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ORIGINAL ARTICLE

Cervicofacial and Pharyngolaryngeal Lymphedema and Deglutition After Head and Neck Cancer Treatment

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Abstract

One of the sequelae of head and neck cancer treatment is secondary lymphedema, with important impact on breathing, swallowing and vocal functions. The aim of the study was to assess the presence, staging characteristics and relationship of external and internal lymphedema and dysphagia after head and neck cancer treatment. The MDACC Lymphedema Rating Scale in Head and Neck Cancer was employed for the assessment and staging of face and neck lymphedema; the Radiotherapy Edema Scale for internal lymphedema; and a fiberoptic endoscopic evaluation of swallowing (FEES) for swallowing. The sample consisted of 46 patients with a diagnosis of head and neck cancer. Lymphedema was detected in 97.8% (45) of the evaluations with predominance of the composite type (73.9%—34). A high percentage of external lymphedema of the neck (71.7%—33) and submandibular (63%—29) were detected, with predominance of the more advanced levels. Internal edema was found in almost all structures and spaces at moderate/severe level. At FEES, residue (higher percentage in valleculae and pyriform sinus), penetration and aspirations were observed. The residue was detected in higher occurrence in patients with composite lymphedema ($p=0.012$). The combined treatment with radiotherapy was related to submandibular external lymphedema ($p=0.009$), altered pharyngolaryngeal sensitivity (0.040), presence of residue ($p=0.001$) and penetration to pasty ($p=0.007$) and internal edema in almost all structures. There was also a higher percentage of residue in cases with internal altered pharyngolaryngeal sensitivity, residue, penetration and aspiration. Combined treatment with radiotherapy is an associated factor of edema. Cervicofacial and pharyngolaryngeal lymphedema is a frequent event after treatment for HNC, with important impact on swallowing performance characterised by altered pharyngolaryngeal sensitivity, residue, penetration and aspiration. Combined treatment with radiotherapy is an associated factor.

Keywords Lymphedema · Head and neck neoplasms · Neck dissection · Radiotherapy · Deglutition disorders · Deglutition

Introduction

Head and neck cancer (HNC) treatment entails multimodal therapies, which helped to increase survival rate, despite complication risks [1–4]. A large spectrum of tissue effects is involved in cancer treatment. The surgical scar depends on the technique, extent of resection area and type of reconstruction used. Systemic chemotherapy (Ch) affects normal and malignant cells in the entire body, and Radiotherapy (Rt) may involve the tumour region and adjacent tissues; however, significant volumes of normal tissue in the beam trajectory, though relatively distant from the target, may be compromised. Radiotherapy is associated with a variety of undesirable side effects such as changes in neuromuscular functions. In the case of head and neck cancer, they are

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mainly related to swallowing, voice and breathing functions. [2] Clinical manifestations vary according to dose, fraction, volume, disease staging and other factors [1–14].

In many cases, regional lymph nodes are compromised, and neck dissection (ND) and adjuvant treatment are necessary due to late diagnosis. The more invasive the approach, the greater the impact. Nevertheless, the appropriate approach regarding cervical metastases is one of the most important aspects for disease control [15]. Treatment may cause several dysfunctions, such as mucositis, xerostomia, odynophagia, actinic dermatitis, dysphonia, dysphagia, nausea, fatigue, dysgeusia, stomatitis, weight loss, edema and lymphedema, whose manifestations may vary according to the staging of the disease, tumour site, damage to lymph node levels, type of treatment adopted and patient's clinical and nutritional condition, with important impact on quality of life [8–11].

Some of the complications inherent in the treatment are secondary edema and lymphedema, which occurs when lymphatic structures or surrounding soft tissues are damaged by cancer and its treatment, limiting the lymphatic system's capacity to transport the lymph volume delivered to the tissues. The damage to these structures caused by tumour, surgery or radiation results in movement reduction by hindering, blocking or breaking the lymph flow, causing soft tissue edema [4–7].

The lymphedema may involve external (face and neck soft tissues) and internal (upper aerodigestive tract) anatomical sites, causing important impact on the patient's quality of life. Besides these two types, the combination thereof can also exist, known as composite or combined head and neck lymphedema [4–7, 16–20].

Clinical evaluation methods for external lymphedema may involve anthropometric analysis, palpation and standardised scales of facial and cervical measurements with functional impact, such as the Földi Scale, Miller Scale and American Cancer Society Scale Lymphedema of the Head and Neck Staging Criteria [7, 21]. Lymphatic imaging by fluorescence, measurement of fluid in tissues by bioelectrical impedance analysis and ultrasonography image are also cited in the literature to measure external lymphedema [22–25]. The methods to internal lymphedema analysis are computerised tomography, endoscopy, ultrasonography and magnetic resonance imaging [16].

Studies have indicated that 75.3% of patients with head and neck cancer developed some type of lymphedema-related alteration in the period of 3 months or more after cancer treatment [15, 16]. Although internal lymphedema is also observed in most cases of external lymphedema, only few studies have commented on their impacts on swallowing, especially with objective examination [4]. The endoscopy is a validated method for evaluating pharyngolaryngeal lymphedema and Functional Endoscopic Evaluation of Swallowing (FEES) is performed using the same instrument. These two points makes this method a facilitator in head and neck cancer investigation.

Our hypothesis is that there is in fact a relationship between external and internal lymphedema, and that signs of dysphagia are more common in patients with lymphedema when it comes to objective exam.

The aim of this paper was to characterise and stage face, neck and pharyngolaryngeal lymphedema and correlate the findings with swallowing in patients that had undergone HNC treatment.

Methods

Study Design

This is a transversal study approved by the institute's Ethics Committee for Research, number 137/14.

