Lateral skull base malignancies

BENJAMIN M. MCGREW, M.D., C. GARY JACKSON, M.D., AND RAQUEL A. REDTFELDT, M.D.

Hawaiian Island Ear, Nose, and Throat Specialists, Honolulu, Hawaii; and The Otology Group, Nashville, Tennessee

Object. Historically poor outcomes have been characteristic in patients with lateral skull base malignancies. As advances in skull base surgical techniques have been made, complete resection has increasingly been achieved. This has resulted in improved survival rates and local tumor control.

Methods. The authors performed a retrospective review of 95 patients treated for lateral skull base malignancies. The mean age of the patients was 49.4 years. There were 44 females and 51 males. The mean follow-up period was 50 months. Resection was performed in all patients, and postoperative radiotherapy was undertaken in 54% of the cases. Local disease control was maintained in 73% of the patients. Tumor involvement of the facial nerve and intracranial tumor extension did not jeopardize the rate of local control.

Conclusions. Despite the fact that technical advances in skull base surgery have resulted in a higher incidence of complete tumor resection and improved survival rates, a respect for the poor prognosis historically associated with lateral skull base malignancies should be maintained and treatment should be appropriately aggressive.

KEY WORDS • skull base tumor • temporal bone

Although primary malignancies involving the lateral skull base are rare, their treatment has been historically challenging and their prognosis has been poor. The complex and intricate vital neurovascular structures that penetrate the lateral skull base have often made complete tumor removal difficult if not impossible. After early experience was gained in the treatment of lateral skull base lesions, malignant tumors involving the lateral skull base were often considered to be unresectable.⁹

Because initial resections were frequently incomplete or piecemeal and associated with high rates of morbidity, mortality, and recurrence, primary radiotherapy was quickly adopted as the preferred alternative intervention.^{2,10} Unfortunately, results of radiotherapy alone in the treatment of lateral skull base malignancies have been poor; the 5-year survival rates have ranged from 0 to 22%.^{2,4,10} Consequently, resection has become the critical component in the management of lateral skull base malignancies. This therapeutic need for complete resection of skull base tumors has driven the advancement of skull base surgery.

Prior to the mid-1950s, lateral skull base malignancies were primarily treated by radical mastoidectomy combined with radiotherapy.^{3,15} In 1954, the en bloc total temporal bone resection was described by Parsons and Lewis.¹¹ In 1974 Lewis⁹ popularized single-stage total temporal bone resection in reporting a series of 100 cases. In that series, the overall 5-year survival rate was 27%.

Since the advancement of lateral skull base surgery began in the early 1970s, postresection survival rates have been improving as complete tumor excision has become

more common.⁴ In some series, the combination of radiotherapy and resection has resulted in increased survival rates.^{2,5,14} Consequently, some authors have advocated this combined intervention in most if not all cases. Unfortunately, successful treatment remains difficult. Even with combined-modality treatment, 5-year survival rates range from 20 to 58% in the best of series.^{1,4,7,8,10,12,13}

CLINICAL MATERIAL AND METHODS

We conducted a retrospective review of patients treated from 1972 to 2002 for lateral skull base malignancies. Ninety-five patients were identified, and outcome measures were reviewed. Rates of survival and local recurrence were reviewed and used as outcome measures. Data on diagnosis and treatment choices were reviewed as factors affecting outcomes.

Patient Population

The mean patient age was 49.4 years (range 5–83 years). There were 44 females and 51 males. The mean duration of follow up was 50 months (range 1–180 months).

Surgical Technique

Based on the knowledge that successful outcome is contingent on complete tumor removal, lateral skull base malignancies are treated by an aggressive surgical procedure. The surgical approach is based on the location and extent of the disease.

In cases in which the lesion is limited to the ear canal, a lateral temporal bone resection is performed. In this approach, the entire ear canal and drum with attached lateral and anterior extensions are removed en bloc. This is accomplished after a mastoidectomy is performed. Via an

Abbreviations used in this paper: CA = carotid artery; ICA = internal carotid artery.

extended facial recess approach, after the ossicular chain has been disconnected at the incudostapedial joint, dissection is performed anteriorly between the posterior inferior ear canal and the facial nerve. Superiorly, the plane of dissection connects with the temporomandibular joint to allow complete removal of the ear canal in one piece.

