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HEAD AND NECK

# Surgical treatment for squamous cell carcinoma of the temporal bone: predictors of survival

## *Il trattamento chirurgico del carcinoma a cellule squamose dell'osso temporale: fattori predittivi di sopravvivenza*

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### SUMMARY

**Objective.** Evaluation of the management and survival in patients treated for temporal bone squamous cell carcinoma (TBSCC) in a tertiary referral centre.

**Methods.** Forty-nine patients underwent primary treatment for TBSCC. Thirty-six patients underwent a lateral temporal bone resection (LTBR) or subtotal temporal bone resection (STBR). Overall survival (OS) and disease-specific survival (DSS) analysis were assessed. **Results.** Five-year OS of the 49 patients was 39%. Five-year OS of the 36 patients who underwent LTBR or STBR was 46%. Tumour-free margins were achieved in all patients with T1 and T2 disease, in 59% patients with T3 tumours and 0% patients with T4 disease. Five-year DSS was 85% for all T1/T2 tumours, 53% for T3 tumours and 0% for T4 tumours. Clear resection margins was the only significant predictor of DSS in our cohort.

**Conclusions.** The mainstay of treatment for TBSCC is temporal bone resection with tumour free resection margins, with or without adjuvant radiotherapy. Survival is negatively influenced by non-radical resection. T1 and T2 tumours can be managed safely with LTBR. More advanced disease requires a more extensive resection, with a higher likelihood of non-radical resections and decreased survival rates.

**KEY WORDS:** temporal bone carcinoma, squamous cell carcinoma, survival analysis, lateral temporal bone resection, subtotal temporal bone resection

### RIASSUNTO

**Obiettivo.** Valutazione della gestione e sopravvivenza in pazienti trattati per carcinoma a cellule squamose dell'osso temporale (TBSCC) in un centro di riferimento terziario.

**Metodi.** Quarantanove pazienti sono stati sottoposti a trattamento primario per TBSCC. Trentasei pazienti sono stati sottoposti a resezione ossea temporale laterale (LTBR) o resezione ossea temporale subtotale (STBR). Sono state eseguite analisi della sopravvivenza globale (OS) e della sopravvivenza specifica per la malattia (DSS).

**Risultati.** L'OS a cinque anni di tutti i 49 pazienti è stata del 39%. L'OS a cinque anni di tutti i 36 pazienti sottoposti a LTBR o STBR è stata del 46%. Margini liberi da tumore sono stati raggiunti in tutti i pazienti con malattia T1 e T2, nel 59% dei pazienti con tumori T3 e nello 0% pazienti con malattia T4. Il DSS a cinque anni era dell'85% per tutti i tumori T1 / T2, del 53% per i tumori T3 e dello 0% per i tumori T4. I margini di resezione chiari erano l'unico predittore significativo di sopravvivenza specifica per malattia nella nostra coorte.

**Conclusioni.** Il cardine del trattamento per TBSCC è la resezione dell'osso temporale con margini di resezione senza tumore, con o senza radioterapia adiuvante. La sopravvivenza è influenzata negativamente dalla resezione irradicale. I tumori T1 e T2 possono essere gestiti in sicurezza con LTBR. Una malattia più avanzata richiede una resezione più estesa, con una maggiore probabilità di resezioni irradicali e tassi di sopravvivenza ridotti.

**PAROLE CHIAVE:** carcinoma osseo temporale, carcinoma a cellule squamose, analisi di sopravvivenza, resezione laterale dell'osso temporale, resezione dell'osso temporale subtotale

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### Conflict of interest

The Authors declare no conflict of interest.

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## Introduction

Squamous cell carcinoma of the temporal bone (TBSCC) is rare. The reported annual incidence of squamous cell carcinoma (SCC) of the external auditory canal (EAC) and middle ear is 1-6:1,000,000 people, which accounts for 0.2% of all head and neck tumours<sup>1-9</sup>. SCC accounts for 60-80% of all primary malignancies of the temporal bone<sup>1-9</sup>. The presenting symptoms of TBSCC can be similar to those of chronic suppurative or external otitis, which often leads to initial misdiagnosis and diagnostic delay.

There is no consensus on the management of malignant tumours of the EAC and temporal bone. Lateral (LTBR) or subtotal temporal bone resections (STBR) are commonly used, depending on the extent of the tumour. Due to lack of comparable studies, the role of parotidectomy, neck dissection, condylectomy and adjuvant radiotherapy remains unclear<sup>2-11</sup>.