Patients

Patients included were those with histologic diagnosis of squamous cell carcinoma of the upper aerodigestive tract, submitted to surgical treatment with or without reconstruction for oral cavity, oropharynx, larynx, hypopharynx and nasopharynx cancer, with or without neck dissection; or patients submitted to RT associated or not with Ch and/or surgery; patients submitted to surgical resections for the treatment of advanced thyroid or parotid gland cancer, who underwent neck dissection at least 3 months after the treatment. Patients who underwent total laryngectomy, with (previous to the treatment) chronic lymphedema, with no clinical conditions at the time the tests were performed or unable to perform any of the tests, were excluded.

Data were collected from patients' records and assessment interview with information referring to their identity, tumour data (site, TNM) and treatment (type of treatment, dose, and time since the end of the treatment), presence of feeding tube and tracheotomy, type of feeding and symptoms.

The external and internal lymphedema test combined a photographic and video register, as well as the record of the edema measurements and stage to characterise the global appearance and its severity.

Investigation

Assessment of Facial and Cervical Lymphedema

The protocol includes visual and tactile assessment of the face. For the visual evaluation, the patient's face was marked with an antiallergenic pen to bilaterally measure the facial

proportions (Fig. 1), using adapted perimetry (anthropometric measuring tape), as per the criteria adopted by Smith et al. in Lymphedema Rating Scale in Head and Neck Cancer translated and adapted to Brazilian Portuguese, which has two facial circumference measurements (diagonal and submentonian), point to point, and seven measurements that characterise the facial composite [7, 17, 19].

The protocol was applied by two healthcare professionals independently (one being a speech pathologist, and the other being physical therapist), both certified in the Leduc method, by means of face and neck tailored perimetry, and a visual and tactile evaluation, in order to stage the lymphedema. The patient was assessed by the professionals individually, who then compared the evaluations. Since they are similar measurements, the evaluators reached a consensus. The assessment of the face involves two measurements:

(1) Facial circumference:

   (a) Diagonal: chin to crown of head
   (b) Submental: < 1 cm in front of ear, vertical tape alignment

(2) Point to point:

   (a) Mandibular angle to mandibular angle
   (b) Tragus to tragus

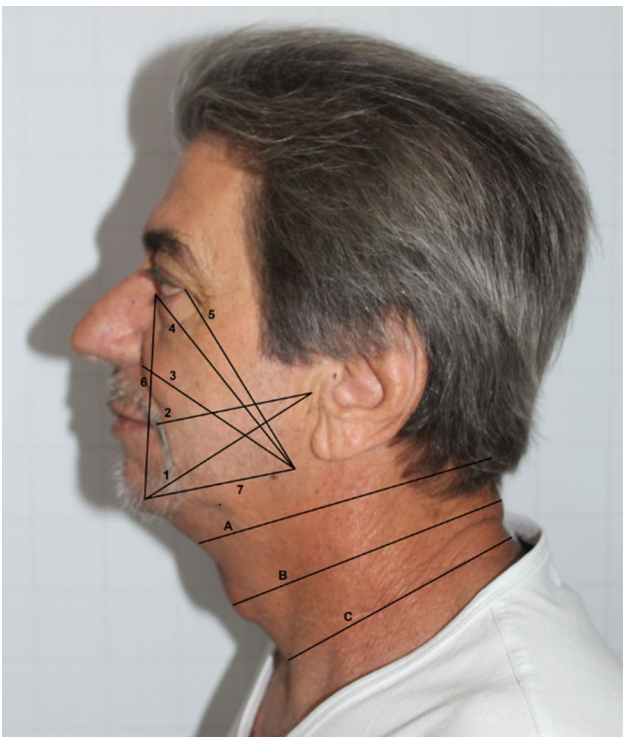

Fig. 1 Numbers correspond to facial and cervical composite

(c) Facial composite

   (l) Tragus to mental protuberance
   (II) Tragus to mouth angle
   (III) Mandibular angle to nasal wing
   (IV) Mandibular angle to internal eye corner
   (V) Mandibular angle to external eye corner
   (VI) Mental protuberance to internal eye corner
   (VII) Mandibular angle to mental protuberance and seven measurements of the facial composite.

The diameter of the patient's neck was measured by the extraction of measurements of the neck circumference: (A) superior neck: immediately beneath mandible; (B) medial neck: midway between points A and B; and (C) inferior neck: lowest circumferential level which comprises the neck composite [7, 17, 19].

The patients were photographed, as recommended by the authors, using as background a checkered frame, with a Canon EOS T4i camera, and an 18–55-mm objective lens [7, 17, 19]. The instruments were applied to all patients of the Head and Neck Service of the organisation where the study was carried out.

Lymphedema Staging

To stage the lymphedema, the adapted MD Anderson Cancer Center Head and Neck Rating Scale was used [17, 19]. The scale was created to characterise the lymphedema appearance and severity, and is based on the traditional Földi Scale for staging of lymphedema in the extremities [21]. The evaluation was made by digital pressure on the skin of the edema area, which indicates the presence of interstitial fluid in the region. Pressure was exerted softly on the area for 10 s. The edema was considered as pitting when the pressing caused a tissue depression persisting for some time after the release of the digital pressure. The depth of the tissue depression and the time it remained showed the severity of the edema. Pitting edema is softer, while non-pitting edema is more rigid and not likely to be pressure [7, 17, 19]. The scale contains 5 levels: 0—no visible edema but patient reports heaviness, 1a—soft visible edema; no pitting, reversible; 1b—soft pitting edema; reversible; 2—firm pitting edema; not reversible; no tissue changes; and 3—irreversible; tissue changes. The site of the edema could be located in the face, submentonian region and neck individually, or in all of them [7, 17, 19].

Assessment of Pharyngolaryngeal Edema

The FEES was performed without topical anaesthesia, so as to not interfere with pharyngolaryngeal sensitivity. For

the identification of the pharyngolaryngeal edema, the Radiotherapy Edema Rating Scale criteria by Patterson et al. translated into Brazilian Portuguese were used [20, 26]. The classification is normal—absence of edema, mild edema, moderate or severe, and the spaces (valleculae and pyriform sinus) classified as normal, mildly reduced, moderately reduced and severely reduced. Structures assessed were base of tongue, posterior pharyngeal wall, epiglottis, pharyngoepiglottic folds, aryepiglottic folds, interarytenoid space, cricopharyngeal prominence, arytenoids, false vocal folds, true vocal folds and anterior commissure [20, 26].