In cases in which the lesion extends medial to the eardrum, a subtotal temporal bone resection is performed. A lateral temporal bone resection is combined with local excision of the involved portion of the temporal bone. When possible, the tumor is removed en bloc with a margin of uninvolved bone. When it is not possible to remove the entire tumor en bloc with an obviously clear margin, as much of the tumor as possible is removed en bloc. The remaining affected tumor margins are then removed using aggressive skull base dissection until a clear margin is obtained. Tumor-involved bone margins are drilled until clear, involved cranial nerves are resected until clear, and involved dura with intracranial extension is resected. Postoperative radiotherapy always follows these surgical procedures.

Involved neurovascular structures are aggressively resected and immediately reconstructed when possible. We perform vascularized dural reconstructions because they are associated with a much lower incidence of postoperative cerebrospinal fluid leakage compared with non-vascularized dural reconstructions.⁶ In the immediate perioperative period, we perform various rehabilitative interventions for resected cranial nerves, when possible, including hypoglossal-facial nerve anastomosis, cable nerve grafts, eyelid gold weight implants, medialization laryngoplasty, and palatal adhesion. Facial reanimation and maintenance of laryngeal competence, avoiding chronic aspiration, are our highest priorities.

We conduct postoperative radiotherapy in the following cases: after subtotal temporal bone resection and subtotal tumor resection (positive margin), and when there is CA involvement, dural venous sinus or jugular bulb involvement, cranial nerve involvement, nodal metastasis, intracranial tumor extension, and advanced skull base involvement.

In cases in which patients undergo surgery after preoperative radiotherapy, the classic total en bloc temporal bone resection is performed as popularized by Lewis.^{9,11} In this procedure the entire temporal bone is removed en bloc. The CA, sigmoid sinus, jugular bulb, internal jugular vein, and dura are preserved when possible. The initial step is a temporal craniotomy. Extradural dissection is performed to the petrous ridge and superior petrosal sinus. The sigmoid sinus is isolated posteriorly and followed in an inferior and anterior direction to the jugular bulb. Anteriorly, the parotid gland is dissected, the distal facial nerve is divided, the mandibular condyle is mobilized or resected, and the petrous portion of the internal CA is dissected through the infratemporal fossa. Once proximal and distal arterial and venous control is established, the remaining medial attachments of the temporal bone are separated, including dural attachments, CA and jugular bulb attachments, and proximal division of the cochleovestibular and facial nerves.

Characteristic lymphatic drainage of the temporal bone is anterior into the lymph nodes of the parotid gland and inferior into the upper jugular lymph nodes within the

neck. Typically, auricular resection, parotidectomy, mandibular displacement or resection, infratemporal fossa dissection, and neck dissection are combined with the appropriate temporal bone resection. Ideally, this allows en bloc removal of local/regional disease.

RESULTS

A retrospective review 95 patients treated for primary malignancies involving the lateral skull base was performed.

There were three cases of perioperative deaths, six cases lost to follow up, and three cases in which only subtotal resection was achieved. In the remaining 83 patients, local control was maintained in 61 (73.5%). Twenty-one patients (25%) died of their disease, six (7%) were alive with their disease, and five (6%) died of other causes.

Outcome Results Based on Diagnostic Groups

Based on pathological findings, cases were classified into the following diagnostic groups: epithelial, salivary, and mesenchymal malignancies (Table 1).

Epithelial Group. There were 35 patients with epithelial malignancies: 30 squamous cell carcinomas and five basal cell carcinomas. In this group the mean age of patients was 60.3 years (range 39–83 years), and the male/female ratio was 2:1.

There were no perioperative deaths; two patients underwent subtotal resection, and three patients were lost to follow up. In the remaining 30 patients, local disease control was maintained in 21 (70%). Eight patients (26.7%) died of disease, one (3.3%) was alive with disease, and two died of other causes (6.7%).

