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PRS GLOBAL OPEN

ORIGINAL ARTICLE
Reconstructive

Swallowing and Speaking Evaluation After Resection and Reconstruction Versus Definite Radiochemotherapy for (Sub)total Tongue Cancer

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Background: In very advanced tongue cancer, definite radiochemotherapy (RCHT) is often preferred over total or near total glossectomy due to organ preservation and functionality, particularly swallowing.
Methods: This retrospective study compares the functionality and survival of 10 patients with very advanced tongue cancer who received (sub)total glossectomy with prior or adjuvant RCHT and reconstruction by a musculocutaneous anterolateral thigh flap. All 10 patients had comparable tongue carcinomas treated by definite RCHT. Airway protection and swallow efficiency were evaluated by fiberoptic endoscopic evaluation of swallowing and graded using the Rosenbek Penetration and Aspiration Scale (PAS) and the Yale Pharyngeal Residue Severity Rating Scale (YPRS).
Results: Of 10 surgical patients, 7 were completely oralized after a mean of 17 days. For surgical patients, PAS scores swallowing saliva (mean 1.6 versus 2.9, $P = 0.04$) as well as vallecula (mean 4.0 versus 2.9, $P = 0.05$) and piriform sinus (mean 3.5 versus 2.5, $P = 0.05$) YPRS scores for saliva were significantly lower compared with definite RCHT. Irrespective of treatment, age older than 65 years (YPRS sinus piriformis H_2O 3.4 versus 2.5, $P = 0.47$), body mass index less than 20 kg/m^2 (PAS Jelly 4.7 versus 2.2, $P = 0.015$, YPRS sinus piriformis 4.0 versus 2.7, $P = 0.028$), and Karnovsky index less than 80 (PAS saliva 2.8 versus 1.6, $P = 0.049$) were associated with worse swallowing. Speech was intelligible in 80% of patients of both groups. Overall survival did not differ between the surgical group and definite RCHT.
Conclusions: Patients after (sub)total glossectomy with RCHT and adequate reconstruction with a musculocutaneous anterolateral thigh flap show equal or even better swallowing compared with patients after definite RCHT for advanced tongue cancer.
(Plast Reconstr Surg Glob Open 2025;13:e6533; doi: 10.1097/GOX.0000000000006533; Published online 14 March 2025.)

INTRODUCTION

Involvement of the tongue is very common in oral cancer and implies major functional impairment such as malfunction of swallowing, articulation, and mastication.[1] Failures in swallowing may again lead to aspiration and recurrent pneumonia which is associated with decreased overall survival (OS) independent from the oncological status.[2] Reconstruction of the tongue after cancer resection is very challenging and aims at reconstruction of adequate tongue mobility or bulk—depending on residual tongue volume—allowing for proper swallowing.[3] Classical options for tongue reconstructions by free tissue grafts include the radial forearm flap for partial tongue replacements and the latissimus dorsi or rectus abdominis myocutaneous flap for advanced tongue defects with the absence of considerable portions of tongue muscle.[4–8] Currently, perforator-based free flaps such as the anterolateral thigh flap (ALTF) and the medial sural artery perforator flap

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Received for publication July 22, 2024; accepted December 10, 2024.

Presented at the Congress of the German Society of Oral and Maxillofacial Surgery, 2023, Hamburg.

DOI: 10.1097/GOX.0000000000006533

Disclosure statements are at the end of this article, following the correspondence information.

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are increasingly used.[9] Some groups also try to restore the sensory or motor function of the transplant.[10–12] The current work evaluates the functional outcome after total or subtotal tongue resection and reconstruction by use of a myofasciocutaneous ALTF with or without nerve anastomosis. Airway protection, swallowing function, and speaking ability are measured and compared with matched tongue cancer patients treated by definite radio(chemo) therapy (RCHT).

Takeaways

Question: Is definite radiochemotherapy (RCHT) more functional than resection and reconstruction for (sub) total tongue cancer?

Findings: Investigation of swallowing by fiberoptic endoscopic evaluation of swallowing and grading by the Rosenbek Penetration and Aspiration Scale and the Yale Pharyngeal Residue Severity Rating Scale revealed lower or at least equal scores (means equal or even better swallowing) for surgical tongue resection and flap reconstruction compared with definite RCHT.

Meaning: (Sub)total glossectomy and adequate reconstruction by a myofasciocutaneous anterolateral thigh flap with prior or adjuvant RCHT are as functional as definite RCHT for very advanced tongue cancer.

METHODS

Following institutional review board approval (23-3605-104) from the ethics committee of the University Hospital Regensburg, Germany, records of all patients who underwent subtotal or total glossectomy with reconstruction by a free myofasciocutaneous ALTF due to tongue cancer were retrospectively reviewed. This kind of surgery routinely started in 2020, and 2 archived cases from 2016 and 2007 could be added. Patient-, treatment-, and follow-up-specific data were retrieved from the charts of the departments of oral and maxillofacial surgery and otorhinolaryngology, including the division of phoniatrics.

The 10 surgical cases were compared with 10 patients with similar advanced squamous cell carcinoma (SCC) of the tongue or base of the tongue who were solely treated by definite RCHT.

Treatment decision for all patients was made in the interdisciplinary head and neck tumor board. Primary surgery was chosen if the tumor showed no or just minimal pharyngeal extension, if major comorbidities were absent, and if the patient was willing to undergo maximum treatment. For the study, patients with gross pharyngeal or even laryngeal tumor extension were excluded from the definite RCHT group to keep the comparison.

