Current Otorhinolaryngology Reports (2019) 7:58–64
https://doi.org/10.1007/s40136-019-00229-x

OTOLOGY: TUMORS OF THE EAR AND LATERAL SKULL BASE (G DANESI, SECTION EDITOR)

Update in Temporal Bone Resection Outcomes

K. R. Magliocca[1,2] · S. A. Ballestas[3] · H. M. Baddour[1,3] · P. A. Hudgins[1,4] · G. Pradilla[5] · C. A. Solares[1,3,5]

Published online: 2 March 2019

Abstract
Purpose of Review Surgical outcomes data related to temporal bone malignancy can be challenging to interpret and apply to a specific patient population due to the overall rarity of the disease and the heterogeneity of disease types often studied in aggregate in this anatomic region. Large institutional series are commonly composed of a diverse patient cohort, with numerous pathologic entities studied in aggregate despite known differences in biologic behavior.
Recent Findings Our current aim is to provide a review of recent literature on surgical resection of primary, untreated squamous cell carcinoma of the temporal bone and examine associated outcomes.
Summary A general overview of temporal bone carcinoma and illustrated, contemporary update of surgical techniques is additionally provided.

Keywords Squamous cell carcinoma · Lateral temporal bone resection · Subtotal temporal bone resection · Oncology · Head and neck surgery

Introduction

Primary malignancy of the temporal bone is rare and makes up less than 1% of all head and neck tumors [1, 2], affecting an estimated rate of 1 person per million people every year with the highest incidence affecting adults in the 6th to 7th decade of life [3].

This article is part of the Topical Collection on *OTOLOGY: Tumors of the Ear and Lateral Skull Base*

✉ C. A. Solares
clementino.arturo.solares@emory.edu

[1] Winship Cancer Institute, Emory University, Atlanta, GA, USA

[2] Department of Pathology, Emory University School of Medicine, Atlanta, GA, USA

[3] Department of Otolaryngology, Emory University School of Medicine, Atlanta, GA, USA

[4] Department of Radiology, Emory University School of Medicine, Atlanta, GA, USA

[5] Department of Neurosurgery, Emory University School of Medicine, Atlanta, GA, USA

Pathology, Pathologic Examination, and Staging

In contrast to more commonly encountered sites of head and neck malignancy such as oral cavity or laryngeal squamous cell carcinoma, there is no universally accepted staging system in place for staging of primary temporal bone carcinoma [4]. The institutional pathology and surgery teams should mutually agree on a preferred staging system for primary temporal bone carcinoma. At our institution, the modified University of Pittsburgh staging system is accepted for use in cases of primary temporal bone carcinoma [4] (Table 1). The International Collaboration on Cancer Reporting has developed readily accessible guidelines for the pathologic reporting of multiple organ sites, including the ear at http://www.iccr-cancer.org.

Surgical Technique

The main surgical goal of any temporal bone surgery is complete tumor removal and limiting morbidity and damage to adjacent structures [5]. The definitive treatment for temporal bone malignancies is a temporal bone en bloc resection, which depending on the extent of the disease can be lateral temporal bone resection (LTBR), subtotal temporal bone resection

Table 1 Modified University of Pittsburgh staging system for temporal bone malignancy

Status description	
T status	
T1	Tumor limited to the EAC without bony erosion or evidence of soft tissue extension
T2	Tumor with limited EAC bony erosion (not full thickness) or radiographic finding consistent with limited (< 0.5 cm) soft tissue involvement
T3	Tumor eroding the osseous EAC (full thickness) with limited (< 0.5 cm) soft tissue involvement, or tumor involving middle ear and/or mastoid
T4	Tumor eroding the cochlea, petrous apex, medial wall of the middle ear, carotid canal, jugular foramen, or dura, or with extensive (> 0.5 cm) soft tissue involvement; patients presenting with facial paralysis
N status	
N0	No regional nodes identified
N1	Single ipsilateral regional node < 3 cm
N2a	Single ipsilateral regional node 3–6 cm
N2b	Multiple ipsilateral regional nodes 6 cm
N2c	Bilateral or contralateral regional nodes
N3	Bilateral or contralateral regional nodes
M status	
M0	Absence of distant metastatic disease
M1	Presence of distant metastatic disease
Overall stage	
I	T1N0M0
II	T2N0M0
III	T3N0M0
IV	T4N0M0, T1–4N1M0, T1–4N0–3M1

