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# Treatment outcome and prognostic factors of external auditory canal squamous cell carcinoma: A retrospective study in a tertiary center

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## Abstract

**Objective:** Squamous cell carcinoma (SCC) of the external auditory canal (EAC) is a rare malignancy with various treatment strategies and outcomes. The purpose of this study was to evaluate the clinical characteristics and survival outcomes and identify prognostic factors in patients with SCC of EAC.

**Methods:** Twenty-one patients with SCC of EAC treated in a single tertiary center between 2009 and 2021 were retrospectively reviewed and analyzed. The modified Pittsburgh classification system was applied for staging. Factors associated with survival were identified by univariate survival analysis.

**Results:** The mean age at diagnosis was 61 years (range: 41–79 years). Early-stage (T1 + T2) accounts for 38.1% of the series and advanced-stage (T3 + T4) accounts for 61.9%. Eighteen (85.7%) patients underwent primary surgery with curative intent. The 5-year overall survival rate of the 21 patients was 67.4%. Tumor invasion to the otic capsule, eustachian tube, sigmoid sinus, and dura were associated with poor prognosis in univariate analysis ($p = .046$; .008; .027; and .08, respectively).

**Conclusions:** Factors predictive of less favorable survival include the history of COM, tumor invasion to the otic capsule, eustachian tube, sigmoid sinus, and dura. It is important to make a precise and systemic preoperative evaluation of disease extent.

**Level of Evidence:** 4

KEYWORDS
external auditory canal, prognostic factor, squamous cell carcinoma, survival outcome, temporal bone

## 1 | INTRODUCTION

External auditory canal (EAC) malignancy is a rare disease, accounting for only 0.2% of all head and neck tumors. Squamous cell carcinoma (SCC) is the most common type, representing approximately 60%–80% of all cases.[1,2] EAC SCC's clinical presentation is unspecific, making it challenging to differentiate from inflammatory diseases such as chronic otitis media or otitis externa, leading to difficulties in early diagnosis and treatment. Patients usually present at advanced stages, and due to the temporal bone's complex structure, the tumor can

spread aggressively along various anatomical routes. The modified Pittsburgh staging system is the most widely used staging system for the SCC of EAC. Due to the extreme rarity of SCC of EAC, no large-scale trials are available currently, and it hampers the development of treatment guidelines. En bloc resection of the temporal bone followed by adjuvant radiotherapy (RT) to achieve clear margins is generally agreed to be the optimal treatment. Sleeve resection, lateral temporal bone resection (LTBR), and subtotal temporal bone resection (STBR) are the most commonly used surgical methods. Surgical resection generally yields good outcomes for early-stage disease (T1 and T2) confined within the EAC, while the prognosis is generally poor for advanced disease (T3 and T4). Despite advances in imaging, surgical techniques, and adjuvant therapy, treating EAC SCC remains challenging. Collaboration among institutes worldwide is essential to expand understanding of this rare disease. This study aims to analyze treatment outcomes and identify prognostic factors in patients with SCC of EAC treated at a single tertiary center.

## 2 | MATERIALS AND METHODS

### 2.1 | Patients and data collection

A retrospective analysis of patients treated at the Department of Otorhinolaryngology—Head and Neck Surgery, National Cheng Kung University Hospital (Tainan, Taiwan), a tertiary referral center for otology and skull base surgery, between 2009 and 2021 with a diagnosis of EAC SCC was performed. The study protocol was approved by the Institutional Review Board of National Cheng Kung University Hospital (No. B-ER-111-152). The requirement of informed consent was waived due to the retrospective nature of the study. All data was retrieved from the electronic medical record system of the National Cheng Kung University Hospital. The patients were searched using "malignant tumors of the EAC" and "cancer of the EAC" as the search criteria. We reviewed the pathology reports of all the cases searched to identify patients who had a final diagnosis of SCC. Patients diagnosed with SCC originating from the EAC and those who were diagnosed and treated at our hospital were included in the study. SCCs invading EAC but arising from the parotid, auricle, or periauricular skin were not included due to the different clinical behaviors and outcomes. Patients who received treatments, including surgery and RT for this disease before referral, were excluded. Patients with incomplete medical records were also excluded from the study. The demographic and clinical data (age, sex, presenting symptoms, preoperative facial nerve function, cancer staging, histology, surgical procedures, adjuvant treatment, microscopic resection margins, cancer invasion sites, and survival outcome) of the patients were collected and analyzed. Preoperative computed tomography scans or magnetic resonance imaging scans were collected and reviewed by two authors. A checklist included seven main pathways of tumor spread and the corresponding anatomical subsites were used to define the tumor extension (Table SI).

