastomosis is less frequent because of the larger diameter. Total obstruction is very rare, in contradistinction to dumping and reflux.

I.2 Conclusions

Oropharyngeal swallowing comprises every act from the moment the food enters the mouth until it passes through the pharyngo-esophageal sphincter.
In head and neck surgery often one of these features has been altered as a result of surgical interventions. Reconstructive surgery aims at achieving primary woundhealing but also a good functional outcome must be considered. The choice of donor material is essential in postoperative functional outcome and depends on the goal one wants to achieve. However, it must be stressed that even when a perfect anatomical soft tissue reconstruction has been performed, swallowing disorders as a result of functional neurological deficit can remain.

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II.1 Questionnaires: quality of life protocols

II.1.1 Review of literature

During the past decade the evaluation parameters employed in cancer clinical trials have changed from traditional biological markers of therapeutic success (cure rate, disease free and overall survival, tumour response, etc.) towards evaluating the impact of the treatment on the physical, psychological and social function of the patient namely, the patient's quality of life (QOL). Consequently, numerous QOL studies have been performed and a lot of questionnaires or clinical protocols have been developed.

EORTC (European Organization for Research and Treatment of Cancer)
In 1987 a first generation core questionnaire was developed by EORTC. This was refined to form the EORTC QLQ-C30 version 1.0, which incorporates 9 multi-item scales: 5 functional scales, 3 symptom scales and a global health and a QOL scale (1,2). Nowadays the EORTC QLQ-C30 version 3.0 is routinely used (**Appendix I**). Because there is a large physical and psychosocial morbidity in head and neck cancer patients, the core questionnaire was modified to a head and neck specific module: the EORTC QLQ- H&N35 (**Appendix II**). In Europe this is the most frequently used module.

FACT (Functional Assessment of Cancer Therapy)
The Functional Assessment of Cancer Therapy- scale is another method used to evaluate QOL after cancer treatment (**Appendix III**). This module has also been adjusted to address the specific physiological and psychological problems in head and neck cancer (FACT-HN) (**Appendix IV**).

UW-QOL (University of Washington Quality of Life)
The University of Washington Head and Neck Quality of Life questionnaire is a specific instrument, which has been developed and validated with patient samples in the USA. It was designed to specifically apply to head and neck cancer patients; it is self-administered and only elicits responses from the patient. The scale consists of nine categories (**Appendix V**).

SF-36 (Short Form)
The SF-36 questionnaire is one of the most widely used QOL instruments in the USA. It measures two major health concepts (physical and mental status) with 36 items generating eight multi-item scales (**Appendix VI**) (4). Rogers et al. performed a longitudinal study in which they evaluated the SF-36 modular and compared it to the UW-QOL measure (5). Both SF-36 and UW-QOL provide outcome information suitable for internal comparison.

SIP (Sickness Impact Profile)
The Sickness Impact Profile was developed in 1974 at the University of Washington and consists of 136 questions grouped into 14 categories (**Appendix VII**). Due to its length, the modular is inefficient and patient non-compliance is often a problem. Comparing three questionnaires (SIP, UW-QOL, Karnofski scale), based on acceptability, responsiveness, the UW-QOL scale was preferred (6). The UW-QOL scale is comparable to the Karnofski scale and SIP scales for validity and reliability.

PSS (Performance Status Scale) and PSS-HN (Performance Status Scale Head and Neck)
The Performance Status Scale consists of three subscales: 1) normalcy of diet, 2) ability to understand speech, 3) ability to eat in public. Each of these elements is rated from 0 % to 100 % with 100 % representing no dysfunction (**Appendix VIII**). List et al. developed and tested the PSS-HN. They found a strong relationship to the FACT scale, but there appeared to be a consistent lack of relationship between functional and psychological adjustment (7).

A longitudinal study in which the SF-36 modular is compared to the UW-QOL measure demonstrates that SF-36 and UW-QOL provide outcome information suitable for internal comparison (5). Comparing SIP, UW-QOL and the Karnofski scale the acceptability, reliability and responsiveness were in favour of the UW-QOL scale (6). SIP is inefficient due to its length and patient non- compliance is often a problem. Comparing the UW-QOL with the SF-36, the EORTC QLQ-C33 and the EORTC H&N 35 questionnaires, Rogers et al. found that the UW-QOL is brief and self-adminstered, multifactorial and allows sufficient detail to identify subtle changes (3). The EORTC H&N module seemed to be more sensitive to identify minor shifts in speech and swallowing.

II.1.2 Personal remarks

QOL is a relative notion. It becomes a different concept comparing the patient's perception to the medical standpoint. Being able to smoke and drink alcohol again is an increase of QOL to the patient, while the medical doctor makes every effort to reduce or prohibit those habits. In the study of Jay et al. 9 % of the total laryngectomy population continues smoking after surgery (8). De Beule and Damsté however report 50 % of the patients smoking, albeit in another manner (9). The QOL assessed by relatives or caregivers results in different data. Caregivers tend to overrate bodily pain and underrate general health (10).
Results also depend on socio-cultural parameters. QOL varies greatly between demographic groups (for example, Japanese people provide different answers to those provided by European or American people) and socio-economic groups (11,12,13,14).

The modules confirm the interdisciplinary approach in cancer treatment but, mainly due to the general part often are long lists of detailed questions and sometimes difficult to fill out by the patient himself. In order to become a practical handout the questionnaires have to be simplified and must reflect a relevant clinical approach.
We are convinced that QOL has to be assessed for reflecting treatment success, for comparing certain treatment methods and for being able to draw general conclusions between various patient populations. The available questionnaires can be used for this general assessment. However, for studying the pathophysiology of specific pathologies (e.g. deglutition) these questionnaires are sometimes not sufficiently detailed. We agree with Mujica et al. who state that in 80 % to 85 % of cases, the cause of dysphagia can be identified by a careful, detailed history taking (15). Ruhl et al. stress the importance of using both a general QOL questionnaire and a disease- specific module (16). Of course, the choice of the 'disease-specific module' depends on the 'disease' one wants to study.

In Europe, the EORTC H&N 35 questionnaire is most often used. This questionnaire is an extension of the EORTC QLQ-C30 questionnaire and increases the former 30 questions to 65. The first 30 questions of the QLQ-C30 questionnaire consider the general physical condition and include 5 common digestive items. The EORTC H&N 35 is more specifically related to the head and neck patient and strives to demonstrate signs such as tumour recurrence, therapy related discomfort, social impairment etc. The EORTC H&N 35's questions for swallowing disorders, lack specificity to study physiologic causes and to relate them to the nature of surgical procedures. We believe that questions, such as eventual obstruction level or stagnation, food consistency, duration of meal, etc. must be included. However, the kind of questions needed depends on the pathology. Therefore, a swallowing-specific questionnaire can vary and a short general swallowing-specific questionnaire cannot be developed.

When studying specific disorders, more specified questionnaires become indispensable. Since there is a lot of variety in swallowing pathology, questionnaires will also vary. Therefore, we advocate linking these specific questionnaires with other assessment methods for its robustness, as we will see further in this manuscript (see II.5).

II.2 Clinical examination

II.2.1 Essential Topics

In head and neck surgery, swallowing disorders are secondary to end-organ impairment. In this perspective, separate assessment of the different motion and sensory subsystems is evident. The assessment of the anatomical integrity (mouth, pharynx, larynx) in conjunction with the neuromuscular and sensory function (lips, tongue, velopharynx, larynx) provides important information.
Swallowing function is clinically evaluated by using small amounts (1.5 –2 ml) of substance, which are insufficient to block the airway. Liquid and semisolid food is used to minimize the risk for lung trauma. If mastication is assessed, solid food is used.
The swallowing act is analyzed in terms of valving efficiency and propulsion forces at different levels (oral phases and pharyngeal phase). The duration of the oral phases and the pharyngeal phase can be estimated by manual evaluation (17).
Aspiration is not always clear, as coughing may not appear. In that case, voicing and perception of the voice quality is important.

The information gained from the oropharyngeal examination permits the speech pathologist to document the swallowing impairment and its severity and leads to a better end-result through detailed follow up. However, Logemann is convinced of the essential role of videofluoroscopy (18,19)!

II.2.2 Functional clinical examination

Clinical examination of swallowing disorders is essential. These clinical observations can not only be used for data registration, but also for gaining insight in swallowing physiology. This examination must consider the several stages of swallowing physiology, and therefore focus on both sensitivity and motor function. Anatomically considering the upper aerodigestive tract, also articulation, resonance and speech examination may add to the clinical information.
Table 3 (1-6) gives a schematical view of the protocol used in our department for evaluating swallowing dysfunction. The feature variety is evaluated in relation to the anatomy and in relation to the physiology as various food consistencies are used.

Table 3 (1-6)

3.1 Sensitivity

Function		Innervation	Sensitivity
Lips			
- Upper lip:	left		+/-
	right	n. trigeminus (n.V)	+/-
- Lower lip:	left		+/-
	right		+/-
Gum			
- Maxillar:	left		+/-
	right	n. trigeminus (n.V)	+/-
- Mandibular:	left		+/-
	right		+/-
Cheeks: inner side:			
	left	n. trigeminus (n.V)	+/-
	right		+/-
Hard Palate		n.trigeminus (n.V)	+/-
Soft Palate		n.trigeminus (n.V)	+/-
Tongue: anterior 2/3			
	left	n.trigeminus (n.V)	+/-
	right	n.facialis (n.VII)	+/-
Tongue: posterior 1/3			
	left	n.glossopharyngeus (n.IX)	+/-
	right		+/-
Velar reflex		n.glossopharyngeus (n.IX) n.trigeminus (n.V)	
Gagreflex		n.glossopharyngeus n.vagus (n.X)	+/-

3.2 Motor Function

Instructions/ Observations	Normal	Pathological
PHASE 1: PREPARATORY ORAL PHASE - POISE - (n.XI and cervical plexus)		
Observation	O upright	O deviant poise O shifting balans O ...
• SHOULDER CARRIAGE (n. XI and cervical and brachial plexus) Instruction: Relax shoulders	O relaxed	O asymmetrical O tensed
• JAW MOVEMENTS (n. v) Instruction: - open mouth - close mouth - mandibular motion left/right	O sufficient opening O adequate closure O supple movements	O insufficient opening O inadequate closure O tense motion left/right O asymmetry O stiffness of floor of mouth O pain
• CHEEK TONE (n. VII) Observation	O symmetry O normal tone	O weak tone left/right
• LIPFUNCTION (n. VII) Instruction: - closure - squeeze	O closure in repose O supple	O closure not possible O inefficient diadocho-kinesis
- squeeze - dispersion - shaping - shifting dispersion/ shaping - diadochokinesis: 3x /p/ Piet pakt potlood en papier	O symmetrical	O tensed closure O asymmetry O anterior leakage O upper lip: left/right: inadequate movements O lower lip: left/right: inadequate movements

Instructions/ Observations	Normal	Pathological
PHASE 2: ORAL TRANSPORTPHASE - TONGUE MOVEMENTS- (n.x)		
Instruction: - put out your tongue - placement of tongue tip in left/right corner of mouth - placement of tongue tip towards maxillary alveolar ridge - placement of tongue tip towards the front teeth - diadochokinesis: 3x /t/ - diadochokinesis : 3x /k/ - keeping tongue flat in mouth	O symmetrical O possible placement of tongue tip in left/right corner O possible placement of tongue tip towards O sufficient elevation of tongue tip O sufficient elevation of base of tongue O supple movements	O rotation to the left/right O bilateral impairment O insufficient elevation of tongue tip O insufficient elevation of base of tongue maxillary alveolar ridge O fibrillations
PHASE 3: PHARYNGEAL PHASE - VELOPHARYNGEAL CLOSURE - (n.V, n.IX, and n.X)		
Instruction: Say: - /a/ - Piet zit op de stoep en Jan zit op de fiets	O symmetrical O velar elevation left/right O absence of resonance disorders	O asymmetrical O no velar elevation left/right O nasality

3.3 Observation of motor function in solid food

Normal swallow	Pathological swallow
O upright	POISE O swallowing impediment O swallowing support
O relaxed	SHOULDERS O swallowing impediment
O sufficient O unimpaired biting O normal jaw movements	JAW MOVEMENTS O insufficient O impaired biting caused by…… O limited jaw movements
O no residue	CHEEK TONE O residue left/right, maxillar/mandibular
O good closure on cutlery O anterior seal	LIPFUNCTION O anterior spillage O insufficient closure on cutlery O residue between lip/teeth
O normal bolus handling O bolus holding is possible O normal bolus transport	TONGUE MOVEMENTS O delayed transport O residue unther tongue O residue on tongue O anterior spillage
O absence of nasal reflux	VELOPHARYNGEAL CLOSURE O nasal reflux left/right

3.4 Observation of motor function in semi-solid food

Normal swallow	Pathological swallow
O upright	POISE O swallowing impediment O swallowing support
O relaxed	SHOULDERS O swallowing impediment
O sufficient O unimpaired biting O normal jaw movements	JAW MOVEMENTS O insufficient O impaired biting caused by…… O limited jaw movements
O no residue	CHEEK TONE O residue left/right, maxillar/mandibular
O good closure on cutlery O anterior seal	LIPFUNCTION O anterior spillage O insufficient closure on cutlery O residue between lip/teeth
O normal bolus handling O bolus holding is possible O normal bolus transport	TONGUE MOVEMENTS O delayed transport O residue unther tongue O residue on tongue O anterior spillage
O absence of nasal reflux	VELOPHARYNGEAL CLOSURE O nasal reflux left/right

3.5 Observation of motor function in liquids

Normal swallow	Pathological swallow
O upright	POISE O swallowing impediment O swallowing support
O relaxed	SHOULDERS O swallowing impediment
O sufficient O unimpaired biting O normal jaw movements	JAW MOVEMENTS O insufficient O impaired biting caused by…… O limited jaw movements
O no residue	CHEEK TONE O residue left/right, maxillar/mandibular
O good closure on cutlery O anterior seal	LIPFUNCTION O anterior spillage O insufficient closure on cutlery O residue between lip/teeth
O normal bolus handling O bolus holding is possible O normal bolus transport	TONGUE MOVEMENTS O delayed transport O residue unther tongue O residue on tongue O anterior spillage
O absence of nasal reflux	VELOPHARYNGEAL CLOSURE O nasal reflux left/right

3.6 Observation of swallowing function in various consistencies

Normal swallow	Pathological swallow
O fluent swallowing act 1 or 2 movements	SOLID O no swallowing act O delayed onset O stagnation O regurgitation O pain
O fluent swallowing act 1 or 2 movements	SEMI-SOLID O no swallowing act O delayed onset O stagnation O regurgitation O pain
O fluent swallowing act 1 or 2 movements	SOLID O no swallowing act O delayed onset O stagnation O regurgitation O pain

II.3 Technical investigations

II.3.1 Literature review

II.3.1.1 Videoendoscopy Swallowing Study (VESS)

Endoscopy is an essential examination for visualising the larynx, velopharynx and hypopharynx. It is complementary to the taking of historic data and other technical investigations.
Videoendoscopic Swallowing Study has recently developed (20). There is a good correlation between VESS and videofluoroscopy for aspiration and pharyngeal residue (21,22). Périé et al. studied the ability of VESS in assessing pharyngeal propulsion and compared this method with videofluoroscopy and manometry (23). They found a good agreement between VESS and videofluoroscopy or manometry for pharyngeal propulsion and a good agreement between VESS and videofluoroscopy for aspiration.

II.3.1.2 Videofluoroscopic Swallowing Study (VFSS)

This dynamic imaging of the swallowing act, recorded on videotape, allows a slow motion analysis, which facilitates the diagnosis of abnormal movement patterns. Interfaced with a video counter timer, this method provides accurate durational information.
Logemann performed a study in which she compares the impact of the diagnostic procedure on swallowing rehabilitation, in two groups of similar head and neck patients (24). One group was clinically evaluated for therapy guidance (bed-side examination); the other group received videofluoroscopic control. In the videofluoroscopic arm, time to achieve oral intake and duration of follow up was significantly longer. But patients whose therapy was based on videofluoroscopic assessment exhibited faster oral and pharyngeal transit times (i.e., more normal). At 3 months after surgery overall swallow efficiencies revealed significantly better function in the videofluoroscopy group, probably because swallowing therapy was more accurately directed!
The most important feature in dysphagia is aspiration as it can cause life-threatening pulmonary disease. However, the difference between aspiration and penetration must be made clear. Feinberg calls bolus entering to

Table 4

Protocol for VESS

Explain procedure to patient.

Assess the patient's anatomy/function apart from swallowing
- -Palate (Nasopharynx view)
  - "Pick up the cupcake" – "Koen ect een kock"
  - Forced "sss"
  - Spontaneous speech
- -Pharynx (Panoramic laryngopharynx view)
  - Look for pooling of patient's saliva
  - Elicit "pharyngeal squeeze" via extreme high voice; elicit vase of tongue motion
- -Larynx (larynx view)
  - Mobility, control, closure of vocal folds
- -Sensation
  - Touch tip of fiberscope to various areas of hypopharynx and larynx

Food administration (panoramic laryngopharynx view, or via tracheotomy)
- Puree, then crackers, water as appropriate
- Look for latency; early spill-over; pooling (where, how much, effect of multiple swallows, head position change, water "chaser"; laryngeal vestibule soiling; efficiency of expectoration; degree of aspiration; tracheal soiling (especially if tracheotomy tube present)

Visual feedback training (optional)

(From Bastian RW. Videoendoscopic evaluation of patients with dysphagia: an adjunct to the modified barium swallow. Otolaryngol Head Neck Surg 1991; 104:339-350.)

the level of the laryngeal vestibule **penetration**; and bolus entering below the level of the true vocal folds, **aspiration** (25).
VFSS has some significant limitations: radio-exposure, costs, inaccessibility for physical unabled etc.
In "Evaluation and Treatment of Swallowing Disorders", Logemann describes this method in detail (26). We use a shorter version for practical implementation in our hospital (table 5).

TABLE 5

Videofluoroscopy

Anatomical abnormalities:
O no O yes: .....

Foodconsistency: liquid / semisolid / solid

PREPARATORY PHASE

Duration:

Uncontrolled spreading of contrast fluid in the oral cavity:
O no O yes (insufficient tonguemobility or –control)

Residue in the buccoalveolar sulci or unther the tongue:
O no O yes (insufficient tonguemobility or cheektonicity)

ORAL PHASE

Duration:
O < 1 second O > 1 second

Unability for holding the bolus in the oral cavity:
O no O yes (insufficient tonguemobility or faucal tension)

PHARYNGEAL PHASE

Duration:
O < 1 second O 1 à 2 seconds O 2 à 10 seconds
O 10 à 20 seconds O > 20 seconds

Delayed swallowing reflex:
O no O yes

Regurgitation:
O no O yes (insufficient velopharyngeal closure)

Residue in pseudovalleculae:
O no O yes

Residue to pharyngeal walls:
O no O yes

Opening of the upper esophageal sphincter:
O normal O delayed O ahead of time

OESOPHAGEAL PHASE

Peristaltic movements:
O normal O diminished O none

TABLE 6

VESS versus VFSS: a preliminary comparison of capabilities by findings

ITEM	VESS	VFSS
Palate mobility and closure	Excellent	Good
Pharynx squeeze	Excellent	Good
Vocal fold mobility and closure	Excellent	Goo
Sensation	Excellent	Fair
Anatomic detail	Excellent	Fair
Pooling	Excellent	Fair
Aspiration	Excellent	Excellent
Latency	Good	Excellent
Duration	Good	Excellent
Laryngeal elevation	Good (include neck palpation)	Excellent
Oral cavity behavior	Fair (use direct inspection)	Excellent
Esophagus	Poor	Excellent

(FROM BASTIAN RW. VIDEOENDOSCOPIC EVALUATION OF PATIENTS WITH DYSPHAGIA: AN ADJUNCT TO THE MODIFIED BARIUM SWALLOW. OTOLARYNGOL HEAD NECK SURG 1991; 104:339-350.)

TABLE 7

VESS versus VFSS : a comparison of clinical usefulness

CLINICAL CIRCUMSTANCE OR DISORDER	VESS	VFSS
Initial work-up	Good	Excellent
Esophageal disease	Poor	Excellent
Cranial neuropathies	Excellent	Fair
Postsurgical anatomy	Excellent	Good
Rapidly evolving swallowing disorder	Excellent	Fair
Bedfast patient	Excellent	–
Biofeedback, as to teach pharyngeal squeeze	Excellent	Poor

VESS, VIDEOENDOSCOPIC SWALLOWING STUDY; VFSS, VIDEOFLUOROSCOPIC SWALLOWING STUDY. (FROM BASTIAN RW. VIDEOENDOSCOPIC EVALUATION OF PATIENTS WITH DYSPHAGIA: AN ADJUNCT TO THE MODIFIED BARIUM SWALLOW. OTOLARYNGOL HEAD NECK SURG 1991; 104:339-350.)

II.3.1.3 Manometry

Manometry measures pressure changes that reflect cricopharyngeal or upper esophageal sphincter opening. However, there is a lot of controversy about the accuracy of manometry.
The anatomy of the pharyngo-esophageal segment is horseshoe shaped (27). Therefore, when measured with solid-state transducers, the highest pressures are recorded from the antero-posterior directions and the lowest from the latero-lateral directions (28). Orientation of the probe influences significantly the measured values. Only recording of average sphincter pressures over 360° is independent of catheter shape, although earlier studies have shown that catheters of different diameters will measure different pressures (29,30).
The most challenging difficulty is the normal swallow physiology. The larynx elevates whilst swallowing, which means that the pharyngoesophageal segment, firstly, has to relax and, secondly, has to regain tone. During cricopharyngeal relaxation, the UES moves cephalad and the pharyngeal propulsion forces influence the manometric measurements (31,32).
Other possible factors that influence the manometric results are age, temperature, bolus size and consistency, stress and anxiety (33).
Because of all of the above factors and because, in clinical practice, this tool does not show significant differences between groups, it is preferable to perform manometry in conjunction with videofluoroscopy, which is called manofluoroscopy (32). However, many centres do not have the equipment for this latter technique.

II.3.1.4 Manofluoroscopy

This technique permits a frame-by-frame analysis of the temporal relationship between the pressure changes and oropharyngeal movement parameters. However, it may be difficult to insert the catheter in patients with strictures or hyperactive gag-reflex and the technique is not commonly available in all centres.

II.3.1.5 Ultrasound

This technique has some value in imaging the soft tissue anatomy of the tongue and floor of mouth, but has a major limitation because of its inability to transmit through bone and air. However, ultrasound may be

combined with time measures and Doppler imaging and thus provide useful information (34).
Ultrasound of the esophagus is routine practice for imaging structural causes of lower dysphagia, e.g. esophageal tumours.

II.3.1.6 Scintigraphy

This imaging modality provides an accurate quantitative analysis of bolus flow and transit times and can provide quantified information on the residue in the oral, pharyngeal, esophageal and airway cavities, but it does not provide any description of the anatomy or motion of the structures involved (34). Hamlet et al. used this technique as an objective measure in total laryngectomy patients (35). They conclude that scintigraphy provides the best means for quantifying bolus residues in the mouth and pharynx. Pharyngeal transit time determined by scintigraphy correlates well with pharyngeal transit time determined by videofluoroscopy. A major disadvantage, however, is that for this method the use of radionuclide is required and that the number of subsequent swallows is limited. The radiation exposure is much less than for fluoroscopy but the accumulated background scatter (from residuals) degrades the quality of the data for a subsequent swallow.

II.3.2 Personal remarks

There is a considerable choice of QOL instruments available to the head and neck caregiver and many of these overlap in their scope.
In an overall estimation of the QOL, questionnaires are long and time consuming. When the goal is to focus on deglutition, more specific questions have to be asked. These questions change according to the pathology and anatomical location of defects. In order to ask the right questions, knowledge of the deglutition physiology is mandatory. Of course history taking alone is not sufficient for obtaining insight in swallowing disorders. And, answering questionnaires remains a *subjective* examination, which depends on the subjective rating of the patient him/herself.

Clinical examination is essential in diagnosis and documentation of swallowing disorders and a first step procedure in detecting physiologic causes. The purpose of a thorough clinical examination is, next to an individual anatomical and functional view, confirming eventual signs revealed by the questionnaire. Therefore, for gaining insight in the individual swallowing act, we advocate to perform a standard clinical examination (see Table 3). Preferentially this examination is done by the speech pathologist him/herself.

