Lateral Skull Base Surgery: The Otology Group Experience

ABSTRACT—Lateral skull base surgery has remained the surgical frontier of new developments in the treatment of lesions heretofore difficult to access. Examination of surgical results stimulates technical innovation and provides an intervention risk-benefit ratio assessment for particular lesions useful in management planning. With this in mind, we report the updated collective experience with lateral skull base surgery at the Otology Group over the past 20 years. Two hundred ninety-eight patients underwent surgical intervention for lateral skull base lesions. In 81 patients these lesions were malignant; in 217, benign. Of the benign lesions, 165 were glomus tumors: 139 glomus jugulare, 19 glomus vagale, and 7 glomus tympanicum. The remainder comprised 21 meningiomas, 14 neuromas, two neurofibromas, and a small group of much rarer entities. The philosophy of surgical approach, results, and follow-up are discussed.

Skull base surgery is a young surgical discipline that has seen a tremendous evolution in the last 20 years. The pioneering work of William House in applying microsurgical dissection techniques to the middle fossa and translabyrinthine approaches was a strong impetus for the development of lateral skull base surgery.^{1,2} Glomus tumors, since their recognition as a separate pathologic entity by Rossenwaser and Guild and their subsequent classification by Alford and Guilford, have been a major focus of this discipline.³⁻⁵

Fisch, Glasscock, and Jackson advanced the techniques of addressing these tumors surgically in one stage.^{6,7} This led to separate but similar classification systems both for staging of the disease and for the types of surgical approaches.⁸ In neurosurgery, the initial approaches by Mullen, Hilding, and Kempe provided appropriate but limited access with potential for complications.⁹⁻¹¹ The addition of the extreme lateral, transcondylar, and foramen magnum craniotomies have extended access to lateral skull base lesions. Wide field frontolateral approaches have allowed the skull base surgeon to address the more complex lesions with anterior skull base involvement.¹²

Most recent developments are focused on prevention of operative morbidity. Phonosurgery, such as vocal cord medialization and gold-weight lid implantation, are thrusts in the right direction.^{13,14} These simple techniques have been shown to improve postoperative rehabilitation and decrease the length of hospitalization.¹⁵

Skull base surgery has proven to be a safe and effective way of curing disease that is otherwise life-threatening and has the potential for loss of quality of life if treated improperly. Long-term outcome analysis of patients undergoing skull base surgery is a topic that will draw further attention in a systematic way in the near future. Quantification of deficits and loss of quality of life should be applied in the follow-up of these patients to buttress with data the excellent results that the modern skull base surgeon knows he or she can achieve.^{16,17}

MATERIALS AND METHODS

A retrospective chart review of all lateral skull base surgery at the Otology Group P.C. from 1970 to 1995

Table 1. Histologic Subtypes of the Otology Group Skull Base Series

<i>Malignant</i>		<i>Benign</i>	
SCCA	26	Glomus jugulare	139
Adenocarcinoma	10	Glomus vagale	19
Adenoid cystic carcinoma	6	Glomus tympanicum	7
Sarcomas	8	Meningioma	21
Chordoma	6	Neuromas	14
Malignant glomus	5	Cholesteatoma	3
Acinic cell carcinoma	4	Neurofibroma	2
Ca ex pleo	3	Giant cell tumors	2
CNS malignancy	3	Chondroma	2
Hemangiopericytoma	3	Inverting papilloma	1
Malignant neuroma	2	Hemangioma	1
BCCA	4	Sarcoidosis	1
Lymphoma	1	Hamartomatous lipoma	1
Rhabdomyosarcoma	1	ICA aneurysm	2

SCCA: squamous cell carcinoma; Ca ex pleo: carcinoma ex pleomorphic adenoma; BCCA: basal cell carcinoma; ICA: internal carotid artery.

identified a total of 309 cases. Ten patients were excluded because of incomplete data. One more patient was excluded because of planned incomplete resection. A total of 298 operations were analyzed in 288 patients (six patients had two operations and two patients had three operations).

Descriptive Statistics

Eighty-one cases involved malignant tumors; 217 involved benign lesions. The ratio of benign to malignant disease was approximately 3 to 1. The histologic subtypes are summarized in Table 1.