(STBR), or total temporal bone resection (TTBR) Fig. 1. Parotid involvement is not unexpected, making parotidectomy a common complementary procedure when performing a temporal bone resection [3, 6–10]. While facial nerve resection is described [3, 7, 9, 11], it should be reserved for those cases in which definitive nerve involvement is identified. Surgical treatment is contraindicated in cases where there is a compromise of structures such as brain, cavernous sinus, carotid artery, paraspinous musculature, cervical spine, distant metastasis, and/or poor general health [12]. Involvement of the infratemporal fossa is not a contraindication to a surgical resection and negative margins can be achieved in a significant number of patients.

Lateral Temporal Bone Resection

- A postauricular C-shaped incision (1 cm posterior to the postauricular sulcus) or a preauricular incision may be used, the last one preferred when doing a large parotidectomy. The incision can be extended inferiorly when a neck dissection is needed.
- The skin flaps are elevated to the parotidomasseteric and temporalis fascia anteriorly and above the temporalis, mastoid bone, and sternocleidomastoid fascia posteriorly. The conchal cartilage and tragus can be resected if needed. The anterior skin flap is extended deep to the temporalis fascia at the zygomatic root if the retromandibular area is included.
- EAC is closed into a blind sac if the lateral canal is free of disease, and is reinforced with an anterior musculoskeletal flap.
- Sigmoid sinus and middle cranial fossa dura are exposed by performing a cortical mastoidectomy.
- An extended facial recess approach (posterior tympanotomy) is performed to inspect middle ear space and disarticulate incudostapedial joint (Fig. 2).
- Mastoidectomy is extended to the root of the zygoma and the epitympanum is opened (Fig. 3).
- The tympanotomy is extended inferiorly to the hypotympanum and the chorda tympani is transected
- Anterior epitympanic region is then drilled and extended anteroinferiorly and medially to reach the superior portion of the TMJ.
- Hypotympanic opening is extended anteriorly, lateral to the jugular bulb and internal carotid to reach the inferior part of the TMJ. It may be necessary to raise the facial nerve from the stylomastoid foramen to the second genu in order to drill the hypotympanic region.
- Pressure should be applied to the specimen in anterior direction to remove it. If there is resistance encountered, a 2-mm osteotome can be used via posterior tympanotomy (Fig. 4). When there is a narrow posterior tympanotomy (facial nerve to tympanic annulus), the temporal bone is

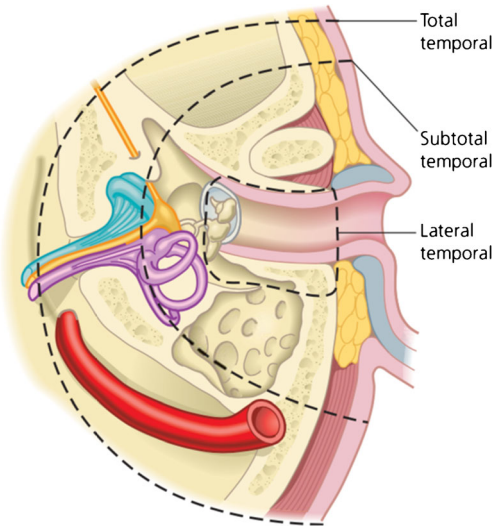

Fig. 1 Diagram that illustrates the structures that are removed with each technique