But also other, more technical, investigations are useful. The Video-Endoscopic Swallowing Study (VESS) is easy to perform in routine clinical practice. There exists a good correlation between the VESS and the videofluoroscopy, the latter recently seen as the golden standard. The fact that this investigation is cheap, easy to perform and that there is a good agreement with videofluoroscopy makes this examination essential in swallowing assessement (see table 6 and 7). We are convinced that this investigation adds anatomical and clinical information and as such increases pathophysiological insight. For this, we would advocate to routinely perform this investigation in clinical examination. However, this is not always mentioned explicitely further in this work. These types of examination can be considered as semi-*subjective* tools as the speech therapist scores the items based on the videoregistration at a particular moment.
Comparing the existing methods, videofluoroscopy is preferred as the standard technical investigation. This procedure provides a lot of useful information, such as objective registration of propulsion efficiency, laryngeal elevation, aspiration, etc. It has also been proven competitive with the VESS and manometry on behalf of pharyngeal propulsion and aspiration. Manometry, ultrasound and scintigraphy have no supplementary value to

the videofluoroscopy. On the contrary, there are important drawbacks such as, for ultrasound, inability to transmit through air and bone, and for scintigraphy, radio exposure and a large background scatter. Manofluoroscopy can provide useful information but far to few centres have this technique available.
As videofluoroscopy provides visual information and data (swallowing efficiency, transit-times), which can be measured with a video counter timer, these technical investigation can be considered as an objective tool. This procedure can be used as a quantitative and diagnostic measure in addition to the qualitative and therapeutic assessment.

We are convinced that a fundamental swallow study must consist of a **specific questionnaire** and a **thorough clinical examination** (included VESS), also performed during the swallowing act. The latter is the most essential tool to gain insight in the pathophysiology. Technical investigations are more objective methods for supplying information and confirming clinical experience. We prefer **videofluoroscopy** for its visual information of this dynamic feature. Although this method has its restrictions, costs and supplementary bother to the patient are low. The combination of these three assessment methods is called "refined asessment" further in this work.

We are glad to detect an analogue approach in the DOSS (36). However, this Scale has been developed for neurological swallowing disorders and is as such, not to borrow.

The DOSS describes functional dysphagia severity. It is a 7-point scale based on historic data, clinical examination and videofluoroscopy. Factors such as the nutrition level, the independence level, cognition, and the objective videofluoroscopy are fundamental. This scale has been developed by O' Neill et al. and was evaluated in 135 patients, mainly neurological diagnoses. The intra- and interjudge reliability was 93 % and 90 % resp. O' Neill et al. developed this severity scale because they found that other scales such as the FIM (functional independence measure), the ASHA Functional Communication Measure and the (CED) Clinical Evaluation Manual of Dysphagia do not focus on dysphagia specifically (FIM) or have not been proven reliable until now.

This scale has been developed for the purpose of establishing a consistent method of documentation and improved quality of care. Such a robust method with a good inter- and intra- judge agreement may be convenient for reimbursement purposes. However, there are some shortcomings:

videofluoroscopy may well be routine practice in an academic setting, but for smaller centers videofluoroscopy is not always available. Furthermore, videofluoroscopy cannot be performed in all patients (e.g. physically disabled).
A. Goeleven translated the DOSS from O' Neill in Dutch.

In conclusion, studying swallowing disorders, combining a specific history taking, a thorough clinical examination and -whenever possible- a videofluoroscopy is essential in achieving an accurate diagnosis and causal explanation. These items are combined in what we define further in this work: a "refined assessment".

The reported incidence of dysphagia after total laryngectomy ranges from 10% to 58% (37). However, many patients do not actively complain (37, 38). Total laryngectomy is frequently performed in our department and we find that when specifically asked for, patients often admit to experience a change in swallowing to some –albeit minimal- extent. In order to assess these findings we administered this refined assessment method (combination of focused history taking, clinical examination and videofluoroscopy) in a pilot study of 8 total laryngectomees. Although the questionnaire revealed no severe problems in deglutition (which was expected, as we ourselves had to specifically ask for eventual changes in swallowing), the videofluoroscopy showed swallowing delay and stagnation in the pseudo vallecullae. The following chapter illustrates the use of the so-called "refined assessment".

II.4 Practical implementation of a refined assessment in a pilot study of 8 total laryngectomy patients

II.4.1 Abstract

The different swallowing phases are evaluated and analysed by a specific questionnaire, a thorough clinical examination and –whenever possible- videofluoroscopy.
As a pilot study, this protocol is applied to a population of 8 total laryngectomy patients.
Although the clinical examination does not reveal swallowing problems, the questionnaire and the videofluoroscopy demonstrate repetitive swallowing movements and pharyngeal narrowing.
We want to stress the importance of combining all three-assessment methods in order to obtain a complete evaluation. The result of the evaluation will help to establish the rehabilitation procedure and to elaborate on adjusted surgical procedures.

II.4.2 Introduction

Malignancies in the head and neck region mostly concern squamous cell carcinomas and are in general preferentially treated by surgery. Wide resection demands meticulous reconstruction to preserve the functions of the upper aero-digestive tract: swallowing and speech. For larger tumours of the upper aerodigestive tract combined radio-chemotherapy can offer an alternative for surgery. Postoperative radiotherapy in case of multiple adenopathies or adenopathies with extra capsular spread is generally applied. Whenever postoperative radiotherapy is necessary, immediate and late reactions worsen the swallowing disabilities of the patient. Organ preserving chemotherapy is not yet generally accepted.
Assessing the quality of life in patients with head and neck cancer becomes more often the goal of interesting studies. The past decade, the evaluation parameters employed in cancer clinical trials have changed from traditional biologic markers of therapeutic success (cure rate, disease free and overall survival, tumour response, etc.) towards the impact of the treatment on the physical, psychological and social functioning of the patient: the quality of life (QOL). Since, numerous QOL studies have been performed and a lot of questionnaires or clinical protocols have been

developed (1,2). There is a considerable choice of QOL instruments available to the head and neck oncologist and many of these overlap in their inquiry. Ruhl et al. stress the importance of using both a general QOL questionnaire and a disease-specific module (16). In an overall estimation of the QOL, questionnaires are long and time consuming.
We advocate a refined approach in the specific assessment of the swallowing function by combining a to-the-point questionnaire with a thorough clinical examination and a focused videofluoroscopy. This avoids long and time-consuming questionnaires and provides accurate information about deglutition.

II.4.3 Materials and methods

Combining the insight in surgical techniques and the speech pathologist's experience, a specific protocol was developed.

The first part consists of a questionnaire in which the patient's subjective interpretation of swallowing is reflected. The patient himself subjectively rates speech and deglutition.
The questions asked were:

(I) Can you swallow fluids?
(II) Can you swallow semi-solid foods?
(III) Can you swallow solid food?

The possible answers were:

(I) Fluently
(II) Moderately
(III) Not

And:

(I) Do you avoid certain kinds of foods?
(II) Do you notice a change in swallowing between now and before the operation?
(III) Do you notice a change in swallowing between now and before the radiotherapy?

The second part is a clinical examination by the speech pathologist (see chapter II - 2.1- Table 3). Herein the sensitivity and the motility of the oral cavity and oropharynx are checked. The general posture (head and shoulder), the cranial nerves function (V, VII, IX, X, XI, XII), the mandibular motility, the tonicity of the cheeks, lips, tongue and the velopharyngeal

function are evaluated. These same items are assessed during deglutition (liquids, semi-solid and solid food).

The third part is a videofluoroscopy (liquids, semi-solid and solid food) (see chapter II –3.1.2- Table 5). The preparatory phase, the oral transport phase and the pharyngeal phase are scored on time and quality by an independent radiologist. Although manofluoroscopy provides more details, we preferred the videofluoroscopy procedure because a video registration is easy and cheap to perform and there is no supplementary burden of the manometry (38).

We performed a pilot study on 8 laryngectomy patients because although the speech disability is well known, we experience that swallowing problems could be present in some degree (39). The patients were chosen at random. The postoperative period ranged from 3 to 137 months. One patient received radiotherapy postoperatively; the other 7 patients received radiotherapy preoperatively.

TABLE 8

Results of the pilot study

GENERAL INFORMATION

Patients	*Age*	*Months since oper*	*RT*	*Dental Prosthesis*
P1	68	13	preop	no
P2	51	3	preop	yes
P3	70	16	preop	no
P4	55	84	preop	yes
P5	51	3	preop	yes
P6	67	4	preop	yes
P7	63	62	postop	no
P8	77	137	preop	yes

QUESTIONNAIRE RESULTS

	Fluid	*Semi-solid*	*Solid*	*Prolonged Transit*	*Avoidance*	*Change*	*Taste*	*Speed*	*Chewing*
P1	+	+	+/-	meat, fibers	no	no	+/-	diminished	longer
P2	+	+	+/-	meat	no	yes	+/-	diminished	longer
P3	+	+	+/-	meat, fibers	no	no	+/-	diminished	longer
P4	+	+	+	no	no	no	+	no	nl
P5	+	+	+/-	meat	no	yes	+/-	diminished	longer
P6	+	+	+/-	meat, fibers	no	yes	+/-	diminished	longer
P7	+	+	+/-	meat, fibers	no	yes	+	diminished	longer
P8	+	-	+/-	no	no	no	+	diminished	longer

CLINICAL EXAMINATION RESULTS

	Sensitivity	*Motility (fluid)*	*Mot (semisol)*	*Mot (solid)*	*Remnants*
P1	nl	nl	nl	nl	no
P2	nl	nl	nl	nl	no
P3	nl	nl	nl	nl	no
P4	nl	nl	nl	nl	no
P5	nl	nl	nl	nl	no
P6	nl	nl	nl	nl	no
P7	nl	nl	nl	nl	no
P8	nl	nl	nl	nl	no

VIDEOFLUOROSCOPY RESULTS

FLUIDS

	Prepar ph	*Pharyngeal phase*	*Peristalsis movem*	*Number*	*Time phar phase*
P1	nl	stagn pseudovall	diminished	2	< 1 sec
P2	nl	no stagnation	absent	2	< 1 sec
P3	nl	stagn pseudovall	normal	3	< 1 sec
P4	nl	stagn pseudovall	absent	3	1 sec

SEMI-SOLID

	Prepar ph	*Pharyngeal phase*	*Peristalsis movem*	*Number*	*Time phar phase*
P1	nl	stagn pseudovall	diminished	3	< 1 sec
P2	nl	stagn pseudovall	absent	3	< 1 sec
P3	nl	stagn pseudovall	normal	2	< 1 sec
P4	nl	stagn pseudovall	absent	3	1 to 3 sec

SOLID

	Prepar ph	*Pharyngeal phase*	*Peristalsis movem*	*Number*	*Time phar phase*
P1	nl	stagn pseudovall	diminished	6	1 sec
P2	nl	stagn pseudovall	absent	3	1 sec
P3	nl	stagn pseudovall	normal	3	1 sec
P4	nl	stagn pseudovall	absent	3	3 sec

P: patients
number movem: number movements
oper: operation
time phar phase: time pharyngeal phase
RT: radiotherapy
stagn: stagnation
preop: preoperative
pseudovall: pseudovallecula
mot: motility
nl: normal
prepar ph: preparatory phase
+: fluently
+/-: moderately
-: not

II.4.4 Results

(TABLE 8)

Part one: the questionnaire

Three patients claim to have a total loss of taste, three have a diminished taste and two do not have any loss of taste whatever.

All patients define their deglutition as easy. However, all patients but one notice a difference in the feeding pattern in the sense that it happens more cautiously and that it takes more time. The feeding tempo slackens because of longer chewing.

Part two: clinical examination

Sensitivity was normal in all 8 patients. Motor functions were intact but in 6 patients there was a fibrosis of the floor of the mouth (m. geniohyoideus, m. mylohyoideus, m. digastricus venter anterior). In solid food, deglutition takes more time than in liquids because of longer chewing. Taking liquids, 4 out of 8 patients made noise in each swallow.

Part three: videofluoroscopy

Only half of the patients were put under this examination (four were not willing to come back for this supplementary exam). All 4 had a normal preparatory and oral phase in liquids, semi-solid and solid food. Mastication of solid food however varied.

The pharyngeal phase took less than 1 second except for 1 person who needed 1 to 3 seconds for semi-solid and solid food. In all patients and for almost all kinds of food, there was stagnation in the vallecullae at the end of the pharyngeal phase. Esophageal peristalsis was diminished or absent in all but 1 patient. All patients had to swallow several times to evacuate the bolus completely (2-3 times in liquids, 3 times in semi-solid and 3-6 times in solid food).

II.4.5 Discussion

Already in 1970 Sandberg et al. studied the influence of total laryngectomy on the motility of the pharynx and esophagus (40). They suggested that pharyngo-esophageal spasm was an aetiological factor for dysphagia after total laryngectomy. Roed-Petersen et al. performed a manometry of the pharyngo-esophageal sphincter and on the contrary found that the tonicity is reduced or absent after total laryngectomy (41). We believe that manometry of this segment is not reliable as the position of the probe is

not steadfast. We are convinced that the most important factor to define dysphagia is the subjective interpretation of the patient himself. Therefore a thorough questionnaire is the first condition in an accurate evaluation. Reviewing literature most quality of life protocols contain a subjective self-evaluation. The EORTC QLQ-H&N35 protocol aims to evaluate the global health and functioning of the individual, but, according to us, stresses too little the item 'swallowing', in order to achieve an accurate evaluation of this function for eventual surgical adaptations.
Regarding our pilot study, the questionnaire did not reveal swallowing problems at first sight, but reviewing it in detail we notice a difference in feeding pattern. Feeding takes longer because of longer chewing and –more important- because of "cautiousness". In some substances like meat and fibres the transit is prolonged. Retrospectively, the "cautiousness" might be interpreted as the perception of narrowing at the vallecullae causing repetitive swallowing movements.
Clinical examination shows no abnormalities except for a curious noise that could be heard in 4 out of 8 patients. This can be compared with noise produced by filling a recipient with fluids. Gravity forces make the fluids rapidly pass through the pharynx. When the bolus arrives into the vallecullae, before the previous bolus has passed into the esophagus, a clocking noise is produced. This is also confirmed by the videofluoroscopy findings.

Although subjectively there were no severe problems in deglutition, the videofluoroscopy showed that there are some objective signs of prolonged swallowing and stagnation at the pseudovallecullae. Stagnation in the vallecullae and diminished peristalsis are easy to explain as a consequence of surgery. In a laryngectomy the constrictor muscles and branches of the pharyngeal and cervical plexus are cut, which causes a diminished peristalsis. In each swallow the passive dilation of the esophagus (in non laryngectomees due to the larynx elevation) is absent. Food collects at the pseudovallecullae and causes the relative obstruction in the pharyngoesophageal segment (42). Due to this, most patients experience repeated swallowing movements, especially with solid food.
Certain treatment side effects cannot be avoided. Radiotherapy causes taste alterations and fibrosis; the surgical procedure induces fibrosis, diminished pharyngeal peristalsis caused by cutting the constrictor muscles and neural plexus and lack of passive dilation of the upper esophageal sphincter (as a consequence of the impairment of the laryngeal anterocranial movement) (43). Mc Connel et al. stated that in a total laryngopharyngectomy the most important factor for a preserved deglutition

is accurate tongue propulsion against a wide-open graft (44). We are convinced that also in total laryngectomy, a patent pharyngeal tube with a wide-open hypopharyngeal anastomosis can improve deglutition. Increasing the pharyngeal diameter and esophageal inlet will reduce the 'prestenotic' pressure in favour of the swallowing function.

II.4.6 Conclusions

We advocate the combination of focused questionnaire taking, a thorough clinical examination and a non-expensive videofluoroscopy in order to achieve an accurate evaluation of deglutition. A pilot study in 8 at random chosen laryngectomy patients proves that matching these three assessment methods can enhance the diagnostic workout.
The results of the pilot study may suggest a reconstructive procedure to enlarge the pharynx and proximal esophagus. Increasing the pharyngeal diameter and esophageal inlet may reduce the 'prestenotic' pressure in favour of the swallowing function.

II.5 Conclusions

In head and neck surgery, QOL is determined by the two main functions, swallowing and verbal communication. Several questionnaires exist for evaluating this QOL, but often these questionnaires are too long and time consuming. Also, if somebody wants to focus on deglutition, these standard questionnaires will not provide enough detail. Therefore, we are convinced that, particularly in swallowing disorders, more specific questionnaires should be used.
Focused history taking is essential in dysphagia assessment. Identification of the cause can often be achieved by a careful, detailed history taking. Of course, history taking alone is not sufficient for obtaining an accurate idea of the swallowing disorder. Clinical examination and other, more technical, investigations are useful. We think that a thorough clinical examination (included videoendoscopic swallowing study), also performed during the swallowing act, is an essential tool to gain insight in the pathophysiology. Technical investigations are more objective methods for supplementary information and confirmation of the clinical experience. As is described above, there are many disadvantages to each of these technical methods. We prefer videofluoroscopy for its visual information of the dynamic swallowing features. Although this method has its restrictions, costs and additional bother to the patient are low.
Therefore, we advocate a combination of three assessment methods, namely (I) a detailed, focused questionnaire, (II) a thorough clinical examination and (III) an objective technical investigation, videofluoroscopy, which is named a 'refined assessment' further in this work.
The DOSS, a recently developed scale for rating the functional severity of neurological related dysphagia, is also based on historic data, clinical examination and videofluoroscopy. This confirms the importance of combining these three assessment methods. We as well, want to stress the value of this combination for examining the pathophysiology and for demonstrating eventual causality in swallowing impairment after head and neck surgery.

The refined assessment was applied to a population of eight total laryngectomy patients and although clinical examination did not reveal swallowing problems, the questionnaire and the videofluoroscopy demonstrated repetitive swallowing movements and pharyngeal narrowing.
This pilot study demonstrates that combining this three assessment methods may provide a surplus value in (I) tracking discrete swallowing disorders and (II) obtaining a complete evaluation of the swallowing disorders.

We think that -albeit discrete- swallowing problems in total laryngectomees are related to the section of the pharyngeal plexus with subsequently diminished constrictor muscles peristalsis and cricopharyngeal muscle hypertonicity. In addition, the beneficial effect of the laryngeal elevation to passively enlarge the esophageal inlet is absent. This leads to an increase of the prebolus resistance.

Speech therapists have an essential role in the clinical examination and in the documentation of the disorders. When the history taking and/or the clinical examination reveal some swallowing impairment, videofluoroscopy -whenever possible- is the next step. By using a combined approach, even discrete impairments can be demonstrated. This can lead to surgical improvement, as is suggested in this pilot study. As such, bilateral communication between the speech therapist and the surgeon is essential.

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II.7 Appendices

Appendix I

EORTC QLQ-C30 (Version 3.0)
(European Organization for Research and Treatment of Cancer Quality of Life Questionnaire)

We are interested in some things about you and your health. Please answer all of the questions yourself by circling the number that best applies to you. There are no "right" or "wrong" answers. The information that you provide will remain strictly confidential.

Please fill in your initials:

Your birth date (Day, Month, Year):

Today's date (Day, Month, Year):

During the past week:

		Not at all	A little	Quite a bit	Very much
1	Do you have any trouble doing strenuous activities, like carrying a heavy shopping bag or a suitcase?	1	2	3	4
2	Do you have any trouble taking a long walk?	1	2	3	4
3	Do you have any trouble taking a short walk outside of the house?	1	2	3	4
4	Do you need to stay in bed or a chair during the day?	1	2	3	4
5	Do you need help with eating, dressing, washing yourself or using the toilet?	1	2	3	4
6	Were you limited in doing either your work or other daily activities?	1	2	3	4
7	Were you limited in pursuing your hobbies or other leisure time activities?	1	2	3	4
8	Were you short of breath?	1	2	3	4
9	Have you had pain?	1	2	3	4
10	Did you need to rest?	1	2	3	4
11	Have you had trouble sleeping?	1	2	3	4
12	Have you felt weak?	1	2	3	4

	Not at all	A little	Quite a bit	Very much
13 Have you lacked appetite?	1	2	3	4
14 Have you felt nauseated?	1	2	3	4
15 Have you vomited?	1	2	3	4
16 Have you been constipated?	1	2	3	4
17 Have you had diarrhea?	1	2	3	4
18 Were you tired?	1	2	3	4
19 Did pain interfere with your daily activities?	1	2	3	4
20 Have you had difficulty in concentrating on things, like reading a newspaper or watching television?	1	2	3	4
21 Did you feel tense?	1	2	3	4
22 Did you worry?	1	2	3	4
23 Did you feel irritable?	1	2	3	4
24 Did you feel depressed?	1	2	3	4
25 Have you had difficulty remembering things?	1	2	3	4
26 Has your physical condition or medical treatment interfered with your family life?	1	2	3	4
27 Has your physical condition or medical treatment interfered with your social activities?	1	2	3	4
28 Has your physical condition or medical treatment caused you financial difficulties?	1	2	3	4

For the following questions please circle the number between 1 and 7 that best applies to you

29 How would you rate your overall health during the past week?

Very poor 1 2 3 4 5 6 7 Excellent

30 How would you rate your overall quality of life during the past week?

Very poor 1 2 3 4 5 6 7 Excellent

Appendix II

EORTC QLQ-H&N35 (European Organization for Research and Treatment of Cancer - Head and Neck)

Patients sometimes report that they have the following symptoms or problems. Please indicate the extent to which you have experienced these symptoms or problems *during the past week*. Please answer by circling the number that best applies to you.

During the past week:

	Not at all	A little	Quite a bit	Very much
31 Have you had pain in your mouth?	1	2	3	4
32 Have you had pain in your jaw?	1	2	3	4
33 Have you had soreness in your mouth?	1	2	3	4
34 Have you had a painful throat?	1	2	3	4
35 Have you had problems swallowing liquids?	1	2	3	4
36 Have you had problems swallowing pureed food?	1	2	3	4
37 Have you had problems swallowing solid food?	1	2	3	4
38 Have you choked when swallowing?	1	2	3	4
39 Have you had problems with your teeth?	1	2	3	4
40 Have you had problems opening your mouth wide?	1	2	3	4
41 Have you had a dry mouth?	1	2	3	4
42 Have you had sticky saliva?	1	2	3	4
43 Have you had problems with your sense or smell?	1	2	3	4
44 Have you had problems with your sense of taste?	1	2	3	4
45 Have you coughed?	1	2	3	4
46 Have you been hoarse?	1	2	3	4
47 Have you felt ill?	1	2	3	4
48 Has your appearance bothered you?	1	2	3	4
49 Have you had trouble eating?	1	2	3	4
50 Have you had trouble eating in front of your family?	1	2	3	4

	Not at all	A little	Quite a bit	Very much
51 Have you had trouble eating in front of other people?	1	2	3	4
52 Have you had trouble enjoying your meals?	1	2	3	4
53 Have you had trouble talking to other people?	1	2	3	4
54 Have you had trouble talking on the telephone?	1	2	3	4
55 Have you had trouble having social contact with your family?	1	2	3	4
56 Have you had trouble having social contact with friends?	1	2	3	4
57 Have you had trouble going out in public?	1	2	3	4
58 Have you had trouble having physical contact with family or friends?	1	2	3	4
59 Have you felt less interest in sex?	1	2	3	4
60 Have you felt less sexual enjoyment?	1	2	3	4

During the past week:	No	Yes
61 Have you used painkillers?	1	2
62 Have you taken any nutritional supplements (excluding vitamins)?	1	2
63 Have you used a feeding tube?	1	2
64 Have you lost weight?	1	2
65 Have you gained weight?	1	2

Appendix III

FACT (Functional Assessment of Cancer Therapy)

Below is a list of statements that other people with your illness have said are important. Circle one number on each line indicates how true that statement has been for you during the past seven days

PHYSICAL WELL-BEING during the past 7 days:	Not at all	A little bit	Somewhat	Quite a bit	Very much
1 I have a lack of energy	0	1	2	3	4
2 I have nausea	0	1	2	3	4
3 I have trouble meeting the needs of my family	0	1	2	3	4
4 I have pain	0	1	2	3	4
5 I am bothered by the side effects of treatment	0	1	2	3	4
6 In general, I feel sick	0	1	2	3	4
7 I am forced to spend time in bed	0	1	2	3	4

8 How much does your physical well-being affect your quality of life?

Not at all 1 2 3 4 5 6 7 8 9 10 Very much so

SOCIAL/FAMILY WELL-BEING during the past 7 days:

	Not at all	A little bit	Somewhat	Quite a bit	Very much
9 I feel distant from my friends	0	1	2	3	4
10 I get emotional support from my family	0	1	2	3	4
11 I get support from my friends and neighbours	0	1	2	3	4
12 My family has accepted my illness	0	1	2	3	4
13 Family communication about my illness is poor	0	1	2	3	4

If you have a spouse/partner or are sexually active, please answer #14 and #15; otherwise go on to #16

14 I feel close to my partner (or main support)	0	1	2	3	4
15 I am satisfied with my sex life	0	1	2	3	4

16 How much does your social and family well-being affect your quality of life?

Not at all 1 2 3 4 5 6 7 8 9 10 Very much so

RELATIONSHIP WITH DOCTOR during the past 7 days:

	Not at all	A little bit	Somewhat	Quite a bit	Very much
17 I have confidence in my doctor(s)	0	1	2	3	4
18 My doctor is available to answer my questions	0	1	2	3	4

19 How much does your relationship with the doctor affect your quality of life?

Not at all 1 2 3 4 5 6 7 8 9 10 Very much so

EMOTIONAL WELL-BEING during the past 7 days:

	Not at all	A little bit	Somewhat	Quite a bit	Very much
20 I feel sad	0	1	2	3	4
21 I am proud of how I am coping with my illness	0	1	2	3	4
22 I am losing hope in the fight against my illness	0	1	2	3	4
23 I feel nervous	0	1	2	3	4
24 I worry about dying	0	1	2	3	4
25 I worry that my condition will get worse	0	1	2	3	4

26 How much does your emotional well-being affect your quality of life?

Not at all 1 2 3 4 5 6 7 8 9 10 Very much so

FUNCTIONAL WELL-BEING during the past 7 days:

	Not at all	A little bit	Somewhat	Quite a bit	Very much
27 I am able to work (including work in the home)	0	1	2	3	4
28 My work (including work in the home) is fulfilling	0	1	2	3	4
29 I am able to enjoy life "in the moment"	0	1	2	3	4
30 I have accepted my illness	0	1	2	3	4
31 I am sleeping well	0	1	2	3	4
32 I am enjoying my usual pursuits	0	1	2	3	4
33 I am content with the quality of my life right now	0	1	2	3	4

34 How much does your functional well-being affect your quality of life?

Not at all 1 2 3 4 5 6 7 8 9 10 Very much so

Appendix IV

FACT – HN
(Functional Assessment of Cancer Therapy – Head and Neck)

ADDITIONAL CONCERNS during the past 7 days:

	Not at all	A little bit	Somewhat	Quite a bit	Very much
35 I am able to eat the foods I like	0	1	2	3	4
36 My mouth is dry	0	1	2	3	4
37 The treatment has disrupted my breathing	0	1	2	3	4
38 My voice has its usual quality and strength	0	1	2	3	4
39 I am able to eat as much food as I want	0	1	2	3	4
40 I am self-conscious about how my face/neck looks	0	1	2	3	4
41 I can swallow naturally and easily	0	1	2	3	4
42 I smoke cigarettes or other tobacco products	0	1	2	3	4
43 I drink alcohol (beer, wine, liquor)	0	1	2	3	4
44 I am able to communicate with others	0	1	2	3	4
45 I can eat solid foods	0	1	2	3	4

46 How much to these additional concerns affect your quality of life?

Not at all 1 2 3 4 5 6 7 8 9 10 Very much so

Appendix V

UWQOL – section one
(University of Washington Quality of Life)

Below is a list of statements related to your illness. For each category, please circle the number next to the statement you most agree with.
For the eating category, please circle one statement for chewing and one for swallowing.