Pharyngolaryngeal sensitivity was assessed by observing the response to a subtle touch of the tip of the fiberscope on the aryepiglottic folds and the presence or absence of adduction reflex and/or cough. The FEES was recorded on DVD and analysed by two head and neck surgeons and two speech pathologist in consensus.

Swallowing Assessment

For the analysis of the FEES, the test was continued using four consistencies: liquid, nectar, pasty and solid, dyed with Arcolor liquid blue aniline and prepared according to the texture with Resource®Thicken UP Clear thickener. The quantities offered were 5 mL and 10 mL of orange juice in a coffee cup (50 mL) or in a spoon (5 mL) for the thicker consistencies. Although 100 mL was not the amount given to patients, to achieve each consistency the following proportions between the thickener and the liquid were used: to test the nectar, 1 measure for 100 mL of juice, 3 measures for pasty and for the solid consistency a piece of bread of approximately 1.5×1.5 cm. The items assessed in the deglutition protocol were early spill, penetration, aspiration, presence of residues at base of tongue, vallecula, posterior pharyngeal wall and pyriform sinus. To quantify and characterise the degree of residue, the Modified Penetration–Aspiration Scale and the Pharyngeal Residue Severity Scale were classified in four levels: 0-none; 1-coating: coating of the pharyngeal mucosa; no pooling; 2-mild: mild pooling/residue, 3-moderate: moderate pooling/residue and 4-severe: severe pooling/residue [27]. For the severity of penetration and aspiration, the Scale of Penetration and Aspiration was used [28]. The analysis was performed from deglutition of saliva and the consistencies offered. Data were recorded on DVD and analysed by two speech therapists in consensus, identifying the protocol items.

To help the data analyse regarding the degree of internal edema were grouped according the classification of moderate and severe to moderate/severe.

To compare variables with the other categories, treatment was grouped in two items:

(a) A—Rt divided by

(1) no Rt: every treatment in which Rt was not performed
(2) Rt: surgery + Rt, surgery + Rt + Ch, Rt + Ch and Rt exclusively

(b) B—ND divided by (1) no ND; (2) ND

The pharyngolaryngeal sensitivity was interpreted as follows: (1) preserved and (2) altered.

Statistical Analysis

The distribution of frequencies was used to describe the categorical variables and the central tendency measurements (median and mean) and variability (minimum, maximum and standard deviation) for the numerical ones. To compare categorical variables in relation to radiotherapy treatment (yes/no), residue/pooling (yes/no), pharyngolaryngeal sensitivity (preserved/altered) and ND (yes/no) in contingency tables, the χ^2 frequency test was used, and in 2×2 tables, when at least one expected frequency was less than 5, the Fischer exact test was adopted. The significance level of 5% was adopted for all the statistical tests.

Results

Patients

An assessment of forty-six patients diagnosed with HNC was carried out. They were selected from January, 2016 to January, 2018 at the Outpatients Department of the Head and Neck Surgery Service. Table 1 shows the demographic and clinical characteristics, and Table 2 presents the aspects of the treatment.

Two patients referred partial oral feeding as they were under training for assisted oral feeding by the speech pathologist with liquid, nectar and honey consistencies. Three patients were using tube feeding: 2 with nasogastric tube and 1 with gastrostomy. From the 41 patients that mentioned exclusive oral feeding, 40 (97.5%) were fed on nectar and pasty; 33 (80.5%) took in solid; no group had any liquid restriction.

A total of 30 (65.2%) patients complained of swallowing difficulty, 24 (52.2%) swelling and vocal difficulty, 23 (50%) changes in appearance, 15 (32.6%) of a feeling of heaviness in the region treated, 21 (45.6%) neck stiffness and mobility reduction and 12 (26%) pain. Reduction of neck mobility symptom was detected in a higher percentage among the patients who underwent neck dissection (26.8%—no vs. 76.2%—yes, $p = 0.027$).

Table 1 Demographic and clinical characteristics

Variable	Category	Freq. (%)
Age	Min.–max.	29–82
	Median	61
	Mean ± SD	61.17 ± 11.55
Gender	Female	13 (28.3)
	Male	33 (71.7)
Race	Caucasians	42 (91.3)
	Afrodescendants	4 (8.7)
Tumour site	Mouth	13 (28.3)
	Oropharynx	11 (23.9)
	Nasopharynx	5 (10.9)
	Larynx	8 (17.4)
	Subglottic	1 (2.2)
	Thyroid	4 (8.7)
	Face (skin)	2 (4.3)
	Unknown primary	2 (4.3)
Stage	T0	5 (10.9)
	T1b	2 (4.3)
	T2	21 (45.7)
	T3	6 (13)
	T4	8 (17.4)
	Tx	2 (4.3)
	Not available	2 (4.3)
	N0	28 (60.9)
	N1	4 (8.7)
	N2	3 (6.5)
	N2a	3 (6.5)
	N2b	3 (6.5)
	N2C	2 (4.3)
	N3	2 (4.3)
	M0	45 (97.8)
	M1	1 (2.2)

Freq. frequency

Assessment of Lymphedema

Lymphedema was identified in 97.8% of cases, with 5 (10.9%) external, 6 (13%) internal and 34 (73.9%) of the combined type. When analysing the distribution of the external edema localisation, it is possible to verify that there was a greater occurrence of lymphedema in the neck region (71.7%). In both submandibular and neck lymphedema, the level of staging was higher, indicating some degree of fibrosis (Table 3).

Pharyngolaryngeal Edema and FEES Results

Internal edema was detected in all structures, especially in the arytenoids—73.9% (Table 4). Changes in pharyngolaryngeal sensitivity were detected in 45.6% of the exams.