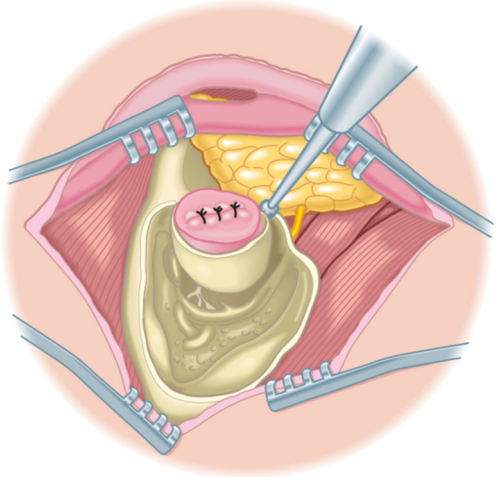

Fig. 2 Cortical mastoidectomy with extended posterior tympanotomy

fractured anteriorly, enlarging the space and facilitating the drilling and clean excision of the specimen (Fig. 5).
- Muscle fascia is used to plug the Eustachian tube.
- Obliteration of the mastoid cavity is done to prevent osteoradionecrosis after radiation therapy.
- The wound is closed in multilayered fashion. A padded compression dressing may be applied.

Subtotal and Total Temporal Bone Resection

This technique is used to extirpate tumors that are medial to the tympanic membrane, into the mastoid or have facial nerve involvement and will result in the exposure of air cells of the petrous apex.

As its name implies, a TTBR is a total en bloc resection of the temporal bone, including petrous apex, sigmoid sinus, and occasionally the petrous internal carotid artery. En bloc

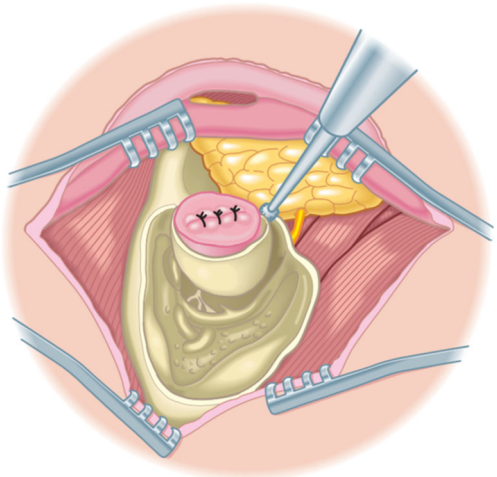

Fig. 3 Anterior extension of the hypotympanic opening towards inferior aspect of temporomandibular joint

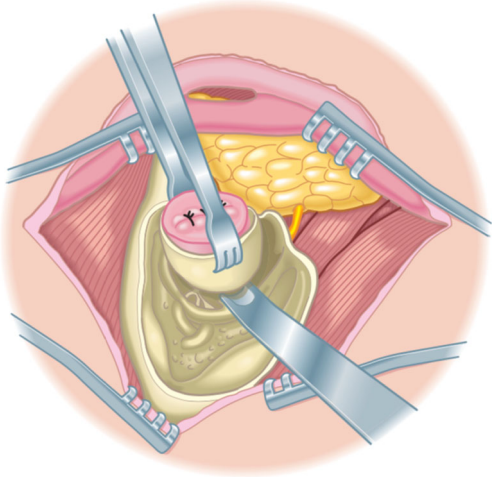

Fig. 4 Liberation of the anterior component of the tympanic plate with 2 mm osteotome

resection of the sigmoid sinus and/or internal carotid artery adds little survival benefit and thus it will not be discussed [13]. Herein, we will describe the technique for STBR. A case example is presented on Fig. 6.

- The skin incision should allow access to the middle cranial fossa and mastoid, parotid, and retromandibular fossa. A C-shaped incision from the frontotemporal region (6–8 cm above the auricle) extending it 4–5 cm postauricularly and 4 cm below the mandibular angle into the submental region.
- The superior flap is elevated prior to the elevation of the temporal muscle.
- A temporal craniotomy is done. A drill hole is performed at the asterion in order to find the lateral and sigmoid sinuses junction. The craniotomy will measure 6 × 4 cm typically extending to the zygoma root.
- The middle cranial fossa dura is dissected from the anterosuperior petrous bone, and inspected to ascertain