PAIN

1 I have no pain
2 There is mild pain not needing medication
3 I have moderate pain – requires regular medication (codeine or non-narcotic)
4 I have severe pain controlled only by narcotics
5 I have severe pain not controlled by medication

DISFIGUREMENT

1 There is no change in my appearance
2 The change in my appearance is minor
3 My appearance bothers me but I remain active
4 I feel significantly disfigured and limit my activities due to my appearance
5 I cannot be with people due to my appearance

ACTIVITY

1 I am as active as I have ever been
2 There are times when I can't keep up my old pace, but not often
3 I am often tired and I have slowed down my activities although I still get out
4 I don't go out because I don't have the strength
5 I am usually in bed or chair and don't leave home

RECREATION/ENTERTAINMENT

1 There are no limitations to recreation at home and away from home
2 There are a few things I can't do but I still get out and enjoy life
3 There are many times when I wish I could get out more but I'm not up to it
4 There are severe limitations to what I can do, mostly I stay home and watch TV
5 I can't do anything enjoyable

EMPLOYMENT

1 I work full time
2 I have a part-time but permanent job
3 I only have occasional employment
4 I am unemployed
5 I am retired *(circle one below)*
   - Not related to my cancer treatment
   - Due to cancer treatment

EATING

1 Chewing *(circle one below)*
   - I can chew as well as ever
   - I can eat soft solids but cannot chew some foods
   - I cannot even chew soft foods
2 Swallowing *(circle one below)*
   - I can swallow as well as ever
   - I cannot swallow certain solid foods
   - I can only swallow liquid food
   - I cannot swallow because it goes down the wrong way and chokes me

SPEECH

1 My speech is the same as always
2 I have difficulty with saying some words but I can be understood over the phone
3 Only my family and friends can understand me
4 I cannot be understood

SHOULDER DISABILITY

1 I have no problem with my shoulder
2 My shoulder is stiff but I have not affected my activity or strength
3 Pain or weakness in my shoulder has caused me to change my work
4 I cannot work due to problems with my shoulder

CANCER CONCERN

1 I am not worried at all about the return of my cancer
2 I worry about my cancer returning, but it does not affect my life
3 I worry about my cancer returning, several times every day
4 I constantly worry about my cancer returning

Each category is assigned 100 points and each contributes equally in the final score of 900 points.

Appendix V

PSS-HN
(Performance Status Scale – Head and Neck)

Normalcy of Diet

100	Full diet (no restrictions)
90	Peanuts
80	All meats
70	Raw carrots, celery
60	Dry bread and crackers
50	Soft chewable foods (egg, macaroni, canned/soft fruits, cooked vegetables, fish, hamburger, small pieces of meat)
40	Soft foods requiring no chewing (egg, mashed potatoes, apple sauce, pudding)
30	Pureed foods (in blender)
20	Warm liquids
10	Cold liquids
0	Tube feeding only

Eating in public

100	No restriction of food, companion (eats out at any opportunity)
75	No restriction of place, but restricts diet when in public (eats anywhere, but may limit intake to less "messy" foods)
50	Eats only in presence of selected person
25	Eats only at home in presence of selected persons
0	Always eats alone

Understandability of Speech

100	Always understandable
75	Understandable most of the time; occasional repetition necessary
50	Usually understandable; face-to-face contact necessary
25	Difficult to understand
0	Never understandable; may use written communication

Karnofsky Scale of Performance Status

100	Normal, no evidence of disease
90	Able to carry on normal activity, minor signs of disease
80	Normal activity with effort, some signs or symptoms of disease
70	Unable to carry on normal activity or do active work
60	Requires occasional assistance, is able to care for most needs
50	Requires considerable assistance and frequent medical care
40	Disabled, requires special care and assistance
30	Severely disabled, hospitalisation indicated but death not imminent
20	Hospitalisation necessary, active supportive care necessary, very sick
10	Moribund, fatal processes progressing rapidly
0	Dead

Appendix V

SF-36 (Short Form)
Effect size of treatment extent index

	Effect size*
Scales	
Physical functioning (PR)	0.45
Role physical (RP)	0.78
Bodily pain (BP)	0.88
General health (GH)	0.74
Vitality (VT)	0.04
Social functioning (SF)	0.66
Role emotional (RE)	0.40
Mental health (MH)	0.29
Component summary scores	
Physical (PCS)	1.1
Mental (MCS)	0.09

** mean score of level 1-mean score of level 5/Standard deviation of the whole sample*

CHAPTER III

MODIFYING SURGICAL TECHNIQUES TO LIMIT POSTOPERATIVE SWALLOWING IMPAIRMENT IN HEAD AND NECK SURGERY

Moerman, M., Callier, Y., Dick, C., Vermeersch, H. (2002).
Botulinum toxin for dysphagia due to cricopharyngeal dysfunction.
European Archives of Oto-Rhino-Laryngology 259: 1-3

Moerman, M., Fahimi, H., Ceelen, W., Pattyn, P., Vermeersch, H. (2003).
Functional outcome following colon interposition in total pharyngo-esophagectomy with or without laryngectomy.
Dysphagia, 18 (2): 78-84

Moerman, M., Vermeersch, H., Van Lierde, K., Fahimi, H., Van Cauwenberge, P. (2003).
Refinement of the free radial forearmflap reconstructive technique after resection of large oropharyngeal malignacies with excellent functional results.
Head and Neck, 25 (9): 772-777

Vermeersch, H., Moerman, M., Fahimi, H., Bonte, K., Van Cauwenberge, P. (2003).
Early oral food intake in total laryngectomy. Closure of the constrictor muscles does not provide additional advantages.
Submitted

Moerman, M., Vermeersch, H., Heylbroeck, P. (2003).
A simple surgical technique for closure of tracheo-esophageal fistulas
Published online European Archives of Oto-Rhino-Laryngology

On grounds of subdivision of swallowing disorders causality, namely, decrease of propulsion efficiency and increase of the prebolus resistance, the surgical techniques described in this work are divided into I) surgery aiming at an increase of propulsion efficiency and II) surgery aiming at a lowering of the prebolus resistance. In addition, III) a surgical technique for restoration of the continuity of the digestive tract and IV) modification of standard surgical techniques are evaluated in their functional outcome. For this, reconstruction with the free radial forearm flap at various sites, a refined reconstructive technique in wide oropharyngeal defects, botulinum injection for cricopharyngeal dysfunction and restoration of the upper digestive tract with colon interposition are studied in relation to deglutition. In addition, early oral food resumption is evaluated in total laryngectomy whilst the surgical pharyngeal closure technique is modified. Early oral food resumption is also studied in a simple surgical closure technique for tracheo-esophageal fistulae, albeit from aside.

III.1 Limitation of swallowing impairment by increasing propulsion efficiency

III.1.1 Preface

Surgery for head and neck cancer demands wide resections and often results in an impaired swallowing function. This impairment is predictable as functional deficits related to specific anatomic or neurologic attacks are produced by the resection (see Chapter I).
If the defect is relatively small, the wound can be closed primarily. If the removal of tissues results in a larger defect, a surgical closure must be performed using grafts or flaps. Furthermore, after primary closure, the natural tension or pull of the tissues may cause separation of the wound margins (which prevents primary healing and creates fistulas) and so additional tissue may be needed. Apart from primary wound healing, the goal of reconstruction in the oral cavity and oropharynx is to improve bolus transport and secure an adequate triggering of the pharyngeal phase. Meticulous reconstruction increases efficient bolus propulsion. Nowadays also innervated free flaps are used to improve the functional outcome (1,2).

Using a questionnaire, clinical examination and objective evaluation of deglutition by videofluoroscopy, we investigated the well-known free radial forearm flap reconstructive technique in various postsurgical defects in forty-one patients. The patients differed in terms of the location of their tumours and as such did not form comparable groups. The aim of the study was to confirm that a free radial forearm flap is an excellent type of reconstruction in different anatomical locations to achieve deglutition. J.Robbins mentions the relation of swallowing disorders with speech disorders (3). Therefore, apart from deglutition, articulation is evaluated perceptually and consonant placement disorders are listed, albeit from aside.

In addition, as the free radial forearm reconstructive technique is nowadays common-use for several defects, we evaluated the functional outcome in 4 patients with wide oropharyngeal defects (lateral pharyngeal wall and palatal region) using a surgical refinement in the reconstruction with the free radial forearm flap. This study has shown that this refinement is a very promising technique. None of the patients experienced swallowing problems. Resonance disorders, which form a more discrete impairment, were absent.

III.1.2 Swallowing function in reconstruction of postsurgical defects of the upper aero-digestive tract with the free radial forearm flap

III.1.2.1 Abstract

We evaluated functional outcome in reconstruction with the free radial forearm flap in different anatomical locations. Forty-one patients with various tumour locations who received a reconstruction with the free radial forearm were questioned on their quality of life in general and on deglutition and speech in particular. Clinical assessment of swallowing and speech and videofluoroscopy completed the historic data. The questionnaire revealed a good overall quality of life in the majority of cases. Deglutition was marked as unimpaired in 28 patients (out of 41) and verbal communication was marked as unaltered in 27 patients. Videofluoroscopy performed in 15 out of the 41 patients showed good oral and pharyngeal clearance.
Reconstruction with the free radial forearm flap is a well-known and excellent technique to cover various defects after head and neck surgery. Also in this series, the reconstruction provides a good functional outcome.

III.1.2.2 Introduction

The different treatment methods for head and neck cancer are surgery and primary or secondary (postoperative) radiotherapy. Radiotherapy combined with radiosensitizers or chemotherapy is preserved for locally advanced tumours. In our department, surgery is the first choice in stage I through III and some stage IV cancer patients. Additional postoperative radiotherapy is always performed in stage III and IV cancer patients. In view of the curability, sometimes large resections have to be carried out with equally large reconstructions.
Various reconstructive principles have been used throughout history. Skin grafts can be used successfully in the floor of the mouth, mostly anteriorly where the graft is not washed out. Local flaps as tongue flaps, nasolabial flaps, buccinator flaps or temporal fascia can be used, although only for rather small defects. Considering the functional outcome, one must take into account that in preparing a local flap, additional scarring is caused with subsequently eventual impairment of the swallowing function. Also, the natural tension of the tissues or pull on the tissues can cause separation of the wound margins and result in fistula formation or secondary

healing. Regional arterialised muscle flaps or myocutaneous flaps such as pectoralis muscle or latissimus dorsi are possibilities but are often too bulky. However, in some cases the bulk is desired to fill up a defect as in case of a hemimandibulectomy. Free tissue transfer has less bulk and allows better modelling. Healing occurs primarily and thus additional fibrosis is absent compared to the locoregional transposition flaps and free skin grafts (4,5,6).
In our department, reconstruction with the free radial forearm flap is used by default for soft tissue defects. A surgeon, on the one hand, familiar with plastic reconstructive techniques, and on the other hand, familiar with the physiology of speech and deglutition, can perform a wide resection with a high cure rate and match the reconstruction to the physiological needs, which is in benefit of the functional outcome. The first goal in treating cancer is, of course, to cure, but when the skill of applying different therapeutic modalities is available, the cure can go hand in hand with function. The purpose of this study is to evaluate the functional outcome in reconstructions with the well-known free radial forearm flap reconstructive technique, at various sites. The quality of life in general, before and after therapy is assessed by a detailed questionnaire, combined with a thorough clinical examination and videofluoroscopy. J. Robbins demonstrated that swallowing function and speech are linked together and stressed the close relationship of dysphagia to speech disorders (3). Therefore, perceptual speech analysis is performed, albeit from aside.

III.1.2.3 Materials and methods

Patients
In a thirty-month period, sixty-nine individuals were surgically treated for squamous cell carcinoma in the upper aero-digestive tract. In all patients the defect was reconstructed with a free radial forearm flap prelevated from the non-dominant arm. This concerned a fascio-cutaneous flap with preservation of the connection between the deep and the superficial venous system. Forty-one of these patients were willing to come back for assessment of the swallowing function according to our protocol.

Questionnaire
A standard questionnaire assessed the following:
(I) Overall quality of life before and after the treatment;
(II) Overall quality of life before the diagnosis of cancer;

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healing. Regional arterialised muscle flaps or myocutaneous flaps such as pectoralis muscle or latissimus dorsi are possibilities but are often too bulky. However, in some cases the bulk is desired to fill up a defect as in case of a hemimandibulectomy. Free tissue transfer has less bulk and allows better modelling. Healing occurs primarily and thus additional fibrosis is absent compared to the locoregional transposition flaps and free skin grafts (4,5,6).
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A standard questionnaire assessed the following:
(I) Overall quality of life before and after the treatment;
(II) Overall quality of life before the diagnosis of cancer;

(III) Change in feeding pattern in
a. duration ;
b. nutrition ;
c. taste;
(IV) Change in verbal communication in
a. Voice quality; and
b. Articulation.

Clinical examination (see chapter II.2.2)
Two independent otorhinolaryngologists assessed organ mobility in the oral cavity and oropharyngeal region. They scored the mobility of the tongue, palate, lips and cheeks separately, from 0 (absent mobility) to 3 (normal mobility) and in the different quadrants.
An independent speech pathologist scored the voice quality with the GRBAS scale according to Hirano and particularly assessed the articulation pattern (7).

Objective measurements
Videofluoroscopy, adapted from Logemann's standard protocol, was performed in 15 patients (see chapter II.3.1.2). The other 26 patients were not willing to return for this additional examination.

III.1.2.4 Results

Patients
In 23 patients (out of 41) the defect was situated in the oral cavity, in 13 in the oropharyngeal region and in 5 at the hypopharynx. As is shown in table 9 the TNM classification and the follow up period is largely variable. Radiotherapy is given according to the tumour stage (T3 or T4 primary lesion and/or multiple cervical nodes) and the histopathological result (extra-capsular spread in a solitary cervical gland or multiple cervical glands in N+ neck).

TABLE 9

Patient's data

Patients	TNM[1]	RT2/CT3	FU4:y;m	Subsite	Laryngect	Gender/Death
P1	rT4N1M0	preop	1999;12	cavum oris	no	M
P2	r fibrosarc	preopRT	20/01/98;23	cavum oris	no	Fem
P3	T2N0M0	no	25/03/97;33	cavum oris	no	M
P4	rT4N1M0	preopRT/CT	25/05/98;19	oroph[5]	no	M
P5	T3N0M0	no	19/08/97;28	oroph	no	M
P6	T2N1M0	no	16/07/98;17	oroph	no	M
P7	T2N1M0	postopRT	22/09/98;15	oroph	no	M
P8	T3N1M0	postopRT	10/03/99;10	oroph	no	M15/11/00
P9	T4N0M0	postopRT	17/06/97;30	cavum oris	no	M
P10	T2N0M0	no	06/10/98;15	cavum oris	no	M
P11	T2N1M0	postopRT	14/04/97;33	cavum oris	no	M
P12	T1N0M0	no	17/11/97;25	cavum oris	no	Fem
P13	T2N1M0	postopRT	03/09/96;40	hypoph[6]	no	M
P14	T3N0M0	postopRT	08/07/98;18	oroph	no	M
P15	T4N2bM0	postopRT	10/06/97;31	hypoph	yes	M
P16	T2N2M0	postop	19/10/98;14	hypoph	no	M
P17	T3N0M0	no	08/11/96;38	cavum oris	no	M
P18	T2N2aM0	postopRT	09/08/96;41	cavum oris	no	M
P19	?	no	10/10/96;39	oroph	no	Fem12/03/01
P20	T3N0M0	postopRT	06/05/99;8	cavum oris	no	M
P21	T3N1M0	postopRT	13/10/97;27	oroph	no	M
P22	T2N1M0	postopRT	15/11/96;38	cavum oris	no	M
P23	T2N2cM0	postopRT	23/04/98;20	cavum oris	no	M
P24	rT2N1M0	postopRT	23/12/97;24	oroph	no	M
P25	rec	preopRT	0/03/98;22	oroph	no	M
P26	rT2N0M0	preopRT	07/02/98;23	cavum oris	no	M
P27	T2N0M0	no	27/01/98;23	cavum oris	no	M
P28	rT3N0M0	postopRT		cavum oris	no	M
P29	T2N2M0	postopRT	15/12/98;13	oroph	no	M
P30	T2N1M0	no		cavum oris	no	M
P31	T2N0M0	postopRT	23/09/97;27	cavum oris	no	M
P32	T3N0M0	postopRT	27/05/95;55	cavum oris	no	M
P33	T4N0M0	postopRT	05/03/96;46	hypoph	no	M
P34	T3N0M0	postopRT	08/04/98;21	cavum oris	no	M died
P35	T2N0M0	no	01/09/98;16	cavum oris	no	M died
P36	T2N1M0	postopRT	17/09/98;15	oroph	no	M
P37	T2N0M0	postop RT	12/05/93;92	cavum oris	no	M
P38	rT2N0M0	preop RT	30/05/96;53	cavum oris	yes	M 24/3/99
P39	rT2N0M0	preopRT/CT	14/07/98;18	hypoph	no	M
P40	T3N1M0	postopRT	22/03/96;45	cavum oris	no	M
P41	T1N0M0	no	12/08/97;29	oroph	no	M

[1] TNM: Tumor Node Metastasis / [2] RT:radiotherapy / [3] CT: chemotherapy / [4] FU: follow-up: year of operation/ FU in months / [5] oroph: oropharynx / [6] hypoph: hypopharynx

Questionnaire (table 10)

• *Deglutition:*

In the overall swallowing assessment, 28 out of 41 patients rated their swallowing function as identical or better than preoperatively. More specifically, the intake of liquids and semi-solid foods was excellent in 37 patients and difficult in 4. Deglutition of solid food was excellent in 23 cases and difficult in 13. Five patients did not take any solid food whatsoever.

• *Overall quality of life:*

When asked for the actual quality of life, compared to the situation before the operation and before the diagnosis of cancer, 14 patients found their quality of life diminished. When asked for the quality of life, compared to the situation before the operation but after the diagnosis of cancer, only 4 patients rated their actual quality of life as worse.

TABLE 10

Questionnaire

Patients	QOL-ca[1]	QOL+ca[2]	Taste	Deglutition	Speech
P1	idem[9]	idem		idem	idem
P2	idem	idem		idem	dim
P3	dim[10]	better		idem	dim
P4	idem	better		idem	idem
P5	idem	idem		idem	idem
P6	better	better		idem	dim
P7	dim	better		idem	idem
P8	idem	better		dim	dim
P9	idem	idem		idem	idem
P10	better	better		idem	dim
P11	dim	idem		dim	dim
P12	idem	idem		idem	idem
P13	dim	idem		idem	idem
P14	dim	better		dim	idem
P15	dim	dim		better	idem
P16	idem	better		idem	idem
P17	idem	better		dim	dim
P18	idem	better		idem	idem
P19	idem	idem		dim	idem
P20	idem	better		idem	idem
P21	better	better		idem	dim
P22	dim	better		idem	dim
P23	idem	idem		dim	dim
P24	dim	better		dim	idem
P25	better	better		better	idem
P26	better	better		dim	idem
P27	better	better		idem	idem
P28	dim	better		dim	dim
P29	dim	dim		dim	dim
P30	better	better		idem	idem
P31	idem	better		idem	idem
P32	better	better		idem	idem
P33	better	better		idem	idem
P34	idem	better	dim	idem	idem
P35	dim	better		dim	idem
P36	better	better		idem	idem
P37	dim	better		dim	idem
P38	dim	dim		dim	no speech
P39		better		idem	dim
P40	dim	dim		idem	dim
P41	idem	better	dim	idem	idem

[1] Qol-ca: Quality of life after treatment compared to quality of life before treatment and before the diagnosis of cancer. / [2] Qol+ca: Quality of life after treatment compared to the quality of life before treatment and after the diagnosis of cancer/ [3] idem: identical / [4] dim: diminished

Clinical examination (table 11)

• *Acceptor site:*

Mobility of the different structures in the oral cavity and oropharyngeal region was moderate to good in most patients. Only 7 patients scored 0 or 1 in one or more subsites.

• *Speech:*

-Voice

Sound production perceptually scored by the GRBAS scale showed a great interindividual variation.

-Articulation

Most patients showed a disturbed articulatory pattern. These disorders occur with a large variability.

Objective measurements (table 11)

Videofluoroscopy, performed in 15 out of the 41 patients, revealed good oral and pharyngeal clearance. Although there was some stagnation at the vallecullae or pyriform sinus, no major aspiration occurred.

III.1.2.5 Discussion

The swallowing act is a sequence of different phases. After chewing the food (**preparatory phase**) the bolus is transported through the oral cavity (**oral phase**). When the food passes the tonsillar pillars, the **pharyngeal phase** is triggered. Consequently, the hyoid bone raises and the esophagus is opened to initiate the esophageal phase.

The objective of tongue reconstruction depends on what part of the tongue is affected. Lazarus et al. found a correlation between tongue strength and oral and pharyngeal temporal swallow measures and a particular relation with the oral phase of swallowing (8). Mc Connel et al. clearly described the tongue's driving force (9,10). At the base of the tongue an accurate volume is essential for creating high pressures and a normal bolus propulsion and fluent pharyngeal phase. Tongue motility is of utmost importance in the preparatory and oral phase and therefore pliable, not bulky tissue is preferred for lesions at the tongue tip or lateral margin.