All patients were staged according to the modified Pittsburgh classification system by Moody et al.[1]

### 2.2 | Treatment

All of the 21 patients were treated by three surgeons in our center. For early-stage tumors (T1 and T2), EAC-wide excision, sleeve resection, or LTBR were performed. For advanced-stage tumors (T3 and T4), LTBR or STBR was performed, except for one patient (No. 15) whose initial staging was underestimated. The checklist for determining tumor extension (Table SI) was employed for preoperative evaluations in cases diagnosed after 2014. In addition to EAC and temporal bone resection, other anatomical structures involved in the tumor were resected to eradicate the cancer. In instances where clinical facial palsy was present or facial nerve invasion was observed during surgery or on imaging, facial nerves were also resected. Superficial or total parotidectomy was performed when preoperative imaging indicated tumor involvement of the anterior wall of EAC or parotid gland. For cases involving tumors with dura involvement, a middle fossa craniotomy with tumor resection on the dura was performed. Similarly, when imaging revealed tumor involvement, a condylectomy or temporomandibular joint resection was performed. If the resulting defect after the radical tumor resection was too large, the defect was reconstructed using a skin graft, local flap, or free flap, depending on the size of the defect. Postoperative adjuvant treatment as RT or concurrent chemoradiotherapy was given for patients with advanced disease (T3 and T4), positive margins, close margins, lymphovascular invasion, perineural invasion, or recurrent disease. Patients with clear temporal dura/temporal lobe invasion or significant involvement of large vessels underwent definitive RT or concurrent chemoradiotherapy if their general condition was poor or if they declined surgical treatment due to the high risks involved.

### 2.3 | Statistical analysis

All statistical analysis was performed with Prism 8 and SAS 9.4. Continuous variables are presented as the mean ± standard deviation. Categorical variables are presented as numbers and percentages. The relationship between survival and the patient factors, tumor factors, and anatomical factors was examined using a univariate Cox proportional hazards model. The survival rate was estimated using the life table method. Univariate survival analysis was performed using the Kaplan–Meier method and log rank test. A two-sided $p < .05$ was considered statistically significant.

## 3 | RESULTS

The detailed profiles of the 21 patients included in the study are presented in Table SII. Table 1 provides an overview of the demographic

**TABLE 1** Patient demographic and surgical characteristics of EAC SCC patients.

| | N | % |
|---|---|---|
| Sex | | |
| Male | 13 | 61.9 |
| Female | 8 | 38.1 |
| Age | | |
| <65 | 13 | 61.9 |
| ≥65 | 8 | 38.1 |
| Side | | |
| Right | 13 | 61.9 |
| Left | 8 | 38.1 |
| Clinical presentation | | |
| Otorrhea | 17 | 81.0 |
| Otalgia | 15 | 71.4 |
| Hearing impairment | 12 | 57.1 |
| EAC mass | 4 | 19.0 |
| Facial palsy | 3 | 14.3 |
| Vertigo | 1 | 4.8 |
| T stage | | |
| T1 | 5 | 23.8 |
| T2 | 3 | 14.3 |
| T3 | 4 | 19.1 |
| T4 | 9 | 42.9 |
| Previous RT | | |
| Yes | 4 | 19.0 |
| No | 17 | 81.9 |
| History of COM | | |
| Yes | 4 | 19.0 |
| No | 17 | 81.9 |
| Surgical procedure ($n = 20$) | | |
| Sleeve resection | 8 | 40.0 |
| LTBR | 9 | 45.0 |
| STBR | 1 | 5.0 |
| Others | 2 | 10.0 |
| Neck dissection ($n = 20$) | | |
| Yes | 7 | 35.0 |
| No | 13 | 65.0 |
| Histology | | |
| Well | 13 | 61.9 |
| Moderate | 3 | 14.3 |
| Poor | 1 | 4.8 |
| Unspecified | 4 | 19.1 |
| Perineural invasion | | |
| Yes | 4 | 19.5 |
| No | 17 | 81.0 |
| Lymphovascular invasion | | |
| Yes | 3 | 14.3 |
| No | 18 | 85.7 |
| Surgical margin ($n = 20$) | | |
| Negative | 5 | 25.0 |
| Close margin | 5 | 25.0 |
| Positive | 8 | 40.0 |
| Indeterminable | 2 | 10.0 |
| Adjuvant RT ($n = 20$) | | |
| Yes | 13 | 65.0 |
| No | 7 | 35.0 |