FEES identified residue in all structures for all tested consistencies. In case of saliva, there was greater occurrence of vallecula (45.6%), posterior pharynx wall (34.8%) and penetration level 5 in 10.9% (in all patients) and aspiration in 8.7% (level 7 in 2.2% and level 8 in 6.5%).

Assessment with liquid was carried out in 43 patients and showed early spill in 18.6% of cases, vallecula residue in 34.9%, in the pyriform sinus in 25.5%; penetration in 27.9% (predominantly level 3—9.3% and level 5—11.6%), and aspiration in 11.6% (distributed among the 3 levels). The nectar consistency was offered to 46 patients, with 17.4% presenting premature spillage, and valleculae residue in 52.2%, penetration in 34.8% (highest percentage at level 4—8.7%, level 5—19. 6%) and aspiration in 6.5%. Assessment with pasty consistency was carried out in 39 patients and showed valleculae residue in 61.5% of cases, 30.8% in pyriform sinus, penetration in 25.6% distributed between levels 2 and 5 and aspiration in 5% (all level 8). Deglutition with solid was evaluated in 37 patients and had valleculae residue in 43.2% of the cases, 18.9% at the base of tongue, and penetration in 16.2% (level 2—2.7%, level 3—8.1%, level 4—5.4%).

External and Internal Lymphedema and FEES Results According to the Treatment

The comparison between external lymphedema and combined treatment with Rt demonstrated a higher occurrence of submandibular lymphedema in patients treated with Rt (Fig. 2). The association between external lymphedema and pharyngolaryngeal sensitivity indicated a higher percentage of pharyngolaryngeal sensitivity preserved in patients with facial lymphedema and altered in submandibular lymphedema (Fig. 3). FEES identified a higher percentage of pharyngolaryngeal sensitivity alteration in subjects with neck lymphedema level 2 (10%—preserved × 90%—altered, $p = 0.007$).

The association between the presence of lymphedema and the residue indicated a difference with a greater number of cases of residues related to the composite lymphedema (11.8% not residue × 88.2% residue, $p = 0.012$). Residue was identified in greater occurrence when the subjects were compared according to the treatment, pointing to patients in the Rt group (22.2%—no × 77.8%—yes, $p = 0.001$). The analysis according to the Penetration and Aspiration Scale detected penetration in the pasty consistency for the subjects submitted to the combined treatment with Rt (0—no Rt × 100%—Rt, $p = 0.007$).

Assessment of Pharyngolaryngeal Edema and FEES Results

The comparison between the pharyngolaryngeal sensitivity pattern according to the Penetration and Aspiration Scale

Table 2 Treatment characteristics

Variable	Category	Freq. (%)
Treatment	Surgery	16 (34.8)
	Surgery + radiotherapy	9 (19.5)
	Surgery + radiochemotherapy	7 (15.2)
	Radiotherapy	11 (23.9)
	Radiochemotherapy	3 (6.5)
Neck dissection	No	19 (41.3)
	Yes	27 (58.7)
Types of neck dissection	Supraomohyoid	13 (28.3)
	Radical	4 (8.7)
	Modified radical	2 (4.3)
	Selective bilateral	2 (4.3)
	Central and modified radical	1 (2.2)
	Level VI	1 (2.2)
	Level IV C	1 (2.2)
	Extended radical	1 (2.2)
	Modified radical and supraomohyoid	2 (4.3)
Reconstruction	No	34 (73.9)
	Yes	12 (26.1)
Reconstruction type	Microsurgical	3 (6.5)
	Supraclavicular	1 (2.2)
	Pectoralis major + plates and screws	1 (2.2)
	Iliac crest bone graft	2 (4.3)
	CHEP	1 (2.2)
	Pectoralis major	1 (2.2)
	Supraclavicular and innervated gracilis flap	1 (2.2)
	Infrahyoid myocutaneous flap	2 (4.3)
Complications	No	40 (87)
	Yes	6 (13)
Type of complication	Osteoradionecrosis of the jaw	1 (2.2)
	Dehiscence	2 (4.3)
	Tracheal stenosis	1 (2.2)
	Esophagus stenosis	1 (2.2)
	Bilateral paralysis of vocal cords	1 (2.2)
Radiotherapy	No	17 (37)
	Yes	29 (63)
Dose	Min.–max.	1800–7020
	Median	7000
	Mean ± SD	6425 ± 1248.3
Radiotherapy site	Cervicofacial	11 (23.9)
	Local	3 (6.5)
	Cervicofacial and local	10 (21.7)
	Cervicofacial and fossae	6 (13)
Chemotherapy	No	29 (63)
	Yes	17 (37)
Chemotherapy cycles	Min.–max.	1–6
	Median	17
	Mean ± SD	4.5 ± 2.0
Period	Concomitant to Rt	17 (37)
Post-treatment time (months)	Min.–max.	3–96
	Median	10
	Mean ± SD	18.8 ± 19.6

Table 2 (continued)

Variable	Category	Freq. (%)
Alcoholism	No	44 (95.7)
	Yes	2 (4.3)
Smoking	Ex-smoker	42 (91.3)
	Smoker	2 (8.7)
Tracheostomy	No	43 (93.5)
	Yes	3 (6.5)

Freq. frequency, *sd* standard deviation, *min*. minimum, *max*. maximum

Table 3 External lymphedema according to the MD Anderson Cancer Center Head and Neck Rating Scale. ($n=46$)

Variable	Category	Frequency (%)
Facial lymphedema	No	30 (65.2)
	Yes	16 (34.8)
Level of facial lymphedema	0	30 (65.2)
	1a	5 (10.9)
	1b	11 (23.9)
Neck lymphedema	No	13 (28.3)
	Yes	33 (71.7)
Level of neck lymphedema	0	13 (28.3)
	1a	3 (6.5)
	1b	9 (19.6)
	2	11 (23.9)
	3	10 (21.7)
Submandibular lymphedema	No	17 (37)
	Yes	29 (63)
Level of submandibular lymphedema	0	17 (37)
	1a	2 (4.3)
	1b	7 (15.2)
	2	8 (17.4)
	3	12 (26.1)

Levels: 0—No visible edema but patient reports heaviness, 1a—soft visible edema; no pitting, reversible; 1b—soft pitting edema; reversible; 2—firm pitting edema; not reversible; no tissue changes; 3—irreversible; tissue changes

indicated a greater occurrence of pharyngolaryngeal sensitivity alteration in cases of penetration for all consistencies and for penetration and aspiration of saliva, with statistical significance (Table 5).