Surgical Procedure

All patients underwent a subtotal or total glossectomy, with resection of at least two-thirds of the tongue. Total glossectomy was defined as the complete removal of the oral and pharyngeal portions of the tongue and the bilateral hypoglossal nerves. Tumor resection was performed transorally, combined with a pull-through approach in 9 cases. In 1 patient, a lip split with a mandibular split was necessary. For primary cancer treatment, a bilateral neck dissection (at least levels I–III) was conducted. The ALTF was harvested as described in detail before.[13,14] (**See figure, Supplemental Digital Content 1**, which displays an outline of the typical dimension of an ALTF for total tongue reconstruction, **http://links.lww.com/PRSGO/D852**.)

Identified perforators were isolated by retrograde dissection through the vastus lateralis muscle. The skin paddle was adjusted to the found perforator and circumcised in the planned dimensions. Care was taken when dissecting the lateral femoral cutaneous nerve. (**See figure, Supplemental Digital Content 2**, which displays dissection of the lateral femoral cutaneous nerve deep in the subcutaneous tissue, **http://links.lww.com/PRSGO/D853**.) The flap, and particularly the muscle portion, was tailored for volume and thickness for each patient (Fig. 1A; Table 1). Vascular and nerve anastomoses were performed with the flap located outside the oral cavity (Fig. 1B). Flap inset started from submandibular, suturing one end to the pharyngeal mucosa (Fig. 1C). For laryngeal suspension, the hyoid was sutured with polydioxanon 2.0 to drill holes of the remaining mandible. Temporary epithelialized tracheotomy followed at the

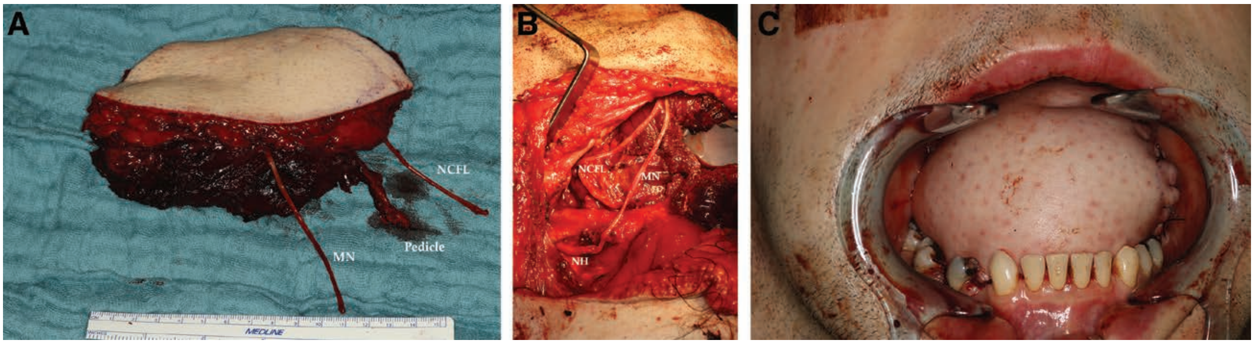

Fig. 1. Total tongue reconstruction with nerve coadaptation. A, Harvested myofasciocutaneous ALTF with motor nerve (MN) and lateral femoral cutaneous (NCFL) nerve. B, Anastomosis of the MN to the hypoglossal nerve (NH) and of the lateral femoral cutaneous nerve (NCFL) to the lingual nerve. Suturing of the NCFL to the lingual nerve stump behind the mandibular angle is demanding. C, Resulting ALTF volume for total tongue reconstruction at the end of surgery.