Abbreviations: COM, chronic otitis media; EAC, external auditory canal; LTBR, lateral temporal bone resection; RT, radiotherapy; SSC, squamous cell carcinoma; STBR, subtotal temporal bone resection.

characteristics and surgical characteristics. Twenty-one patients with SCC of EAC were identified in the study population, with a mean (± standard deviation) age at diagnosis of 61 ± 9.9 years (range: 41–79 years). There were 13 males (61.9%) and eight females (38.1%). The right side was involved in 13 cases (61.9%) and the left side in eight cases (38.1%). The most common clinical presentation was otorrhea (81.0%), followed by otalgia (71.4%), hearing impairment (57.1%), EAC mass (19.0%), facial nerve palsy (14.3%), and vertigo (4.8%). Four cases (19.1%) had previously been irradiated (three for nasopharyngeal carcinoma and one for papilloma at EAC); and four cases (19.1%) had previously been diagnosed with chronic otitis media. Tumor staging was based on preoperative radiology, intraoperative findings, and the surgical pathology report. According to the modified Pittsburgh classification, five cases were T1 (23.8%), three were T2 (14.3%), four were T3 (19.1%), and nine were T4 (42.9%). There were no cases of nodal metastasis or distant metastasis.

Eighteen cases (85.7%) underwent primary surgery with curative intent. The remaining three cases (14.3%) were ineligible for curative surgery due to advanced intracranial or large vessel invasion, while two cases had poor general condition, and one expressed hesitancy about surgical resection. Among the three ineligible cases, one received definite RT and salvage surgery for residual tumor, another underwent debulking surgery followed by definite concurrrent chemoradiotherapy (CCRT), and the third was treated with neoadjuvant chemotherapy and definite CCRT. Of all 20 cases who received surgical intervention, 8 cases (40.0%) underwent modified sleeve resection, 9 (45.0%) underwent LTBR, 1 (5.0%) underwent STBR, 1 (5.0%) underwent modified mastoidectomy, and 1 (5.0%) underwent debulking surgery. Together with temporal bone tumor resection, additional surgical procedures were also performed in selected individuals. Seven cases (35.0%) with advanced T stage were submitted to neck dissection. And there was no pathologic evidence of nodal metastasis. Superficial parotidectomy was performed in four cases (20.0%) with preoperative clinical and radiographic suspicion of invasion of the parotid gland. Facial nerve resection was carried out on three cases (15.0%) who initially presented with facial palsy. In nine cases (45.0%), the surgical defect could not be primarily closed, so different

reconstructive procedures were concurrently performed: split-thickness skin graft (STSG) alone in two cases, pedicled superficial temporoparietal fascial flap with a full-thickness skin graft or STSG in four cases, free anterolateral thigh flap in two cases, and free gracilis muscle flap in one case.

Regarding tumor differentiation, 61.9% were well differentiated, 14.3% were moderately differentiated, 4.8% as poorly differentiated, and 9.1% were unspecified. Perineural and lymphovascular invasion was found in four (19.1%) and three (14.3%) cases, respectively. Positive surgical margin was observed in eight cases (40.0%), close margin, which is defined as less than 1 mm between invasive tumor and cut tissue edge, in five cases (25.0%), negative surgical margin in five cases (25.0%), and indeterminable/unspecified surgical margin in two cases (10.0%). Adjuvant treatment with RT was performed in 13 cases (61.9%), from which 9 received adjuvant concurrent chemoradiotherapy and 4 received adjuvant RT alone.