The published survival rates of temporal bone resection (TBR) for tumours limited to the EAC (T1/T2) are good (80-100%). The reported survival rates of advanced stage disease (T3-T4) are generally much worse (0-60%)<sup>2-11</sup>. Reports on outcomes of primary radiotherapy for T1/T2 tumours are inconsistent, but survival rates after radiotherapy (43-83%) appear to be inferior to adequate LTBR with clear surgical margins (80-100%)<sup>2-11</sup>.

The primary purpose of this retrospective study is to evaluate the management and outcomes of patients treated for TBSCC with curative intent from 1975 to 2018 in our tertiary referral centre. The secondary purpose is to identify predictors of outcome of TBR by using regression analyses.

## Patients and methods

All patients treated with curative intent for primary TBSCC between 1975 and 2018 were evaluated. We excluded all non-squamous histologies and tumours arising from the parotid, pinna or peri-auricular skin. Patients who received surgery or radiotherapy prior to referral were also excluded. Medical charts were reviewed and the following data were collected: gender, age, localization and site of origin, pre-operative facial nerve function, histological differentiation grade, treatment modalities, microscopic resection margins, histological demonstration of parotid involvement, metastases, follow-up and outcomes. Patient characteristics and treatment-related data are shown in Tables I and II. All preoperative computed tomography (CT) and from 1985 magnetic resonance imaging (MRI) scans were also collected and systematically reviewed by three authors (CFS, NBO, and EFH). Preoperative CT and MRI findings (if available) were used to stage all tumours according to the Pittsburgh classification system, originally proposed by

**Table I.** Characteristics of patients treated for temporal bone squamous cell carcinoma.

	Patients (n)	Percentage (%)
<b>Gender</b>		
Male	28	57%
Female	21	43%
<b>Size of tumour (T)</b>		
T1	17	34%
T2	5	10%
T3	19	38%
T4	9	18%
<b>Primary site</b>		
EAC	42	84%
Middle ear	3	6%
Mastoid	5	10%
<b>Lymph node metastases (N)</b>		
N0	41	82%
N+	9	18%
<b>Distant metastases (M)</b>		
M0	50	100.0%
M+	0	0.0%
<b>Squamous differentiation</b>		
I (well)	14	28%
II (moderate)	26	52%
III (poorly)	8	16%
Unknown	2	4%

Arriaga et al., and later modified by the Pittsburgh group in 2000 (PITT2000) (Tab. III)<sup>1,12</sup>.

Ethical considerations: approval by the institutional Medical Ethics Committee (OHRP IRB00002991 FWA00017598) was obtained.

### Surgery

T1 and T2 tumours are managed by LTBR, comprising en bloc resection of the entire bony EAC, tympanic membrane, malleus and incus. The facial nerve, stapes and promontory form the medial limit of the LTBR<sup>3,5,13</sup>.

Over the last decades, our surgical strategy for more advanced tumours involving the middle ear and mastoid (T3/T4) consisted of either a LTBR followed by piecemeal resection of the tumour from the middle ear by local excision and (mainly) drilling (extended LTBR), or a subtotal temporal bone resection (STBR). STBR has been our approach for these tumours during the last 15 years and usually includes a temporal craniotomy with middle fossa approach to achieve en bloc resection of the EAC, mastoid bone, middle ear, facial nerve and otic capsule<sup>3,5,13</sup>.