Table 1. Patient and Treatment Data

Patients	Sex	Age, y	BMI Pre–OP, kg/m²	Karnovsky	Dignity	T,N	Tongue Defect	Flap Size	Muscle (cm)	Anast. Motor Nerve	Anast. Sensory Nerve	Anast. Art	Overall Time of Surgery	RCHT	Comments
1	M	35	24.6	80	rec. SCC	rpT3, cN0	Total	11 × 7	3 × 4	N	N	A. thyr	712	Pre-RCHT (72 Gy)	Salvage surgery
2	M	44	28.4	80	SCC	pT3, pN2c	Subtotal	10 × 7	4 × 4	N	N	A. fac	472	Post-RCHT (66.6 Gy)	Primary surgery
3	M	62	26.6	60	SCC	pT4a, pN2b	Subtotal	15 × 10	4 × 5	N	N	A thyr	508	Post-RCHT (72 Gy)	OP, SP involvement, AMT harvest
4	M	48	27.1	80	SCC	pT3, pN3b	Total	14 × 9	7 × 4	Y	N	A. thyr	441	Post-RT (72 Gy)	Primary surgery
5	M	53	23.8	90	SCC	pT4, pN1	Total	18 × 9	7 × 4	Y	N	A. fac	558	Post-RCHT (66.6 Gy)	Primary surgery
6	M	80	19.7	50	SCC	pT3, pN0	Subtotal	16 × 9	5 × 3	Y	N	A. thyr	545	Post-RT (66 Gy)	Primary surgery
7	M	66	24	80	rec. ACC	ypT3, rpN0	Subtotal	11 × 7	5 × 3	Y	N	A. fac	476	Pre-RT (67.5 Gy)	Salvage surgery
8	M	46	29.4	90	SCC	pT3, pN3b	Total	15 × 9	7 × 4	Y	Y	A. fac	440	Post-RCHT (66.6 Gy)	Primary surgery
9	M	62	23.8	70	rec. SCC	ypT4a, pN0	Subtotal	15 × 8	6 × 3	Y	N	A. thyr	440	Pre-RCHT (68Gy)	Add. FFF, salvage surgery
10	M	53	18.4	70	rec. SCC	ypT4a	Total	16 × 10	8 × 4	N	N	A. thyr	418	Pre-RCHT (72 Gy)	Add. mandible resection, salvage surgery
11	M	72	23.1	70	SCC	cT3 cN1	Subtotal							69.5 (RT)	
12	M	70	25.1	70	SCC	cT2, cN0	Subtotal							71.1 (RCHT)	
13	M	55	18.8	80	SCC	cT4, cN2c	Total							69.6 (RCHT)	
14	M	51	24.2	70	SCC	cT4, cN2c	Total							63.6 (RCHT)	
15	M	53	27.7	70	SCC	cT4, cN2	Total							72 (RCHT)	
16	F	62	24.8	70	SCC	cT4, cN2b	Subtotal, BOT							64.8 (RCHT)	
17	M	56	31.1	70	SCC	cT3, cN2c	Subtotal							72 (RCHT)	
18	M	62	22.5	50	SCC	cT4a, N2b	Subtotal							70.2 (RCHT)	
19	M	57	23.6	90	SCC	cT3, cN2	Subtotal							72 (RCHT)	
20	M	73	22.6	80	SCC	cT4a, cN2c	Subtotal							63.6 (RCHT)	

Patients 1–10 after glossectomy and reconstruction and 11–20 after definite RCHT.
ACC, adenoid cystic carcinoma; AMT, anterior medial thigh flap; BOT, base of tongue; FFF, free fibula flap; OP, oropharynx; SP, sinus piriformis.

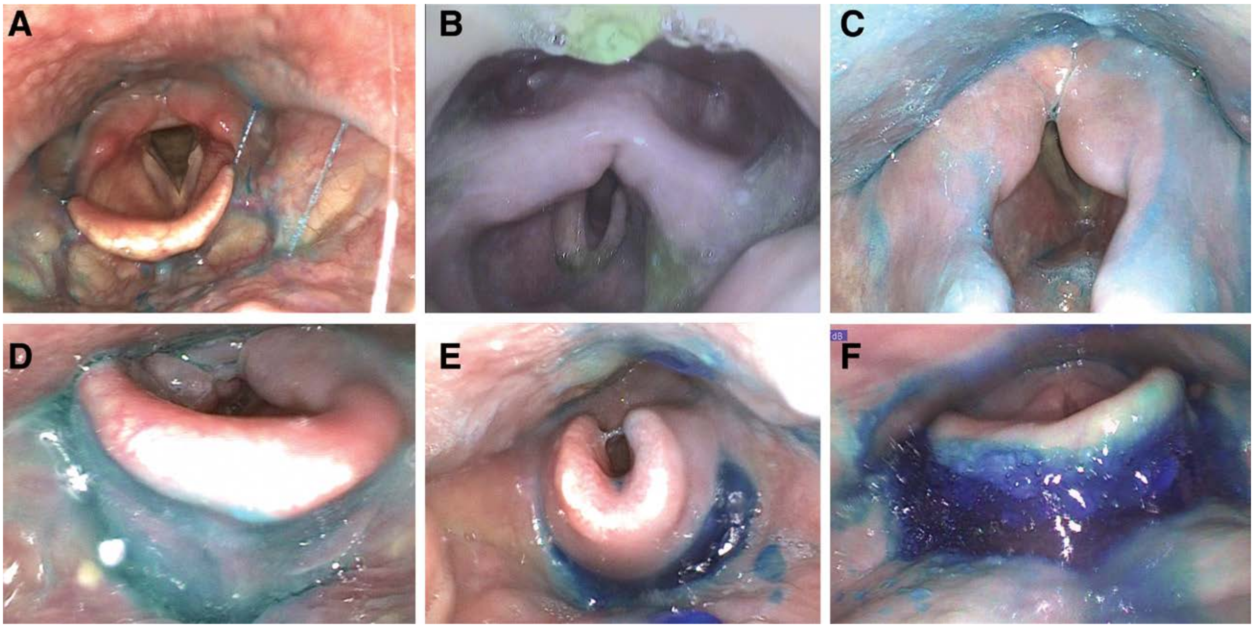

Fig. 2. Representative figures of the FEES with scoring: PAS = 1, YPRSSP = II (A), PAS = 7 (B), PAS = 8 (C), YPRSVal = III (D), YPRSVal = IV (E), and YPRSVal = V (F).

end of surgery, and the patient was transferred to the intensive care unit (ICU) for standard monitoring and prophylactic heparinization. The patient's tracheostoma was kept blocked for the first 5–7 days. For weaning from tracheotomy, the cuff was deflated for at least 24 hours while sufficient oxygenation and expectoration were assured. Afterward, phoniatric dysphagia diagnostics were performed using fiberoptic endoscopic evaluation of swallowing (FEES). If aspiration was inapparent, a speech cannula was inserted and the stoma was surgically closed some days later. The 4 patients who had previous radiotherapy (RT) were fed by nasogastral tubes. All other patients with determined postoperative RCHT received perioperative percutaneous gastrostomy feeding tubes. Patients were usually discharged when feeding was secure without aspiration and preparation for adjuvant RT was completed. Follow-up visits were planned at 1 week and 1, 3, and 6 months. Whenever possible, phoniatric evaluation was included.