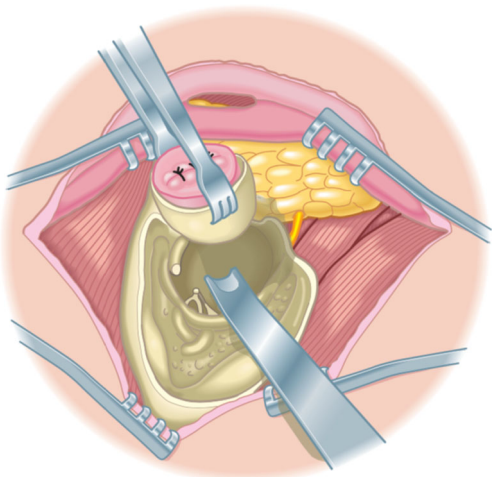

Fig. 5 Removal of the specimen

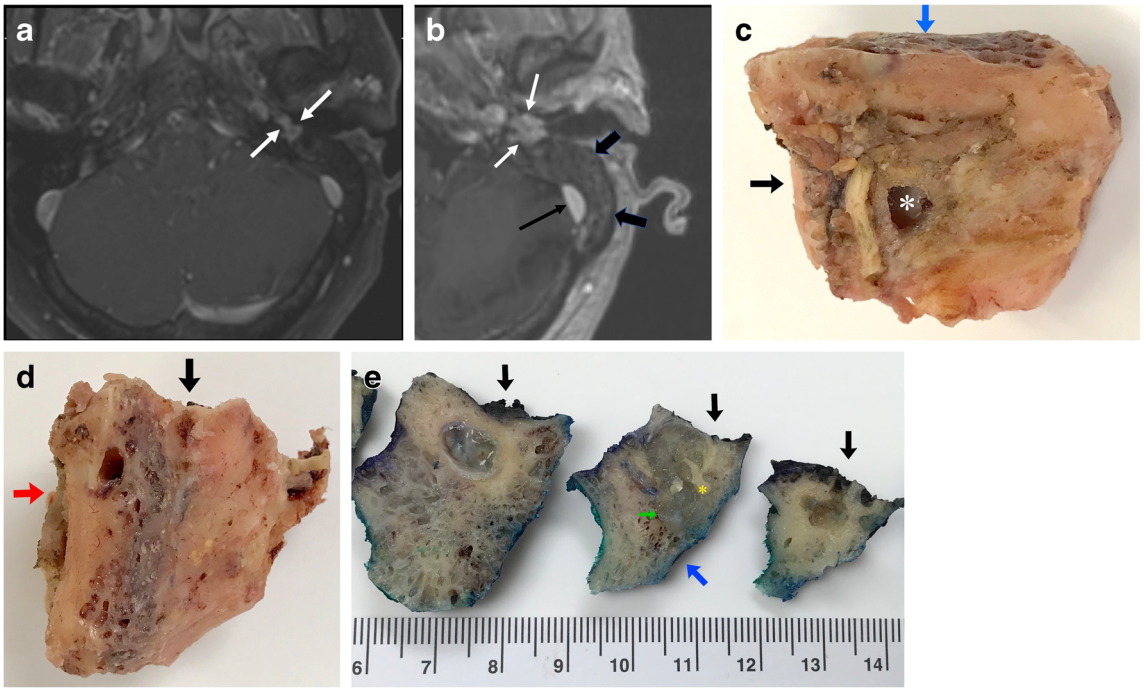

Fig. 6 **a** Axial T1 image, post gadolinium contrast-enhanced and with fat saturation. **b** Axial T1 image, post gadolinium contrast-enhanced and with fat saturation technique. The mass is in the hypotympanum and is lobular and larger at this level (white arrows). Note mastoid complex opacification without enhancement (black arrows), characteristic for benign fluid. There is normal enhancement in the left proximal sigmoid sinus (black long arrow). **c** Lateral view of temporal bone resection. Anterior (black arrow) and superior (blue arrow) surfaces indicated. Portion of lateral (cartilaginous) external auditory canal visible (asterisk). **d** Superior view of temporal bone resection. Anterior (black arrow) and lateral (red arrow) surfaces indicated. **e** Cross section of temporal bone resection after formalin fixation. Anterior (black arrow) and superior (blue arrow) surfaces indicated. Tumor invading tympanic membrane and ossicular tissue (asterisk) and temporal bone (green arrow)

that the tumor can be resected. If dura involvement is encountered, it may also be excised.