The incisions and soft tissue management depend on the

**Table II.** Characteristics of patients treated with temporal bone resection.

Patient	Gender	Age	Site	Side	T stage	Resection	Parotidectomy	Neck dissection	Post op. RT	Resection margins	Parotid involvement	pN	Recurrence	FU-months	Outcome
1	F	68	EAC	L	1	LTBR	-	-	+	-	-	0		18	DOC
2	F	45	EAC	R	1	LTBR	-	-	+	-	-	0		58	DOC
3	M	57	EAC	L	1	LTBR	-	+	-	-	-	0		36	NED
4	M	84	EAC	R	1	LTBR	-	-	+	-	-	0		169	NED
5a	F	48	EAC	L	1	LTBR	+	+	+	-	-	0		172	NED
5b	F	52	EAC	R	1	LTBR	+	+	+	-	-	0		123	NED
6	M	63	EAC	L	1	LTBR	+	-	+	-	-	0		193	NED
7	M	62	EAC	R	1	STBR	+	-	-	-	-	0		5	DOD
8	F	73	EAC	R	2	LTBR	+	+	+	-	-	1	LR + N	10	DOD
9	M	78	EAC	L	2	LTBR	+	+	+	-	-	0		29	DOC
10	M	81	EAC	R	2	LTBR	+	+	+	-	-	1		55	NED
11	M	70	EAC	L	2	LTBR	+	-	+	-	-	0		167	NED
12	M	79	EAC	R	2	STBR	+	-	+	-	-	0		152	NED
13	F	69	EAC	R	3	eLTBR	+	+	+	+	+	2b	LR + N	6	DOD
14	F	85	EAC	L	3	eLTBR	+	+	+	+	-	0	LR + N	9	DOD
15	F	74	EAC	L	3	LTBR	+	+	+	-	-	0		39	NED
16	F	56	EAC	R	3	LTBR	+	+	+	-	-	1		81	NED
17	F	78	EAC	R	3	eLTBR	+	+	+	-	-	2b		110	NED
18	M	82	EAC	R	3	STBR	+	-	-	-	-	0		3	DOD
19	F	78	EAC	R	3	STBR	+	+	+	-	+	2b	N	10	DOD
20	M	44	EAC	R	3	STBR	+	+	+	-	-	0	LR	12	DOD
21	M	54	EAC	R	3	STBR	+	+	+	+	+	2b	LR	22	DOD
22	F	37	EAC	L	3	STBR	+	+	+	-	-	0	LR	23	DOD
23	M	58	MB	L	3	STBR	+	+	+	+	-	0	LR	31	DOD
24	M	90	EAC	R	3	STBR	+	-	+	-	-	0		62	DOC
25	M	68	EAC	R	3	STBR	+	-	+	-	-	0		175	NED
26	M	47	EAC	R	3	STBR	+	+	+	+	-	2b		204	NED
27	M	79	ME	L	3	STBR	+	-	+	+	-	0		205	NED
28	M	52	EAC	R	3	STBR	+	+	+	+	-	0		219	NED
29	F	29	EAC	L	3	STBR	+	+	-	-	-	0		355	NED
30	F	75	EAC	L	4	eLTBR	+	+	+	+	+	1	LR + N	9	DOD
31	F	48	EAC	R	4	eLTBR	+	+	+	+	+	0	LR + N	34	DOD
32	F	71	EAC	L	4	STBR	+	+	+	+	-	0	RD	9	DOD
33	F	69	ME	R	4	STBR	+	+	+	+	-	0	LR + N	12	DOD
34	M	78	EAC	L	4	STBR	+	+	+	+	+	0	LR	14	DOD
35	M	55	MB	R	4	STBR	+	+	+	+	-	0		32	DOC
36	F	71	MB	R	4	STBR	+	+	+	+	-	0		33	NED

F: female; M: male; EAC: external auditory canal; ME: middle ear; MB: mastoid bone; LTBR: lateral temporal bone resection; eLTBR: extended lateral temporal bone resection; STBR: subtotal temporal bone resection; LR: locoregional; N: nodal disease; RD: residual disease; FU-time: follow-up (months); NED: no evidence of disease; DOD: dead of disease; DOC: dead other cause.

planned management of the pinna, parotid and neck. Prophylactic superficial parotidectomy is performed in tumours of the anterior wall of the external auditory canal. Total parotidectomy is performed in tumours growing beyond the anterior wall of the external auditory canal and in

subtotal temporal bone resections. Our policy towards elective neck dissection has changed somewhat over time. It was not standard in the beginning of the series and changed thereafter from more comprehensive to selective dissection. If the pinna is preserved, a circumferential incision in the

**Table III.** Modified Pittsburgh classification system.

T status	Description
T1	Tumour limited to the external auditory canal without bony erosion or evidence of soft tissue involvement
T2	Tumour with limited external auditory canal bony erosion (not full thickness), or limited (< 0.5 cm) soft tissue involvement
T3	Tumour eroding the osseous auditory canal (full thickness) with limited (< 0.5 cm) soft tissue involvement, or tumour involving the middle ear and/or mastoid
T4	Tumour eroding the cochlea, petrous apex, medial wall of middle ear, carotid canal, jugular foramen or dura, or with extensive (> 0.5 cm) soft tissue involvement, such as involvement of temporomandibular joint or styloid process, or evidence of facial paresis
N status	Lymph node involvement is a poor prognostic sign; any node involvement should automatically be considered as advanced stage, i.e. T1N1 = stage III and T2, 3, 4 N1 = stage IV
M status	Distant metastases indicate a very poor prognosis and should be considered as stage IV disease