In the group with benign tumors, mean patient age was 41 years, with an age range of 1 to 82 years. The average follow-up period was 53 months (range 0 to 234 months). There were 154 females and 63 males for a ratio of 2.4 to 1. One hundred nine tumors were located on the left side of the skull, 108 tumors on the right side. Similarly, the age and sex distribution as well as follow-up period for the group with malignant lateral skull base tumors did not differ significantly. Mean patient age was 48.5 years, with a range of 5 to 83 years. There

were 42 males and 39 females. The average follow-up period was 54 months (range 1 to 180 months). Thirty-four patients were followed up for periods longer than 60 months, and 44 patients were followed up for more than 36 months.

Symptoms and Findings

In the group with benign lesions pulsatile tinnitus was the most common complaint, reflecting the large number of patients with glomus tumors. Hearing loss and hoarseness were the next most common symptoms, representing respective cranial nerve dysfunction. Hearing loss as a symptom was found in 37 (17%) of these patients. However, hearing loss as a finding on audiometric analysis was seen in 133 (62%) of patients. In the same group, findings on examination were seen in 119 patients (55%). Of the 165 patients with glomus tumors, a middle ear mass was seen in 107 (65%). In 36 patients (22%) this mass filled the middle ear cavity while in 71 (43%) it occupied only the hypotympanic area of the middle ear. Seven of these 165 patients (4.2%) presented with symptoms of autonomic dysfunction of variable degree; these patients were found to have elevated levels of catecholamines.

In the group with malignant lesions, presenting symptoms of significance included some type of hearing loss (59 patients; 73%); 27 patients (26%) had some degree of facial paralysis at presentation, and 47 (58%) presented with pain as their primary symptom. Otorrhea was also observed in 20 (24%) of these patients (Table 2). Hearing was audiometrically assessed at presentation and follow-up in both groups. The following categories were defined according to the pure tone average (PTA) of thresholds at 500 Hz, 1000 Hz and 2000 Hz. The Fletch average of two thresholds was utilized whenever appropriate. Normal hearing was defined as PTA better than 20 dB. Mild hearing loss was defined as PTA = 21 dB to 50 dB, moderate hearing loss as PTA = 41 dB to 70 dB, severe hearing loss as PTA = 71 dB to 95 dB. A deaf ear was defined as one with no response on audiometric testing to pure tones or with any type of response and a speech discrimination score of less than 20%.

Table 2. Symptoms at Presentation According to Benign or Malignant Lesion

<i>Benign</i>			<i>Malignant</i>		
<i>Symptom</i>	<i>Number of Patients</i>	<i>Percent</i>	<i>Symptom</i>	<i>Number of Patients</i>	<i>Percent</i>
Tinnitus	126	58%	Otorrhea	20	34%
Hearing loss	37	17%	Tinnitus	15	26%
Vertigo	29	13%	Vertigo	7	12%
Dysphonia	21	10%	Bleeding	2	3%
Dysphagia	16	7%	Ear lesion	5	9%
Facial palsy	16	7%	Auricular lesion	7	12%
Trigeminal	7	3%			

Table 3. Hearing Loss at Presentation for the Two Groups

Hearing Loss	Benign		Malignant	
	Number of Patients	Percent	Number of Patients	Percent
Normal	78	36%	22	27%
Mild	50	23%	25	31%
Moderate	34	16%	13	16%
Severe	10	5%	21	26%
Deaf	39	20%	0	0%

Table 3 describes the breakdown of hearing loss in the two groups.

Cranial Nerves

Patients were assessed for cranial nerve deficits before surgery. In the benign lesion group, the distribution according to cranial nerve is presented in Table 4. In 94 cases (43%) some cranial nerve was involved, whereas in 122 cases (57%) there was no evidence of cranial nerve involvement. In order of frequency of involvement, cranial nerve IX was most often involved, followed by cranial nerve VII, X, XII, V, VI, and XI. In the malignant lesion group, 17 patients (21%) presented with some cranial nerve deficit other than cranial nerves VII or VIII, and 64 patients (71%) had no such deficits at presentation.

Examined in a different way, of the 94 cases in the benign group presenting with some cranial nerve deficit, 35 cases (37%) had involvement of only one cranial nerve, 24 cases (25%) had involvement of two cranial nerves, 14 cases (15%) three cranial nerves, 13

Table 4. Cranial Nerve (CN) Deficits at Presentation, Benign Lateral Skull Base Lesions

Cranial Nerve	Number of Patients	Percent	Association with Other CNs
V	5	2%	4
VI	4	1.5%	3
VII	34	16%	21
IX	43	20%	40
X	16	7%	10
XI	3	1%	3
XII	10	5%	3

cases (14%) four cranial nerves, and 8 cases (8%) five cranial nerves.