Apart from mobility and tongue strength, sensitivity is an important feature as well for achieving efficient deglutition. Boyd et al. used a reinnervated free radial forearm flap in hemiglossectomy for restoring mucosal sensation (2). However, they considered sensitivity restoration attributable

TABLE 11

Clinical and objective observations

Patients	Mobility (0-3[1])	Oral clear in sec	Phar[2] clear in sec	Stagnation	Aspiration (0-3)[3]	Articulation disorders	Nasality	GRBAS[4]
P1	3					r	no	00000
P2	3					r,l,b	no	00000
P3	3					r,z	no	00000
P4	1 3					nl	no	00000
P5	3					s,r	no	00000
P6	3					g,r	no	00000
P7	1 3					s,r	slight	11000
P8	3					nl	no	11000
P9	2 3					s,z,g	no	00000
P10	3					s,z,g	no	00000
P11	3	?	<3	no	2	k,g,r	slight	12000
P12	3					k,r	No	00000
P13	3					nl	No	21100
P14	2 3					nl	no	11010
P15	3					l,r	no	TE[5] speech
P16	3					g,p,m	no	22000
P17	3	1	>3	vall[6], pyrif's[7]	1	r,l,g,k	yes	00000
P18	1 3	1	<3	no	0	r,g,k	no	00000
P19	2	2	>3	vall, pyrif's	1	s,d,k	slight	00000
P20	3	<1	<3	vall, pyrif's	1	r,g,m	no	00000
P21	2 3	<1	<1	no	1	r,l,k	no	00000
P22	2 3					s,r,l	no	12001
P23	1 3	<1	<1	vall, pyrif's	2	r,k,p,s	no	11001
P24	2	<1	<1	no	0	r	no	21101
P25	2 3	<1	<1	vall	1	r,g,k	no	21200
P26	0 3	<1	<1	vall, pyrif's	2	r,g,k	no	21220
P27	3					r	no	20200
P28	2					k,s,t,r	no	00000
P29	2 3					k	no	22001
P30	2 3	<1	1	vall, pyrif's		r,k,p	no	00000
P31	3	<1	<1	vall		s,r,k	no	21112
P32	1 3					z,r,g	no	22000
P33	3					r,k	no	22000
P34	2 3	<1	<1	vall, pyrif's		nl	no	21001
P35	3	<1	<1	no		r	no	21100
P36	2 3	<1	<1	vall, pyrif's		r	no	11000
P37	3					nl	no	00000
P38	3					no speech	no	no speech
P39	3					z,r	no	12001
P40	0 3					z, k, t	no	10010
P41	3					nl	no	00000

[1] mobility: 0: no mobility, 3: normal mobility / [2] phar: pharynx / [3] aspiration: 0: no aspiration, 3: severe aspiration/ [4] GRBAS: Grade, Roughness, Breathiness, Asthenity, Strain / [5] TE: trachco-esophageal speech / [6] vall: vallecula / [7] pyrif's: pyriform sinus

to neurotization from the recipient bed because of the thin and pliable nature of the flap. Katou et al. compared the sensitivity of innervated versus noninnervated free radial forearm flaps and concluded that in an innervated flap the sensitivity restores sooner (1).
Based on the swallow physiology, surgical reconstructive techniques must meet the needs of I) non-bulky, pliable tissue in the intra-oral region and II) large volume at the base of the tongue to create high pressures.

Our findings confirm the findings in the literature (4,5,6,8,9,11,12). History taking and videofluoroscopy proved that in the majority of cases deglutition was optimal. The free radial forearm flap did not interfere with the 'propulsion efficiency'. Of course, in order to prove that the free radial forearm flap adds to the 'propulsion efficiency', a comparison with a series of similar lesions without any type of reconstruction should be performed. However, this is not possible. The surplus value of primary healing is well known and covering large defects with additional tissue remains the standard surgical technique.

Table 11 gives an overview of the perceived articulation disorders. As the population concerned adults with normal speech development, omissions or substitutions did not occur. Because surgery did not interfere with the laryngeal anatomy and physiology (except for 2 cases who received a total laryngectomy), we supposed that the glottal consonants /h/, /ʔ/ would not be disturbed and thus these were not taken into account. We observed a variety of articulation disorders, however, not related to the type of the surgical event. Resections of lesions in the oral cavity can result in disorders identical to the disorders perceived after surgery for oropharyngeal lesions. Hypopharyngeal surgery also results in a variety of articulation disorders. As this study only reports on subjective perception of articulation disorders by one individual, further and more detailed study is mandatory. Although there is no relationship between the type of articulation disorder and the type of surgery, the general impact of these articulation disorders on quality of life is pregnant: these articulation disorders did moderately influence the questionnaire results. Fourteen out of the total group of 41 (34%) rated their speech quality as diminished.
Thirteen patients (32%) rated their swallowing as diminished.

Although we agree with the findings of J. Robbins et al., namely that dysphagia and speech disorders are linked, table 10 demonstrates that speech and swallowing impairment occurs in various patients. In general, functional impairment concerning swallowing and speech occurs in approxi-

mately one half of the population,. In 6 out of 41 patients both deglutition and speech are subjectively rated as diminished. However, considering swallowing alone, almost 70 % rated swallowing function as identical or better.

Questioning the overall quality of life, the majority of patient's scores quality of life better after surgery than immediately preoperatively. Comparing the actual postoperative situation with the preoperative situation before the patient had knowledge of having cancer shows different figures. This reflects the negative psychological influence of being conscious of the diagnosis and is conform the findings of Burstrom et al. (13).

III.1.2.6 Conclusion

Reconstruction with a free radial forearm flap is a well-known therapeutic option in the treatment of cancer in the upper aero-digestive tract. The assessment of swallowing function in this type of surgery, notwithstanding the large diversity of subsites of the lesions, results in a positive functional outcome.

III.1.3 Refinement of the free radial forearm flap reconstructive technique after resection of large oropharyngeal malignancies with optimal functional results

MOERMAN, M., VERMEERSCH, H., VAN LIERDE, K., FAHIMI, H., VAN CAUWENBERGE, P. (2003).
Head and Neck 25 (9): 772-777

III.1.3.1 Abstract

Wide resection of oropharyngeal malignancies implicates the risk of velopharyngeal insufficiency, which can cause nasal regurgitation and hypernasality. A meticulous reconstruction is necessary to avoid handicap in deglutition and speech. In the classic reconstructive techniques for large oropharyngeal defects, functional outcome only regards deglutition. We also focus on nasality, as hypernasality often occurs as a consequence in this type of reconstruction.
In four patients, the surgical defect is closed with a free radial forearm flap, sutured to the posterior side of the hard palate, thus imitating a caudally based pharyngeal flap. Speech is assessed by an independent speech pathologist, using subjective and objective assessment techniques. Deglutition is evaluated by a questionnaire and videofluoroscopy.
All patients had normal food intake. They did not report alterations in speech quality or verbal communication. Perceptual evaluation of articulation, voice and nasality was optimal. Objective measurements with acoustical analysis and nasality scores confirmed the optimal functional outcome.
Videofluoroscopy showed an unimpaired bolus transport with a complete velopharyngeal closure and optimal oral and pharyngeal clearance times. This meticulous reconstructive technique ensures an optimal functional outcome. The absence of nasality in particular, proves the value of this refinement. The technique allows wide surgical margins and complete velopharyngeal closure.

III.1.3.2 Introduction

Oropharyngeal malignancies, mostly squamous cell carcinomas, are preferentially treated by surgery. Wide resection implicates the risk of velopharyngeal insufficiency, due to a (partial) resection of the soft palate. This can cause hypernasality in speech but also nasal regurgitation and swallowing problems. A meticulous reconstruction of the defect is necessary to avoid a handicap in deglutition and speech.
The free radial forearm flap is frequently used for intraoral soft tissue reconstruction. This fascio cutaneous flap is not too bulky and is pliable. The pedicle is long and can easily be anastomosed in the neck when suturing the flap at the level of the palate.
We developed a specific reconstructive technique by which wide resection with oncological free margins can be performed and yet an optimal function of deglutition and speech can be preserved. As a pilot study, deglutition and speech and nasality in particular, was assessed in four patients.

III.1.3.3 Materials and methods

TABLE 12

Patient's characteristics

Patients	Operation m/d/y	TNM[1]	Tracheotomy	RT[2]	Sexe
1	05/09/2000	T3N2bM0	10 days	Postoperative	M
2	04/18/2000	T2N1M0	10 days	No	M
3	08/19/1997	T3N0M0	14 days	No	M
4	11/21/2000	T2N0M0	10 days	No	F

[1] TNM: Tumor Node Metastasis / [2] RT: Radiotherapy /

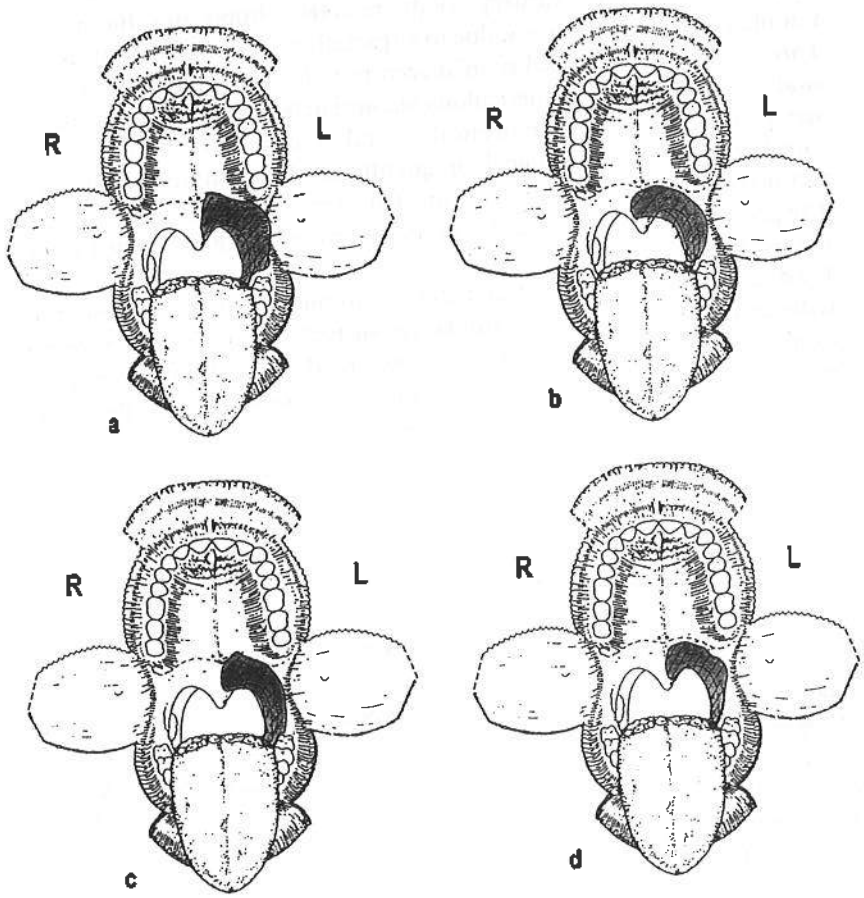

FIGURE I:
Outline of tumour extension in the four patients.

Patients (Table 12, Fig 1): We focused on oropharyngeal lesions with extension towards the soft palate. In contrast to surgery for lesions limited to the lateral pharyngeal wall, surgery for lesions with extension to the palatal region results in a large velopharyngeal gap causing nasal regurgitation and hypernasality. Four patients, selected consecutively, underwent a wide resection of the lateral pharyngeal wall, the retromolar triangular space and the homolateral soft palate and received our refined reconstructive technique. One patient had a T3 N2b M0 lesion from the left tonsillar fossa with extension into the left side of the soft palate reaching the midline and the border of the hard palate. Downwards, the lesion affected the lateral pharyngeal wall to the cranial border of the pyriform sinus. The second patient had a T3 N0 M0 lesion from the left tonsil towards the left side of the soft palate crossing the midline. The hard palate was not invaded. The third patient suffered from a T2 N1 M0 lesion located at the left tonsillar region with extension to the left side of the soft palate reaching the midline cranially and the lateral border of tongue caudally. The last patient had a T2 N0 M0 lesion from the left tonsil, the left side of the soft palate reaching the midline.

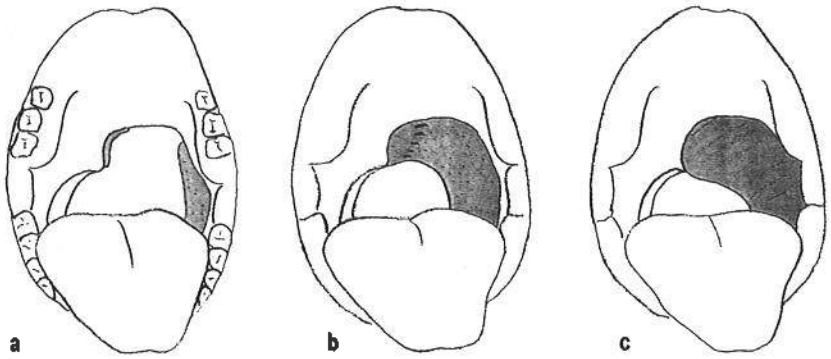

FIGURE II:
Three stages of the surgical procedure: illustration of (a) the defect with raw surfaces at the tonsillar region and soft palate remnant. (b) Approximation of the vertical layer of the dorsal pharyngeal wall towards the soft palate remnant. (c) Free radial forearm flap covers the raw surfaces.

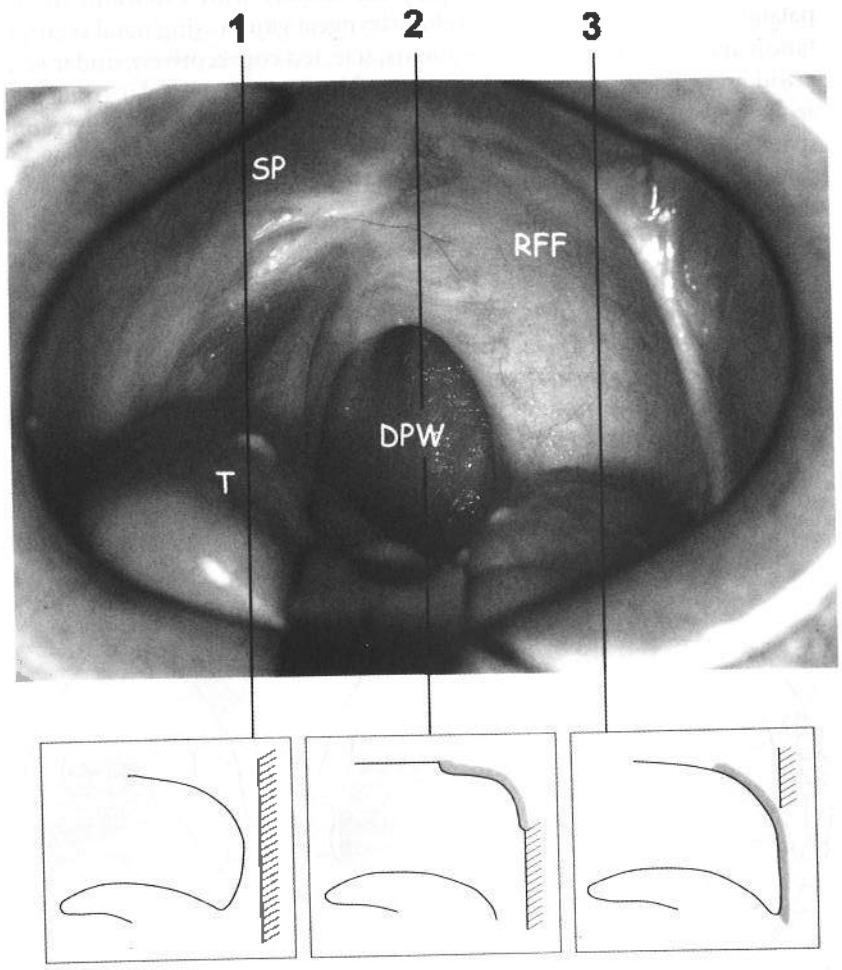

Figure III:
Section through the reconstruction, schematical drawing
RFF: free radial forearm flap
DPW: dorsal pharyngeal wall
SP: soft palate
T: tongue

Surgical technique (Fig II, Fig III): Wide resection of the lesion of the lateral pharyngeal wall, retromolar space and the soft palatal area was performed transorally, without mandibular split. Oncological free margins were assured by excision of the lesion into the homolateral soft palate cranially and by removal of a large strip of healthy mucosa around the primary lesion. This resulted in a resection of half up to two thirds of the soft palate. In all cases the completeness of the resection was confirmed histopathologically. A functional neck dissection was performed in all cases for oncological reasons and to obtain access to the neck veins for the microvascular anastomosis.
Reconstruction started with approximation of the dorsal layer of the soft palate remnant to the vertical edge of the dorsal pharyngeal remnant. The pharyngeal raw area was covered with the radial forearm flap: the tonsillar fossa at the lingual edge, the retromolar triangular space. The free radial forearm flap was cranially sutured to the posterior edge of the hard palate, thus performing a unilateral pharyngoplasty and narrowing of the velopharyngeal space.

Oncological and functional outcome assessment:
Our protocol consisted of questionnaire taking, speech evaluation and standard videofluoroscopy.
The questionnaire included the two topics speech (voice, resonance, articulation) and swallowing (several food consistencies, nasal regurgitation), which were rated overall and in detail. The sort of questions asked was: Can you take solid food, semi-solid food, fluids not/difficult/easily/fluently?; Is there any leakage through the nose?; Do you experience a change in feeding pattern?; Do you experience a change in verbal communication (resonance, articulation, voice)?
Speech evaluation was performed by an independent speech pathologist with more than 5 years of experience[20]. Objective and subjective assessment techniques were used on overall speech intelligibility, nasality, nasalance and voice. A sample of connected speech was audiorecorded in a sound-treated room using a Sony DAT recorder (55ES) and a Maxell DAT (DM120) cassette. The sample consisted of 5 minutes spontaneous speech (on leisure activities) and the reading of specific nasality weighted sentences. The samples were perceptually judged for intelligibility and nasality by an experienced speech pathologist. For evaluating the degree of perceived nasality disorders (hypernasality, hyponasality, nasal emission, etc.) a nominal scale with 4 categories was used (normal resonance, mild hypernasality/nasal emission, moderate hypernasality/nasal emission, severe hypernasality/nasal emission). A similar scale was used to

judge the overall speech intelligibility (from normal intelligibility to severely impaired intelligibility). The Nasometer (model 6200), a microcomputer based system manufactured by Kay-Elemetrics was used for registration of the nasalance values. Following calibration, each subject was asked i) to sustain three vowels (/a/, /i/, /u/) and one consonant /m/ and ii) to read three passages. The first passage, the "oronasal" text contains 11.67 % nasal consonants, which is equal to the percentage found in standard Dutch speech (14). The second passage, the "oral" text, excludes nasal consonants and is used for detection of hypernasality. The third passage, the "nasal" text, is loaded with nasal consonants (57%) and is designed to detect hyponasality in a subject's speech. Voice assessment included a perceptual rating of the voice with filling out the GRBAS(I)-scale, developed by Hirano (15). Also the Dysphonia Severity Index (DSI) was determined (16). The DSI is designed to establish an objective and quantitative correlate of the perceived voice quality. It is based on the weighted combination of the following set of voice measurements: highest frequency (F0 high), lowest intensity (I low), maximum phonation time (MPT) and Jitter (J%). The DSI is constructed as DSI = 0.13xMPT-0.0053xF0high-0.26xI low-1.18xJ (%)+12.4. The DSI for perceptually normal voices, scored as G0 on Hirano's scale, equals +5. DSI values below 1.6 are deviant and a value of –5 matches an extremely bad voice, G3 on Hirano's scale.

The videofluoroscopy was a standard procedure, adapted from Logemann, we already described in functional outcome assessment of patients with total laryngopharyngectomy and colon interposition (II.3.1.2) (17,18)

III.1.3.4 Results

Morbidity and mortality

In the immediate postoperative period no major wound problems or necrosis occurred.

After a mean follow up of 21 months (3y8m-1y) all patients are alive and well; there was no evidence for residual tumour or tumour recurrence.

The mean hospital stay was 19.7 days (16-23 d). All patients received a tracheotomy temporarily during a mean period of 11 days (10-14 d).

Functional outcome

Questionnaire: The questionnaire revealed an undisturbed swallowing function in 3 patients; in 1 patient there was a slightly altered 'overall swallowing' pattern, because of mouth dryness caused by postoperative radiotherapy. In general, liquids could be taken fluently and there was no (3 patients) to minimal (1 patient) nasal regurgitation. There were no subjective alterations in speech or verbal communication.

TABLE 13

Questionnaire results

Pat	Voice	Resonance	Articulation	Solid food	Semisolid food
1	0	0	0	2	1
2	0	0	0	0	0
3	0	0	0	1	0
4	0	0	0	0	0

Pat	Fluid	Nasal regurgitation	Overall speech	Overall swallowing
1	0	1	0	2
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0

Index:
Pat: patient
Voice: self-assessment of voice quality, corresponding to the GRBAS scale (0= unaltered, 1= slightly altered, 2 = moderately altered, 3 = severely altered)
Resonance: 0= unaltered, 1= slightly altered, 2 = moderately altered, 3 = severely altered
Articulation:0= unaltered, 1= slightly altered, 2 = moderately altered, 3 = severely altered
Solid food: ease of swallowing (0= unaltered, 1= slightly altered, 2 = moderately altered, 3 = severely altered)
Semisolid food: ease of swallowing (0= unaltered, 1= slightly altered, 2 = moderately altered, 3 = severely altered)
Fluid: ease of swallowing (0= unaltered, 1= slightly altered, 2 = moderately altered, 3 = severely altered)
Nasal regurgitation: 0= none, 1= slight, 2 = moderate, 3 = severe nasal regurgitation
Overall speech: self-assessment of speech quality (0= unaltered, 1= slightly altered, 2 = moderately altered, 3 = severely altered)
Overall swallowing: self-assessment of swallowing function (0= unaltered, 1= slightly altered, 2 = moderately altered, 3 = severely altered)

Figure IV: Deglutition
Lateral videofluoroscopy
Bolus at the oropharynx
Videofluoroscopy confirmed the questionnaire in the absence of nasal regurgitation. It also showed normal oral and pharyngeal clearance times.

Table 14

Perceptual rating and acoustical analysis by an independent speech pathologist

Sub-jects	Sex	Articu-lation[1]	Voice			Nasality[2]		Nasalance[3] (%)		
			DSI[4]	Pitch[5] (Hz)	Jitter %[6]	Nasality	Nasal emission	Oronasal text	Oral text	Nasal text
1	M	normal	3,4	95	0.45	Normal	normal	31	5	55
2	M	normal	-3,4	107	2.27	Normal	normal	27	13	41
3	M	normal	-2.9	125	2.78	Normal	normal	43	15	49
4	F	normal	-8.8	131	4.98	Normal	normal	37	18	55

[1] Articulation: by perceptual evaluation
[2] Nasality: by perceptual evaluation
[3] Nasalance: by nasometry
Mean nasalance scores:
oronasal text: 33.8 % (22.8-44.8)
oral text: 10.9 % (2.5-19.3)
nasal text: 55.8 % (43.6-68)

[4] DSI: 0.13x MPT – 0.0053 x FOhigh-0.26 x I low-1.18 x J (%) + 12.4
Normal voices: + 5
Dysphonic voices: < 1.6
Extremely deviant voice quality: - 5
[5] Pitch: by acoustical analysis in Hz
[6] Jitter: by acoustical analysis in %

Speech (Table 14): The speech pathologist perceptually rated articulation, intensity, and nasality and interpreted these items as normal. Acoustical analysis showed a normal fundamental frequency in all 3 men, but a very low fundamental frequency in the female. Assessment of voice quality, demonstrates a low DSI in the majority of cases. This is according the findings that all patients had a G1 score on the GRBAS(I) scale. In the fourth patient an extremely deviant DSI value is calculated, because of the high Jitter% value (4.98 %).
Objective measurement of nasality with the Nasometer model 6200-3 IBM PC confirmed the perceptual analysis. The nasalance scores remained in the normal range for the nasal, oronasal and oral text.

Deglutition: Videofluoroscopy confirmed the questionnaire in the absence of nasal regurgitation. It showed normal oral and pharyngeal clearance times.

III.1.3.5 Discussion

Reconstruction with the free radial forearm flap is frequently used for soft tissue defects in head and neck surgery in general and for the oropharyngeal region in particular (19,20,21,22). Brown et al. use a superiorly based pharyngeal flap in 5 patients in addition to the free radial forearm flap to reduce swallowing and speech impairment. They recommend the use of additional tissue for defects of more than one quarter of the soft palate (20). Zeitels et al. use an advancement of the superior constrictor muscle to obtain narrowing of the velopharyngeal port (23). This procedure was performed in ten patients in whom a 35% to 65% soft palate resection was performed.
In our population the soft palate is removed for one half up to two thirds. Although several procedures for reconstruction of the soft palate have been described (such as prostheses, pedicled or locoregional flaps etc.), we are convinced that the use of a free flap is opportune. In this way, tissue bulk is added and a complete oral lining can be made which favours a primary healing. Because of the need for microvascular anastomosis also the neck is explored for regional lymph nodes, which is oncologically sound. The free radial forearm flap is preferred for its suppleness and modest bulk. However, other type of free flaps can be used as well.
We advocate this type of reconstruction in defects of one half to two thirds of the palate with a coexisting defect of the lateral pharyngeal wall. However, the pharyngeal defect may not exceed the dorsal midline at the velopharyngeal level, because in such defects reconstruction results in a velopharyngeal obstruction with hyponasality as a consequence.