*In the absence of metastatic lymph nodes or distant metastases, T status of the tumour defines clinical stage.*

lateral EAC skin is performed and the external meatus is closed as a blind sac to prevent tumour spillage. If the pinna is affected, it is completely or partially resected in continuity with the temporal bone and parotidectomy specimen. In all cases the surgical defect is closed using a fat graft, vascularised soft tissue transposition or a free vascularised flap reconstruction. Tumours with carotid artery encasement, intracerebral infiltration and petrous apex involvement are deemed not suitable for surgery with curative intent. Tumour-free resection margins cannot safely be achieved in these tumours and total temporal bone resection seems to be of no benefit<sup>3-5,13,14</sup>.

#### Statistical analysis

Kaplan-Meier curves for overall survival (OS) and disease-specific survival (DSS) were plotted and hazard ratios (HR) with corresponding 95% confidence intervals (CI) were obtained with Cox regression models using Stata/SE (version 14.1 for Windows; StataCorp LP, College Station, TX, USA). P values < 0.05 were considered statistically significant, and p values < 0.1 were considered to indicate a trend. All 36 patients who underwent temporal bone resection entered the OS analysis. Patient 5 with bilateral tumours participated in the OS analysis only with the first diagnosed tumour (patient 5a). For DSS, however, both tumours (patient 5a and 5b) entered the analysis individually.

Two patients (patient 7 and 18) died from early postoperative complications related to the surgery and their general condition. We expected that these two patients would strongly affect our analyses and – at the same time – the cause of death in these patients was not associated with the disease-specific risk factors that were evaluated. Therefore, we performed an additional regression analysis for DSS, excluding these two patients.

Potential factors that could influence OS or DSS of patients who underwent temporal bone resection were individually analysed using the log-rank test. These factors were age

(median, stratified in two age categories: ≤ 68 years and ≥ 69 years), gender, T-stage (stratified in three categories: T1/T2, T3, T4), histological differentiation grade, neck dissection, parotidectomy, condylectomy, post-operative radiotherapy, resection margins and pN-status.

## Results

A total of 49 patients (with 50 tumours) who received curative treatment for primary TBSCC were identified. Twenty-eight patients (57%) were men, and 21 (43%) were women. The site of origin was the EAC for 42 tumours (84%), middle ear (ME) for 3 tumours (6%) and mastoid for 5 tumours (10%). Thirteen tumours were classified as T1, 9 tumours as T2, 19 tumours as T3 and 9 tumours as T4. Two patients presented with facial paralysis and were thus staged as T4. Nine patients presented with positive neck nodes on clinical examination, CT and/or MRI. More than 50% of all tumours showed a moderate squamous differentiation (Tab. I).

Four patients were treated with primary radiotherapy (RT) because of a contraindication for major surgery; i.e. extensive comorbidity or an explicit desire for non-surgical treatment. Nine patients, treated in the earlier part of the series, were treated with a local resection (pinna amputation with sleeve resection and/or modified radical mastoidectomy) combined with radiotherapy. Two patients were lost to follow-up after less than 5 years, and were censored after their last known contact date.

A total of 37 tumours (36 patients) were treated by TBR (Tab. II). These resections include 18 (extended) lateral temporal bone resections (17 patients) and 19 en-bloc subtotal temporal bone resections. One patient (patient 5a) developed a SCC of the EAC after a disease-free interval of four years following treatment for a T1 SCC of the contralateral EAC (patient 5b). This patient therefore had undergone bilateral LTBR.

LTBR was performed for seven T1 tumours (88%) and four T2 tumours (80%). Five T3 tumours (29%) and two T4 tumours (29%) were treated with a LTBR followed by exenteration of infra- and supra-labyrinthine air cells and resection of tumour from the middle ear, mastoid and dura (extended LTBR). Each LTBR resulted in macroscopically-free resection margins.