Definite RCHT

Ten patients with comparable tumor locations (tongue and base of tongue) and comparable sizes (T3 and T4) who received definite RCHT were retrieved from the charts. Only cases with phoniatric FEES evaluation of dysphagia were included. Patient and tumor-specific data, such as TNM stage, body mass index (BMI), or radiation dose, were documented (Table 1). Long-term follow-up data were obtained from the Tumor Center, Regensburg.

Clinical and Phoniatric Evaluation

Instrumental Assessment of Swallowing Function

Oropharyngeal swallowing function was evaluated via FEES (Fig. 2).[15,16] (**See Video 1 [online]**, which displays FEES in patient 5 1 year after total glossectomy and ALTF reconstruction with motor nerve coadaptation and adjuvant RCHT [66.6 Gy] for pT4, pN1 tongue cancer. The patient shows proper and efficient swallowing without aspiration and without major pharyngeal swallowing residue.) (**See Video 2 [online]**, which displays FEES in patient 19 2 years after definite RCHT [72 Gy] for cT3, cN2 tongue cancer. The patient shows severe jelly residue at the vallecula and the piriform sinus as well as aspiration [Penetration and Aspiration Scale (PAS) 7] after drinking liquids.)

The phoniatrist (P.K. and S.V.) completed a clinical, anatomical observation of the nasopharynx, oropharynx, hypopharynx, and larynx before bolus presentation. Bluish-dyed jelly and water liquid boluses were presented in 5 and 10 mL amounts. Additionally, swallowing was clinically observed for coughing and signs of dysphagia (clinical aspiration) after drinking 5 mL of water (water swallowing test).

Airway Protection

The phoniatrist rated airway protection for each bolus type and volume during the FEES procedure using the Rosenbek PAS.[17] The Rosenbek 8-point PAS was used to assess the safety of swallowing. The scores ranged from 1 (no materials enter the airway) to 8 points (the material passes below the vocal cords, but no effort is made to eject the material), representing the severity of risk for aspiration and penetration (Fig. 2). A score of 4 or 5 is defined as penetration, a score of 6 or more as aspiration.

Swallow Efficiency

The severity of pharyngeal residue observed during FEES for each bolus type and volume presented was rated using the Yale Pharyngeal Residue Severity Rating Scale (YPRS).[18]

The YPRS is a standardized and validated measurement tool to assess the severity of postswallow pharyngeal residue as observed during FEES. The YPRS is an anatomically defined, image-based tool that consists of a 5-point ordinal rating scale based on residue location (vallecula or pyriform sinus) and amount (none, trace, mild, moderate, and severe).[19] Representative examples are shown in Figure 2 and Videos 1 and 2 (**see Videos 1 and 2 [online]**).

Speech

Postoperative speech intelligibility was defined as the percentage of words understandable to the speech therapist, who assigned a percentage score as the patient read a standardized passage. The following numeric scale was used: 4 (80% intelligible), 3 (50%–80% intelligible), 2 (<50% intelligible), 1 (unintelligible), and 0 (inability to speak).[20]

Statistics

Statistical analysis was performed with SPSS, version 25 (IBM Corp., Endicott, NY). For descriptive analyses, variables were presented in absolute numbers and percentages. The chi-squared test and *t* test were used depending on the scale level and normal distribution of the compared variables. Statistical significance was set at *P* values of less than or equal to 0.05.

Univariate survival analysis was carried out with the Kaplan–Meier method, and distributions were compared by use of the log-rank test. Time from therapy (surgery or beginning of RCHT) to tumor-caused death or end of follow-up was defined as OS. For all examinations, a *P* value of less than or equal to 0.05 was considered statistically significant.

RESULTS

Surgical Patients

Patient and surgical data are presented in Table 1. Nine patients received an ALTF; in 1 patient, an anteromedial thigh flap was performed. All patients were men with a mean age of 52.6 years. The mean BMI was 24.6, and the mean Karnovsky index was 75. All patients showed at least a pT3 stage. The mean flap size was 117.6 m^2. All flaps were based on a single perforator; in 9 out of 10 cases, the perforator took an intramuscular course. The muscle portion of the flaps ranged between 3 × 4 cm and 8 × 4 cm; in 6 flaps, the motor nerve was anastomosed to the hypoglossal nerve, and in 1 patient, the lateral cutaneous femoral nerve was additionally anastomosed to the remaining lingual nerve stump (Fig. 1B). Recipient vessels were the facial or superior thyroid arteries and vein. The mean overall time of total surgery was 501 (range 440–712) minutes. In 6 patients, bilateral neck dissection was performed. Six patients received adjuvant radiochemotherapy or RCHT, and 4 patients already had RCHT before salvage surgery of the recurrent tumor. The mean dose was 68.7 Gy. Decannulation was possible in all patients. Nine patients were decannulated after 9–24 days, and 1 patient was decannulated after 52 days due to development of an acute abdomen on day 6 following open abdominal surgery with hemicolectomy and prolonged ICU treatment. Average hospitalization after surgery was 20.4 days including the patient described above staying 54 days in ward. During follow-up, the total oral diet was achieved in 7 patients (after a mean of 17 days, range 12–26); 2 patients had oral intake supported by gastral feeding, and 1 patient depended on gastrostomy feeding in the long-time course (Table 2).