Another important aspect related to deglutition is that all patients who showed residue with the pasty consistency presented penetration (0 no residue × 100% residue, $p=0.004$).

The association between internal edema and treatment combined with Rt showed a greater percentage of edema in the group submitted to Rt in almost all structures and spaces. ND also indicated the association with internal edema in some structures (Table 6).

The correlation between internal edema and residue of any consistency, and pharyngolaryngeal sensitivity demonstrated a higher number of cases in patients with internal edema in several structures and analysed spaces with statistical significance (Table 7).

Discussion

In the last decades, HNC has been treated through surgeries, in many cases extensive ones, which have caused chronic pain, disfigurement and functional changes. With Rt techniques and Ch agents, treatments have combined these resources aiming at saving organs, preserving the tissue without compromising survival or disease control; however, in fact, the function is not always preserved [1, 2, 29].

Several symptoms were referred at the clinical report, with swallowing difficulty (65.2%), speaking difficulty (52.2%), swelling (52.2%), changes in appearance (50%) and neck stiffness and neck mobility reduction (45.6%) being more frequently reported. Some studies relate the occurrence of secondary lymphedema in HNC to multimodal therapies with various symptoms such as neck stiffness, difficulty in swallowing, voice, speech, breathing, weight loss and disfigurement with consequent psychosocial impairment. The impact of lymphedema on HNC is usually related to regions affected by the tumour and adjacent to it and its reflection is determined depending on the severity and the adopted treatment [4, 7, 16, 17].

The mobility of the neck is compromised by the ND and evolves with the Rt leading to the reduction of the range motion, edema, lymphedema and fibrosis. Although neck dissection is important to control the disease, it is also associated to functional sequelae, which are aggravated when it involves complementary Rt. The difficulty of swallowing was indicated by more than half of this sample, although without direct relation with the lymphedema. This result is due to the small sample [4–7, 16–18, 30, 31]. Studies indicate that besides changes in appearance, the severity of the external lymphedema is related to the self-reporting of difficulty in swallowing [10]. It is important to understand that the swelling, even at the slightest and minimal level, implicates compression of the structures near the affected

Table 4 Internal edema according to Radiotherapy Edema Rating Scale ($n=46$)

Variable Structures	Category Classification	Frequency (%)
Base of tongue	Normal	25 (54.3)
	Mild	16 (34.8)
	Moderate/severe	5 (10.9)
Posterior pharyngeal wall	Normal	20 (43.5)
	Mild	8 (17.4)
	Moderate/severe	18 (39.1)
Epiglottis	Normal	13 (28.3)
	Mild	14 (30.4)
	Moderate/severe	19 (41.3)
Pharyngoepiglottic folds	Normal	20 (43.5)
	Mild	5 (10.9)
	Moderate/severe	21 (45.6)
Aryepiglottic folds	Normal	15 (32.6)
	Mild	6 (13)
	Moderate/severe	25 (54.4)
Interarytenoid space	Normal	14 (30.4)
	Mild	4 (8.7)
	Moderate/severe	28 (60.9)
Cricopharyngeal prominence	Normal	18 (39.1)
	Mild	3 (6.5)
	Moderate/severe	25 (54.4)
Arytenoids	Normal	12 (26.1)
	Mild	4 (8.7)
	Moderate/severe	30 (65.2)
False vocal folds	Normal	32 (69.6)
	Mild	1 (2.2)
	Moderate/severe	13 (28.3)
Vocal folds	Normal	38 (82.6)
	Mild	3 (6.5)
	Moderate/severe	5 (10.9)
Anterior commissure	Normal	42 (91.3)
	Mild	3 (6.5)
	Moderate	1 (2.2)
Spaces	Classification	
Vallecula	Normal	22 (47.8)
	Mildly reduced	10 (21.7)
	Moderately/severely reduced	14 (30.4)
Pyriform sinus	Normal	23 (50)
	Mildly reduced	5 (10.9)
	Moderately/severely reduced	18 (39.1)

area and, when it is able to spread, it interferes in mobility and the physiology of deglutition and speech [5, 6].

In this sample, the percentage of subjects diagnosed with lymphedema was high (97.8%), with most of them presenting the composite type (73.9%) of various degrees, similar to what was observed in other studies [4, 29]. Regarding external lymphedema, only facial lymphedema (34.8%) was classified as levels 1a and 1b, indicating a pattern of tissue reversibility. The rate of preserved pharyngolaryngeal sensitivity was significantly higher in subjects who presented facial lymphedema ($p=0.040$). This demonstrates that the tissue that is not affected by lymphedema may have better functional performance by preserving sensory and motor conditions in the absence of swelling [5, 6].