Staging

Both groups were evaluated. Staging for the benign lesion group is presented here. One hundred ninety-six cases were available for staging using the Fisch and Glasscock-Jackson classifications. Twenty-one cases were excluded because of pathology that was not suitable for staging [cholesteatoma, internal carotid artery (ICA) aneurysm, giant cell tumors, sarcoidosis, neurofibroma, etc]. Table 5 presents the data in both staging systems.

Staging for the group of patients with malignancies is significantly more elaborate and involves a variety of criteria such as histopathology, anatomic invasion, and local/regional spread. It is the subject of a separate report.

Surgery

All patients in both groups were treated by surgery with curative intent as the primary modality. In the malignant lateral skull base group, 42 patients (52%) were treated with adjuvant postoperative radiation and eight patients (10%) were treated with both radiation and chemotherapy. In the benign lateral skull base group, only one patient received postoperative radiation as part of the treatment.

In the benign lesion group, the following surgical treatments were undertaken:

Extended Facial Recess

Tumor extirpation was performed in 10% (21 patients) via an extended facial recess approach without facial nerve mobilization despite a preoperative plan to use an infratemporal fossa approach. The majority of the tumors in this subgroup were glomus tumors in which temporal bone anatomy allowed access without facial nerve mobilization.

Infratemporal Fossa Type A

This procedure was performed in 38% (82 patients). In this group, there were 37 cases (45%) in which temporal bone anatomy allowed the preservation

Table 5. Classification System Comparison of the 196 Tumors Classifiable in the Benign Lateral Skull Base Group

Fisch Stage	Number of Patients	Percent	Jackson Stage	Number of Patients	Percent
A	5	2.5%	Type 1	15	8%
B	41	21%	Type 2	46	23%
C1, C2, C3	34+34+17	43%	Type 3	72	37%
D1, D2	26+31	33%	Type 4	63	32%

Table 6. Surgical Approaches Used in the Treatment of Benign Lateral Skull Base Disease

<i>Procedure</i>	<i>Number of Patients</i>	<i>Combined with Other Procedures</i>	<i>Percent</i>
Extended facial recess	21		10%
ITF A	82	11: transotic 3: retrosigmoid 2: MCF 1: MCF + FM craniot.	38%
ITF B	57	12: transotic 1: retrosigmoid	26%
ITF C	48	13: transotic 5: other craniotomies 2: MCF + transotic 4: ICA sacrifice	22%
Other	9	2:ITF type D 2: MCF + suboccipital 4: transotic 1: suboccipital 1: preaural	4%

ITF: infratemporal fossa; MCF: middle cranial fossa; FM: foramen magnum; ICA: internal carotid artery

of the external auditory canal with mobilization of the mastoid segment of the facial nerve, and 17 cases (21%) in which the infratemporal fossa type A approach was combined with additional approaches to increase the access for a more complicated tumor situation.

Infratemporal Fossa Type B

This approach was required by 26% (57 patients) for extirpation of their tumors. In 13 cases (23%), this approach was extended to provide additional access. In 12 of these extended access cases, the additional approach was transotic, requiring sacrifice of the cochlea and labyrinth due to medial tumor extension.

Infratemporal Fossa Type C

This approach was required by 22% (48 patients) for extirpation of their tumors. In 22 cases (46%), this approach was extended to provide additional access. Most notably, four cases (8.3%) in this group required carotid sacrifice or bypass grafting, reflecting the extent of the tumors addressed by this approach.

Other approaches

Some other type of approach was required in 4% (9 patients); two were infratemporal fossa type D approaches with far anterior access.

The types of surgical approaches for benign lesions are summarized in Table 6.

Surgery for malignant lateral skull base tumors was more variable and was more often combined with adjunctive procedures, either to gain exposure in order to facilitate resection or to reconstruct the defect.

Lateral temporal bone resection followed by total temporal bone resection were the most common primary operations, accounting for 53% of the surgeries in this group of patients. The primary procedures were

combined with 91 adjunctive procedures. The types of surgical approaches for malignant lesions are summarized in Table 7.

Outcome

In the benign lesion group, 176 patients were alive without disease (AsD); 24 were alive with disease (AwD); 12 were dead of their disease, including three postoperative deaths (DoD); three were dead of other causes (DoC); and three were lost to follow-up. Therefore, the determinate cure rate was 83%. The failure rate (DoD and AwD) was 17%.

By contrast, in the malignant lesion group, 25 patients (30.9%) were dead of their disease (DoD), 43 patients (53.1%) were alive without evidence of disease (AsD), six patients (7.4%) were alive with disease (AwD), four patients (4.9%) were lost to follow-up (Lost), and 3 patients (3.7%) were dead of other causes (DoC). Therefore the determinant cure rate was 58%. The failure rate (DoD and AwD) was 42% (Table 8).