- The sigmoid sinus and jugular bulb are exposed with a high speed drill. Dura anterior to the sigmoid is then exposed and permits dissection of the dura with the posterior aspect of petrous bone towards the internal auditory meatus and pars nervosa (jugular foramen). The dura in the area is inspected for tumor involvement.
- Procedures such as total parotidectomy, neck dissection, and/or resection of additional structures are performed
- The sigmoid sinus may be opened and packed with hemostatic plug proximally and distally down towards jugular bulb if necessary. Sometimes the sigmoid sinus can be preserved.
- The carotid canal anterior to the jugular bulb is opened and the carotid is followed.
- An osteotomy is made across the petrous bone to get to the carotid canal anteriorly and the wall of the jugular fossa inferiorly, with attention to avoid cranial nerve damage
- A final medial to lateral cut is done to complete the joining the area of the glenoid fossa or zygomatic root (across the middle cranial fossa floor) to the foramen ovale and carotid canal.
- From the posterior surface of the petrous bone, anteroinferiorly pressure is applied to free the specimen. In case there is soft tissue attachments, they can be divided, and if there is bleeding from the inferior petrosal sinus, hemostatic packing can resolve it.
- Close the residual dural defects with primary closure, taking into consideration that large-sized defects may require fascial grafts.

Reconstruction Techniques

Reconstruction of the temporal bone and lateral skull base requires a wide armamentarium of operative techniques to provide adequate functional and cosmetic restoration. Depending on the extent of extirpation required for oncologic control, the resulting defects can include soft tissue, nerve, bone, dura, or a combination thereof. It is therefore imperative that a systematic, algorithmic approach be followed to achieve a sufficient restoration. Principles for repair of the lateral skull base defect include (1) obtaining a watertight dural seal if a dural defect is present; (2) obliteration of all dead space; (3) restoration of soft tissue bulk; (4) restoration of bony defects, particularly those that may result in craniofacial deformity or brain herniation; and (5) cranial nerve repair with nerve

grafting and transfer as indicated. Depending on the extent of the defect, some or all of these principles may require adoption for an adequate reconstruction. An additional factor to consider in the reconstructive decision is the need for possible adjuvant radiation therapy, which can affect wound healing and ultimate soft tissue bulk. A well-vascularized reconstruction is therefore necessary to avoid post-operative wound complications.

Free tissue transfer has become the standard method of reconstruction for large defects, particularly those with both bony and soft tissue components [7]. Composite free flaps, in particular, can provide the necessary vascularized bone and soft tissue constituents in a single flap. The bony constituents can be used to restore existing maxillary or mandibular defects while the soft tissue constituents can be used to create a watertight dural closure, obliterate dead space, and replace missing skin or subcutaneous tissue. The subscapular system offers a wide variety of composite flap options, which makes it an ideal system for use in these conditions. Regional flap reconstruction can be considered for smaller defects isolated to the lateral skull base, particularly those with minimal dead space requirements and only a need for vascularized tissue overlay following dural closure. A common regional flap employed for these conditions is the temporalis muscle flap. Free flap options for these same conditions include the anterolateral thigh free flap and rectus abdominis free flap [14].

Cranial nerve repair, particularly involving the facial nerve, is often a requirement following lateral skull base resection. The method of facial nerve reconstruction is dependent on the availability and integrity of the remaining nerve segments. If the proximal facial nerve stump is available, then segmental interpositional nerve grafting should be employed to all remaining distal branches. Common donor nerves include the cervical sensory nerves, sural nerve, and nerve to vastus lateralis. If the proximal facial nerve is unavailable, then facial nerve transfer should be employed using either the masseteric or hypoglossal nerve as the donor source. If nerve procedures are not possible, then regional or free muscle transfer may be indicated. Additionally, static procedures (e.g., midfacial sling, upper lid weight, brow lift, etc.) may be indicated in conjunction with dynamic procedures [11].