Patients with Definite RCHT

Data of the irradiated patients are also shown in Tables 1 and 2. Mean age in this group of patients was 61.1 years, which was 8.5 years more than the surgical group without reaching significance ($P = 0.13$). The mean BMI and Karnovsky indices of the primary irradiated patients were 24.5 and 72, respectively, both comparable to the surgical patients. Nine patients received RCHT with cisplatin and 1 patient received single RT due to his advanced age. The mean radiation dose was 68.8 Gy. The average hospitalization was 45 days, which was 24.6 days longer than in the surgical group ($P = 0.006$). In the irradiated patient group, the feeding tube was removed after a mean of 102 days. Complete oralization was possible in 6 patients; 3 patients needed additional gastral feeding, and 1 patient could not be oralized at all.

Airway Protection and Swallow Efficiency (FEES)

The results of the FEES are presented in Tables 3 and 4 and Figure 3. Comparing the treatment modalities, surgery and ALTF reconstruction came up with lower penetration and aspiration scores when swallowing saliva compared with definite chemoradiation (mean 1.6 versus 2.9, $P = 0.041$, Table 4). Swallowing efficiency of saliva was also better in the surgery group regarding the vallecula (mean YPRS 2.9 versus 4.0, $P = 0.051$) and piriform sinus (mean YPRS 2.5 versus 3.5, $P = 0.053$). In the surgery group, 1 patient (ID no. 3) was graded 6 when swallowing water, which means aspiration by definition. In the RCHT group, 2 patients (ID nos. 17 and 19) were graded 6 and 7 (aspiration), respectively, for swallowing water. During simple clinical observation without FEES, aspiration seemed more often obvious after drinking 5 mL of water. In the surgical group, 4 patients (nos. 3, 6, 7, and 9) had to cough for ejection of the swallowed water. In the irradiated group also, 4 patients (nos. 1, 2, 7, and 9) were documented for clinical aspiration, leading to pneumonia. Irrespective of treatment, age older than 65 years (YPRS SP H_2O 3.4 versus 2.5, $P = 0.47$), BMI less than 20 kg/m^2 (PAS Jelly 4.7 versus 2.2, $P = 0.015$, YPRS SP 4.0 versus 2.7, $P = 0.028$), and Karnovsky index less than 80 (PAS saliva 2.8 versus 1.6, $P = 0.049$) were associated with worse swallowing performance (Table 4).

Feeding Tube Dependency

The mean dependency on a feeding tube was 75.3 days in the surgical group and 108.7 days in the definite RCHT group ($P = 0.56$). Overall, dependency on feeding tubes was associated with older ages (mean 64.8 versus mean 52.5 y, $P = 0.031$) and higher Karnovsky indices (mean 78.5 versus 68.9, $P = 0.004$). Patients with feeding tube

Table 2. Clinical Outcome

Patients	Stay in ICU (d)	Stay in Ward (d)	Decannulation (d)	Feeding Tube (d)	Oralization	Clinical Aspiration	Speech	Follow-up (mo)	Recurrence	Comments
1	2	28	24	26	Yes	No	3	180	No	Sarcoma after 60 mo, pharynx stenosis after 12 y, secondary SCC oropharynx after 12 y
2	2	13	9	14	Yes	No	3	21	Yes (regional)	Regional recurrence after 8 mo, death after 20 mo
3	4	54	52	144	Partial	Yes	3	16	No	Delirium postsurgery. Acute abdomen on day 6, death after 16 mo due to unknown reason
4	3	11	10	12	Yes	No	3	34	Yes (local)	Patient denied initial post-OP irradiation, local and regional recurrence after 6 mo, lung metastasis after 31 mo, RT for recurrence, then dysphagia IV, death after 34 mo
5	6	11	16	21	Yes	No	3	34	No	None
6	2	26	22	374	No	Yes	2	13	No	Intermittent aspiration, death after 12 mo
7	2	10	10	12	Yes	Yes	3	26	No	Rarely aspiration, aspiration pneumonia after 6 mo
8	1	17	12	16	Yes	No	3	21	Yes (regional)	Regional metastasis after 12 mo, RT for metastasis
9	2	20	14	92	Partial	Yes (early)	3	13	Yes (regional)	Early aspiration, missing lip competence, oral diet and feeding tube, lymph node metastasis after 7 mo
10	2	14	13	18	Yes	No	2	7	Yes (local)	local recurrence after 5 mo, PEG due to recurrence
11	n.a.	49	0	82.00	partial	Yes	2	107	No	Death due to aspiration pneumonia
12	n.a.	57	0	78.00	Yes	Yes	3	7	No	Post-CRT aspiration pneumonia
13	n.a.	26	24	87.00	Partial	No	2	33	Yes (local)	
14	n.a.	44	0	26.00	Yes	No	3	48	Yes (regional)	
15	n.a.	55	0	53.00	Yes	No	3	118	No	
16	n.a.	85	0	82.00	Partial	No	3	28	Yes (distant)	Oral diet and feeding tube
17	n.a.	32	0	40.00	Yes	Yes	3	32	Yes (local)	
18	n.a.	55	0	491.00	No	No	3	15	Yes (local)	Feeding tube
19	n.a.	5	0	40.00	Yes	Yes	3	30	Yes (regional)	Aspiration and death due to resp. insufficiency
20	n.a.	42	0	43.00	Yes	No	3	67	Yes (distant)	Pulmonary metastasis, immunotherapy

Patients 1–10 after glossectomy and reconstruction and 11–20 after definite RCHT.
CRT, chemoradiotherapy.

dependency showed a lower BMI (mean 22.7 versus 25.4, $P = 0.091$) without reaching statistical significance.