Salivary Group. There were 28 patients with salivary malignancies: 14 adenocarcinomas, seven adenoid cystic carcinomas, four acinic cell adenocarcinomas, and three carcinoma ex pleomorphic adenomas.

The mean age of patients was 45.4 years (range 18–71 years), and the male/female ratio was 1:1.08.

There was one perioperative death, and one patient was lost to follow up. In the remaining 26 patients, local disease control was maintained in 18 (69%). Seven patients (27%) died of their disease, two (8%) were alive with their disease, and one died of other causes.

Mesenchymal Group. There were 32 patients with

TABLE 1
Summary of outcomes based on diagnostic group classification

Factor	Lesion Group (%)		
	Epithelial	Salivary	Mesenchymal
no. of patients	35	28	32
mean age	60.3	45.4	40.7
male/female	2:1	1:1.08	1:1.36
no. excluded	5	2	5
local control	21 (70)	18 (69)	22 (81.5)
alive w/ disease	1 (3.3)	2 (8)	1 (3.7)
died of disease	8 (26.7)	7 (27)	5 (18.5)
died of other cause	2 (6.7)	1 (3.8)	2 (7.4)

Lateral skull base malignancies

mesenchymal malignancies: two chondroblastomas, four chondrosarcomas, six chordomas, three primary central nervous system malignancies, three hemangiopericytomas, one lymphoma, seven malignant glomus tumors, three sarcomas, and three schwannomas.

The mean age of patients was 40.7 years (range 5–69 years), and the male/female ratio was 1:1.36.

There were two perioperative deaths, one subtotal resection, and two patients were lost to follow up. In the remaining 27 patients, local disease control was maintained in 22 (81.5%). Five patients (18.5%) died of their disease, one (3.7%) was alive with disease, and two died of other causes (7.4%).

Outcome Based on Treatment Groups

Patients were also classified into groups based on the treatment each received (Table 2).

Surgery Only. There were 44 patients (46%) who underwent resection alone. In this group there were three perioperative deaths, and two patients were lost to follow up. In the remaining 39 patients, local disease control was maintained in 37 (94.9%). One patient (2.6%) died of the disease, one (2.6%) was alive with disease, and five died of other causes (12.8%).

Surgery and Preoperative Radiotherapy. Ten patients (10.5%) underwent radiotherapy prior to resection. There were no cases of perioperative death, subtotal resection, and no patients lost to follow up. Local disease control was maintained in four (40%) patients. Two patients were also treated with chemotherapy. Five patients (50%) died of their disease, and one (10%) was alive with disease.

Although we found a survival advantage in cases in which postoperative radiotherapy was performed compared with preoperative radiotherapy, this difference was not statistically significant according to chi-square analysis because of the small numbers of patients in the preoperative group.

Surgery and Postoperative Radiotherapy. There were 41 patients (43%) who underwent resection followed by postoperative radiotherapy. Four patients were lost to follow up, and subtotal resections were performed in three cases. In the remaining 34 patients, local disease control was maintained in 20 patients (58.8%). Seven patients (20.6%) were also treated with chemotherapy. Fifteen patients (44.1%) died of their disease, four (11.8%) were alive with their disease, and none died of other causes.

TABLE 2
Results based on treatment*

Factor	Resection Group (%)		
	Op Only	W/ Preop XRT	W/ Postop XRT
no. of patients	44	10	41
no. excluded	5	0	7
local control	37 (94.9)	4 (40)	20 (58.8)
alive w/ disease	1 (2.6)	1 (10)	4 (10.8)
died of disease	1 (2.6)	5 (50)	15 (40.5)
died of other cause	5 (12.8)	0	0

* XRT = radiotherapy.