Velopharyngeal function has been thoroughly described in cleft palate pathology (24). A main concern in cleft palate speech is hypernasality due to velopharyngeal inadequacy. Velopharyngeal inadequacy caused by a structural problem is called 'velopharyngeal insufficiency' and adjustment of the velopharyngeal port by using a velopharyngeal flap may be necessary. Even if the supplementary tissue has no real muscular activity, hypernasality is reduced. However, on long-term, scar tissue formation and retraction due to secondary healing diminishes the immediate postoperative benefit (25).

We have thought that partial closure of the velopharyngeal port with intact muscularity of the palatal remnant would most likely result in a good functional outcome. Technically this was achieved by using the soft and pliable radial forearm flap as a cover of the pharyngeal defect and as

a caudally based pharyngeal flap. For closure or narrowing of the velopharyngeal port, several surgical techniques are available such as the caudally or cranially based median velopharyngeal flap and the muscular sling procedure. Although nowadays a cranially based flap is advocated in cleft pathology, we prefer a caudally based flap (25). In this latter procedure the tissues are easy to address and manipulate, which is an advantage when the resection is performed transorally, without mandibular split.

Regarding the functional outcome in reconstruction for large oropharyngeal resections, often only the swallowing function is assessed. Deglutition turns out to be excellent in the majority of cases. Reviewing the literature we found only four reports, which address speech outcome, albeit very brief (20,21,23,26). The high disability rate in both swallowing and speech reported by Bodin et al. confirms the need for meticulous reconstruction (26).
In our population resonance disorders are investigated subjectively and objectively. Both methods prove the good functional outcome. Also swallowing impairment is minimal. This is confirmed by the length of tracheotomy period (11 days), which is short compared to the data of Remmert and al. that report decanulation on 34 days postoperatively (22).

Clinical practice nasopharyngoscopy in cleft patients shows that muscular activity in deglutition differs from muscular activity in speech. Absence of nasal regurgitation does not necessarily mean that velopharyngeal function in speech is accurate. Even a small gap, too small for nasal regurgitation, can result in hypernasality. Therefore, reports on good functional outcome in this type of reconstructive surgery should not only focus on deglutition but also on resonance. In order to prevent hypernasality in our population of major oropharyngeal resections, we developed a reconstructive refinement, which can be compared to a caudally based, unilateral velopharyngoplasty. As the contralateral palatal remnant keeps its muscular activity, a functionally optimal velopharyngeal closure can be obtained by obliteration of the velopharyngeal gap caused by the resection. A remnant of the dorsal layer of the soft palate is sutured to the vertical border of the dorsal pharyngeal wall, thus resulting in a transition of the remnant of the soft palate into the posterior pharyngeal wall. This corresponds with the nasal lining of the classic velopharyngeal flap. Covering the raw surface with the free radial forearm flap, the oral lining is restored. We cannot expect muscular activity in this reconstructed area, but as is

known from cleft pathology, this is not mandatory to prevent nasalance, especially when the contralateral soft palate remains functional. In contrast to the pharyngoplasty in cleft pathology, scar tissue formation and retraction of the tissues will not occur, as there are no raw surfaces left for secondary healing.

The evaluation of the functional outcome in four patients, performed as a pilot study, suggests this surgical technique is technical feasible and oncologically safe. Deglutition and speech were optimal both on subjective and objective rating.

III.1.3.6 Conclusion

This reconstructive technique allows wide surgical marges with restoration of an accurate velopharyngeal closure. Moreover, the technique can provide optimal deglutition and speech, and in particular prevent hypernasality.

III.2 Limiting swallowing impairment through lowering the prebolus resistance

III.2.1 Preface

The cricopharyngeal muscle contains oblique muscle fibres of the inferior constrictor muscle and circular muscle fibres of the upper esophageal sphincter. The motor innervation is partly controlled by the pharyngeal plexus and partly by the recurrent nerve (27). The term "**cricopharyngeal muscle**" can be regarded as an anatomical terminology.
In the manometric literature "**Upper Esophageal Sphincter**" is used to indicate a zone of high pressure, 3-4 cm in length that separates the atmospheric pressure in the pharynx from the sub-atmospheric pressure in the cervical oesophagus. From functional point of view, "**pharyngo esophageal sphincter**" would be more appropriate.

Until recently the cricopharyngeal muscle's generally accepted role was to maintain adequate tonicity to prevent air from passing into the esophagus in respiration and during swallowing the muscle relaxes to allow bolus transport into the lower digestive tract. However, in profound studies, the exact role of the cricopharyngeal muscle remains controversial. Goyal et al. state that the high-pressure zone in swallowing lies above the level of the cricopharyngeal muscle. They suggest that the pressure peak is mainly caused by the muscular activity of the lower constrictor muscle (28). Cook et al. studied the cricopharyngeal function and dysfunction with simultaneous manometry and cineradiography (29). The onset of manometric sphincter relaxation precedes the radiological opening by approximately 150 msec. There is a resting tone, which is myogenic in origin. Additional forces are required to open the sphincter following its relaxation. External traction forces exerted by the supra- and infra-hyoid muscles are essential for removing this residual intrinsic tone. The coordination of UES opening with pharyngeal propulsive forces is important for the normal and complete transfer of the swallowed bolus into the esophagus.

If the bolus propulsion forces in relation to the pre-bolus pressure are inadequate, stagnation will occur at the cricopharyngeal segment. As it is not always possible to increase the bolus propulsion forces, lowering the pre-bolus pressure may be a possible solution for specific swallowing problems.

We used botulinum toxin in 4 patients. We started with infiltration of the muscle in a patient complaining of dysphagia unconnected to a malignant or postoperative basis. In this first case, the main problem was a hypertonicity of the muscle itself, albeit unilaterally. The three other patients had previously been treated for a malignancy either by surgery or by radiotherapy. The swallowing problem was caused by a disturbed pharyngeal motility as a result of the section of the pharyngeal plexus during surgery or, in the second case, extirpation of an adenopathy. In the third and fourth case, the dysphagia can be considered as a relative hypertonicity of the horizontal part of the cricopharyngeal muscle.

III.2.2 Botulinum toxin for dysphagia due to cricopharyngeal dysfunction

MOERMAN, M., CALLIER, Y., DICK, C., VERMEERSCH, H. (2002). European Archives of Oto-Rhino-Laryngology 259: 1-3

III.2.2.1 Abstract

Botulinum injection in the cricopharyngeal muscle has not yet been described thoroughly. In reviewing the literature, only 24 cases were found in which botulinum injection was used to treat cricopharyngeal dysfunction. We want to add another 4 cases and discuss specific indications and necessary pre-treatment examinations. Depending on the patient's history and the clinical findings, botulinum injection may be performed. Manometry and videofluoroscopy are not mandatory. The type of functional pathology defines whether botulinum toxin will be a definite treatment or a temporary relief.

III.2.2.2 Introduction

In reviewing the literature, we have found 24 cases in which Botox injection was used to treat cricopharyngeal dysfunction (30, 31, 32, 33, 34). The use of botulinum toxin is well established in ophthalmologic and laryngological diseases such as blepharospasm, laryngeal dystonia or spasmodic dysphonia. The product is a toxin produced by the *Clostridium botulinum* bacteria, in which type A is preferred for human use because of immunological reasons and its efficacy. It is an acetylcholine-release inhibitor, which blocks the release of calcium ions and thus causes a temporary and reversible palsy. Since spasm of the cricopharyngeal muscle is a known aetiology of dysphagia, it is obvious that botulinum toxin should be considered as a possible therapeutic option.

III.2.2.3 Materials and methods

TECHNIQUE

This was a standard procedure in each case: 100 U of botulinum toxin A, obtained from Allergan (Botox) was diluted with 0.5 ml of sterile normal saline. This results in a 20 U per 0.1 ml solution. During a short endoscopic

procedure, the solution was injected under general anesthesia with a tuberculin syringe in three locations in the horizontal part of the cricopharyngeal muscle: dorsomedially, and ventrolaterally on both sides, according to Schneider et al. (30). Directed by nasopharyngolaryngoscopy, the injected amount (100 U) was divided into 1X 40 U and 2X 30 U and distributed over the three different sites. A total dose of 100 U was always administered.

Case 1

A 32-year-old man suffered from dysphagia for 2 years. He could only take liquids and needed very long feeding times. His meals were repeatedly interrupted by regurgitation and vomiting. Clinical examination with nasopharyngolaryngoscopy revealed stagnation in the right pyriform sinus. He had lost 14 Kg in 1 year. Manometry and videofluoroscopy were performed and normal. The full dose of 100 U botulinum was divided as 40 U (0.2 ml) ventrolaterally at the right, 30 U (0.15 ml) ventrolaterally at the left and dorsomedially.

Three months after the injection, he was able to take semisolid and solid foods, needed shorter feeding times and did not have to interrupt his meal for regurgitation or vomiting. Nasopharyngolaryngoscopy showed an absence of stagnation in the pyriform sinus, and he had gained 2 Kg in 2 months. Since manometry and videofluoroscopy did not show any pathology before the treatment, they were not repeated.

Case 2

One year after total laryngectomy and postoperative radiotherapy, a 60-year-old male laryngectomy patient underwent a neck dissection for an adenopathy secondary to his earlier T4 N0 M0 glottis carcinoma. After surgery, he was unable to take solids, complained of nasal reflux and had lost 6 Kg in 1 month. Clinical examination showed an absence of glossopharyngeal paralysis but endoscopy showed that the neopharynx was totally filled with saliva, which was impossible to clear with repeated deglutition. Videofluoroscopy was normal; manometry was not performed due to the clinical circumstances. Forty units of botulinum were given dorsomedially and 30 U on each side ventrolaterally. One month thereafter, he claimed a complete recovery. He was able to take any kind of food except meat, which, however he had not been able to eat since his total laryngectomy. Clinical examination showed a complete normal postlaryngectomy status. His weight increased by 2 Kg in 3 months.

Case 3

A 66-year-old male patient was treated for a pT2 pN2b M0 hypopharyngeal carcinoma with surgery and postoperative radiation therapy. A careful lateral approach with meticulous preservation of the hypoglossal nerve and superior laryngeal nerve allowed us to resect a tumour of the right base of the tongue and lateral pharyngeal wall. The defect was closed with a split thickness skin graft. A tracheotomy was performed, and a nasogastric tube was placed. The bolus dressing was removed through endoscopy 1 week post surgery. Swallowing problems persisted postoperatively and during radiotherapy. Videofluoroscopy showed major aspiration, which could easily be confirmed by nasopharyngolaryngoscopy. We administered the full dose of 100 U (40 U dorsomedially and 30 U on each side ventrolaterally). Three months thereafter, he took semisolid and solid foods; the nasogastric tube and the tracheal canula were removed. Videofluoroscopic control documented the improvement and only showed slight but significant laryngeal influx.

Case 4

A 65-year-old man with a T3 N0 M0 oropharyngeal carcinoma was treated with concomitant radio chemotherapy. He had suffered from severe dysphagia since that treatment. There was no oral intake possible except for a few drops of water, which resulted after a few attempts in a total block at the pharyngoesophageal sphincter. He was fed by a gastrostomy. Videofluoroscopy showed obstruction at the pharyngo-esophageal sphincter and major aspiration. This dysphagia was mainly due to a high degree of soft tissue fibrosis, mucosal dryness and adherent secretions. As a last possibility, botulinum was injected. The dose was given in a symmetrical way (40 U dorsomedially and 30 U on each side ventrolaterally). One month later, although he pretended to have an improvement in his ability to drink water, he had no spectacular improvement. This was foreseeable. However, nasopharyngolaryngoscopy showed that the cricopharyngeal muscle was unquestionably enlarged. At this point, a videofluoroscopy has not yet been performed.

III.2.2.4 Results

In these four cases, a *subjective* improvement is remarkable. This is confirmed by a questionnaire taken by the patient themselves and their immediate partners. Two of the patients described very serious swallowing problems before the injection, which improved spectacularly after the injection to a limited degree of dysphagia. This is illustrated by the gain in weight (case 2) or by the removal of the nasogastric tube and the tracheal canula (case 3). One out of four patients described the improvement as good (case 1) and one (the patient in case 4 who received radio chemotherapy) as moderate. We conclude that in all cases the botulinum injection augmented their quality of life.

III.2.2.5 Discussion

Botulinum toxin causes a temporal palsy and is often used for muscular spasm or hyperfunction. The normal swallowing pattern is a combination of pharyngeal motility, bolus pressure, anterosuperior movement of the larynx and upper esophageal relaxation. In this latter case, two muscles play a significant role: the inferior constrictor and the cricopharyngeal muscle, in which the horizontal part and the oblique part have to be considered separately. The oblique part conjuncts with the fibers of the inferior constrictor muscle and helps in the coordination of the pharyngeal propulsion. The horizontal part has its origin at the posterior border of the cricoid cartilage and because of its anatomical configuration has a more 'sphincteric' function. Too often, the terminology only reflects this horizontal part of the cricopharyngeal muscle. Therefore, we agree with Goyal et al. that hypopharyngeal dysphagia generally refers to the 'pharyngoesophageal sphincter dysfunction', which is a better term for 'cricopharyngeal dysfunction' (28).

In our series, manometry was not performed systematically, because we believe that it is not always reliable. Relaxation and opening of the upper esophageal sphincter are not synchronous in onset (29). Because of the laryngeal elevation and anatomical relation of the cricopharyngeal muscle to the cricoid cartilage, the measured region moves cephalad to the manometry probe. Also, Goyal et al. claim that there is a disparity between the anatomical location of the cricopharyngeal muscle and the manometric high-pressure zone of the pharyngoesophageal sphincter (28). The highest-pressure zone is above the level of the cricopharyngeal muscle and varies according to phonation, respiration and head posture. Therefore,

we are convinced that the most reliable indication for botulinum injection is based on the patient's history and the clinical signs in laryngopharyngoscopy. Clinical signs such as stagnation in the pyriform sinus, nasal reflux and aspiration are valuable indicators, but they must be linked to the pathogenesis in each patient. In our cases, the swallowing problems can be reduced to a relative hypertonicity of the pharyngo- esophageal sphincter. We tried to achieve a relaxation of the horizontal part of the cricopharyngeal muscle. We believe that in the first case, the main problem was a hypertonicity of the muscle itself, albeit unilaterally. In the second case, the swallowing problem was caused by a disturbed pharyngeal motility owing to section of the pharyngeal plexus during surgery for extirpation of the adenopathy. Also, in the third and fourth case, the dysphagia can be considered as a relative hypertonicity of the horizontal part of the cricopharyngeal muscle. The disturbed pharyngeal contraction pattern, resulting from fibrosis of the pharyngeal walls and the constrictor muscles, is insufficient for transfer of the bolus into the upper esophagus. Perhaps this fibrosis explains the delay (of 3 months) in the third case and the only moderate improvement in the fourth case. Probably in this last case the psychological effect of performing a surgical act also adds to the subjective improvement.

Botulinum toxin can be used as a diagnostic means to predict the outcome of an eventual myotomy (which could be considered in the first case). Dysphagia resulting from pharyngeal fibrosis can be treated by botulinum injections on the condition that the cricopharyngeal muscle itself keeps its muscular contractibility. In these cases, the anterograde resistance to the bolus is reduced, and a better transit into the esophagus is obtained. This becomes the treatment of choice when surgery is hazardous.

III.3 Limiting swallowing impairment by restoring the digestive tract

III.3.1 Preface

In large hypopharyngeal tumours or tumours of the upper esophagus, removal of the upper digestive tract is necessary, often in combination with a total laryngectomy. Restoring the digestive tract requires the creation of a tubular structure from the stomach to the pharynx. This can be achieved by free jejunal grafts, pedicled colonic grafts or tubed stomach (see Chapter I).

We assessed deglutition in 10 patients who received a pedicled colon interposition with or without laryngectomy. This study reveals that colon interposition is a good reconstructive technique in relation to deglutition. However, in the total laryngectomy group, the effect of lacking the anterocranial laryngeal movement is clear.
Next to deglutition, speech is an important feature in functional outcome. Secondary voice prosthesis placement can meet this condition (35).

III.3.2 Functional outcome following colon interposition in total pharyngo esophagectomy with or without laryngectomy

Moerman, M., Fahimi, H., Ceelen, W., Pattyn, P., Vermeersch, H. (2003).
Dysphagia, 18.2: 78 - 84

III.3.2.1 Abstract

Our study compares deglutition between a group who had undergone total esophago pharyngo laryngectomy and a group who had esophagectomy and partial pharyngectomy with preserved larynx, after reconstruction of the upper digestive tract with pedicled colon interposition. In four patients the laryngeal structures could be preserved (three caustic burns and one proximal esophageal tumour). Six patients underwent a total laryngopharyngectomy for large pharyngeal tumours. Swallowing was assessed by a questionnaire, clinical examination and videofluoroscopy. All patients had normal intake of semisolid foods and fluids. All patients but three experienced some feeling of "narrowing" of the tract: four at the level of the hypopharynx, two at the oropharyngeal level, one at the oral level. In the laryngectomy group, solid food caused some degree of delayed swallowing in two patients. Dumping occurred in one case out of the non-laryngectomy group. On clinical examination a tense motility in all laryngectomy patients appeared, food remnants in five and repeated swallowing movements in four. The videofluoroscopy confirmed repeated swallowing movements and presence of residual food in the oral cavity. Temporal stagnation occurred at the anastomosis site in all patients and in two patients at a place of colon redundancy. Colon interposition is a reliable reconstruction and gives the possibility of a good functional outcome. Although preservation of the larynx facilitates swallowing even in this reconstructive procedure, it may be better to perform a total laryngopharyngectomy and colon interposition in oncological cases where the pharyngeal remnant is borderline for primary closure.

III.3.2.2 Introduction

Advanced neoplastic or caustic lesions of the hypopharynx are treated with pharyngo-esophagectomy with or without laryngectomy. Restoration of the upper gastrointestinal tract may be performed by interposition of pedicled stomach, colon, free jejunal graft, a combined pedicled graft, or myocutaneous graft (36,37,38,39). Due to the variability of the arterial blood supply and more extensive surgery, the colon is infrequently used as a pedicled graft. In theory, however, the larger diameter and greater length of a colonic graft makes it a good choice for restoration of the gastrointestinal tract at the level of the hypopharynx, oropharynx, or high oropharynx. Little is known about the functional outcome of colonic interposition following pharyngo esophagectomy.

We found some degree of swallowing problems in most patients who underwent a laryngopharyngectomy when thoroughly investigated. Therefore, we think that if a good functional outcome can be proven, the use of pedicled colon as a reconstructive technique can be expanded to include these patients who underwent a total laryngectomy for a squamous cell carcinoma in the pyriform sinus and where there is little mucosa left for primary closure.

We retrospectively reviewed our experience with patients who had undergone (partial) pharyngo esophagectomy with or without laryngectomy and interposition of the pedicled left colon.

III.3.2.3 Methods

Patients

Ten consecutive patients underwent a pharyngo esophagectomy with colonic graft interposition from 1996 to 2000 at the author's institution. In 3 patients treated for caustic burns and 1 patient treated for proximal esophageal cancer, reconstruction was performed with preservation of the larynx (Table 15). In these cases the hypopharyngeal mucosa in the postcricoid area was meticulously removed, creating a raw surface on both arytenoids and a bare prevertebral fascia at the same level. The reconstruction was then performed as described by Moerman et al. (40).

The other patients underwent a total laryngectomy. This includes a circular defect up to the level of the oropharynx. The colonic anastomosis comprises an anterior suture line at the base of the tongue and a posterior suture line at the dorsal pharyngeal remnant, high in the oropharynx (at the level of the soft palate).

The patient's characteristics were drawn from the medical records.

TABLE 15

Patients' characteristics

Initials	*Gender*	*Age*	*Indication*	*RT*[1]	*Laryng-ectomy*	*Preop complaints*	*pTNM*
PA	F	36	caustic burn	-	-	none	-
BF	F	28	caustic burn	-	-	none	-
BH	M	63	proximal esophageal cancer	-	-	none	?
GB	F	47	caustic burn	-	-	none	-
ML	M	47	hypopharyngeal cancer	postop	+	pain, obstruction	T4N0M0
DWN	M	60	supraglottis cancer	preop	+	pain, obstruction	T4N1M0
VM	M	46	hypopharyngeal cancer	preop	+	none	T4N0M0
DVN	M	54	hypopharyngeal cancer	postop	+	none	T4N2aM0
DSM	F	55	hypopharyngeal cancer	-	+	pain, obstruction	T2N0M0
VHR	F	55	hypopharyngeal cancer	postop	+	pain, obstruction	T3N2a

[1] RT: radiotherapy

Surgical technique

The surgical technique in our centre conforms to the technique described by Loinaz et al. (41). All patients underwent preoperative colonoscopy; angiography of the mesenteric vessels was not performed. Mechanical bowel preparation was administered two days before surgery. Abdominal and neck surgery was performed simultaneously by two surgical teams. Following laparatomy for inspection and palpation of the abdominal wall contents, the right and transverse colon and splenic flexure of the left colon were mobilized. The colon pedicled on the left colic artery was used in all patients. The adequacy of the marginal artery blood supply was ascertained by temporary occlusion of the right and middle colic arteries. After transsection of the cervical esophagus and transhiatal blunt dissection of the lower third, the esophagus was removed by stripping it from

above. The pedicled left colon was then isoperistaltically and orthotopically brought up to the cervical region, where a wide anastomosis between the cut end of the colon and the hypopharynx or oropharynx was performed with interrupted inverted Vicryl 00 sutures. The distal end of the pedicled colon was then sutured to the posterior wall of the gastric antrum. A pyloroplasty and jejunal feeding catheter completed the abdominal procedure.

Functional and oncological outcome assessment
A questionnaire assessed the following: I) food tolerance, II) changes in quantity or frequency of feeding, III) dumping, IV) regurgitation, V) altered taste, VI) signs of obstruction and VII) general well-being. Routine clinical examination assessed the motility and sensitivity of the oral cavity, cranial nerve function and deglutition (see chapter II.2.2). Videofluoroscopy was performed six weeks after surgery. This method was based on Logemann's videofluoroscopic assessment (see chapter II.3.1.2). Apart from this specific functional evaluation, surgical morbidity and the period of hospital stay are noted, the latter representing the period for oral food intake.

Statistical analysis
Quantitative data are expressed as mean +/- standard deviation (SD) of the mean. Differences between fractions were evaluated with chi-square or Fisher's exact test where appropriate. Statistical significance was assumed at the $p<0.05$ level.

III.3.2.4 Results

Morbidity and mortality
Median hospital stay was 25 days. Mortality within this period was 0%. Major wound problems or necrosis of the colonic graft did not occur. The cranial suture at the level of the retrocricoidal hypopharynx or at the oropharynx (base of the tongue/soft palate) healed primarily without fistulous tract formation. In one case, minor leakage was present which sealed spontaneously after two weeks.

Functional outcome
Questionnaire results (table 16)
All patients had a normal intake of semi-solid foods and fluids, albeit in smaller portions so there were more meals a day. Solid food caused some degree of delayed swallowing in two patients of the laryngectomy group. A history indicating dumping was noted only in one patient. Regurgitation occurred moderately in two laryngectomy patients and slightly in two non-laryngectomees. All but three patients (two non-laryngectomy and one laryngectomy) experienced some feeling of "narrowing" of the tract: four at the level of the hypopharynx, two at the oropharyngeal level, and one at the oral level. Altered taste occurred in all but one patient of the laryngectomy group for which the causal relation with radiotherapy was spontaneously suggested by themselves. The only statistically significant difference between laryngectomy and non-laryngectomy groups regarded altered taste perception in laryngectomy patients, probably related to radiotherapy.

TABLE 16

Questionnaire results

Item	*Non laryngectomy n=4*	*Laryngectomy n=6*
Change in feeding habits	1	0
Tolerance of fluids	4	6
Tolerance of semisolid food	4	6
Tolerance of solid food	3	4
Change in quantity of meals	3	4
Change in frequency of meals	3	6
Dumping symptoms	1	0
Regurgitation	2	2
Taste abnormalities[1]	0	5
Avoidance of certain food	3	1
Obstructive symptoms	2	5

[1] p=0.048; Fisher exact test

Clinical examination

Oral sensitivity was normal in all patients, but motility was significantly reduced in laryngectomy patients. This was clinically demonstrated by the presence of food remnants at the level of the tongue or the cheek. Repeated swallowing movements helped to eventually clear the oral cavity. No significant differences were noticed in deglutition or head posture.

TABLE 17

Clinical examination

Item	*Non laryngectomy n=4*	*Laryngectomy n=6*
Normal sensibility	4	6
Normal motility[1]	4	0
Normal deglutition of fluids	4	6
Normal deglutition of semisolid food	4	6
Normal deglutition of solid food	4	3
Normal head posture	2	4
Repeated swallows necessary	1	4
Remnants at base of tongue	1	5
Normal chewing[2]	3	0

[1] p=0.002
[2] p=0.012; Fisher exact test

TABLE 18

Videofluoroscopy results

Item	*Non laryngectomy* *n=4*	*Laryngectomy* *n=6*
Normal oral phase	4	5
Normal pharyngo-esoph phase[1]	4	1
Stagnation of food bolus	4	6
Presence of peristalsis	0	0
Food remnants	1	3
Repeated swallows	1	3
Redundancy	1	1

[1] p=0.048; Fisher exact test

Videofluoroscopy

This confirmed repeated swallowing movements and the presence of residual food in the oral cavity. As peristalsis was diminished or absent in the colon graft, food was mainly transported by gravity and the propulsion forces of the base of the tongue in repeated swallowing manoeuvres. Temporal stagnation occurred at the anastomosis site in all patients and also at a place of colon redundancy in two patients. The pharyngo-esophageal swallowing phase was significantly more disturbed in laryngectomy patients.