Complications

Pre-surgical counseling of patients requiring a temporal bone resection is critical as a spectrum of possible post-surgical deficits may be encountered such as hearing loss, tinnitus, loss of taste, and transitory vertigo. Where dissection of the infratemporal fossa is required, post-operative trismus can be problematic for patients. An extended procedure such as STBR requires facial nerve sacrifice and patients must be counseled regarding expected loss of function and inherent cosmetic consequences (see cranial nerve repair, prior section). Even in those cases of LTBR in which the facial nerve is preserved, unintended injury to the nerve, most often temporary, can result from the thermal effect of rotary instrumentation requiring the adjacent dense bone. Complications involving the intracranial compartment such as meningitis or cerebrospinal fluid are exceedingly rare. Complications related to free tissue transfer and reconstruction may occur at the donor and/or recipient site. Surgical experience, center volume, patient age, and patient medical comorbidities represent possible variables influencing ablative and reconstruction outcomes.

Literature Review of Surgical Outcomes

A PubMed database query was performed to search for English language publications pertaining to surgical management of primary, untreated temporal bone squamous cell carcinoma in patients published in the last 5 years (2013–2018). Patients with recurrent temporal bone carcinoma, prior history of radiation therapy to the area, peri-auricular facial skin or external ear cutaneous malignancy, melanoma, and salivary gland adenocarcinoma were excluded. This specific search yielded six publications detailing the surgical management and outcome of 132 patients (Table 2) [15–17, 18••, 19•, 20]. Table 2 shows the study population size, spectrum of tumor stage, and selected surgical resection technique in relation to tumor stage. Forty-two T1 and T2 tumors were treated uniformly with LTBR, with a small group of patients in Ghavami et al. [19•], treated by a modified LTBR sparing the tympanic membrane and ossicles. The remaining 90 more advanced tumors were treated with a spectrum of surgical techniques; LTBR, STBR, and in some cases TTBR, however, lacked detail within the studies and precluded more specific calculations. The mandibular condylar complex was resected in some cases. The use of superficial or total parotidectomy was uncommon in T1 tumors, but frequency of this procedure increased and was nearly uniformly utilized in advanced-staged tumors. In the current cohort reviewed, surgical management of the neck was omitted for T1 tumors, but similar to parotidectomy, increased in frequency with advancing tumor stage. Post-operative radiation therapy was performed on a case-by-case basis dependent on the final pathology report (i.e., positive margins, or other) in T1 and T2 tumors, and uniformly included in T3–T4 primary temporal bone squamous cell carcinoma. In all 42 cases of T1–T2 primary tumors, overall survival was reported as 100%, though the mean follow-up interval was short and ranged from 27 to 46.7 months. Overall survival was reduced in T3 tumors and ranged between 50 and 100%, and for patients with T4 tumors, 33.3 to 50% within a relatively short follow-up period of 25.5 to 46.7 months. While the six studies reviewed herein each identified and presented parameters of interest, comparison studies remained difficult

Table 2 The study population size, spectrum of tumor stage, and selected surgical resection technique in relation to tumor stage

Author	Ref#	Year	N	Primary Tumor Stage and # cases				Temporal Bone Surgical Technique				Parotidectomy				Neck Dissection				Post-Operative Therapy				Mean Follow-up (Months)	Overall Survival (%)			
				T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4		T1	T2	T3	T4
Ouaz et al	15	2013	6	0	0	2	4			Ec or S	S or T			Y	±			Y	±			Y	Y	25.5			50	50
Leong et al	16	2013	35	4	1	3	27	L	L	L or E	L or E	±	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	27	100	100	100	41.4
Bacciu et al	17	2013	45	5	6	15	19	L	L	L or S	L or S ± CR	N	±	±	±	N	N	±	±	Y	Y	Y	Y	46.7	100	100	86.2	48.7
Morita et al	18	2016	34	13	9	8	4	L	L	L or S	L or S	N	N	±	±	N	±	Y	Y					37.5	100		55.6	
Ghavami et al	19	2017	4	1	3	0	0	mL	mL			N	±			N	±			N	Y			30.5	100	100		
Wierzbicka et al	20	2017	8	0	0	2	6			S	L or S or T			Y	Y			NS	NS			Y	Y	45			100	33.3