Nineteen patients were treated with STBR, these included one T1 tumour, one T2 tumour, 12 T3 tumours and 5 T4 tumours. The patients who underwent STBR for T1/T2 disease would nowadays be planned for a LTBR procedure. In one patient (with T4 disease) we failed to achieve macroscopically-free resection margins with STBR due to intracranial and intracerebral infiltration. In 9 patients with STBR, positive resection margins were found on histological examination.

A form of selective neck dissection (24 cases) or modified radical neck dissection (2 cases) was performed in 70% of the procedures. Partial parotidectomy was performed in 25/37 (68%) cases, total parotidectomy in 8/37 (22%) cases, and in four cases (11%) no parotidectomy was performed.

Fractionated postoperative radiotherapy (Intensity Modulated RT from 2003 onwards), 50-60 Gy over 6 weeks, directed at the primary tumour and to the neck in case of positive nodes, was given to 33/37 patients (89%). Two patients (patient 7 and 18) died shortly after STBR due to treatment related complications. Two patients (patient 3 and 29) did not receive postoperative radiotherapy for unknown reasons.

Histopathological examination showed tumour-free (R0) resection margins in 23/37 temporal bone resection specimens (62%), tumour positive (R1) margins were found in 14/37 patients (38%), in one of these patients macroscopic radical resection could not be achieved (R2). A radical resection was achieved in all 13 T1 and T2 tumours, in 10 of 17 (59%) T3 tumours and in none of 7 T4 tumours.

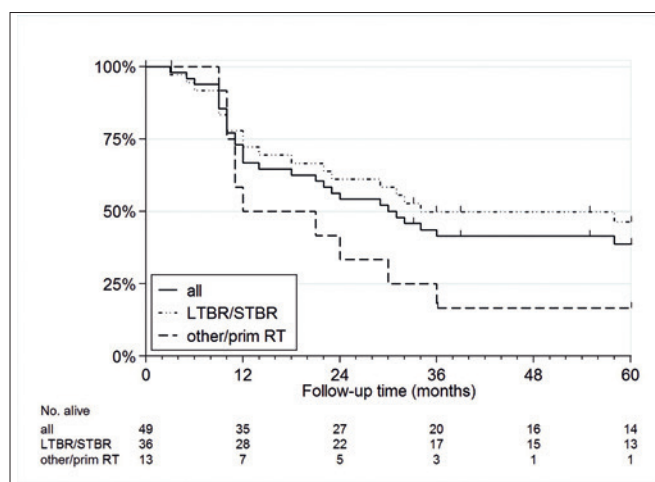
Multiple ipsilateral lymph node metastases were found in nine patients with clinically positive neck disease. Histological evidence of extra nodal spread was found in the neck dissection specimens of five patients (patients 10, 14, 16, 32 and 33). No occult lymph node metastases were encountered in patients with a cN0 neck. Parotid involvement was found in six cases; local tumour infiltration in four parotid specimens and parotid lymph node metastases were found in 3 patients.

Local or neck recurrence occurred in 12 of 37 (32%) resections (36 patients). In 8 of 12 (67%) patients locoregional recurrence was seen after failure to achieve macroscopically-free resection margins with temporal bone resection. All 12 patients with recurrent or residual disease died of

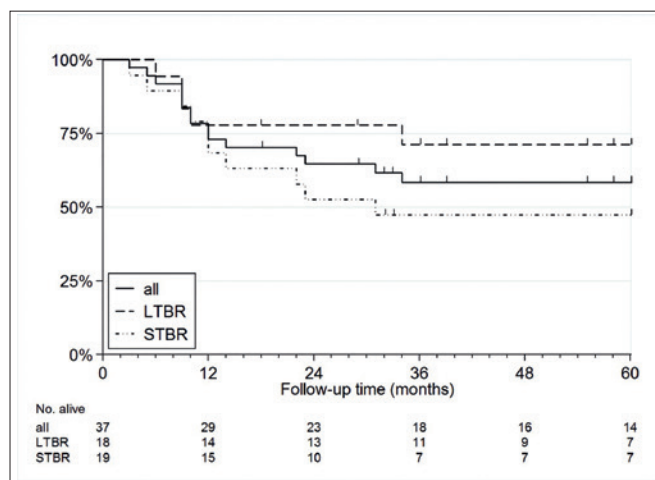
disease. All patients with histological evidence of parotid involvement developed locoregional recurrence and died within three years after treatment. No patients in our cohort developed distant metastases.