Speech

Speech was intelligible in 80% of patients of both groups at the latest follow-up (Table 2). (**See Video 3 [online]**, which displays patient 8 speaking after total glossectomy and ALTF reconstruction with motoric and sensoric nerve coaptation.)

Survival

The mean follow-up was 36.3 months in the surgical group and 48.5 months in the definite RCHT group ($P = 0.55$). OS did not differ between surgery and definite RCHT. (**See figure 3, Supplemental Digital Content 3**, which displays OS depending on treatment modality, **http://links.lww.com/PRSGO/D854**.) However, worse OS was associated with a PAS score greater than or equal to 5 ($P = 0.024$). (**See figure, Supplemental Digital Content 4**, which shows that OS is significantly worse if PAS ≥ 5 when swallowing water, **http://links.lww.com/PRSGO/D855**.)

DISCUSSION

The correct treatment of very advanced (T3, T4) tongue cancer remains under debate. Surgery followed by adjuvant RCHT has been the treatment of choice for many years but is criticized for its functional impairments regarding swallowing and speaking compared with organ-preserving therapies such as definite chemoradiation.[21–23]

Function after glossectomy worsens with the extent of glossectomy.[20,24,25] From a reconstructive point of view, glossectomy defects where one-third to one-half of the tongue is present are better treated by a thin, pliable flap like the radial forearm flap to preserve the mobility of the tongue. If less than one-third of the tongue remains, the importance of flap bulk increases.[26] Due to resorption, it is recommended to design the flap 30% wider (9–10 cm in width) than the defect to get the necessary protuberans for proper swallowing.[27,28] In our cohort, the flap sizes ranged from 10 × 7 to 16 × 10 cm. For total glossectomy, a flap size of 9 × 15 cm seems appropriate and comparable to previous reports.[11] For additional bulk, a vastus muscle

Table 3. Results of PAS and YPRS

Patients	Time FEES (Months)	PAS Saliva	PAS Jelly	PAS H_2O	YPRS Saliva val	YPRS Saliva SP	YPRS Jelly Val	YPRS Jelly SP	YPRS H_2O Val	YPRS H_2O SP
Surgery										
1	150.70	1	1	1	IV	II	IV	II	IV	II
2	1.70	1	3	1	II	II	III	III	II	II
3	1.90	1	5	6	II	II	V	II	II	II
4	25.00	1	1	2	V	III	V	III	V	III
5	26.40	1	1	1	II	II	III	II	II	II
6	6.20	3	5	5	III	IV	III	IV	III	IV
7	12.30	1	1	5	II	II	V	III	III	II
8	12.36	1	1	1	II	II	III	II	II	II
9	6.00	3	3	3	III	III	III	IV	II	III
10	5.00	3	5	5	IV	III	V	III	III	III
Definite RCHT										
11	26.40	4	5	4	V	IV	IV	IV	IV	IV
12	6.20	1	3	1	II	III	V	III	II	II
13	14.40	2	4	4	V	V	V	V	III	III
14	9.00	5	2	2	V	V	V	III	II	II
15	12.20	3	1	1	IV	III	III	III	II	II
16	2.40	3	1	3	IV	III	IV	II	III	III
17	18.00	4	4	6	V	IV	V	I	III	II
18	1.20	1	1	1	II	II	III	II	III	II
19	29.20	1	1	7	III	I	V	III	V	IV
20	88.20	5	4	1	V	V	V	IV	V	V

Patients 1–10 after glossectomy and reconstruction and 11–20 after definite RCHT.
H_2O, liquid; SP, sinus piriformis; val, vallecula.

Table 4. Swallowing Outcome (Mean Values) Depending on Therapy, Age, BMI, and Karnovsky Index

	PASSal	PASJelly	PASH_2O	YPRSValSal	YPRSSPSal	YPRSValJelly	YPRSSPJelly	YPRSValH2O	YPRSSPH2O
Therapy									
Surgery	**1.6000***	2.6000	3.0000	**2.9000***	**2.5000***	3.9000	2.8000	2.8000	2.5000
Definite RCHT	**2.9000**	2.6000	3.0000	**4.0000**	**3.5000**	4.3000	3.0000	3.2000	2.9000
Age, y									
<65 (n = 15)	2.0667	2.2667	2.9333	3.4667	2.8000	4.0000	2.6667	2.8667	**2.4667***
>65 (n = 5)	2.8000	3.6000	3.2000	3.4000	3.6000	4.4000	3.6000	3.4000	**3.4000**
BMI									
<20 (n = 3)	2.6667	**4.6667***	4.6667	4.0000	4.0000	4.3333	**4.0000***	3.0000	3.3333
>20 (n = 17)	2.1765	**2.2353**	2.7059	3.3529	2.8235	4.0588	**2.7059**	3.0000	2.5882
Karnovsky									
<80 (n = 11)	**2.8182***	3.1818	3.3636	3.5455	3.2727	4.0000	2.8182	2.6364	2.6364
>80 (n = 9)	**1.5556**	1.8889	2.5556	3.3333	2.6667	4.2222	3.0000	3.4444	2.7778
Overall	2.2500	2.6000	3.0000	3.4500	3.0000	4.1000	2.9000	3.0000	2,7000

*Significant association $P \leq 0.05$ in bold.
H_2O, liquid; Sal, saliva; SP, sinus piriformis; val, vallecula.

component of 4 × 7 cm resulted in an adequate volume of the neotongue.