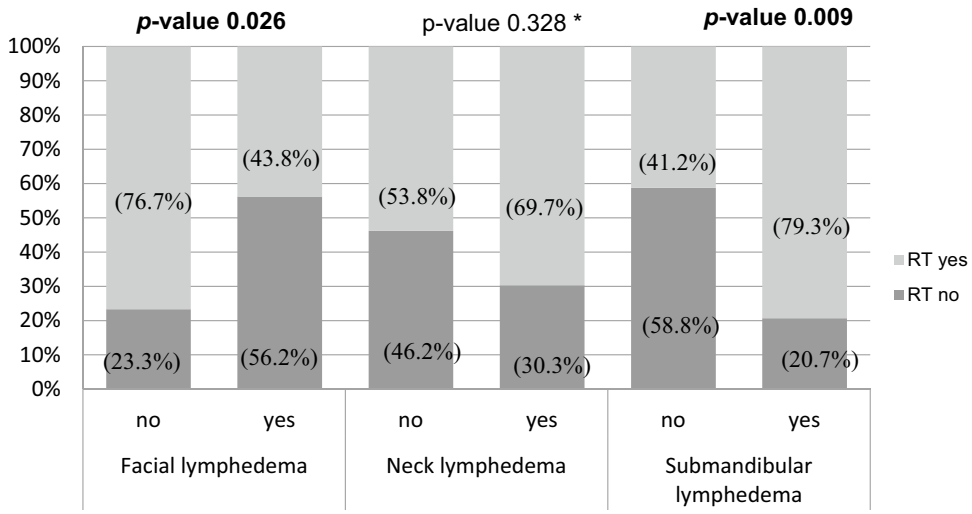

Fig. 2 Association between external lymphedema and combined treatment with radiotherapy. *p* value obtained by the χ^2 test, **p* value obtained by Fisher's exact test

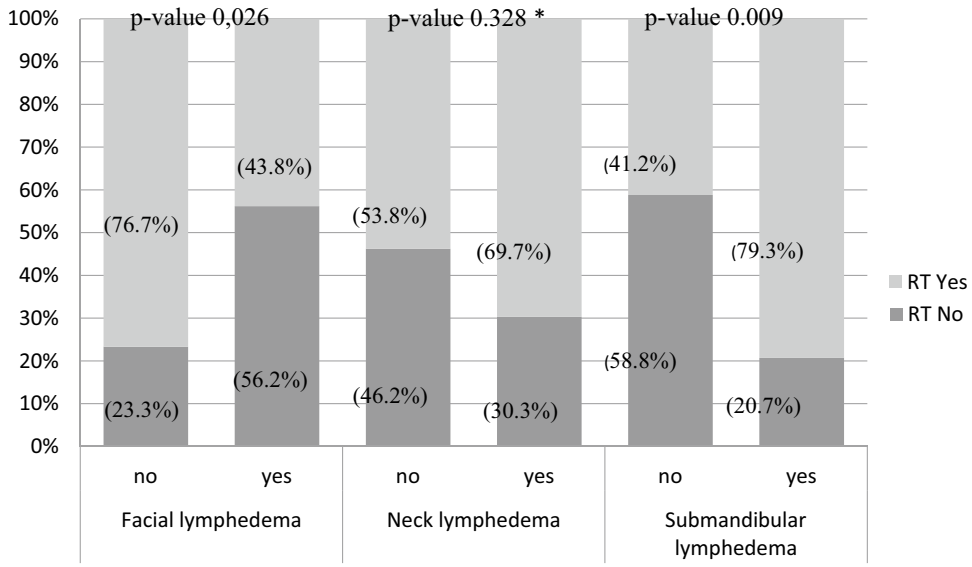

Fig. 3 Association between pharyngolaryngeal sensitivity and external lymphedema. *p* value obtained by the χ^2 test, **p* value obtained by Fisher's exact test

However, the occurrence of submandibular lymphedema was detected in 79.3% of the patients, with 63.3% being in more advanced levels indicating a certain degree of fibrosis in both neck and submandibular regions (68.9%) with association ($p = 0.009$) with the combination of Rt. Both lymphedema and fibrosis are common effects after the treatment of HNC. The literature points to 2 distinct clinical trajectories related to external, internal lymphedema and fibrosis during the first 18 months after treatment of Ch for HNC. The first one is characterised by a slight degree of tissue change during this period and the second by a moderate to severe evolution from 6 to 12 months post-treatment with slight decline between 12 and 18 months. Cases classified as moderate to severe pattern fibrosis peaked within a period shortly after these 12 months. In this series, the mean post-treatment time was 18 months, with 65% undergoing the combined treatment with Rt. We can consider that the type of treatment has direct interference in the evolution of lymphedema and fibrosis [29, 32].

HNC treatment impact leads to broad spectrum functional impairment. Internal edema was also detected in almost all structures and spaces evaluated at a degree predominantly moderate/severe and pharyngolaryngeal sensitivity change in 45.6% of the exams. The percentage of patients with these changes was higher in the Rt group (81%—pharyngolaryngeal sensitivity altered and edema in almost all structures in the Rt group). Rt combined treatment had a direct correlation with the occurrence of internal edema. A study reported that external lymphatic drainage in these patients is transitorily remodelled in response to cancer, surgery and radiotherapy. Rt associated with extensive surgery and/or neck dissection resulted in dermal lymphatic reflux starting from days to several weeks after the beginning of fractional scheme, while contralateral regions submitted to the same

Table 5 Association between the Penetration and Aspiration Scale (saliva, liquid, nectar, pasty and solid) according to pharyngolaryngeal sensitivity

Variable	Category	Pharyngolaryngeal sensitivity		*p* value
		Freq. (%)		
		Preserved	Altered	
Saliva penetration	No	25 (61)	16 (39)	0.015
	Yes	0 (0)	5 (100)	
Saliva aspiration	No	25 (59.5)	17 (40.5)	0.037
	Yes	0 (0)	4 (100)	
Liquid penetration	No	21 (67.7)	10 (32.3)	0.040*
	Yes	4 (33.3)	8 (66.7)	
Liquid aspiration	No	24 (63.2)	14 (36.8)	0.144
	Yes	1 (20)	4 (80)	
Nectar penetration	No	21 (70)	9 (30)	0.004*
	Yes	4 (25)	12 (75)	
Nectar aspiration	No	25 (58.1)	18 (41.9)	0.088
	Yes	0 (0)	3 (100)	
Pasty penetration	No	21 (72.4)	8 (27.6)	0.007
	Yes	2 (20)	8 (80)	
Pasty aspiration	No	23 (62.2)	14 (37.8)	NA
	Yes	0 (0)	2 (100)	
Solid penetration	No	21 (67.7)	10 (32.3)	0.031
	Yes	1 (16.7)	5 (83.3)	
Solid aspiration	No	22 (59.5)	15 (40.5)	NA
	Yes	0 (0)	0 (0)	