*Survival analysis*

Five-year OS for all 49 patients was 39%. Five-year OS of the 36 patients treated with temporal bone resection was 46%. Five-year OS of 13 patients treated with local resection (LR) or primary radiotherapy (RT) was 17% (Fig. 1). DSS for the 36 patients (37 tumours) who were treated with temporal bone resection was 59% (Fig. 2). Two patients with T1/T2 disease died of disease-specific causes. One with T1 disease developed postoperative endocarditis



**Figure 1.** Overall survival of all 49 patients treated with curative intent, grouped by their treatment.



**Figure 2.** Disease-specific survival per temporal bone resection and all 37 cases.

resulting in sepsis, and the other patient with T2 disease developed locoregional recurrence (Fig. 3).

Univariate survival analyses were performed on the 36 patients who were treated with LTBR or STBR (Tab. IV). This group consisted of 19 men and 17 women. Median age at presentation was 69 years (range 29 to 90 years). Follow-up time ranged from 3 to 355 months (median 34).

Disease-specific analysis revealed that patients with clear resection margins had significantly better outcomes than those with positive resection margins (HR 2.9, 95% CI 1.04-8.3,  $p = 0.032$ ) (Fig. 4). None of the other variables tested was statistically significant, although patients with T1/T2 disease showed a trend towards better outcomes than T3 or T4 patients (HR 3.4, 95% CI 0.72-16.0, and HR 6.0, 95% CI 1.2-31.3, respectively,  $p = 0.064$ ).

Additional disease-specific analysis in 35 patients (36 tu-

mours) confirmed the statistical significance of resection margins (HR 4.5, 95% CI 1.4-14.9,  $p = 0.006$ ) and clinical T-status (HR 6.0, 95% CI 0.74-49.0, and HR 12.6, 95% CI 1.5-10.9), respectively ( $p = 0.019$ ) (Tab. IV).

For overall survival, no significant predictors were found, and only a trend for histological differentiation grade ( $p = 0.099$ ).

## Discussion

The primary goal of curative treatment of a temporal bone malignancy is to eradicate disease by surgical resection with tumour-free resection margins. En bloc LTBR for tumours limited to the EAC (T1 and T2), and en bloc STBR for tumours extending to middle ear or mastoid (T3 and T4) are the most suited surgical techniques to obtain clear resection margins with acceptable morbidity<sup>2-11,13</sup>. In extensive T3 and T4 tumours it is technically difficult to achieve tumour-free surgical margins and the nature of the resection technique (with otologic burrs) might sometimes hamper the accuracy of histopathological evaluation of resection margins. Both false positive and false negative resection margins may occur. This provides a rationale for postoperative radiotherapy in all T3 and T4 tumours<sup>1-9,13-16</sup>. The role of adjuvant radiotherapy for small tumours remains unclear<sup>1-9,15,16</sup>.

To create a homologous series we used strict inclusion criteria for our study, including only primary TBSCC and tumours arising from the bony ear canal. Therefore, all tumours originating from the external ear (pinna), cartilaginous framework, peri-auricular skin and parotid gland were excluded. We retrospectively staged all tumours uniformly, according to the modified University of Pittsburgh grading system, using clinical data and the available imaging studies. Our study confirms the significant role of clinical T stage (PITT2000) and clear resection margins on survival in SCC of the temporal bone ( $p = 0.006$ ; Tab. IV)<sup>10,17</sup>.

Several authors have agreed that sleeve resection and mastoidectomy will unintentionally compromise resection margins for all stages of TBSCC and consequently increase the risk of developing recurrent disease with a fatal prognosis<sup>8,9,18</sup>. The present study shows that radical tumour resection can be achieved with the LTBR technique in 100% of T1 and T2 tumours, and we have found 85% DSS for T1 and T2 tumours treated with LTBR (Fig. 3). In our study, 7 patients with a T4 tumour were treated with curative intent. We did not achieve radical resection in any and despite postoperative radiotherapy 6 of 7 patients died within three years, while one had no evidence of disease after 33 months. Other studies have described successful and curative treatment of T4 tumours with (e)LTBR or STBR and adjuvant radiotherapy<sup>4,18-21</sup>. There is much debate about the