The mean follow-up duration was 52.2 months (range: 2.3–149.5 months). After the initial treatment, seven cases (33.3%) developed local recurrence during follow-up, with a mean time for recurrence of 20.2 months (range: 4.9–59.5 months). Of the seven cases with recurrence, four of them were submitted to salvage operation with adjuvant RT, chemotherapy, immunotherapy, or concurrent chemoradiotherapy. One case who developed recurrence after definite CCRT received salvage immunotherapy and chemotherapy. Five of the cases with recurrence died during the follow-up period. Two cases were alive with no evidence of disease after salvage treatment. Of the 21 cases, seven (33.3%) died due to the EAC malignancy (died of disease [DOD]), including one with T1, one with T3, and three with T4 disease. No cases died of other medical diseases. No DOD occurred in T1 or T2 cases within 5 years, with a mean follow-up of 51.9 (range: 2.3–85.3) and 114.9 (range: 96.8–149.5) months, respectively. The mean follow-up of T3 and T4 cases was 37.6 (range: 11.0–106.4) and 37.7 (range: 3.27–101) months, respectively. Among the 14 living cases during the follow-up period, all of them showed no evidence of disease. For the entire cohort of cases, the estimated 5-year overall survival rate calculated via the life table method was 67.4%. The disease-specific survival (DSS) rate was the same as the overall survival rate during our research period.

In regards to patient factors and tumor factors (Table 2), univariate analysis showed underlying chronic otitis media was a significant predictor of poor prognosis ($p = .003$, hazard ratio [HR] = 10.39). Previous exposure to RT was not significantly related to survival but showed a high HR ($p = .130$, HR = 3.51). Close margin and positive surgical margin were not significant predictors of poor prognosis but showed high HR ($p = .594$; .204, HR = 2.75, 8.93, respectively). Univariate analysis for the anatomical prognosis factors (Table 2) identified invasion of the otic capsule, eustachian tube, sigmoid sinus, and dura as significant predictors of poor prognosis ($p = .046$; .027; .008; and .08, respectively). Extension into the middle ear cavity, mastoid cavity, parotid gland, temporomandibular joint, petrous part of carotid artery, and supratubal recess showed a high HR (HR > 2) but was not statistically significant. Survival analysis with the Kaplan–Meier curves showed that cases with involvement of the parotid gland, otic capsule, eustachian tube, sigmoid sinus, and dura had a significantly worse prognosis than cases without the invasion of these structures ($p = .043$; .030; 0.002; .007; and .002, respectively) (Figure 1).

**TABLE 2** Patient factors and anatomical factors predictive of survival of EAC SCC patients.

| | HR | 95% CI | *p* Value |
|---|---|---|---|
| Patient factors predictive of survival | | | |
| Sex (female/male) | 0.46 | (0.05, 2.29) | .432 |
| Age (≥65/<65) | 0.09 | (<0.01, 0.78) | .132 |
| T stage (T3 + T4/T1 + T2) | 3.85 | (0.79, 37.47) | .169 |
| History of COM | 10.39 | (2.46, 47.45) | **.003*** |
| Positive margins | 8.93 | (0.99, 1179.84) | .204 |
| Facial palsy | 1.56 | (0.16, 7.53) | .651 |
| Anatomical factor predictive of survival | | | |
| Middle ear cavity | 2.44 | (0.57, 13.81) | .281 |
| Mastoid cavity | 3.39 | (0.78, 19.36) | .144 |
| Parotid gland | 4.1 | (0.98, 18.73) | .068 |
| TMJ | 3.68 | (0.88, 20.61) | .112 |
| Otic capsule | 10.79 | (0.99, 81.13) | **.046*** |
| Eustachian tube | 7.96 | (1.86, 36.95) | **.008*** |
| Carotid canal | 0.84 | (0.01, 7) | .913 |
| Carotid artery (petrous part) | 6.9 | (0.66, 42.37) | .078 |
| Jugular foramen | 1.72 | (0.18, 8.39) | .579 |
| Sigmoid sinus | 9.25 | (1.42, 60.25) | **.027*** |
| Dura | 7.96 | (1.86, 36.95) | **.008*** |
| Supratubal recess | 3.07 | (0.75, 13.78) | .142 |

*Note*: Bolded values signify statistical significance.
Abbreviations: CI, confidence interval; COM: chronic otitis media; EAC, external auditory canal; HR, hazard ratio; SSC, squamous cell carcinoma; TMJ, temporomandibular joint.