Freq. frequency, *NA* not available

p value obtained by the χ^2 test, **p* value obtained by Fisher's exact test

treatment or attenuated Rt, but without ND, did not develop patterns. This reflux is caused by the pressure change in the lymphatic endothelial cells that are part of the lymphatic system and functions as microvalves that allow the opening and closing of its filaments. When a change in this pressure occurs, and consequently a reduction in valve closure, the result is lymphatic reflux. Studies indicate that one of the mechanisms used in radiotherapy to reduce lymphatic function is the depletion of lymphatic endothelial cells and lymphatic vessels, thereby reducing transport capacity of the lymphatic system. When associated with surgery, it can cause chronic lymphedema and soft tissue fibrosis [30, 33, 34].

FEES identified residues of both saliva and the consistencies offered in the evaluation, as well as penetration and aspiration, except for solid. The percentage of residues was higher for pasty consistency and for patients with composite lymphedema. It is estimated that the coexistence of internal and external lymphedema interferes in the integrity of external and internal tissues and muscles leading to fibrosis affecting the propulsion of food bolus. Swallowing with pasty consistency may be more difficult because the internal edema reduces the free passage of the thickened bolus, with more residue.

So, it is important to consider the data obtained in this study indicating the risk related to pasty consistency. The more severe the edema, the greater the difficulty. Many of these patients undergo Rt in association with changes such as xerostomia. It is likely that these associated factors are responsible for the higher penetration percentage with pasty consistency. Severe swelling in any structure of the Patterson Scale causes swallowing dysfunction, and patients with lymphedema or pharyngeal fibrosis, for example, are more likely to develop dysphagia [5, 32].

The association between the presence of lymphedema and the residue indicated a greater number of cases of residues related to the composite lymphedema (11.8% not residue × 88.2% residue, $p = 0.012$). This finding demonstrates once again that the greater the number of compromised tissues, the worse the performance of swallowing. The analysed group had a minimum of 3 months and an average of 18 months after head and neck treatment, and the lymphedema was detected in almost all the sample with prevalence of the composite type. When Rt is combined with ND, the rupture of the lymphatic vessels can result in lymphatic stasis and the filling of dermal capillary lymphatic vessels. If this problem is not solved, this rupture leads to chronic inflammation, edema, fibrosis, deposition of adipose tissue, and finally, to functional deficits and disfigurement [9, 30, 33, 34]. Rt causes repeated damage to the tissues, not only at cellular but also at extracellular levels, delaying the body inflammatory and healing responses. These effects lead to a dysfunction in the wound healing process, resulting in an increased production of fibroblasts in the affected tissues and areas, besides excessive deposition of extracellular matrix. This late radiation response may occur years after the end of the treatment and continue progressing or worsening as time goes by [30, 33, 34].

The FEES provided a clearer view of the pharyngeal structures and made it possible to assess not only saliva and food deglutition, but also classify the degree of pharyngeal residue, as well as penetration and aspiration. Although aspiration is the primary focus of an objective evaluation for pneumonia risk and its morbidity, it is known that the residue can also lead to penetration and aspiration. However, many patients submitted to treatment for HNC have deglutition difficulties, but they do not aspirate. Meyer et al. consider that dysphagia in these cases is characterised by changes in propulsion, in pharyngeal transit and in the clearing of the bolus, which lead to residue, causing great impact on the individual's quality of life. The increase in pharyngeal residue has a more relevant effect on the functional status, regardless of the penetration and aspiration scores.

Table 6 Association between internal lymphedema, radiotherapy and neck dissection ($n=46$)

Variable Structure	Category Edema	Radiotherapy		p value	Neck dissection		p value
		Frequency (%)			Frequency (%)		
		No	Yes		No	Yes	
Base of tongue	No	13 (52.0)	12 (48.0)	0.007	8 (32.0)	17 (68.0)	0.162
	Yes	3 (14.3)	18 (85.7)		11 (52.4)	10 (47.6)	
Posterior pharyngeal wall	No	13 (65.0)	7 (35.0)	< 0.001	6 (30.0)	14 (70.0)	0.172
	Yes	3 (11.5)	23 (88.5)		13 (50.0)	13 (50.0)	
Epiglottis	No	9 (69.2)	4 (30.8)	0.002	3 (23.1)	10 (76.9)	0.115
	Yes	7 (21.2)	26 (78.8)		16 (48.5)	17 (51.5)	
Pharyngoepiglottic folds	No	12 (60.0)	8 (40.0)	0.002	4 (20.0)	16 (80.0)	0.010
	Yes	4 (15.4)	22 (84.6)		15 (57.7)	11 (42.3)	
Aryepiglottic folds	No	10 (66.7)	5 (33.3)	0.002	4 (26.7)	11 (73.3)	0.161
	Yes	6 (19.4)	25 (80.6)		15 (48.4)	16 (51.6)	
Interarytenoid space	No	7 (50.0)	7 (50.0)	0.152	3 (21.4)	11 (78.6)	0.070
	Yes	9 (28.1)	23 (71.9)		16 (50.0)	16 (50.0)	
Cricopharyngeal prominence	No	9 (50.0)	9 (50.0)	0.082	4 (22.2)	14 (77.8)	0.035
	Yes	7 (25.0)	21 (75.0)		15 (53.6)	13 (46.4)	
Arytenoids	No	7 (58.3)	5 (41.7)	0.046	3 (25.0)	9 (75.0)	0.182
	Yes	9 (26.5)	25 (73.5)		16 (47.1)	18 (52.9)	
False vocal folds	No	16 (50.0)	16 (50.0)	0.001	13 (40.6)	19 (59.4)	0.887
	Yes	0 (0.0)	14 (100.0)		6 (42.9)	8 (57.1)	
Vocal folds	No	14 (36.8)	14 (36.8)	0.694*	14 (36.8)	24 (63.2)	0.246
	Yes	2 (25.0)	2 (25.0)		5 (62.5)	3 (37.5)	
Anterior commissure	No	16 (38.1)	26 (61.9)	0.282*	16 (38.1)	26 (61.9)	0.292
	Yes	0 (0.0)	4 (100.0)		3 (75.0)	1 (25.0)	
	Spaces						
Valleculae	No	13 (59.1)	9 (40.9)	0.001	7 (31.8)	15 (68.2)	0.211
	Yes	3 (12.5)	21 (87.5)		12 (50.0)	12 (50.0)	
Pyriform sinus	Normal	14 (60.9)	9 (39.1)	< 0.001	6 (26.1)	17 (73.9)	0.036
	Reduced	2 (8.7)	21 (91.3)		13 (56.5)	10 (43.5)	