Intracranial Tumor Extension

Intracranial tumor extension was present in 28 (29.4%) of the 95 patients (Table 3). There were two perioperative deaths with one patient lost to follow up and one subtotal resection. In the remaining 24 patients, local disease control was maintained in 17 (70.8%). In patients in whom there was no intracranial tumor extension, local disease control was maintained in 44 (74.6%) of 59. The observed difference in local disease control was not statistically significant according to chi-square analysis.

Cranial Nerve Resection

Cranial nerve resection was aggressively performed in cases in which tumor involvement was confirmed intraoperatively (Table 3). At three patients' requests, involved cranial nerves were preserved accounting for all cases of subtotal resections in this series.

Tumor involved the facial nerve and was resected in 23 patients (24.2%). These patients also underwent postoperative radiotherapy. In cases of facial nerve resection, four patients were lost to follow up. In the remaining 19 patients, local control was maintained in 15 (79%).

In cases in which facial nerve resection was not performed, there were three perioperative deaths, two patients were lost to follow up, and there were three subtotal resections. In the remaining 64 patients, local disease control was maintained in 46 (71.9%). The difference in local control between patients requiring facial nerve resection and those not requiring resection was not statistically significant according to chi-square analysis.

Internal CA Resection

Resection of the ICA was performed in five patients. Despite the routine provision of preoperative angiography balloon occlusion in cases of suspected CA involvement, ICA resection was initially associated with perioperative death in three patients. These initial cases in which ICA resection was performed without reconstruction account for all the cases of surgery-related mortality in this series. Because of this high rate of associated mortality, ICA resection without reconstruction was abandoned; in recent patients with CA involvement resection has been immediately followed by primary reconstruction. Since this practice was instituted there have been no cases of associated mortality.

DISCUSSION

Successful treatment of lateral skull base malignancies continues to require multimodality therapy including pri-

TABLE 3
Results based on facial nerve and intracranial tumor resection

Factor	Facial Nerve Resection		Intracranial Tumor Resection	
	Yes	No	Yes	No
no. of patients	23	72	28	67
no excluded	4	8	4	8
local control (%)	15 (78.9)	46 (71.9)	17 (70.8)	44 (74.6)

mary resection combined with radiotherapy and, when appropriate, chemotherapy. To achieve higher local disease control rates when performing complete tumor removal, the resection must be aggressive and include involved neurovascular structures. When subtotal resection has been performed, outcomes are dismal.^{1,4} Modern skull base resection techniques are a critical component in treatment and are responsible for improving survival rates from less than 20% to greater than 50%.^{1,4,7,8,10,12,13} In this series, overall local disease control was maintained at 74%.

Malignant lateral skull base tumors develop from common structures present at the lateral skull base. As previously noted by Manolidis, et al.,¹⁰ the local control rate associated with lesions of mesenchymal origin was better than those related to epithelial and salivary neoplasms.

In our cases tumors involving the facial nerve were aggressively excised, and this was followed by radiotherapy. Local disease control was not jeopardized by cranial nerve involvement. In this series, statistically equivalent local control rates were obtained in patients requiring facial nerve resection and those without facial nerve involvement. Based on this outcome, it is established that the morbidity associated with facial nerve resection was not in vain.

Resection of the ICA should be performed with caution. The cases in which the ICA was resected without vascular reconstruction accounted for the entire incidence of surgery-related mortality in this series. Consequently, we have taken the position that ICA resection should be cautiously and deliberately considered after appropriate preoperative preparation and with a plan for immediate vascular reconstruction.

Citing improved survival rates in patients undergoing combined-modality treatments, the authors of several reports have suggested that resection combined with radiotherapy is appropriate in most and possibly all cases of malignancy involving the lateral skull base.^{2,5,14} In our series, combined-modality therapy was not required for successful tumor control in 46% of cases but was reserved for patients with advanced disease. Instead of undertaking routine combination therapy in all cases, the addition of radiotherapy was based on the following intraoperative and pathological findings: subtotal temporal bone resection, CA involvement, dural venous sinus or jugular bulb involvement, subtotal tumor resection (with positive margin), cranial nerve involvement, nodal metastasis, intracranial tumor extension, and advanced skull base involvement. In maintaining respect for the historically poor prognosis associated with this disease, surgery combined with postoperative radiation was also performed in cases in which tumor removal was difficult or in which clear margins were technically difficult to obtain. Because combined-modality treatment was reserved for advanced cases, this factor (advanced disease) may explain the notable decrease in local disease control observed in the combined-modality treatment groups compared with the surgery-only group.