## 4 | DISCUSSION

Primary SCC of EAC is a rare clinical entity and the establishment of a standardized treatment protocol for this condition remains elusive. Comparing survival rates between studies is difficult, and the results can vary significantly. Previous case series have reported 5-year overall survival rates ranging from 39% to 70.4% for patients across all stages.[3,4] The survival rate was generally high for early-stage (T1 and T2) disease, while the prognosis for advanced-stage (T3 and T4) disease was poor. Recent study has reported 3- or 5-year DSS rates of 85%–100% for T1 and T2 disease, 53%–88% for T3 disease, and 0%–51% for T4 disease.[3,5–8] In our series, the estimated 5-year DSS for all patients was 67.4%, which is consistent with the existing literature. Many authors and institutions recommend performing LTBR instead of sleeve resection in T1 and T2 cases to achieve adequate margins. However, in our series, all T1 cases and two T2 cases underwent a modified sleeve resection with or without postoperative RT. The modified sleeve resection involved drilling the bony portion of the EAC

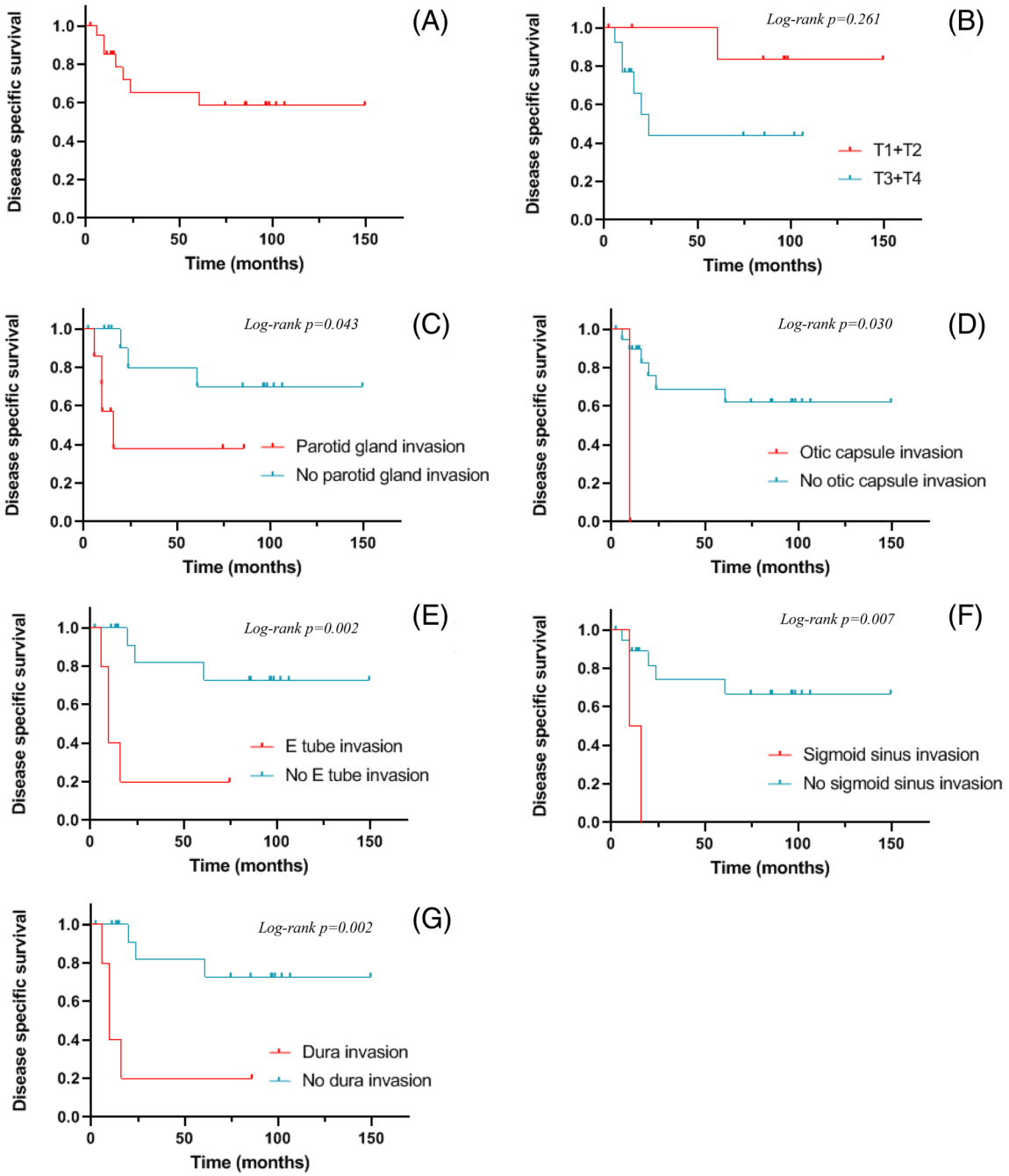


**FIGURE 1** Kaplan–Meier curves of disease-specific survival (DSS) for (A) all 21 patients, (B) patients with early (T1 + T2) and advanced (T3 + T4) disease, patients with tumor invasion to (C) parotid gland, (D) otic capsule, (E) eustachian tube (E tube), (F) sigmoid sinus, and (G) dura.

with a cutting burr in addition to a standard sleeve resection to achieve an adequate deep margin. The main advantages of this modified sleeve resection were hearing preservation and reduced risk to neurovascular structures. All patients with T1 and T2 disease in our study survived longer than 5 years. Despite three of seven patients developing local recurrence during follow-up with an average time to occurrence of 124.0 months, all patients survived for more than 5 years after salvage surgery with postoperative RT. Modified sleeve resection may be a suitable option for T1 and T2 disease without nodal involvement in patients who are compliant and able to maintain long-term, regular outpatient follow-up. In addition, it could be considered for patients with comorbidities who cannot tolerate the risks associated with LTBR. Postoperative RT should be considered for better local control. And LTBR remains a more oncologically sound surgical method.

The literature has identified several prognostic factors for survival. Negative prognostic factors frequently mentioned include positive surgical margin, nodal metastasis, advanced T stage, facial palsy, dural involvement, and vascular involvement.[1,3,9,10] In our series, a positive surgical margin had a high HR (HR = 8.93) but was not