III.3.2.5 Discussion

Malignancies of the hypopharynx or pyriform sinus demand a partial pharyngectomy, often combined with a total laryngectomy. The need for additional tissue to restore the digestive tract is defined by the amount of pharyngeal remnant. Hui et al. concluded that the minimum width of the pharyngeal remnant for primary closure should be 2.5 cm stretched (42). After a total laryngopharyngectomy, a free jejunal graft, a gastric pull-up or a myocutaneous flap, can restore the upper digestive tract. Although pectoralis major or latissimus dorsi flaps are frequently used, these tubed myocutaneous flaps have a small diameter. Schuller et al. reported disappointing results caused by the extensive bulk and inflexibility of these myocutaneous flaps (43). Pedicled stomach grafts often do not allow the creation of an anastomosis at the oropharyngeal level or higher because of inadequate length. Free jejunal grafts are a reliable alternative but demand a microvascular anastomosis. Furthermore, because the preserved jejunal peristalsis is not coordinated with the end of the oral phase, the bolus is often delivered to a closed graft, thus causing dysphagia (4).

Too often a compromise is made between wide tumour-free margins and sparing as much mucosa as possible for primary closure. We are convinced of the advantage of removing small pharyngeal remnants followed by a circular reconstruction in order to I) obtain high cure rates and II) restore swallowing function.

Total pharyngectomy with esophagectomy and colonic interposition meets the demands of total oncological clearance with a perfect restoration of the upper digestive tract. In this study, we reviewed our experience with this technique in a consecutive series of 10 patients. Functional results of colonic interposition were good, both in patients with and without laryngectomy. Fluoroscopically, peristalsis is absent in the pedicled graft and although most patients experienced some degree of narrowing, fluids and semi-solid food passed easily. Clinical examination showed a diminished solid food bolus transit in only 3 patients. Although videofluoroscopy showed stagnation, it demonstrated that there was no obstruction for solid food in most patients. We agree with Mc Connel et al. that in a total laryngopharyngectomy, the propulsion forces of the base of the tongue against an open reconstructive tract are the most important factor for guaranteeing successful swallowing (11,44). The advantage of isoperistaltic versus antiperistaltic colonic interposition has been confirmed experimentally (45).

In literature, swallowing is mentioned, but in too little detail. Popovici states that in a series of 253 colon or jejunum interpositions with pre-

served larynx, 70% had a normal diet, 21% had mild dysphagia but were satisfied with their postoperative situation, and 7% had severe dysphagia. However, he does not mention how dysphagia was assessed (46). Wain et al. assessed deglutition in 52 patients by means of a not- specified questionnaire and weight control (47). They performed barium radiography for evaluation of the anastomoses but not for swallowing purposes. In their study, swallowing function was excellent in 24%, good in 66%, and poor in 10%. Jeyasingham et al. defined dysphagia in a series of 365 patients treated for benign esophageal disease (48). They assessed functional outcome by clinical examination, barium radiography, esophago colo gastroscopy, manometry, and pH-metry. They concluded that long colon interposition has its problems, both mechanically and functional, in contrast to short colon interposition.

Our study compared a small group of laryngectomees with non-laryngectomees in their functional outcome. The statistical difference was in taste perception (questionnaire), oropharyngeal motility and chewing (clinical examination), and pharyngoesophageal phase (videofluoroscopy). The prolonged pharyngoesophageal transit on videofluoroscopy can be linked to chewing and appearance of obstructive symptoms in the questionnaire. However, this does not change feeding habits; there was only one patient who avoided certain foods. The taste alterations can be explained as a result of radiotherapy.

The difference between the laryngectomy and the non-laryngectomy group is, in our view, caused by the extirpation of the larynx itself. Removal of the larynx results in loss of laryngeal elevation and passive opening of the upper esophageal sphincter, in this case the colon anastomosis. We are convinced of the fact that in the perspective of this good functional outcome, this technique can be considered in cases of large hypopharyngeal tumours where surgical treatment implies a total laryngectomy and pharyngeal reconstruction. In these cases little pharyngeal mucosa is left and additional tissue is needed. A larger study design is needed for improving the surplus value of colon interposition compared with other reconstructive procedures in relation to functional outcome, morbidity, and oncological outcome.

In conclusion, use of a pedicled isoperistaltic left colonic graft permits reconstruction at the level of the hypopharynx or the (high) oropharynx following pharyngoesophagectomy with or without laryngectomy. Although preservation of the larynx facilitates swallowing, laryngopharyngectomy and reconstruction of the pharynx with a wide-open tract offers a chance for good functional outcome.

III.4 Limiting swallowing impairment by reviewing generally accepted rules

III.4.1 Preface

Total laryngectomy is a well-known surgical technique. As a rule, oral food intake is started from one week postoperatively on. However, reviewing literature, no sound explanation is found. Most centers reason that i) before oral food resumption, the pharyngeal suture line has to be firm enough as to resist the propulsion forces, and that, ii) when oral food intake is permitted too soon, higher incidence of fistulae tract formation is observed. It is generally assumed that suturing the constrictor muscles as a second layer, superficially to the pharyngeal suture line, can help preventing the latter. But, this reasoning is ambiguous. Immediately postoperatively the act of swallowing is inevitable as saliva production continues, followed by oral and pharyngeal clearance. Also, recently constrictor myotomy for achieving better voice quality is universally advocated. But suturing the constrictor muscles followed by a myotomy seems not logical as these tissues may become avascular and end in a fibrotic bar (49). Therefore, we performed a study in which i) the effect of suturing the constrictor muscles and ii) early oral food resumption was evaluated.

Many papers have been written for optimal voice restoration in total laryngectomy (49, 50,51). Although deglutition and speech are linked, this manuscript focuses on swallowing impairment and not on voice rehabilitation. However, sometimes voice prostheses can cause problems and subsequent swallowing impairment. As voice prostheses are foreign bodies, host versus graft reaction may occur. This may present as i) proliferation of tissues and expulsion of the prosthesis or as ii) retraction of tissues and widening of the tracheo-esophageal fistula. Whatever the kind of host versus graft reaction may occur, the consequence is leakage of fluids and food through the fistula with the inherent risk of aspiration pneumonia. Therefore, closure of the fistula is mandatory. One can assume that closure of an esophageal defect by approximation of tissue margins can result in swallowing impairment. However, our study on 12 patients suggests the contrary. The simple surgical technique provides a good result. Although it was not the purpose of this study, this study also demonstrates that early oral food resumption is possible without surgical failure. In two cases oral food intake was permitted from two days postoperatively on which did not result in fistula recurrence or leakage.

We are convinced that the most important issue in pharyngeal closure is suturing the pharyngeal mucosa very precise, without strangulating the tissues. When this condition is fulfilled, additional tissue is not needed.

III.4.2 Early oral food intake in total laryngectomy: covering the pharyngeal mucosa with muscular layer does not provide additional advantages

Vermeersch, H., Moerman, M., Fahimi, H., Bonte, K., Van Cauwenberge, P.

Submitted

III.4.2.1 Abstract

Statements of the problems This study concerns early oral food intake in total laryngectomy whilst modifying the constrictor muscles closure technique.
Methods of study Twenty-one total laryngectomy patients were randomly divided into two groups. The first group (ten patients) only received pharyngeal mucosa closure, with suturing of the constrictor muscles on the side. The second group (eleven patients) received closure of the constrictor muscles and unilateral myotomy above the two-layer sutured pharyngeal mucosa. The control group was a randomly collected historical group.
Results The complication rate (average 14% for both groups) is comparable to the figures found in literature. The average period before restarting liquids was 4 days for both study groups and 10 days for the control group. For mechanically soft food this period was 6.5 days and 13 days respectively. The hospital stay was reduced from 15 days for the control group to 11 days for both study groups.
Conclusions It seems possible to allow early oral food intake (up to 5 days postoperatively) without increasing the complication rate, and this leads to a shorter hospital stay. Closure of the constrictor muscles does not provide any additional advantages.

III.4.2.2 Introduction

The postoperative course after total laryngectomy is often characterized by starting to restore oral food intake during the period from day 7 to day 10 after the operation. This one-week delay is preferred to ensure firm suture lines that are capable of withstanding the pressure of swallowing (and speech). However, in reviewing literature, we did not find a sound explanation for this rule. Therefore, we reduced the period of delay and began reintroducing oral food intake from the fifth postoperative day.

Several publications state that unilateral myotomy or neurotomy improves the tracheo-esophageal (TE) voice quality by creating more space for the pharyngeal mucosa to vibrate (49, 50, 51). However, we thought it would be irrational to I) first suture the constrictor muscles on the midline and then II) divide the muscles again laterally. The muscular rest (from the midline towards the myotomy line) may end in an avascular and fibrotic bar, thus hampering the stretching of the pharyngeal mucosa and, as a consequence possibly resulting in swallowing problems (and lower TE speech quality). We compared the complication rate of two types of surgery namely, I) pharyngeal closure only and suturing the constrictor muscles at the side versus II) suturing the constrictor muscles above the pharyngeal suture line and unilateral myotomy, whilst restarting oral food intake earlier postoperatively. It was expected that if early oral food intake without higher complication rate was achievable, the length of hospitalisation could also be reduced. We did not focus on speech quality, although this also reflects pharyngeal suppleness through vibration.
Comparing the two study groups, the effect of muscle closure above the mucosal suture line has been evaluated.

III.4.2.3 Material and methods

Patients (tables 19, 20, 21)
Since mid-2001, 21 patients have undergone a total laryngectomy in the department for ENT and Head and Neck Surgery, at Ghent University Hospital, Belgium. The patients were randomly split into two groups. Group I received a closure of the pharyngeal mucosa in two layers, but the constrictor muscles was left open and evenly sutured at the side to prevent spontaneous adhesion towards the midline. Group II received closure of the pharyngeal mucosa in two layers and closure of the constrictor mus-

cles with unilateral myotomy from the base of the tongue cranially to the cricopharyngeal muscle caudally. The patients were alternately assigned between the two groups according to the order in which they presented themselves at the outpatient department (i.e. the first patient was put into group I, the second patient into group II, the third patient into group I etc.). All patients received oral food intake according to a standard protocol, namely: all patients took pure water on the second day after the operation. Liquid food, such as porridge and yogurt, was started between the second and fifth day after the operation, according to the patient's preference. Full oral diet (meat, cheese, etc.), albeit of mechanically soft consistency, was permitted from day 6 postoperatively onwards. The patients left the hospital the moment oral intake was normalized. The individual data for each patient, for example, date recording the exact time of oral intake and type of food, was noted in detail. This data was then used for further calculations.

The control group consisted of 12 patients who had been operated on between 1996 and 2000 at the same centre. The group was randomly selected save that they had all undergone the same surgical procedure using the same surgical technique as that used for the patients in group II. Patients in the control group had been allowed to swallow water from the seventh day after the operation and liquid food from the eighth day onwards. As this was a standard procedure at that time, exact data was not systematically noted in the files and thus is not recorded for some patients in table 21.

TABLE 19

Patients' characteristics (operation type I)

Patients (All males)	*Date of operation*	*Hospital stay (D/M/Y)*	*Remarks (D/M/Y)*	*Liquid*[a]	*mechanical soft*[b] *(D/M/Y)*	*TNM (D/M/Y)*
P1	17/05/01	28/0501	preop RT[c]	21/05/01	23/05/01	rT3N0M0 supraglottis
P2	11/06/01	30/06/01	bil neck[d] abced 20/06	16/06/01	18/06/01	pT4N3M0 hypopharynx
P3	23/07/01	03/08/01		27/07/01	31/07/01	rTa1N0M0 glottis
P4	08/08/01	22/08/01	diabetes	12/08/01	14/08/01	pT2N0M0 glottis
P5	17/09/01	28/09/01		21/09/01	23/09/01	T3N0M0 supraglottis
P6	10/01/02	20/01/02	diabetes preop RT[c]	14/01/02	17/01/02	rT1N0M0 transglottis
P7	14/06/01	05/07/01	unil neck[d] diabetes	18/06/01	20/06/01	pT4pN0M0 hypopharynx
P8	18/10/01	29/10/01	preop RT	23/10/01	25/10/01	rT2N0M0 glottis
P9	30/05/02	13/06/02	hypoglossal nerve[e]	03/06/02	05/06/02	rT1N0M0 supraglottis
P10	30/05/02	12/06/02		01/06/02	03/06/02	rT1N0M0 glottis
P11	17/06/02	26/06/02	preop RT[c]	20/06/02	18/06/02	rT1N0M0 glottis

a: Liquid = start of liquid food intake (water, yogurt, soup etc.)
b: Mechanical soft = start of solid food intake (cheese, meat, bread, etc.)
c: preop RT = preoperative radiotherapy
d: bil/unil neck = bilateral /unilateral neck dissection
e: hypoglossal nerve = unilateral hypoglossal nerve paralysis due to surgery

TABLE 20

Patients' characteristics (operation type II)

Patients (All males)	*Date of operation*	*Hospital stay (D/M/Y)*	*Remarks (D/M/Y)*	*Liquid*[a]	*mechanical soft*[b] *(D/M/Y)*	*TNM (D/M/Y)*
P1	05/06/01	16/06/01	bil neck[c]	09/06/01	12/06/01	pT3pN2cM0 supraglottis
P2	19/06/01	29/06/01	unil neck[c]	24/06/01	25/06/01	pT4N2M0 hypopharynx
P3	14/07/01	26/07/01	COPD[d]	19/07/01	21/07/01	pT4N0M0 translottis
P4	26/07/01	10/08/01	fistula 31/07	30/07/01	08/08/01	pT4N0M0 glottis
P5	13/08/01	24/08/01		18/08/01	19/08/01	T2N0M0 supraglottis
P6	05/11/01	13/11/01		09/11/01	11/11/01	pT4N0M0 transglottis
P7	06/12/01	17/12/01		10/12/01	12/12/01	T2N0M0 subglottis
P8	07/01/02	16/01/02		11/01/02	13/01/02	pT3N0M0 supraglottis
P9	11/01/02	20/01/02		15/01/02	17/01/02	pT1N0M0 glottis
P10	16/05/02	29/05/02	hemat[e] 19/5 preop RT[f]	21/05/02	24/05/02	pT4N0M0 glottis
P11	05/05/02	16/05/02		08/05/02	10/05/02	papillomat[g]

a: Liquid = start of liquid food intake (water, yogurt, soup etc.)
b: Mechanical soft = start of solid food intake (cheese, meat, bread, etc.)
c: bil/unil neck = bilateral /unilateral neck dissection
d: COPD = chronic obstructive lung disease
e: hemat = hematoma on date 19/05/02
f: preop RT = preoperative radiotherapy
g: papillomat = malignant laryngeal papillomatosis

TABLE 20

Patient's characteristics (control group)

Patients (All males)	*Date of operation*	*Hospital stay (D/M/Y)*	*Remarks (D/M/Y)*	*Liquid*[a]	*mechanical soft*[b] *(D/M/Y)*	*TNM (D/M/Y)*
P1	05/06/00	20/07/00		15/06/00	16/06/00	pT3N1M0 supraglottis
P2	21/02/00	08/04/00		05/03/00	06/03/00	rT2N0M0 oropharynx
P3	27/07/00	13/08/00		08/08/00	10/08/00	rT2N0M0 glottis
P4	24/07/00	11/08/00	brachyth base of tongue[e]	05/08/00	09/08/00	T3N0Mx supraglottis
P5	18/11/97	01/12/97	unil neck[c] preop RT[d]			rT1pN1M0 glottis
P6	17/03/97	30/03/97	bil neck[c]			T1pN1M0 supraglottis
P7	07/07/97	18/07/97		16/07/97		recurrency supraglottis
P8	23/03/98					pT4N0M0 supraglottis
P9	10/02/97	24/02/97	preop RT[d]	18/02/97	20/02/97	rT1N0M0 glottis
P10	07/10/97	27/10/97				T3N0Mx glottis
P11	04/08/97	18/08/97		12/08/97		T2N0M0 transglottis
P12	01/07/96			preop RT[d]		rT1N0Mx glottis

a: Liquid = start of liquid food intake (water, yogurt, soup etc.)
b: Mechanical soft = start of solid food intake (cheese, meat, bread, etc.)
c: bil/unil neck = bilateral /unilateral neck dissection
d: preop RT = preoperative radiotherapy
e: brachyth = brachytherapy at base of tongue

III.4.2.4 Results

Oral food intake

Taking the day of operation as day 0, patients were allowed to swallow water on day 2. The initial intake of liquid food (e.g. water, yogurt, soup) varied between 3 to 5 days after the operation in the study groups and between 8 to 12 days in the control group. In the study groups, mechanically soft food was generally started between day 5 and day 8, although for one patient, mechanically soft food was started as late as day 13 because that patient had developed a fistula the day after starting liquids.

The average time for starting liquid food was 3.9 days in group I and 4.3 days in group II. The average time in the control group was 10 days. Calculating the average time at which mechanically soft food intake started, the figures are 6.2 days in group I, 6.9 days in group II and 13 days in the control group.

Hospital stay

The average hospital stay in group I was 13 days and in group II it was 11 days. However, two patients in group I had a prolonged hospital stay (P2: 19 days and P7: 21 days), caused by systemical disease (severe diabetes) and wound infection. Excluding these two patients from the calculations, the average hospital stay was 11 days. In the control group the average hospital stay was 15 days.

Complication rate

Considering hematoma, fistula formation and abcedation as surgical complications, the complication rate for group I was 10% and for group II it was 18%. In the control group there were no complications at all. The complication rate for the whole study group (i.e. taking group I and II together) was 14%.

III.4.2.5 Discussion

Although it is generally accepted that oral food intake may start from one week after the operation, we did not find sound any arguments for this rationale in literature. Therefore, we allowed earlier intake of liquids and solid food. One patient (P4 in group II) developed a fistula the day after he started drinking water. To allow secondary healing, mechanically soft food was delayed until the thirteenth day instead of starting between the fifth to

eighth day after the operation. This case still conforms the average delay period before resuming oral food intake in the control group (i.e.13 days). In literature, a complication rate of between 4% and 38% has been reported for solely fistulae incidence (52, 53). The complication rate in our series concerning fistulae incidence and eventual abcedation or hematoma, was 14%. This is lower than the figures obtained by Shenoy et al., who reported a 28% complication rate and is certainly acceptable when compared to the reported fistulae incidence rate (4% to 38%) (54).

Focusing on the average hospital stay, we notice that two patients in group I had a prolonged hospital stay (group I - P2: 19 days and P7: 21 days). However, this prolonged hospital stay was caused by reasons other than oral food resumption, namely systemical disease such as diabetes, late wound infection. We can therefore exclude these patient's figures when calculating the average hospital stay. This reduces the average hospital stay (from 13 days to 11 days).

If we compare group II with the control group, the average hospital stay is reduced by 4 days.

This means that early oral food intake results in i) an acceptable complication rate and ii) a shorter hospital stay.

Comparing group I with group II, we perceive a difference in the complication rate (10% versus 18%), but only a small or virtually no difference in i) the period of delay before starting oral food intake (6.2 days versus 6.9 days) or ii) the average length of required hospital stay (11 days versus 11 days). The difference in complication rate would probably be even lower for larger study groups. This suggests that closure of the constrictor muscles does not provide any additional advantages. This is consistent with the hypothesis of Horowitz et al. (53). Those authors state that "unilateral myotomy reduces the cricopharyngeal pressure, thereby diminishing forces against the pharyngeal suture line with minimizing postoperative fistulisation, eliminating dysphagia of cricopharyngeal spasm and improving the alaryngeal voice quality". The surgical technique in group I involved suturing the constrictor muscles at the side, thus eliminating propulsion forces against the intact cricopharyngeal muscle. Therefore, the same theoretical viewpoint can be applied.

Focusing on deglutition, we are convinced that when a firm pharyngeal suture line is achieved, closure without the additional muscular layer can be performed without increasing the risk for fistula development. However, if a fistula arises early postoperatively, it is probably due to an incomplete pharyngeal suture. Fistulas occurring in the late postoperative

period are usually the result of complications or slow wound healing, for example, compromised wound healing through radiotherapy, severe diabetes, hematoma etc.

III.4.2.6 Conclusion

Intake of oral food after total laryngectomy can be accelerated without increasing the risk for fistula development. Equally, the hospital stay can be reduced. Suturing an additional muscular layer onto the two-layer closed pharyngeal mucosa seems not to provide any additional benefits.

III.4.3 A simple surgical technique for closure of tracheo-esophageal fistulae

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European Archives of Oto-Rhino-Laryngology, (in press)

III.4.3.1 Abstract

Placement of a voice device in a tracheo-esophageal fistula provides successful speech rehabilitation after total laryngectomy. However, on long term, removal of the voice device and permanent closure of the fistula is sometimes necessary. This paper presents and evaluates a simple surgical technique for primary closure of tracheo-esophageal fistulae.
We retrospectively review 12 laryngectomees who received this technique of primary closure from 1997 to 2000.
In 58 % permanent fistula closure could be obtained. Six patients (50 %) healed primarily; in one patient (8 %) the residual fistula opening healed secondarily. Four patients (33 %) needed a secondary surgical procedure, and in one patient (8 %) inserting a new prosthesis obliterated the residual fistula. Radiotherapy seems to compromise wound healing and therefore may be considered as a contraindication.
Complications such as tracheal stenosis, tissue necrosis, and pneumonia etc. did not occur.

III.4.3.2 Introduction

Primary tracheoesophageal (TE) puncture and placement of a voice device result in successful speech rehabilitation after total laryngectomy. However, on long term extrusion of the prosthesis or –on the contrary- widening of the fistula, can occur with leakage through the TE fistula and pneumonia as a consequence (Figure IV). Brasnu et al report enlargement of the tracheo-esophageal fistula and leakage in 46 % of their study population (55). Several conservative procedures such as silver nitrate application, teflon, collagen or fat injection, have been tried to resolve the latter problem however, these techniques do not consistently provide long-term satisfaction (55,56,57). From that, permanent –surgical- closure of the fistula becomes mandatory. Various authors advise the use of pedicled or free flaps to avoid fistula recurrence (58,59,60,61).
Reviewing literature, we only found one report concerning primary closure without the need for additional tissue (62).
We describe a simple surgical technique and the surgical and functional outcome in 12 patients operated from 1997 to 2000.

III.4.3.3 Methods

Patients (table 22)
From 1997 to 2000, 12 patients underwent tracheoesophageal fistula closure, using the described technique, in the ENT and Head and Neck Surgery department at the Ghent University Hospital, Belgium. Surgery was performed on explicit demand of the patients, by two independent surgeons (MM and HV) after failure of conservative treatment.
In one patient, who had received a tracheoesophageal voice prosthesis by secondary placement for obtaining a superior voice quality compared to his esophageal voice, the prosthesis was removed for reasons of little benefit in voice quality and objections about the intensive cleansing procedure and daily hygiene. For this, and because of leakage around the prosthesis he asked for removal of the prosthesis and closure of the fistula.
In more recent laryngectomy procedures, primary placement of the prosthesis was standard performed. Symptoms of reaction were the main cause for prosthesis removal (58 %). This can present as an exofytic tissue growth with expulsion of the prosthesis as a consequence, or as a widening of the tracheoesophageal fistula with loosening of the prosthesis and secondary leakage around the prosthesis. Other reasons for prosthesis removal were disuse of the TE speech (33%) and obstructive swallowing impairment (8%).