Table 7. Primary Surgical Approaches Used in the Treatment of Malignant Lateral Skull Base Disease

<i>Procedure</i>	<i>Number of Patients</i>	<i>Percent</i>
Lateral temporal bone resection	31	38%
Total temporal bone resection	12	15%
Infratemporal fossa	18	22%
Transotic	9	11%
Middle cranial fossa	6	7%
Posterior cranial fossa	3	4%
Preauricular	1	1%
Extended facial recess	1	1%

Table 8. Patient Outcome in the Two Groups of Skull Base Lesions

<i>Benign</i>			<i>Malignant</i>		
<i>Status</i>	<i>Number of Patients</i>	<i>Percent</i>	<i>Status</i>	<i>Number of Patients</i>	<i>Percent</i>
AsD	176	81%	AsD	43	52%
AwD	24	10%	AwD	6	8%
DoD	12	5%	DoD	25	31%
DoC	2	1%	DoC	3	4%
Lost	3	1%	Lost	4	5%

AsD: alive without diseases; AwD: alive with disease; DoD: dead of their disease; DoC: dead of other causes; Lost: lost to follow-up.

Complications

Immediate postoperative complications were observed in 48 patients (22%) in the benign lateral skull base group and in 14 (21%) patients in the malignant skull base group. The mortality rate for the benign lesion group was 1.4%; for the malignant lesion group, it was 4% (Table 9).

Prolonged deficits associated with this type of surgery were observed. In the benign lateral skull base group, voice disturbances were observed in 56 cases, deglutition problems in 52 cases, persistent vertigo in five, diplopia in three, malocclusion in two, and first-bite syndrome in three. In addition, aspiration was observed in 12 patients. In three of these 12 patients, aspiration was a permanent deficit. In two of these three patients, a permanent feeding tube was required. The majority of these problems were observed in the early group of patients in which routine tracheostomies were utilized (32 patients).

In the benign lesion group, permanent deficits occurred in seven patients. Permanent deficits in the malignant lesion group occurred in eight patients. Problems with mastication were observed in six cases, with deglutition in one, and a permanent gastrostomy/tracheostomy was required in another patient (Table 10).

Facial Nerve

In the benign lesion group, the facial nerve was left in situ in eight cases, and required a short mobilization in 58 cases (Table 11). A short mobilization is defined as up to and including the first genu. A long mobilization was required in 50 cases; a long mobilization is defined as past the first genu and up to and including the geniculate ganglion. An extreme mobilization was required in 50 cases; this was defined as a mobilization past the geniculate and into the internal auditory canal and posterior fossa. In 23 cases the facial nerve was cut and primarily reanastomosed and in 18 cases it was cut and grafted. The graft of choice was great auricular harvested from the same incision in 15 cases; in two cases, sural nerve was used, and in one case vagus nerve was used.

The results were recorded according to the House-Brackmann (HB) score, from 1 to 6. Patients were assigned to one of three categories:

- good facial function, corresponding to House-Brackmann scores of 1%
- fair facial function, corresponding to House-Brackmann scores of 3%
- poor facial function, corresponding to House-Brackmann scores of 5%

Table 9. Postoperative Complications in the Two Groups of Lateral Skull Base Tumors

<i>Benign Lateral Skull Base Disease</i>			<i>Malignant Lateral Skull Base Disease</i>		
<i>Complication</i>	<i>Number of Patients</i>	<i>Percent</i>	<i>Complication</i>	<i>Number of Patients</i>	<i>Percent</i>
Death	3	1.4%	Death	3	4%
CSF leak	21	10%	CSF leak	5	6.2%
Wound	16	7.4%	Wound	6	7.4%
CVA	2	0.9%	CVA	2	2.5%
Aspiration	9	4%	Aspiration	1	1.2%
Residual tumor	8	3.7%			
Pneumonia	5	2.3%			
Airway obstruction	4	2%			
Pneumothorax	2	0.9%			
Hydrocephalus	2	0.9%			

CVA = cerebrovascular accident.