significantly associated with DSS, likely due to the limited sample size. Around 7%–20% of patients with EAC SCC show lymph node metastases when initially diagnosed.[3,11,12] However, in our series, no patients had nodal metastasis, likely due to the small number of cases. This could create a noticeable bias in our study results. Univariant analysis revealed that a past history of long-standing chronic otitis media was a negative prognostic factor ($p = .03$, HR = 10.4), which has not been extensively discussed in previous literature on survival rates. Chronic otitis media, otitis externa, and cholesteatoma have been associated with EAC SCC, but the mechanism of progression to cancer remains unclear.[2,13] High-risk type human papillomavirus (HPV) DNA has been identified in tissue from temporal bone SCC, suggesting a possible causative role in a subgroup of cases, although there were no significant differences in DSS in the HPV-positive group. In this series, a case with papilloma of the EAC required repeated tumor excision and adjuvant RT, but the latest biopsy showed malignant transformation into SCC. If future investigations confirm the role of HPV in the pathogenesis of EAC SCC, it could provide the basis for treatment stratification.[14,15]

The extent of tumor invasion significantly affects the difficulty of achieving clear surgical margins and can consequently impact patients' prognosis. The temporal bone contains multiple natural routes through which primary cancer of the EAC can easily spread in various directions (Figure 2).[1] We analyzed the relationship between patients' survival and the anatomical structures affected by the tumor in our series. The involvement of the otic capsule, eustachian tube, sigmoid sinus, and dura of the temporal lobe were identified as negative prognostic factors. In addition, the involvement of the middle ear cavity, mastoid cavity, parotid gland, temporomandibular joint, petrous part of the carotid artery, and supratubal recess tended to reduce DSS.

Tumors that extend medially can invade the otic capsule through pre-existing pneumatized routes in the temporal bone. Previous studies have yielded conflicting results on the impact of otic capsule involvement on DSS. Some authors have reported no significant effect.[16] Komune et al. found that otic capsule involvement tended to reduce DSS rates (HR > 2), although it was not a significant prognostic factor.[17] Similarly, Bacciu et al. reported that otic capsule invasion significantly worsened recurrence-free survival but not DSS.[9] The study of Shiga et al. also demonstrated that cochlear invasion led to worse patient outcomes by univariate analysis of overall survival.[18]

When an EAC tumor invades medially into the middle ear, it may grow anteromedially through the anterior mesotympanum and enter the tympanic orifice of the eustachian tube. Limited data exists on the prognostic impact of tumor invasion into the Eustachian tube. Komune reported that the eustachian tube was not a significant prognostic factor.[17] Our study represents the first report acknowledging this association.