TABLE 22

Patients' characteristics

Patients (All males)	*Date of Birth (D/M/Y)*	*Date of Laryngectomy (D/M/Y)*	*Placement (primary/secondary)*	*Reason for prosthesis removal*
P1	18/03/41	19/01/99	primary	Pat did not use TE
P2	08/04/31	Jan1994	secondary	Enlargement TE fistula
P3	05/09/23	August 1997	primary	Pat did not use TE
P4	21/06/36	25/03/98	primary	Enlargement TE fistula
P5	15/03/35	27/10/97	primary	Enlargement TE fistula
P6	26/02/46	13/05/95	primary	Exofytic growth
P7	19/01/28	17/03/97	primary	Enlargement TE fistula
P8	28/01/29	20/05/97	primary	Pulmon dis + no TE speech
P9	17/07/25	09/01/98	primary	Obstructive dysphagia
P10	15/05/38	26/06/93	primary	Exofytic growth
P11	31/08/29	06/04/98	primary	Enlargement TE fistula
P12	30/04/22	January 1996	primary	Pat did not use TE

Notes.
Pat = patient
TE = tracheo-esophageal speech
Exofytic growth= proliferative tissue growth
Pulmon dis = pulmonary disease (chronic obstructive lung disease)

Surgical technique (Fig V-VIII)
The procedure is performed under general anaesthesia with high frequency jet ventilation. As cotton gauze blocks the tracheal stoma preventing aspiration, a second ventilation tube is put in place maintaining the air outlet. A longitudinal incision is made in the middle of the posterior tracheal wall, in length of the fistula. The fistula is circumscribed in benefit of the tracheal layer and the esophageal mucosa is separated from the tracheal epithelium. An inverted holding suture with a resorbable monofilament (Monocryl 0000) is put in place both at the cranial and caudal end of the fistula. The first esophageal mucosal layer is closed by separate inverted resorbable sutures, paying attention not to strangulate the tissues. The second esophageal mucosal layer is also sutured by separate inverted sutures. The third layer consists of tracheal epithelium and is sutured with non-resorbable monofilament (Ethilon 0000).
The dressing consists of a tracheal canula for 3 days. Antibiotics were not administered.

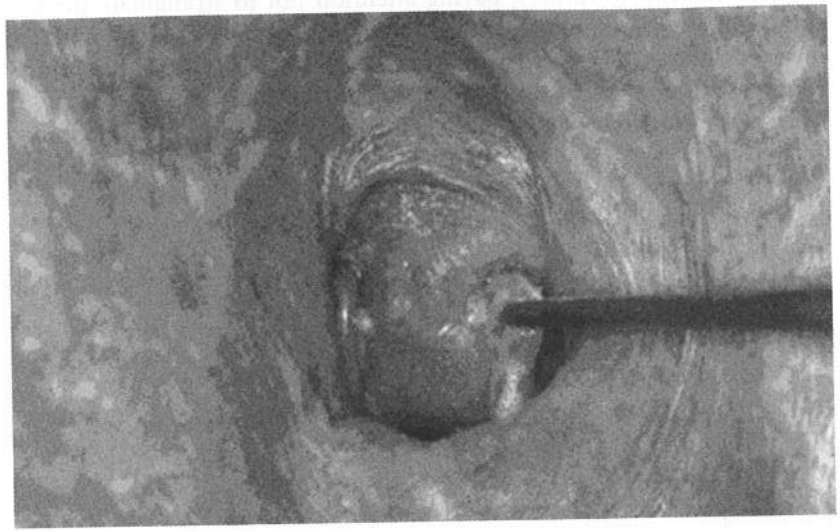

FIGURE IV:
exofytic tissue growth

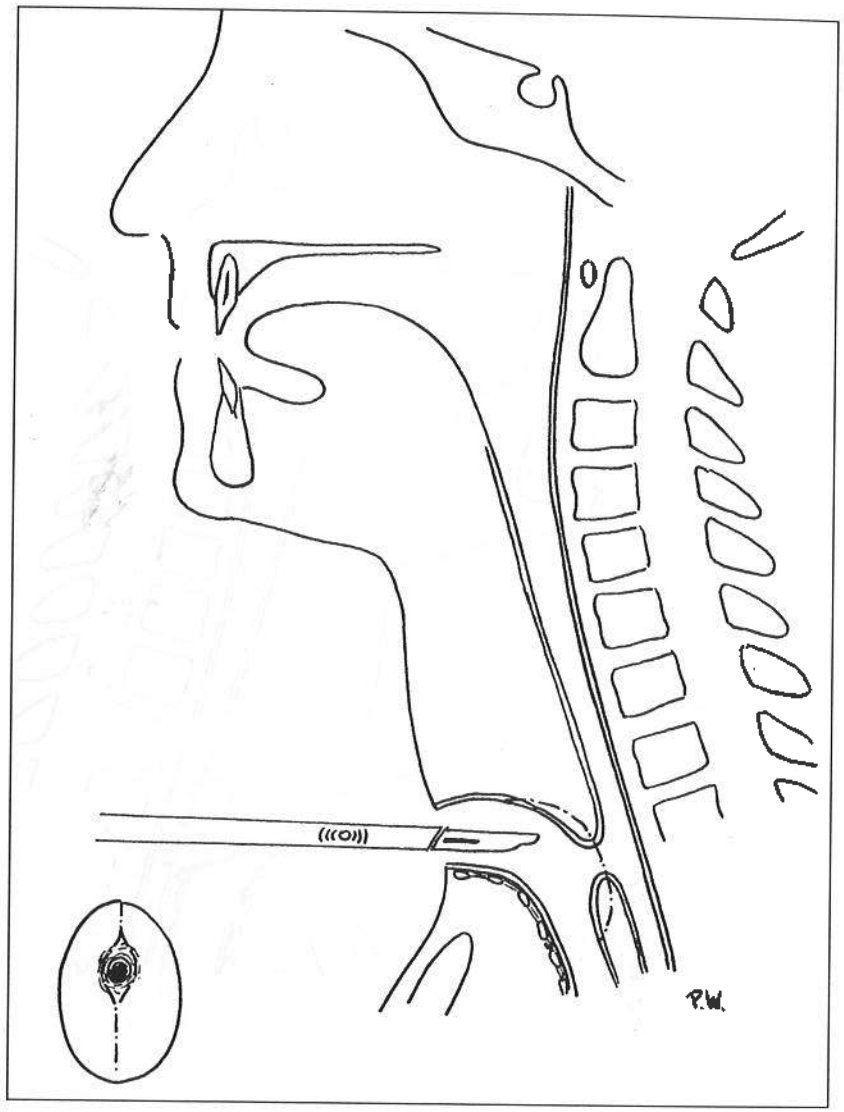

FIGURE V:
outline of the incision around the fistula in favour of the tracheal lining

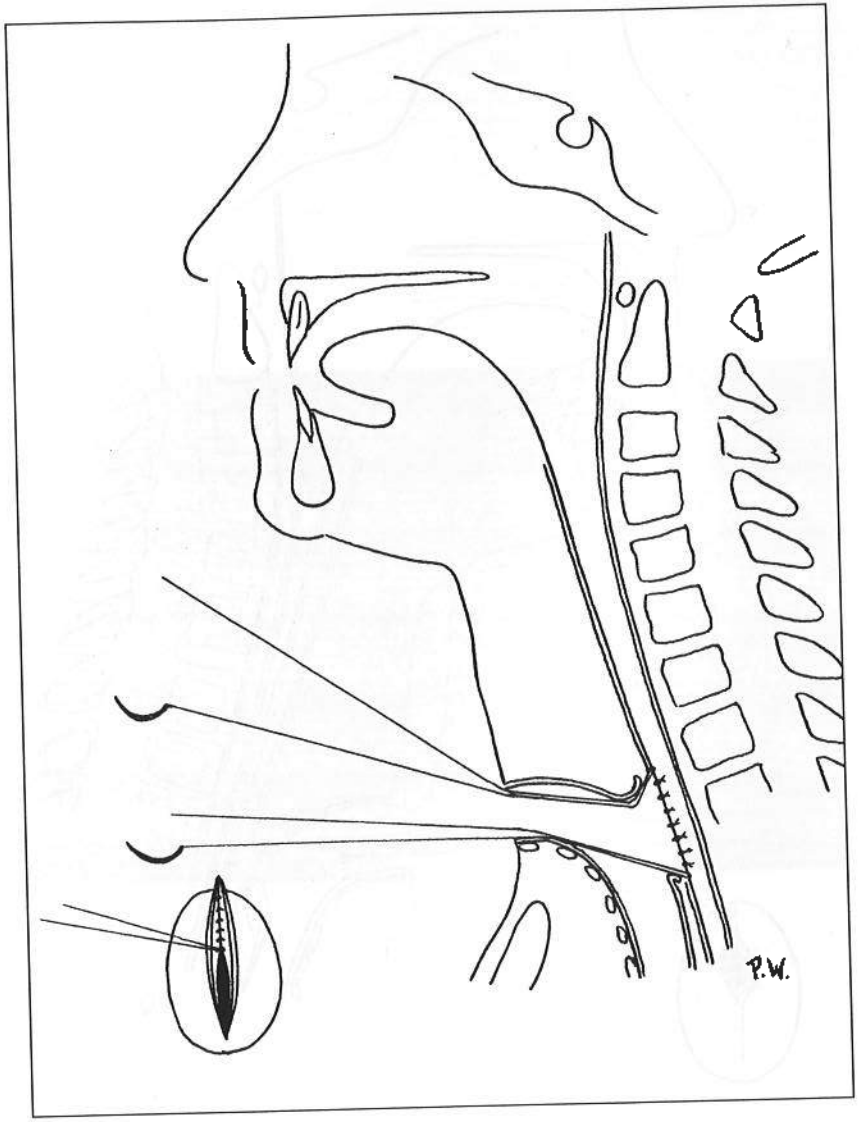

FIGURE VI:
closure of the first esophageal layer, separated inverted sutures

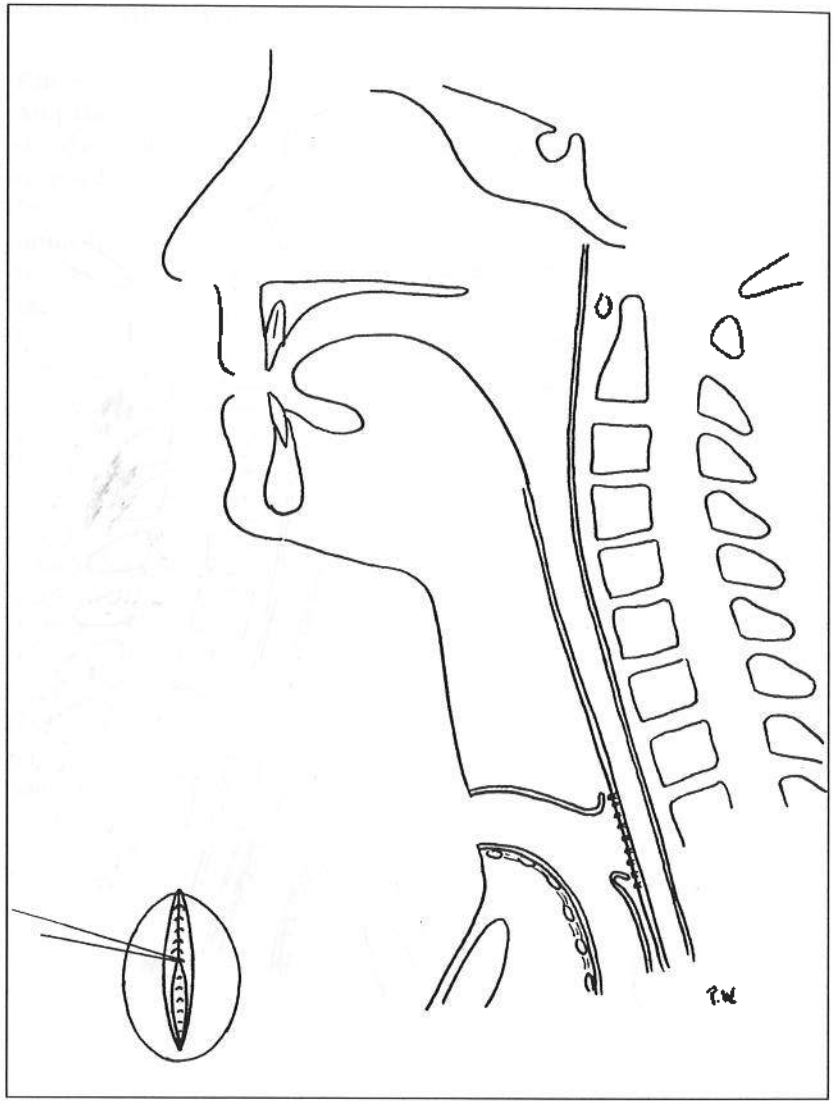

FIGURE VII:
closure of the second esophageal layer

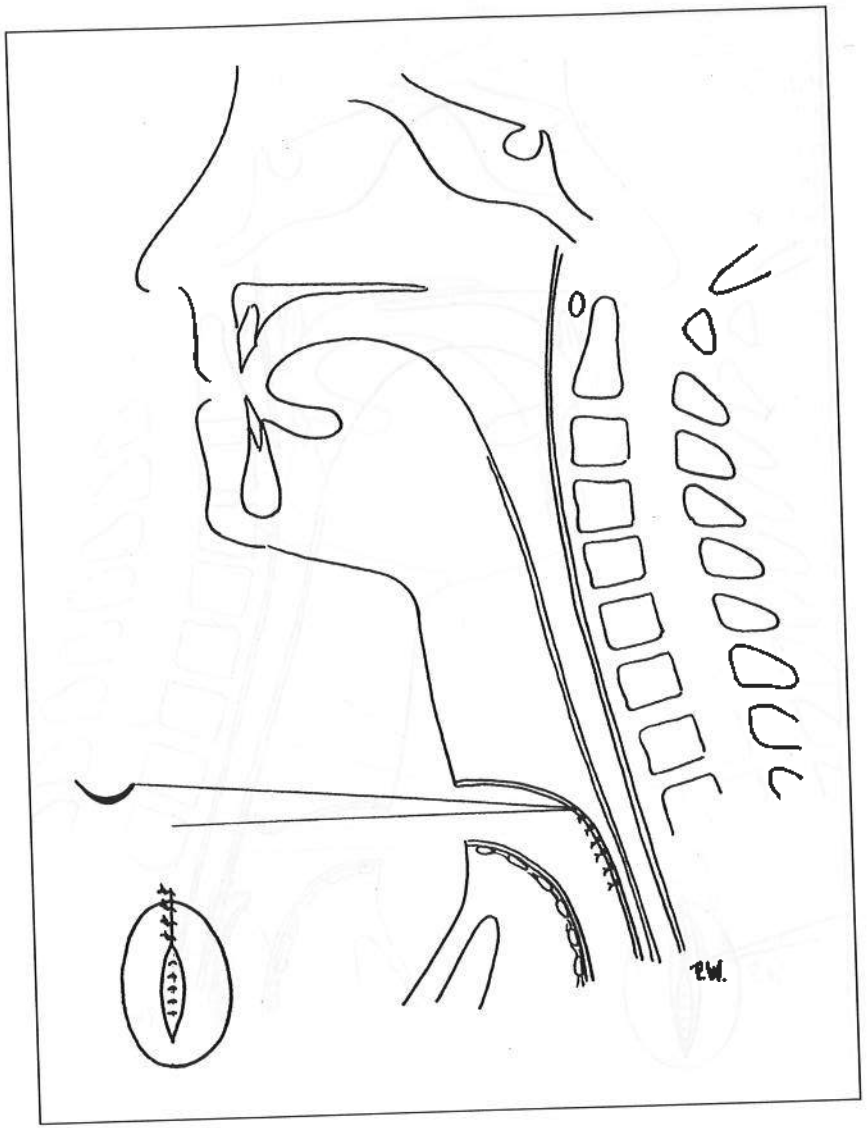

FIGURE VIII:
closure of the tracheal epithelium, separated non-inverted sutures

III.4.3.4 Results

Patients

All patients were operated by two surgeons (MM and HV) and with the standard surgical technique, described above. All but two patients received radiotherapy before TE fistula closure.

In 6 out of 12 patients (50%) there was a perfect wound healing with an immediate surgical success. In the other 6 patients a period of postoperative leakage illustrated slow wound healing. All of these patients had received radiotherapy. In one patient (P1) the fistula closed spontaneously, albeit after a period of leakage (21 days). Another patient (P9) preferred anew voice prosthesis in the residual opening. Four patients (33 %) needed secondary surgical reconstruction with (free) tissue transfer for permanent fistula closure.

No severe complications occurred.

The mean hospital stay was 18 days (3 –43 days). However, the hospital stay is not exclusively linked to the wound healing. The reasons for a prolonged hospital stay were diverse, e.g. for patient 6 the hospital stay was prolonged because the patient was not willing to leave the hospital in between two surgical procedures; for patient 10 the hospital stay was prolonged because of psychosis.

Oral feeding was started up to the 14th postoperative day in 7 patients (58%); in 5 patients (42%) oral feeding was started after the 14th postoperative day. This concerned the 4 patients who needed a secondary surgical procedure and the one patient in whom the fistula was obliterated with anew prosthesis.

TABLE 23

Results

	Surgeon, Date of closure	preop RT	Hospital stay in days	Leakage Stop at day:	Oral feeding	Pneumonia	Wound healing	Second surgical procedure	Dysphagia After TE closure
1	MM 07/02/00	+	14	21	9 d	no	Slow	none	no
2	MM 27/10/99	+	21	Sec surgery >	14 d	no	Slow	(04/01/00) FRFF	no
3	MM 14/7/99	+	5	Sec surgery >	14 d	no	Slow	(01/09/97) FRFF (05/10/99) pec maior	no
4	MM 4/10/99	-	8	immediate	7 d	no	Good	none	no
5	HV/MM 21/10/98	+	3	immediate	2 d	no	Good	none	no
6	HV/MM 29/05/97	+	43	Sec surgery >	14 d	no	Slow	(18/07/97) pec maior	no
7	MM 14/01/99	+	8	immediate	10 d	no	Good	none	no
8	HV/MM 05/02/98	-	19	immediate	6 d	yes	Good	none	no
9	MM 03/11/98	+	6	14	>14 d	no	Slow	New prosthesis	no
10	HV/MM 24/02/97	+	36	immediate	10d	no	Good	none	no
11	MM 04/10/99	+	38	3	>14 d	no	Slow	25/10/99 FRFF	no
12	HV/MM 4/11/97	+	12	immediate	2 d	no	Good	none	no

Notes
Surgeon = initials of the surgeon who performed the operation
Date of closure = date of operation (d/m/y)
Preop RT = =preoperative radiotherapy
+ = radiotherapy before the closure procedure
- = no radiotherapy before the closure procedure
Leakage stop at day = the period of leakage when drinking
Sec surgery = leakage continued and a second surgical procedure was needed to close the fistula
Immediate = leakage stopped immediate after surgery (tested the morning after)
Oral feeding = the day when or after which oral feeding was resumed
Wound healing = the perception of wound healing by the surgeon rated on edema, color (inflammation)
Slow = edema and redness present
Good = edema and redness absent
Second surgical procedure = date (d/m/y) and kind of procedure, if needed
FRFF = free radial forearmflap
Pec Maior = major pectoral myocutaneous flap
Dysphagia after TE closure = swallowing problems when thoroughly asked for

III.4.3.5 Discussion

The surgical procedure we describe is technically a simple procedure and has an immediate success rate of 6/12 (50 %) and a total success rate of 7/12 (66 %). Four patients (33 %) needed a secondary surgical procedure. In one patient (8 %), the residual opening was obliterated with anew button.

Recently, a similar procedure has been described by Hosal and Myers (62). They performed this technique in 9 patients, of which 8 were succesfull. The one failure was dedicated to radiotherapy. In our series, the two not irradiated patients had a sound woundhealing resulting in an immediate success. Vice versa, we observe that all patients with a slow woundhealing had received radiotherapy. Considering the irradiated group (10 patients), 4/10 healed primarily, 1/10 healed secondarily and 4/10 needed a secondary surgical procedure. The last patient (P9) received anew prosthesis in the residual fistula. This suggests and confirms the findings of Hosal et al. that radiotherapy may have a negative influence on woundhealing.

Rosen et al report a success rate of 13/14 (92 %) and state that radiotherapy does not adversely affect closure rate (63). They use a three-layer closure with additional tissue (dermal graft) in between the esophageal mucosa and the posterior tracheal wall. Their technique is similar to the technique of Annyas et al. but has the advantage of avoiding a supplementary skin incision and thus decreases morbidity (64). Matching success rate and technical simplicity is a challenge in primary tracheo-esophageal fistula closure. Our surgical procedure is simple and easily technically feasible. It consists of a three layer closure, firstly of the esophageal mucosa (two layers) and secondly of the tracheal epithelium (third layer). However, in irradiated patients the success rate turned out to be rather low. Therefore, we are convinced that primary closure of tracheo-esophageal fistulae may only be preferred as a first surgical act because its simplicity and effectiveness in patients not having received radiotherapy treament. This is illustrated by i) immediate success in 2 not irradiated patients in our series and ii) Hosal's report.

None of our patients mentioned swallowing impairment postoperatively. This means that although the pharyngeal diameter is anatomically reduced, the smaller diameter seems not to affect functional outcome. No doubt this is due to the elasticity of the esophageal mucosa. Because of the fact that the tracheal epithelium is more rigid, performing the circumcision towards the esophageal lining as much as possible, thus providing more tissue at the tracheal layer enables fistula closure. Apparently, per-

forming the circumcision in favor of the tracheal lining does not result in swallowing impairment.
We started oral feeding up to 14 days in 58 % of the patients and even up to 2 days in two patients. This suggests that a meticulous suture, even on esophageal mucosa can resist mechanical stress and regular (mechanical soft) food can be administered without additional risk on fistula recurrence. As such, and compared to the nasogastric feeding period in the paper of Rosen et al., this surgical technique may provide a shortening of the nasogastric tube feeding period. The hospital stay may likewise be reduced.

In a not irradiated patient population, this simple surgical technique may provide I) a good success rate, and enable II) early oral feeding and III) short hospital stay, thus increasing patient's comfort. We believe that because of its simplicity, this technique may be considered as the initial surgical procedure for tracheoesophageal fistula closure, on the condition that wound healing is not compromised by radiotherapy.

III.4.3.6 Conclusion

Primary closure of TE fistulas is feasible with a simple technical procedure and may allow early oral food intake and a short hospital stay in patients not having received radiotherapy treament. In case radiotherapy has been given, the success rate is only 50 % and secondary surgary is needed in 33 %. However, the simplicity of the procedure makes considering this technique as the initial surgical treament in a selected patient population worthwhile.

III.5 Conclusions

Based on swallowing physiology and the subdivision in two groups decrease of propulsion efficiency and increase of prebolus resistance, reconstructive surgical techniques or surgical modifications aim at limiting or preventing swallowing impairement. The most important questions that must be answered before determining the choice of donor tissue are (I) how much tissue bulk is needed? and (II) can sensitivity be preserved or restored? In regions where mobility or sensation is essential for a good swallowing function, the free radial forearm flap is very reliable and a handy reconstructive technique. This type of donor material is not too bulky so that a wide mobility and suppleness is available and sensitivity can be restored by suturing the cutaneous antebrachial nerve onto the pharyngeal plexus. By filling up the surgical defect and preserving suppleness and sensitivity, the bolus propulsion efficiency is restored.
Evaluation of the swallowing function in the free radial forearm flap reconstructive technique in 41 patients demonstrates a good functional outcome. In 32% only, swallowing function is scored as diminished. In addition to impairment observation and registration, the speech therapist plays an important role in intensive exercising.
Thanks to speech therapist's efforts of years (i.e. documentation of nasality, originally in the field of cleft palate pathology), surgery for velopharyngeal inadequacy has improved. Transfer of these surgical techniques in patients with large oropharyngeal malignancies results in a reconstruction refinement and subsequent optimal functional outcome. A continuous communication between the surgeon and the speech therapist can provide new surgical techniques.

In cases where the bolus propulsion efficiency remains unaltered, a too high pre-bolus resistance can cause swallowing disorders. This resistance usually occurs at the narrowest transition, namely the pharyngo-esophageal segment. A Botox injection in the cricopharyngeal muscle can resolve these swallowing problems. Botox injection is a medical treatment, which reaches the field of speech therapy (e.g. spasmodic dysphonia). This study, describing 4 cases, wants to be a communication from the ENT towards the speech therapist and to provide more information of Botox therapy in swallowing impairment. If swallowing exercise therapy does not result in improvement, other possible solutions can be considered. However, indication and patient's selection is important for achieving a functional result. History taking and clinical examination are essen-

tial, combined with videofluoroscopy. The latter can sometimes be redundant with the clinical signs on nasoendoscopy.

If the digestive tract is interrupted a new tubular structure has to be made. The best option in relation to deglutition is an aperistaltic open tube. As this kind of reconstruction has low prebolus resistance, this results in most efficient swallowing ability. Our study demonstrates that absence of laryngeal elevation negatively influences swallowing function. Or, when laryngeal elevation can be imitated, the effect on swallowing shall be positive. Swallowing exercises such as the Mendelsohn's maneuver or the supraglottic swallow can be in benefit of the functional outcome. Speech therapy must focus on passive opening of this aperistaltic tube. As such, large hypopharyngeal tumours can be treated, oncologically sound (by enabling large resection marges) and with a considerable quality of life.