CONCLUSIONS

Because of the historically poor prognosis associated with malignancies involving the lateral skull base, an aggressive treatment plan is warranted. When surgery is well

executed and appropriately combined with radiotherapy, improved survival rates can be achieved. Combined-modality therapy is not required to obtain tumor control in all cases but is preferred in those with advanced disease.

When aggressive resection is combined with radiotherapy, successful local control can be achieved even in cases of cranial nerve involvement and intracranial tumor extension.

Surgery-related mortality was associated with cases of ICA resection in which arterial reconstruction did not follow the excision. As a result, ICA resection should be cautiously considered after appropriate preoperative preparation and with a plan for immediate reconstruction.

Despite the fact that technical advances in skull base surgery have resulted in a higher incidence of complete tumor resection and improved survival rates, a respect for the poor prognosis historically associated with lateral skull base malignancies should be maintained and treatment should be appropriately aggressive.

References

1. Arriaga M, Hirsch BE, Kameron DB, et al: Squamous cell carcinoma of the external auditory meatus (canal). *Otolaryngol Head Neck Surg* **101**:330–337, 1989
2. Barrs DM: Temporal Bone Carcinoma. *Otolaryngol Clin North Am* **34**:1197–1218, 2001
3. Boland J, Paterson R: Cancer of the middle ear and external auditory meatus. *J Laryngol Otol* **69**:468–478, 1955
4. Goodwin WJ, Jesse RH: Malignant neoplasms of the external auditory canal and temporal bone. *Arch Otolaryngol* **106**: 675–679, 1980
5. Hahn SS, Kim JA, Goodchild N, et al: Carcinoma of the middle ear and external auditory canal. *Int J Radiat Oncol Biol Phys* **9**:1003–1007, 1983
6. Jackson CG, McGrew BM, Forest JA, et al: Lateral skull base surgery for glomus tumors: long-term control. *Otol Neurotol* **22**:377–382, 2001
7. Kinney SE, Wood BG: Malignancies of the external ear canal and temporal bone: surgical techniques and results. *Laryngoscope* **97**:158–164, 1987
8. Lederman M: Malignant tumours of the ear. *J Laryngol Otol* **79**:85–119, 1965
9. Lewis JS: Temporal bone resection. Review of 100 cases. *Arch Otolaryngol* **101**:23–25, 1975
10. Manolidis S, Pappas D Jr, Von Doersten P, et al: Temporal bone and lateral skull base malignancy: experience and results with 81 patients. *Am J Otol* **19** (Suppl 6):S1–S15, 1998
11. Parsons H, Lewis JS: Subtotal resection of the temporal bone for cancer of the ear. *Cancer* **7**:995–1001, 1954
12. Pensak ML, Gleich LL, Gluckman JL, et al: Temporal bone carcinoma: contemporary perspectives in the skull base surgical era. *Laryngoscope* **106**:1234–1237, 1996
13. Prasad S, Janecka IP: Efficacy of surgical treatments for squamous cell carcinoma of the temporal bone: a literature review. *Otolaryngol Head Neck Surg* **110**:270–280, 1994
14. Spector JG: Management of temporal bone carcinomas: a therapeutic analysis of two groups of patients and long-term followup. *Otolaryngol Head Neck Surg* **104**:58–66, 1991
15. Ward GE, Loch WE, Lawrence W Jr: Radical operation for carcinoma of the external auditory canal and middle ear. *Am J Surg* **82**:169–178, 1951

Manuscript received March 18, 2002.

Accepted in final form May 7, 2002.

Address reprint requests to: Benjamin M. McGrew, M.D., 1380 Lusitana Street, Suite 502, Honolulu, Hawaii 96813.