When a tumor extends posteriorly into the mastoid cavity, it can further invade the sigmoid sinus through the posterior cranial fossa. During STBR and TTBR procedures, the sigmoid sinus and jugular bulb are routinely exposed.[19] Intraoperative closure of the sigmoid sinus and jugular bulb has been shown to be generally safe with rare clinical consequences, likely due to the system of collateral drainage and emissary veins that compensate for sigmoid sinus closure.[20] However, some authors classified tumor-invading sigmoid sinus as an unresectable disease.[21] Komune et al. found that sigmoid sinus invasion was

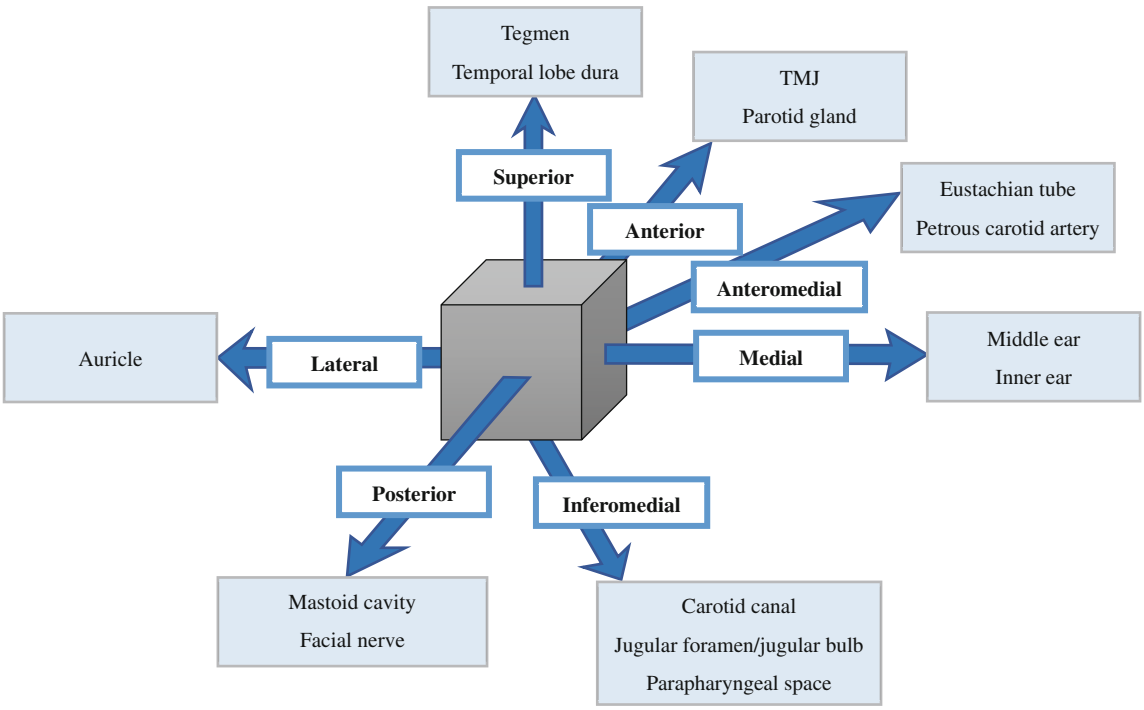


**FIGURE 2** Illustrated are seven simplified natural routes of external auditory canal (EAC) tumor invasion, with the central cube symbolizing the EAC.

associated with poorer DSS and was an independent prognostic factor.[17] In our series, two patients had tumors that invaded the sigmoid sinus. They both opted for definitive RT with or without chemotherapy as primary treatment, considering the higher surgical risks and difficulty in achieving clear margins.