Motor innervation of the flap has been described earlier with varying results.[12] Of course, no directed tongue movement can be expected; however, less resorption and more stable volume were suggested from the clinical course of some patients in our study although objective alteration of flap volume was not evaluated (Fig. 4). In a recent retrospective analysis on 21 patients with ALTF total tongue reconstruction, the group of patients with motor nerve reinnervation (n = 10) presented a muscle volume resorption of 30% after 6 months which was comparable to the flaps' fat resorption and also to the resorption rate of the compared fasciocutaneous ALTFs (n = 11) without motor nerve reinnervation.[29] Although the authors state that dynamic reconstruction was effective for muscle volume maintenance, obvious volume stability by motor nerve readaptation remains unclear.

In 1 patient (no. 8), sensory reinnervation was performed by anastomosing the lateral femoral cutaneous nerve to the lingual nerve, resulting in obvious sensory recovery after 6 months. (**See Video 4, part A [online]**, which displays sensoric tongue testing [part A] and tongue movement [part B] of patient 8 after total glossectomy and ALTF reconstruction with motoric and sensoric nerve coaptation.) Sensory recovery seems superior to noninnervated flaps and takes place within 1 year which is particularly important in this vulnerable group of patients with limited prognosis.[11,30–32] The definite value of sensory nerve reconstruction remains unclear, particularly

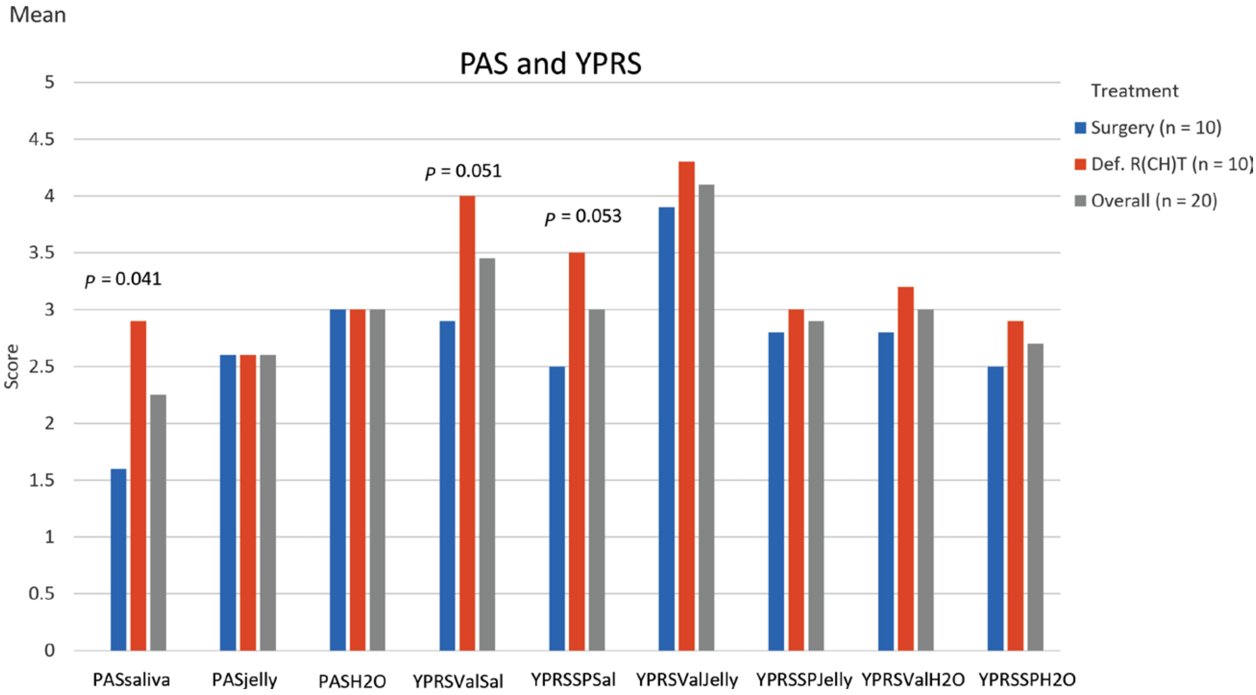

Fig. 3. The figure shows the swallowing scores comparing surgery to definite RCHT.