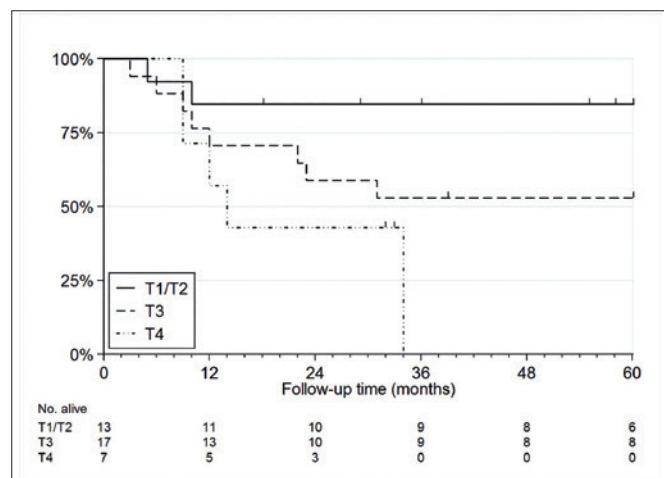


Figure 3. Disease-specific survival by clinical T stage.

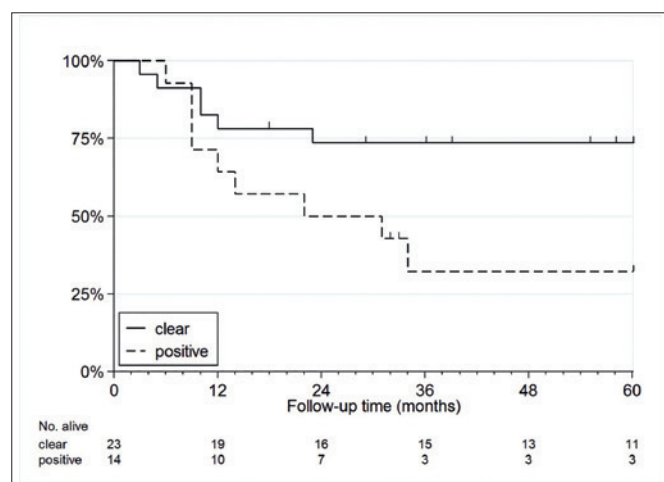


Figure 4. Disease-specific survival for clear and positive resection margins.

**Table IV.** Survival analyses of patients treated with temporal bone resection.

Variable	OS (n = 37)		DSS (n = 37)		DSS (n = 35)	
	p-value	HR [95% CI]	p-value	HR [95% CI]	p-value	HR [95% CI]
Age	0.43		0.25		0.21	
Sex	0.22		0.24		0.07	
Male						1.0
Female						2.8 [0.86-9.2]
cT-status	0.12		0.06		0.02	
T1/T2				1.0		1.0
T3				3.4 [0.72 - 16.0]		6.0 [0.74-49.0]
T4				6.0 [1.2 - 31.3]		12.6 [1.5-109]
Neck dissection	0.34		0.14		0.01	
Parotidectomy	0.67		0.13		0.16	
Condylectomy	0.58		0.53		0.68	
Post-operative radiotherapy	0.73		0.39		0.31	
Histological differentiation	0.10		0.43		0.41	
Well		1.0				
Moderate		2.0 [0.72-5.7]				
Poor		0.37 [0.04-3.2]				
Resection margins	0.11		0.03		0.01	
Clear				1.0		1.0
Positive				2.9 [1.04-8.3]		4.5 [1.4-14.9]
pN-status	0.68		0.31		0.17	

CI: confidence interval; cT-status: clinical T status; DSS: disease specific survival; HR: hazard ratio; OS: overall survival; pN-status: pathological N status.

indications for parotidectomy and (selective) neck dissection in early stage temporal bone tumours with a clinically N0 neck. The parotid gland contains the first echelon lymph nodes of the EAC, but the incidence of parotid metastases from TBSCC remains unclear<sup>4,10,22-24</sup>. In our cohort, both parotid involvement due to direct infiltration or to lymph node metastasis was found only in advanced stages; T3 (n = 3) or T4 (n = 3), and all 6 patients with parotid involvement died within 3 years after surgery.