L Lateral temporal bone resection, *mL* modified lateral temporal bone resection, *Ec* External auditory canal resection, *S* Subtotal temporal bone resection, *T* Total temporal bone resection, *CR* mandibular condyle resection, *Y* yes, *N* No, *NS* not stated

as some variables that may have an impact on outcome were not readily or uniformly identifiable in each paper (Table 3). Detailed reporting of variables in future studies could facilitate interpretation of outcomes and comparison between studies.

Discussion

Based on the literature, the treatment for temporal bone malignancies should include a temporal bone resection tailored to disease extent. The use of post-operative radiation therapy for early-stage disease will be influenced by final pathology reporting. Patients with locally advanced tumors such as T3–T4, or those of aggressive tumor features such as lymph node metastasis, will benefit from post-operative radiotherapy which has been shown to increase overall survival [10, 21]. The results of this contemporary review reveal that similar to prior studies, some T3 and many T4 advanced tumors should be regarded as aggressive tumors. Recommended surgical techniques have remained similar over time when compared to the therapeutic guidelines described in the Belgium Consensus Conference in March 2002 (Table 4), representing an attempt to standardize management of these tumors [22]. The senior author disagrees with a blanket statement for

Table 3 Variables of interest in primary temporal bone resection outcomes

Clinical and Surgical Variables:
- Age
- Sex
- Previous history any radiation treatment to head and neck
- Preoperative clinical status of facial nerve
- Staging system utilized
- Clinical stage
- Preoperative imaging type(s)
- Temporal bone surgical resection technique
- Management of facial nerve
- Management of pinna
- Management of mandibular temporomandibular joint
- Parotidectomy and extent
- Neck dissection, and extent
- Presence of dural invasion, mastoid invasion, otic capsule invasion, jugular bulb invasion

Pathologic Variables:
- Tumor histologic classification (and differentiation where applicable)
- Pattern of growth
- Bone invasion
- Perineural invasion
- Lymphovascular invasion
- Intraoperative tumor cut through
- Final surgical margin status
- Lymph node metastasis, level, and presence of extranodal extension
- Pathologic stage

Adjuvant Treatment and Follow-up
- Adjuvant radiation provided
- Adjuvant chemotherapy provided
- Length of follow-up
- Complications identified

Table 4 Therapeutic guidelines by stage (Belgium Consensus Conference, March 2002)

Stage	
T1	Lateral temporal bone resection and neck dissection
T2	Lateral temporal bone resection and neck dissection followed by radiotherapy
T3	Subtotal temporal bone resection and neck dissection followed by radiotherapy
T4	Palliative treatment

palliative treatment of T4 tumors as it depends on the tumor characteristics that conferred the T4 designation. The role of a total temporal bone resection which mandates a carotid resection, however, is not supported by the literature.