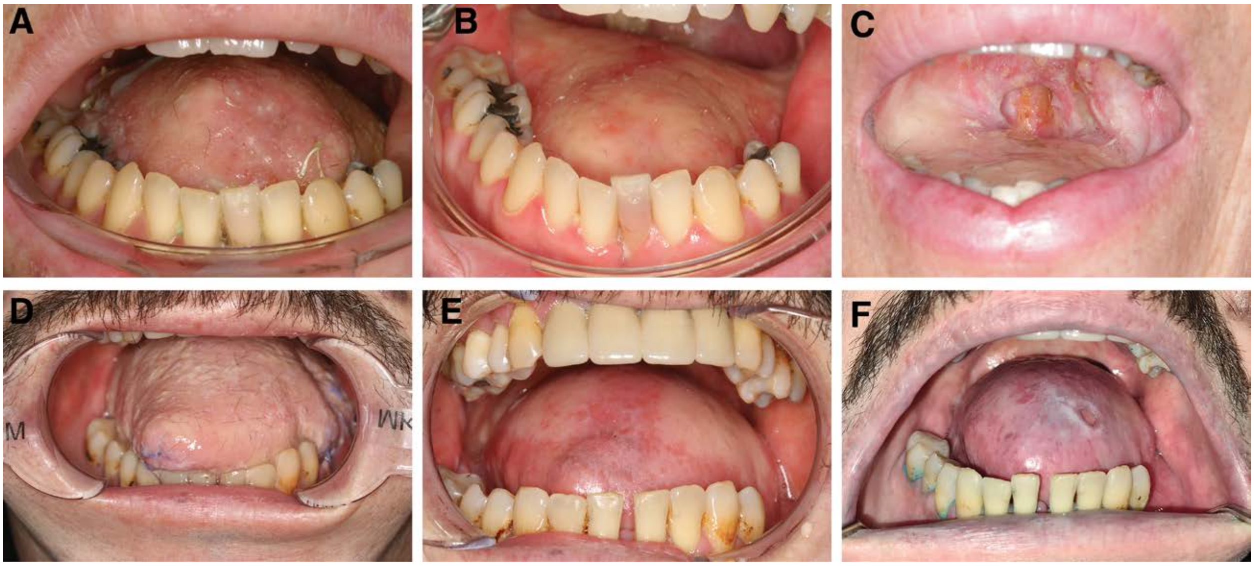

Fig. 4. Case samples for long-term course of ALTFs in tongue reconstruction. Upper row: ALTF without motor nerve coaptation: 3 weeks (A), 4 months (B), 13 years (C). Lower row: Total tongue reconstruction with nerve coaptation: 3 weeks (D), 1 year (E), and 2.5 years (F).

its functional benefits.[30,31] Laryngeal suspension—as it was also performed in this series—is established as an important step during flap inset, bringing the neotongue upward for close interaction with the pharynx and the palate (**see Video 4, part B [online]**).[27]

For evaluation of swallowing function, the 10 patients with ALTF reconstruction and prior or adjuvant RCHT were compared with 10 patients with matched tumors who were treated by primary definite RCHT. Airway protection and efficiency during swallowing were evaluated by means of FEES and graded by the PAS and the YPRS. The results showed that glossectomy and adequate reconstruction enable at least equal function of swallowing compared with definite RCHT. In some categories, for example, swallowing saliva, surgery with proper reconstruction of tongue volume emerged as being functionally superior. Swallowing water and jelly was comparable in both groups.

A complete oral diet was achieved in 70% of surgical patients compared with 60% of RT patients. The remaining patients were at least partially dependent on gastral feeding tubes. In a multicenter project, Araki et al[33] recently developed a risk model for predicting dysphagia after tongue reconstruction on 532 patients with different extents of glossectomy. With increasing defect size, up to 30% of patients are dependent on a feeding tube. In their model, age older than 58.5 years (odds ratio [OR] 6.4), postoperative radiation therapy (OR 3.6), advanced tongue defect (OR 2.7), and BMI less than 21.3 kg/m^2 (OR 1.8) were detected as the strongest predictors for postoperative dependency on feeding tubes.[33] We strongly agree with these results as we also see dysphagia associated with increased defect size, mandible involvement, increased age, and reduced BMI.

The results of this study did not come up with significant differences regarding OS. Valid survival data comparing surgery with definite chemoradiation for advanced tongue cancer are rare, and many studies include all types of oral cavity cancer. One retrospective study came up with a statistically equivalent 5-year OS of 33% versus 24% for patients receiving definitive concurrent RCHT (n = 61) or surgery with adjuvant RT/RCHT (n = 128), respectively.[34] The majority of studies, however, report superior survival rates for surgery and adjuvant chemoradiation.[35–37] In the only prospective trial with level 2 evidence, 119 patients with nonmetastatic stage III/IV SCC of the head and neck were randomized to surgery plus adjuvant RT or definitive concurrent RCHT. Results demonstrated significantly better 5-year disease-specific survival for the subset of patients with primary oral cavity SCC undergoing surgery with postoperative RT (68% versus 12%, $P = 0.038$).[38]

The current study has several limitations: first of all, the statistical power of 10 cases per group is not very strong, so many suggested differences in outcome variables and survival may not become significant. This drawback, however, is common in many tertiary hospitals in this cohort of patients with very advanced tongue cancer. Furthermore, most data were retrieved retrospectively from the charts which means that the time of phoniatric follow-up investigations was not uniform. Also, the exact match of tumor sizes and sites as well as comorbidities between the surgical and RCHT groups cannot be established. Total glossectomy and reconstruction by an ALTF have only been performed for the last years with 1 exception, so long-term data for this group of patients are missing, which may explain the missing significance of OS. Also, more detailed data for speech evaluation would have been desirable.

CONCLUSIONS

In conclusion, this retrospective study shows that adequate tongue reconstruction by use of a myofasciocutaneous ALTF enables functional swallowing and speaking after (sub)total glossectomy and RCHT, at least equal to alternative definite RCHT.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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