Re-examining generally accepted surgical techniques and rules could improve the quality of life.
As the speech therapist is more concerned with the patient's rehabilitation, he/she strives for an early functional recovery. This attitude, followed by communication with the surgeon-caregiver leads to reviewing the generally accepted rules. We decreased the period of nasogastric tube feeding up to two days postoperatively in surgical procedures for total laryngectomy and closure of tracheo-esophageal fistulae. On condition the pharyngeal mucosa is meticulously sutured, the period of oral food resumption and subsequent the hospitalization period can be reduced.
In total laryngectomy, early oral food resumption is possible without higher complication rate. A meticulous pharyngeal suture is essential for preventing fistula tract formation.
Also in closure of tracheo-esophageal fistulae, early food resumption is possible without higher complication risk. A simple surgical technique facilitates reproducibility by other surgeons. Regarding total laryngectomy, covering the pharyngeal mucosa with muscular tissue does not provide additional advantages.

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CHAPTER IV

SUMMARY AND CONCLUSIONS

The multidisciplinary approach for treatment and evaluation of swallowing disorders has already been stressed in the literature.
Our manuscript wanted to focus on prevention of swallowing disorders in head and neck surgery. We wanted to give an answer on the question: "is it possible to advance, facilitate or even expel postoperative rehabilitation and thus limit swallowing impairment through modifying surgical reconstructive techniques?"

This manuscript describes several assessment methods whereafter combining 3 methods is proposed for obtaining the most detailed information. It describes well-known reconstructive techniques in their functional outcome regarding swallowing disorders, but also focusses on evaluating surgical modifications in their functional outcome.

As demonstrated in Chapter 1, surgical procedures in the head and neck region often alter deglutition. Related to the type of surgery, the impairment can be predicted to some extent. Resections in the **oral cavity** result in an impaired oral preparatory phase, but do not necessarily affect the pharyngeal transit time. If reconstruction is required, the best option is to add not bulky, pliable tissue, preferentially with preservation of sensitivity. On the contrary, if a total glossectomy is performed or a large resection of the floor of the mouth, more bulk is needed.
Resections in the **oropharyngeal** area will certainly affect triggering the pharyngeal phase and can result in late aspiration. Reconstruction demands thin tissue layers, preferentially with preserved sensitivity.
Resections at the **hypopharynx** can be divided in two subgroups in relation to the anatomical defect, that is I) the base of the tongue and II) the lateral pharyngeal walls. At the base of the tongue enough tissue bulk is essential to create high pressures for good bolus propulsion downwards. The lateral pharyngeal walls and pyriform sinuses have to be reconstructed with less tissue bulk, in order to preserve peristalsis as much as possible and in order not to obstruct the laryngeal inlet for respiration and phonation.

In general, swallowing disorders can be divided into two groups: ***diminished propulsion efficiency*** and ***increased prebolus resistance.***

Instead of stressing the importance of cure rates, tumour free survival, recurrence rates, etc., recent studies focus on functional outcome. This illustrates the increased importance of quality of life apart from cure, tumour free survival time etc. Various instruments for assessing quality of life exist (Chapter II). When the goal is to focus on deglutition, more specific questions have to be asked. These questions change according to the pathology and anatomical location of defects. In order to put the right questions, knowledge of the deglutition physiology is mandatory.
A functional clinical examination focusing on anatomical impairment is essential in evaluating swallowing disorders after head and neck surgery. The impact of the surgical insult and the improvement by a reconstructive technique must be assessed.
Various technical investigations are available for assessing swallowing disorders. Out of the large diversity, we prefer the videofluoroscopy as the most practical information provider.

We want to stress that taking historical data, performing a thorough clinical examination and videofluoroscopy are rewarding tools to obtain an accurate evaluation of the swallowing pathophysiology. A dysphagia severity scale as is developed for neurologic dysphagia may be used for gaining an image of the impact of the swallowing disorder, but focusing on causality, a combination of the three tools, mentioned above, is essential. Combining these three assessment methods helps in detecting swallowing problems. Minor dysphagia is not always obvious when using only one of the three methods but may become clear when using the combination of assessment methods.

In daily practice, we often experience dysphagia in some – although minor - extent in total laryngectomy patients. As such, specific questions, clinical examination and videofluoroscopy is performed in a group of total laryngectomees, as a pilot study. Although the questionnaire revealed no severe swallowing problems, videofluoroscopy showed prolonged swallowing and stagnation in the pseudo-vallecullae. We are convinced that it may be worthwhile to consider a reconstructive procedure to enlarge the pharynx and proximal esophagus. Increasing the pharyngeal diameter and esophageal inlet may reduce the prebolus resistance.

Reconstruction in the oral cavity and oropharynx wants to reduce bolus transport impairment and to secure an adequate triggering of the pharyngeal phase.
In rather small defects, the wound can be closed primarily. In larger

defects, surgical closure with grafts or flaps is needed. Also, when after primary closure the natural tension or pull of the tissues would cause separation of the wound margins (which prevents primary healing and creates fistulas), additive tissue is needed. Meticulous reconstruction increases bolus propulsion efficiency (Chapter III).

The free radial forearm flap reconstruction technique is a commonly used procedure and gives a good functional outcome.
We investigated this type of reconstruction in various postsurgical defects in forty-one patients by questionnaire taking, clinical examination and videofluoroscopy. Speech is addressed form aside. The patients differed in tumour locations and formed as such no comparable groups. The aim of the study was to confirm that a free radial forearm flap is an excellent type of reconstruction for defects in different anatomical locations in relation to deglutition. The assessment of swallowing function in this type of surgery, notwithstanding the large diversity of sub-sites of the lesions, demonstrates a favourable functional outcome. An important feature to reckon with is the rule of the thumb: non-bulky, pliable tissues in the intra-oral region and a larger volume at the base of the tongue. A likewise reconstruction is in benefit of propulsion efficiency.

We evaluated more in detail the functional outcome of a surgical refinement in reconstruction of wide oropharyngeal defects with the radial forearm flap in 4 patients, again by means of the combination history taking, clinical examination and videofluoroscopy. The free radial forearm flap is sutured to the palatal and dorsal pharyngeal remnants, thus imitating a caudally based velopharyngeal flap. This meticulous reconstructive technique ensures an optimal functional outcome: the subjective and objective well-being of the patients due to optimal deglutition and speech, and in particular due to the absence of nasality, suggests the value of this refinement in reconstruction. The technique allows wide surgical margins with preservation of unimpaired velopharyngeal function. As an answer to our question wether it is possible to establish primary prevention in these types of lesions we can state that with this modified reconstruction postoperative rehabilitation becomes redundant.

Inadequate bolus propulsion forces, in relation to the prebolus pressure, cause stagnation at the cricopharyngeal segment. Preserving the function of the pharyngoesophageal segment is preferentially done by not altering the anatomical relation to the larynx. In this way, the passive opening of

the upper esophageal sphincter due to laryngeal elevation is maintained. Relaxation of the muscle is often sufficient to decrease the resistance and to achieve fluent bolus propulsion into the esophagus (Chapter III).

We used botulinum toxin in 4 patients and evaluated their functional outcome. We started with infiltration of the muscle in a patient complaining of primary dysphagia, not caused by malignancy or surgery. In this first case the main problem was a hypertonicity of the muscle itself, albeit unilaterally. The three other patients were treated for a malignancy either by surgery and radiotherapy, or chemo-radiotherapy. The swallowing problem was caused by a disturbed pharyngeal motility due to section of the pharyngeal plexus during surgery for extirpation of the adenopathy in the second case. Also in the third and forth case the dysphagia can be considered as a relative hypertonicity of the horizontal part of the cricopharyngeal muscle. This report illustrates that in selected cases botulinum injection can improve swallowing disorders and facilitates rehabilitation programs.

In large hypopharyngeal tumours or tumours of the upper esophagus removal of the upper digestive tract is necessary, often in combination with a total laryngectomy. Restoration of this digestive tract demands creation of a tubular structure from the stomach to the pharynx. Free jejunal grafts, pedicled colonic grafts or tubed stomach, can achieve this. When reconstruction of the upper esophagus is necessary, creation of a passive open tube is preferred.

We assessed deglutition in 10 patients who received a pedicled colon interposition with or without laryngectomy with the combination of 3 evaluation tools described earlier in this work. This study reveals that colon interposition is a favourable reconstructive technique in relation to deglutition. Creation of an aperistaltic open tube restores the swallowing function very well. The most important goal is to restore the digestive tract in such a way that there is little prebolus resistance. The pharyngo-esophageal phase on videofluoroscopy was significantly longer in the total laryngectomy group, which illustrates the influence of lacking the antero-cranial laryngeal movement of the larynx, but this does not diminish the value of the colonic interposition as a reconstructive technique. This series demonstrates that reconstruction of the digestive tract can be performed with interposed colon, providing a good functional outcome. This leads to a less intensive rehabilitation program and a better quality of life.

As recently quality of life and functional outcome become more important, we strive for an early functional recovery. The best means to reach this goal is by primary prevention and eventually shorter hospitalisation stay.
In total laryngectomy, pharyngeal closure is standardly performed by I) first suturing the mucosa in two layers and II) then suturing the Constrictor muscles together at the midline. The use of voice prostheses has lead to the origin of unilateral myotomy for obtaining better voice quality. However, from a surgical point of view it is not logical to I) suture a muscle and II) then cut that muscle again. This results in an avascular and thus fibrotic bar, inducing scar tissue. For this, we reasoned that instead of performing the standard procedure with unilateral myotomy, suturing of the constrictor muscle aside is much more logical and provides less tissue trauma. Thus, we studied functional outcome in twenty-one total laryngectomy patients randomly divided into two groups. The first group (ten patients) only received pharyngeal mucosa closure, with suturing of the constrictor muscles on the side. The second group (eleven patients) received closure of the constrictor muscles and unilateral myotomy above the two-layer sutured pharyngeal mucosa. The results show that a more simple surgical technique (first group) can provide in an equal functional outcome with a comparable –or lower- complication rate. This study also demonstrates that the hospital stay can be reduced which provides a better quality of life.

Permanent closure of tracheo-esophageal fistulae has always been a challenge because of high failure rates and consequently the need for complicated reconstructive techniques. Often extensive surgical procedures are mandatory such as pedicled or free flaps for providing a definite solution. We looked for a more simple surgical technique with a good functional outcome. A three-layer closure without the need for additional tissue is proposed and analysed in surgical success rate and functional outcome.
Meanwhile, a similar technique has been published by Hosal and Myers. They report a higher success rate according to ours and dedicate their only failure to radiation therapy. Our technique is as simple as the technique of Hosal and Myers and forms as such a surplus value compared to former manuscripts, but provides a –moderate- success rate of 50 %. However, this is to be explained as a radiotherapy consequence. Focusing on functional outcome, we studied swallowing (only by history taking), which proved to be absent. This is explained through a small surgical modification, namely the position of the incision line and the elasticity of the esophageal mucosa.

We can state that in a non irradiated population this modified surgical technique matches the goal of primary prevention.

Thus, commencing with a survey of normal deglutition physiology and pathophysiology in standard head and neck surgical techniques, this work gives an analysis of existing methods for swallowing assessment. It proposes a refined approach for assessment of the pathophysiological pathway of swallowing disorders, which consists of combining a specific history taking, with a detailed clinical examination and videofluoroscopy. This refined approach is easy to administer, has low costs and little burden to the patient. This refined method is implemented in standard surgical reconstructive techniques and in specific reconstructions and surgical modifications.
This work not only wants to stress the importance of the combination of a focused questionnaire, clinical examination and videofluoroscopy. It also wants to make clear that head and neck reconstructive techniques can help in preventing swallowing disorders. The answer to the question: "is it possible to advance, facilitate or even expel postoperative rehabilitation and thus limit swallowing impairment by applying surgical modifications?" is positive.

SAMENVATTING EN BESLUIT

Dit werk beschrijft de impact van de standaard Hoofd- en Halsheelkunde op de postoperatieve slikfunctie, maar ook de functionele resultaten bij nieuwere chirurgische technieken of modificaties ervan worden beschreven. De beschreven heelkundige technieken zijn modificaties van gekende reconstructieve technieken en hebben als doel de postoperatieve functionaliteit te optimaliseren, dwz de stoornis (i.c. slikstoornis) tot een minimum te beperken. Dit komt tegemoet aan de definitie van primaire preventie. We onderzochten of het mogelijk was om door middel van heelkundige modificaties de postoperatieve revalidatieperiode te beperken in tijd en/of intensiviteit.

Hoofdstuk 1 overloopt slikstoornissen na standaard Hoofd- en Halsheelkundige technieken. Afhankelijk van het type heelkunde kan men de slikstoornis reeds in grote mate voorspellen. Immers, meestal zijn de slikproblemen het rechtstreekse gevolg van een anatomisch deficit (weefseldefect, motorische en neurologische tekorten).
Resecties in de **mondholte** veroorzaken een gestoorde orale fase, maar niet altijd een gestoorde faryngeale klaringstijd. Reconstructieve heelkunde in dit gebied gebeurt best met dunnere weefsels, soepel en plooibaar, liefst met behoud van de gevoeligheid.
In geval van een totale glossectomie of wanneer bijna de volledige mondbodem wordt verwijderd, is meer weefselvolume vereist.
Heelkunde ter hoogte van de **orofarynx** zal de aanzet van de faryngeale fase vertragen wat resulteert in laattijdige aspiratie. Ook hier opteert men voor dunne weefsels, soepel en vervormbaar liefst met bewaarde sensibiliteit.
Ter hoogte van de **hypofarynx** onderscheiden we twee specifieke anatomische lokaties: de tongbasis en de laterale farynxwand. Een defect ter hoogte van de tongbasis dient voldoende opgevuld te worden. Op deze plaats is voldoende weefselvolume noodzakelijk om een hoge druk te kunnen bereiken waardoor het verder geleiden van de voedselbolus naar de slokdarm bevorderd wordt. De laterale farynxwand en sini piriformes daarentegen vragen een reconstructie met dun en soepel weefsel. Dit om de peristaltische golf te kunnen behouden en om een laryngeale obstructie te vermijden, zowel wat betreft ademhaling als fonatie.

In het algemeen kunnen slikstoornissen onderverdeeld worden in twee subgroepen: enerzijds de groep waarbij de slikstoornis veroorzaakt wordt door minder efficiënte voortstuwende kracht (diminished propulsion efficiency) en anderzijds de groep waarbij de slikstoornis veroorzaakt wordt

door een te hoge weerstand op het traject dat de bolus nog moet afleggen (increased pre-bolus resistance).

Recente studies focusseren op levenskwaliteit en niet meer op de traditionele waarden van levensduur, ziekte-vrij interval, recidief, enz. Dit illustreert de tendens naar meer aandacht voor levenskwaliteit in plaats van aandacht voor overleving. Er zijn dan ook verschillende meetinstrumenten voor het evalueren van die levenskwaliteit ontwikkeld (Hoofdstuk II). Nochtans zijn we van mening dat als men zich tot doel stelt specifiek de slikfunctie te onderzoeken, meer gerichte vragen moeten worden gesteld. De aard van deze vragen verandert naargelang de aard van de pathologie en het soort anatomisch defect. Zo is het noodzakelijk een grondige kennis van de fysiologie van het slikproces te bezitten om in staat te zijn de juiste vragen te kunnen verwoorden. In dit werk worden verschillende onderzoeksmethoden voor het opsporen van slikstoornissen beschreven, met name de voor handen zijnde questionnaires, het klinisch onderzoek en de technische investigaties. Kritische evaluatie van de bestaande methoden heeft ertoe geleid een specifiek protocol op te stellen, voor eigen gebruik. Dit protocol bestaat uit I) het afnemen van een gerichte vragenlijst, II) een klinisch onderzoek en III) een videofluoroscopie. Een dergelijke combinatie vinden we terug in de DOSS, een schaal om de ernst van de dysfagie vast te leggen. Alhoewel de DOSS specifiek voor slikstoornissen van neurologische aard is ontwikkeld, kan dit een algemeen beeld geven over de impact van de slikstoornis op het algemeen welzijn van de patiënt, maar om een causaal verband te leggen met de heelkunde of om een zicht te krijgen hoe de heelkundige techniek moet aangepast worden voor verbetering, is deze schaal niet bruikbaar in deze context.
De combinatie is volgens ons essentiëel in het opsporen van slikstoornissen. Het is een efficiënte benadering, zonder teveel supplementaire last voor de patiënt en zonder excessieve meerkost. Ook is het zo dat discrete slikstoornissen beter met de combinatie van de drie benaderingen worden opgespoord aangezien dergelijke stoornissen niet altijd duidelijk naar voren komen wanneer slechts één van de onderzoeksmethoden wordt aangewend. De combinatie wordt in dit werk "refined protocol" genoemd en wordt als illustratie getoetst in een populatie totale laryngectomiepatiënten. In deze pilotstudie wordt aangetoond dat zeer discrete slikstoornissen kunnen opgespoord worden met de combinatie van de drie standaard onderzoeksmethodes. Alhoewel er subjectief geen ernstige slikklachten waren, toonde het klinisch onderzoek en de videofluoroscopie een vertraging van het slikproces en stase ter hoogte van de pseudovallecullae.
We zijn van mening dat het nuttig kan zijn een reconstructieve procedure te overwegen in die gevallen waar de faryngeale mucosarest beperkt is, met als doel de farynx en de bovenste slokdarm te verbreden. Toename van de faryngeale diameter en ingang van de slokdarm vermindert de prebolus weerstand.

Ter hoogte van de orofarynx en de mondholte is het doel van de reconstructie het bolustransport te bevorderen en een adequate triggering van de faryngeale fase te verzekeren.
Wanneer het een beperkt defect betreft, kan de wonde primair gesloten worden. Wanneer het echter een groter defect betreft, is er noodzaak tot bedekken van de wonde met weefsel, enten of flappen. Ook in het geval dat er tractie zou zijn met gevaar op loslaten van de wonde en fistelvorming is het raadzaam additioneel weefsel te gebruiken. In dat geval zal een nauwkeurige reconstructie de voortgeleiding van de bolus efficiënter maken (Hoofdstuk III).

Reconstructie met de vrije radialis voorarm flap is een algemeen toegepaste heelkundige techniek met goed functioneel resultaat.
We bestudeerden de functionele weerslag van het gebruik van de vrije radialis voorarmflap reconstructieve techniek in 41 patiënten met verscheiden anatomische defecten. Dit door middel van een vraagbaak, klinisch onderzoek en objectief onderzoek, videofluoroscopie. De patiënten populatie was te verscheiden in anatomische lokalisatie om in verschillende vergelijkbare groepen te kunnen worden opgesplitst. Het doel van de studie was aantonen dat de vrije radialis voorarmflap een zeer goede optie is voor herstel van de slikfunctie in velerlei soorten defecten. Dit onderzoek toonde aan dat onafhankelijk van de grote diversiteit van laesies de slikfunctie inderdaad goed was. Belangrijk is rekening te houden met de stelregel: soepele weefsels zonder bulk zijn handig ter hoogte van de mondholte en orofarynx, terwijl weefselbulk vereist is ter hoogte van de tongbasis. In het geval de reconstructie op deze wijze kan worden verricht, komt dit de efficiëntie van de bolusvoortgeleidende kracht ten goede.
Meer in detail, gingen we de functies stem en slikken na bij 4 patiënten die een verfijnde reconstructie kregen ter hoogte van de orofarynx. Deze nauwkeurige reconstructieve techniek omvatte een vrije radialis voorarm flap als caudaal gesteelde velopharyngeale flap gebruikt ter bedekking van grotere defecten ter hoogte van de laterale farynxwand en het palatum. Zowel subjectief als objectief waren de resultaten zeer goed dankzij een optimale slik- en spraakfunctie op basis van een bewaarde velopharyngeale sluiting. Meer specifiek bleek nasale reflux en hypernasaliteit afwezig te zijn. Deze chirurgische techniek heeft zijn meerwaarde in het mogelijk

maken van bredere resectiemarges met het gelijktijdig herstellen van de velopharyngeale afsluiting bij dergelijke grote defecten. Gezien het optimale functionele resultaat bleek postoperatieve revalidatie overbodig.

Wanneer de bolus-voortstuwende krachten ontoereikend zijn ten opzichte van de weerstand op het verdere verloop van het traject, ontstaat er stase van voedsel ter hoogte van het nauwste segment, de overgang naar de slokdarm, namelijk het pharyngo-oesofageale segment. Functieherstel van deze regio gebeurt liefst niet door middel van veranderingen in de anatomische verhoudingen met de omliggende structuren, met name de larynx. Immers, de invloed van de larynxelevatie op de passieve opening van de bovenste slokdarm blijft op deze manier bewaard. Relaxatie van de spier (de m cricopharyngeus) is meestal voldoende om een gunstig effect te bekomen. De weerstand daalt en de bolus kan vlot naar de slokdarm overgaan (**Hoofdstuk III**).

We maakten gebruik van botulinum toxine bij 4 patiënten. Vooreerst werd de m. cricofaryngeus geïnjecteerd bij een patiënt waarbij de dysfagie niet van oncologische of heelkundige etiologie was. Het probleem lag in een hypertoniciteit van de spier zelf. De andere patiënten werden behandeld voor maligniteit, hetzij chirurgisch, hetzij radiotherapeutisch, hetzij beiden. In de tweede casus was het slikprobleem gebaseerd op een gestoorde faryngeale motoriek ten gevolge van onderbreken van de plexus faryngeus tijdens de heelkundige ingreep. Bij de laatste twee patiënten kan de dysfagie beschouwd worden als een relatieve hypertoniciteit van het horizontale deel van de m. cricofaryngeus. Infiltratie met botulinum bleek gunstig voor het slikproces. Dit illustreert de mogelijkheid van secundaire preventie.

Bij grote hypofaryngeale tumoren of tumoren van de proximale slokdarm moet de bovenste digestieve tractus verwijderd worden omwille van oncologische redenen. Dikwijls gebeurt tegelijkertijd een totale laryngectomie. Herstel van de digestieve tractus vereist een tubulaire structuur van farynx tot maag. Hiervoor bestaan verschillende mogelijkheden: vrij jejunum, gesteeld colon, getubuleerde maag, enz. Als een reconstructie van de bovenste slokdarm nodig is, gaat de voorkeur uit naar een passief openstaande buis.

Wij onderzochten de slikfunctie bij 10 patiënten met een coloninterpositie met of zonder totale laryngectomie. De studie toont aan dat coloninterpositie een goede keuze is om gebruikt te worden als reconstructie van de digestieve tractus. Het aanleggen van een aperistaltische open buis

geeft een goede slikfunctie als eindresultaat. Het belangrijkste doel in de reconstructie van de digestieve tractus, is het verkrijgen van een lage weerstand op het traject dat de bolus moet afleggen. De duur van de pharyngo-oesofageale fase was significant langer in de totale laryngectomiegroep. Dit illustreert de nefaste invloed van de afwezigheid van de antero-craniale larynxelevatie. Deze studie toont het nut aan van primaire preventie.

Aangezien recent de aandacht meer en meer uitgaat naar kwaliteit van leven wordt vroegtijdig functieherstel belangrijker. In het geval van totale laryngectomie wordt vroegtijdig perorale voeding opgestart, in combinatie met een modificatie van de chirurgische techniek. Het vergelijken van de standaard techniek waar de m.contrictores gesloten worden boven de gesutureerd faryngeal mucosa, gevolgd door een unilaterale myotomie met de vernieuwde procedure, het opzij hechten van de m.constrictores toont aan dat het voorkomen van complicaties in dezelfde orde ligt, en zelfs iets lager. Indien dit dan gepaard gaat met een verkorte hospitalisatieduur, komt dit ten goede aan de kwaliteit van leven.
Hetzelfde wordt onderzocht bij een nieuwe heelkundige techniek voor het sluiten van tracheo-oesofageale fistels. Deze techniek blijkt duidelijk voordelen te bieden in een niet bestraalde populatie. Slikproblemen waren niet aan de orde. De duur van de naso-gastrische sondevoeding en het hospitaal verblijf kon gereduceerd worden, wat uiteraard bijdraagt aan een gunstige functionele uitkomst. Ook deze studie vormt een illustratie van de mogelijkheid tot optimale primaire preventie.

Kortom, vertrekkend van een overzicht over de normale slikfunctie en de pathofysiologie van slikstoornissen na standaard Hoofd- en Halsheelkunde, worden verschillende bestaande onderzoeksmethodes beschreven en geëvalueerd. Hieruit wordt een verfijnde onderzoeksmethodiek gedistilleerd, namelijk een combinatie van een specifieke vragenlijst, een klinisch onderzoek en een videofluorocopie. Deze methodiek geeft een goed inzicht in de pathofysiologie van de slikstoornis en geeft niet veel meerkost, noch bijkomende last voor de patiënt. Vervolgens wordt deze methodiek gebruikt in het evalueren van de slikfunctie bij gekende reconstructieve technieken in het hoofd- en halsgebied, maar ook bij nieuwe chirugische procedures. Op de vraag of het inderdaad mogelijk is de postoperatieve revalidatie te beperken door middel van chirurgische modificaties kan positief geantwoord worden. De meeste studies betreffen primaire preventie, één studie echter (botox) betreft secundaire preventie.