When an EAC tumor extends superiorly, it can invade the tegmen and possibly extend into the dura of the temporal lobe. The impact of dural or intracranial involvement in EAC carcinoma has been widely studied by many authors. Carcinomatous invasion of the dura or temporal lobe indicates aggressive biological behavior of the tumor. While some studies have shown that dural invasion does not significantly worsen the prognosis,[22] many authors have concluded that dural involvement is a negative prognostic factor.[1,9,17] Morris et al. reported that intracranial invasion and the need for a craniotomy were both associated with a poorer survival rate.[16] Traditionally, dural or intracranial extension has been considered a relative contraindication to surgical resection due to the poor prognosis.[1] However, rapid advances in surgical equipment and the cooperation of multidisciplinary surgical teams have improved the surgical outcome over time. Dean et al. reported a 65% 2-year disease-free survival rate in 16 patients with intracranial invasion treated with surgical resection.[22] Seligman et al. reported that 60% of their patients with dural invasion survived for at least 5 years after skull base or dural resection with clear margins.[23] Wide dural excision and reconstruction with soft tissue graft could be performed to achieve clear margins. If the tumor infiltration was superficial, dural coagulation with bipolar diathermy could be an alternative option.[12] If the tumor extended into the temporal or occipital lobe, wide surgical excision could be considered despite significantly higher surgical risks. In our series, five cases had tumor invasion of the dura. One patient received LTBR with modified radical neck dissection, and the margin of the dura showed malignancy. After adjuvant CCRT, the patient has been tumor-free for more than 7 years. The other four patients with dura involvement died of the disease within 2 years.

Staging plays a crucial role in prognostic stratification and guiding clinical management, but a consensus on the optimal staging system for EAC cancer by the American Joint Committee on Cancer (AJCC) or the Union for International Cancer Control (UICC) is currently lacking. The most commonly adopted staging system nowadays is the Pittsburgh staging system modified by Moody et al.[1] Despite advances in skull base surgery and adjuvant therapy, T4 disease generally carries a poor prognosis. The predictive performance limitations of the modified Pittsburgh staging system are believed to be attributed to T4 disease. To address this issue, various proposals for T4 subclassification have been made. Zanoletti et al. suggested subclassifying T4 tumors based on the direction of tumor invasion (T4a: anterior spread, T4b: posterior, superior, inferior, or medial spread).[24] Shinomiya et al. posited that tumors involving the brain, carotid artery, and/or jugular vein should be classified as T4b.[11] In this study, we propose a T4 subclassification based on surgical difficulty, dividing it into T4a and T4b. T4a refers to tumor invasion into parotid gland (>5 mm), periauricular soft tissues (>5 mm), condyle, or the presence of facial paresis (without invading any subsites in T4b), while T4b refers to tumor invasion into deeper structures including the eustachian tube, otic capsule, medial wall of the middle ear, carotid canal, jugular foramen, sigmoid sinus, petrous apex, or dura. Obtaining clear surgical margins in T4b disease, particularly via an en bloc approach, is extremely challenging. The anatomical subsites in T4b are vital organs or structures in close proximity to vital organs, posing significant surgical risks. Thus, some surgeons would suggest that tumors invading these structures are unresectable under certain conditions. In our series, among the nine T4 cases, two were classified as T4a and seven as T4b, according to our proposed subclassification. All T4b cases that underwent curative surgical resection had positive surgical margins and were treated with adjuvant concurrent chemoradiotherapy. And the other three T4b cases that did not undergo curative surgical resection DOD within 2 years. Considering the significance of extranodal extension (ENE) on prognosis, as emphasized by the eighth AJCC staging system for head and neck cancer,[25] we propose integrating the concept of ENE into the modified Pittsburgh staging system to improve prognostic prediction and guide surgical planning. However, due to the limited case number (only nine T4 cases and no cases with nodal metastasis) in this study, the predictive performance of the proposed adjustments has yet to be validated. Future prognostic evaluations will rely on the analysis of clinical data from a large database.

## 5 | CONCLUSIONS

The main treatment for early-stage (T1 and T2) EAC SCC involves surgical resection, which may or may not be combined with adjuvant RT. This approach typically yields a favorable survival outcome. For advanced cases (T3 and T4), surgical resection with adjuvant CCRT is the preferred treatment, although the survival outcomes are generally poor. The direction of tumor invasion affects surgical difficulty, and it is crucial to make a precise preoperative evaluation of disease extent. Several factors can predict a less favorable survival, such as the history of COM, tumor invasion into the otic capsule, sigmoid sinus, eustachian tube, and dura. Multicenter studies with large case numbers are necessary in the future to optimize the staging system, treatment strategies, and improve the prognosis.

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### CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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