Conclusion

The lateral temporal bone resection remains the workhorse of surgical procedures in this anatomic region. Comparison of temporal bone resection outcomes remains problematic and is hampered by the rarity of primary temporal bone carcinoma, inclusion of malignancy secondarily extending into the temporal bone region yet with inherent differences in biologic potential, and variability in use of adjuvant therapy and in reporting of possibly influential variables, including margin status.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. Crabtree JA, Britton BH, Pierce MK. Carcinoma of the external auditory canal. Laryngoscope 1976; 86: 405–415.
2. Testa JR, Fukuda Y, Kowalski LP. Prognostic factors in carcinoma of the external auditory canal. Arch Otolaryngol Head Neck Surg. 1997;123:720–4.
3. Gidley PW, DeMonte F. Temporal bone malignancies. Neurosurg Clin N Am. 2013;24:97–110.
4. Moody SA, Hirsch BE, Myers EN. Squamous cell carcinoma of the external auditory canal: an evaluation of a staging system. Am J Otol. 2000;21:582–8.
5. Beyea JA, Moberly AC. Squamous cell carcinoma of the temporal bone. Otolaryngol Clin North Am. 2015;48:281–92.
6. Sinha S, Dedmon MM, Naunheim MR, et al. Update on surgical outcomes of lateral temporal bone resection for ear and temporal bone malignancies. J Neurol Surg B Skull Base. 2017;78:37–42.
7. Essig GF, Kitipornchai L, Adams F, et al. Lateral temporal bone resection in advanced cutaneous squamous cell carcinoma: report of 35 patients. J Neurol Surg B Skull Base. 2013;74:54–9.
8. Li W, Zhang T, Dai C. Temporal bone malignancies involving the jugular foramen: diagnosis and management. ORL J Otorhinolaryngol Relat Spec. 2014;76:227–35.
9. Martin JR, Filip P, Thorpe EJ, Leonetti JP. Treatment of locally advanced parotid malignancies with parotidectomy and temporal bone resection. Am J Otolaryngol 2017; 38: 380–382.
10. Lavieille JP, Delande C, Kunst H, et al. Management of carcinoma of the temporal. Bone. 2005.
11. Howard BE, Nagel TH, Barrs DM, et al. Reconstruction of lateral skull base defects: a comparison of the submental flap to free and regional flaps. Otolaryngol Head Neck Surg. 2016;154:1014–8.
12. Pensak ML, Gleich LL, Gluckman JL, Shumrick KA. Temporal bone carcinoma: contemporary perspectives in the skull base surgical era. Laryngoscope. 1996;106:1234–7.
13. Panizza BJ, Solares CA, Gleeson M. Surgery by primary site: lateral skull base surgery. In: Watkinson JC, Gilbert R, editors. Stell and Maran's textbook of head and neck surgery and oncology. 5th ed. London: Hodder Arnold; 2012. p. 779–91.
14. Thompson NJ, Roche JP, Schularick NM, et al. Reconstruction outcomes following lateral skull base resection. Otol Neurotol. 2017;38:264–71.
15. Ouaz K, Robier A, Lescanne E, et al. Cancer of the external auditory canal. Eur Ann Otorhinolaryngol Head Neck Dis. 2013;130: 175–82.
16. Leong SC, Youssef A, Lesser TH. Squamous cell carcinoma of the temporal bone: outcomes of radical surgery and postoperative radiotherapy. Laryngoscope. 2013;123:2442–8.
17. Bacciu A, Clemente IA, Piccirillo E, et al. Guidelines for treating temporal bone carcinoma based on long-term outcomes. Otol Neurotol. 2013;34:898–907.
18.•• Morita S, Homma A, Nakamaru Y et al. The outcomes of surgery and chemoradiotherapy for temporal bone cancer. Otol Neurotol 2016; 37: 1174–1182. **This study provides a well-documented single site experience with a large group of patients with temporal bone carcinoma**.
19.• Ghavami Y, Haidar YM, Maducdoc M, et al. Tympanic membrane and ossicular-sparing modified lateral temporal bone resection. Otolaryngol Head Neck Surg. 2017;157:530–2. **This small study describes their short term experience with a modified tympanic membrane and ossicular sparing approach that may benefit a select population**.
20. Wierzbicka M, Kopec T, Szyfter W, et al. Efficacy of petrosectomy in malignant invasion of the temporal bone. Br J Oral Maxillofac Surg. 2016;54:778–83.
21. Zhang T, Li W, Dai C, et al. Evidence-based surgical management of T1 or T2 temporal bone malignancies. Laryngoscope. 2013;123: 244–8.
22. Evidence-based guidelines for the management of patients with external auditory canal carcinomas. In Belgium Consensus Conference. Catholic University of Leuven, St. Lucas University Hospital, Leuven, 2002: 2002.