We encountered no occult metastases in patients with a cN0 neck, but neck recurrence occurred in 3 patients with a negative neck after non-radical resection of the primary tumour. In a study by Zanoletti and Danesi, occult neck metastases were found in 7% (3/45) of patients who received neck dissection in addition to surgical treatment for SCC of the temporal bone<sup>22</sup>. Mazzone et al. found a total of 27% nodal metastases, with a total of 17% occult metastases in clinically N0 necks<sup>11</sup>. The likelihood of encountering occult neck metastases in a resection specimen also depends on the quality of the preoperative evaluation of the neck. In our institute, all patients with TBSCC undergo CT scan, MRI and ultrasound guided fine needle aspiration cytology

of the neck and parotid gland. Comprehensive preoperative evaluation of the neck may help prevent unnecessary prophylactic neck dissection and parotidectomy in an N0 neck. Neither procedure has been shown to increase 5-year survival when performed as prophylaxis<sup>4-6,17,23,24</sup>. In contrast with the studies by Morris et al. and Masterson et al., we did not find a significant effect of nodal disease on survival in our analysis<sup>15,25</sup>.

In 2005, Moffat et al. advocated temporomandibular joint excision for all temporal bone resections<sup>16</sup>. There are no statistical data on the benefits of condylectomy on survival, although the morbidity of condylectomy as an additional step in TBR is significant<sup>16,25,26</sup>. We reserve this additional procedure for tumours located in the anterior part of the EAC or for tumour invasion in the TMJ capsule.

Due to its relative rarity, it is difficult to compare treatment strategies and outcomes of TBSCC in the literature. Moreover, insights into state-of-the-art diagnosis and extent of surgical therapy have evolved over time.

A nationwide study by Nabuurs et al. evaluated the modified Pittsburgh classification and deemed it acceptable. However, for T4 tumours they suggest a revised classifi-

cation with other predictive factors such as surgical margins<sup>27</sup>.

Zanoletti et al. also suggest a prognosis scoring system for T4 tumours, including dural involvement and histological grade as negative prognosticators. In addition, the site of tumour origin and direction of tumour extension seem to play a role, as T3 and T4 tumours growing from the external auditory canal into the mastoid and petrous bone seem to have worse prognosis than T3 and T4 tumours originating from the anterior wall of the canal extending into the parotid space<sup>28</sup>.

In our study, a homogeneous series of patients with primary squamous cell carcinoma of the temporal bone with curative intent was included. Because of the rarity of the disease, the number of patients is limited even in a tertiary referral centre and with a selection period spanning over four decades. As for radiological staging, MRI scanning was introduced in 1985 in our centre and the quality of imaging techniques has improved over time. As a result, the accuracy of radiological staging has increased during the study period.

In our study, the site of origin and direction of tumour extension in T3 and T4 tumours and facial nerve and dura mater involvement in T4 tumours, which seem to impact prognosis, were not taken into account separately.

Of the variables tested, we only found statistically significant better outcomes in patients with clear resection margins compared to patients with positive resection margins. Our sample size was too small to perform multivariable analysis. A multicentre cohort study with more patients and uniform diagnostic criteria and management protocols would be a valuable step to gain further insight in the optimal treatment strategies for TBSCC.

Our retrospective study confirms the excellent results of lateral temporal bone resection for small tumours confined to the EAC, the significance of radical resection margins and the relation between T-stage and survival. Advanced tumours extending in the middle ear, mastoid or more medial are in our opinion best treated with subtotal temporal bone resection, followed by fractionated radiotherapy to the primary site and to the neck in case of positive lymph nodes. We routinely perform selective neck dissection and superficial parotidectomy for advanced disease. The poor outcome of temporal bone resection for T4 tumours necessitates a careful, individual weighing of the benefits versus the morbidity of the surgical intervention.

## Conclusions

In patients with TBSCC, the mainstay of treatment is surgical resection with or without adjuvant radiotherapy. Surviv-

al is negatively influenced by non-radical resection. For T1 and T2 tumours, LTBR is the treatment of choice with good results. More advanced disease requires a more extensive temporal bone resection, with a higher likelihood of non-radical resection and decreased survival. The prognosis of patients with advanced disease is poor. To improve prognosis in these patients more research is needed with larger groups of patients, taking into account histological grade, dural involvement, site of tumour origin and direction of tumour extension. Because of the rarity of the disease, this can only be achieved with multicentre studies.

## Ethical approval

Ethical approval was waived by the local Ethical Committee of the VU University Medical Center Amsterdam IRB00002991 FWA00017598.

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