p value obtained by the frequency by the χ^2 test; *p value obtained by Fisher's exact test

This seems to indicate that the residue in different sites of the upper aerodigestive tract reflects on different deficits in the deglutition mechanism. The residue can be considered a primary measurement for the deglutition function and can be a target for identification, evaluation, as well for the results in deglutition treatment [35].

Another important information is the change in the pharyngolaryngeal sensitivity in the pyriform sinus, while the internal edema was present. These two factors (residue and sensorial changes) offer potential risks to silent aspiration, and this may justify the occurrence of penetration and aspiration.

In the FEES evaluation, residue and penetration of saliva and food are systematic events after treatment for HNC, being more evident for pasty consistency, and is a factor that generates aspiration. In the evaluation protocol used in this group of patients, only 5 mL and 10 mL were offered for each consistency. The results indicated changes in both scales used for the analysis. In larger quantities, the frequency will probably be higher, a fact that usually occurs in the daily life of the patient who is exclusively orally fed. This aspect is an important indicator for the targeting of evaluation and follow-up criteria from the earliest period of treatment. The detection, evaluation and characterisation of cervicofacial and pharyngolaryngeal lymphedema should be part of the daily practice of the speech pathologist and its finding may be an indicator of the coexistence of changes in the biomechanics of deglutition, especially in cases of composite lymphedema and/or combined treatment of Rt. Most patients in this study, who had external lymphedema, also presented internal lymphedema. There were signs of dysphagia in FEES results in patients with lymphedema, as previously assumed.

Table 7 Association between internal edema, swallowing and pharyngolaryngeal sensitivity ($n=46$)

Variable Structure	Category Edema	Residue		*p* value	Pharyngolaryngeal sensitivity		*p* value
		Frequency (%)			Frequency (%)		
		No	Yes		No	Yes	
Base of tongue	No	8 (32)	17 (68.0)	0.066	15 (60)	10 (40)	0.401
	Yes	2 (9.5)	19 (90.5)		10 (47.6)	11 (52.4)	
Posterior pharyngeal wall	No	7 (35)	13 (65)	0.077	13 (65.0)	7 (35)	0.203
	Yes	3 (11.5)	23 (88.5)		12 (46.2)	14 (53.8)	
Epiglottis	No	7 (53.8)	6 (46.2)	0.020*	8 (61.5)	5 (38.5)	0.539
	Yes	29 (8.9)	4 (12)		17 (51.5)	16 (48.5)	
Pharyngoepiglottic folds	No	7 (35)	13 (65)	0.077	13 (65)	7 (35.0)	0.203
	Yes	3 (11.5)	23 (88.5)		12 (46.2)	14 (53.8)	
Aryepiglottic folds	No	8 (53.3)	7 (46.7)	0.001*	10 (66.7)	5 (33.3)	0.243
	Yes	2 (6.5)	29 (93.5)		15 (48.4)	16 (51.6)	
Interarytenoid space	No	6 (42.9)	8 (57.1)	0.047	7 (50)	7 (50)	0.695
	Yes	4 (12.5)	28 (87.5)		18 (56.2)	14 (43.8)	
Cricopharyngeal prominence	No	7 (38.9)	11 (61.1)	0.033*	11 (61.1)	7 (38.9)	0.460
	Yes	3 (10.7)	25 (89.3)		14 (50.0)	14 (50)	
Arytenoids	No	5 (41.7)	7 (58.3)	0.098	7 (58.3)	5 (41.7)	0.747
	Yes	5 (14.7)	29 (85.3)		18 (52.9)	16 (47.1)	
False vocal	No	10 (31.2)	22 (68.8)	0.020*	17 (53.1)	15 (46.9)	0.801
folds	Yes	0 (0.0)	14 (100)		8 (57.1)	6 (42,9)	
Vocal folds	No	8 (21.0)	30 (79)	0.999	22 (57.9)	16 (42.1)	0.439
	Yes	2 (25.0)	6 (75)		3 (37.5)	5 (62.5)	
Anterior commissure	No	10 (23.8)	32 (76.2)	0.562	23 (54.8)	19 (45.2)	0.999*
	Yes	0 (0.0)	4 (100)		2 (50.0)	2 (50)	
Valleculae	No	8 (36.4)	14 (63.6)	0.021*	13 (59.1)	9 (40.9)	0.536
	Yes	2 (8.3)	22 (91.7)		12 (50.0)	12 (50)	
Pyriform sinus	Normal	8 (34.8)	15 (65.2)	0.032	16 (69.6)	7 (30.4)	0.038
	Reduced	2 (8.7)	21 (91.3)		9 (39.1)	14 (68.9)	

p value obtained by the frequency by the χ^2 test; **p* value obtained by Fisher's exact test

Conclusion

Composite lymphedema and pharyngolaryngeal internal edema are frequent after treatment for HNC and are directly related to dysphagia.

Treatment combined with Rt is associated with the occurrence of submandibular external lymphedema, pharyngolaryngeal internal edema, pharyngolaryngeal sensitivity alteration and residues.

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