Table 10. Permanent Deficits Associated with Lateral Skull Base Surgery in Both Groups

<i>Benign Lateral Skull Base Disease</i>		<i>Malignant Lateral Skull Base Disease</i>	
<i>Deficit</i>	<i>Number of Patients</i>	<i>Deficit</i>	<i>Number of Patients</i>
Aspiration Deglutition	2	Mastication	6
Malocclusion	2	Deglutition	1
First bite	3	G-tube & tracheostomy	1

Table 11. Facial Nerve Management in Patients with Benign Lateral Skull Base Lesions

<i>Facial Nerve Management</i>	<i>Number of Patients</i>	<i>Percent</i>
In situ	8	3.7%
Short mobilization	58	27%
Long mobilization	50	23%
Extreme mobilization	50	23%
Cut and reanastomosed	24	11%
Facial hypoglossal	7	3.2%

Of the 8 patients in the in situ group, none experienced any change from preoperative function. One patient with an HB score of % and one with a score of % remained unchanged after surgery. The results of facial nerve management are summarized in Table 12.

In the malignant lesion group, of 52 patients with normal facial function preoperatively, a total of 25 (49%) suffered some degree of paralysis. In 16 (64%) of these patients, the paralysis was total and in 9 (36%) it was partial. Of the 10 patients that presented with mild paralysis,

7 (70%) had a total paralysis; in three the paralysis remained partial but of a worse degree after surgery. Finally, all patients who presented with moderate or total paralysis had total paralysis after surgery (Table 13).

In the benign lesion group, there was no difference in facial nerve outcome when familial (23 cases) versus nonfamilial (166) glomus cases were compared. Similarly, when recurrent (160) versus nonrecurrent (57) cases were compared, the overall results in facial nerve outcome were not significantly different (Table 19).

Table 12. Facial Nerve Outcome in Benign Lateral Skull Base Surgery According to Type of Intraoperative Management

	<i>Good</i>		<i>Fair</i>		<i>Poor</i>	
	<i>Number of Patients</i>	<i>Percent</i>	<i>Number of Patients</i>	<i>Percent</i>	<i>Number of Patients</i>	<i>Percent</i>
In situ	6				2	
Short	53	92%	4	7%	1	1%
Long	33	66%	17	34%	0	0%
Extreme	19	38%	26	52%	6	12%
Cut and reanastomosed	2	9%	12	52%	9	39%
Cut and grafted	1	5%	10	55%	8	44%

Table 13. Fate of Facial Nerve Function in Relation to Preoperative Facial Nerve Status in Malignant Skull Base Disease

<i>Preoperative Function</i>	<i>Number of Patients</i>	<i>Postoperative Total Paralysis</i>	<i>Postoperative Partial Paralysis</i>
No paralysis	52	16	9
Mild paralysis	10	7	3
Moderate paralysis	5	5	0
Total paralysis	14	14	0

Table 14. Paralysis Incidence, Cranial Nerve (CN) other than Cranial Nerves VII and VIII in the Benign Lateral Skull Base Group of Patients

<i>Cranial Nerve</i>	<i>Number of Patients</i>	<i>Percent</i>	<i>Number of CNs</i>	<i>Number of Patients</i>	<i>Percent</i>
III	1	0.5%	None	48	22%
V	17	8%	One	33	15%
VI	11	5%	Two	31	14%
IX	144	66%	Three	18	8%
X	131	60%	Four	75	35%
XI	101	46%	Five	7	3%
XII	96	44%	Six	4	2%

Other Cranial Nerves

Postoperative deficits involving cranial nerves other than VII and VIII were observed in 169 (78%) cases. (Table 14) In the benign lesion group, deficits involving nerves other than cranial nerves VII and VIII were observed in 64 (71%) patients.

DISCUSSION

Fisch reviewed and classified a large number of patients according to operative management, defined as infratemporal fossa approaches type A, B, and C. A variety of histopathologic lesions were included in his series. A limited experience with malignancies, including recurrent nasopharyngeal cancer as well as chordoma and adenoid cystic carcinoma, are discussed for survival with favorable preliminary results. Complications are mentioned but specific follow-up on outcome is not offered.¹⁸ Schwaber discusses preventive intervention at the same sitting for vagal paralysis when this has occurred during extirpation.¹⁹ Poe and Jackson in their report on the long-term results of skull base surgery find no significant problems such as the need for prolonged tracheostomy or feeding tubes in a cohort of 58 patients followed up for more than 5 years.²⁰ Janecka reported the facial translocation approach on 12 patients and outlined the advantages of access to the infratemporal fossa in 1990.²¹ He later reviewed 183 cases comprising 118 malignant tumors and 50 benign skull base lesions. In this series, overall survival was 63%, with benign disease having a survival of 72%; mortality was 2% and the complication rate was 33%, with a Karnofsky score average of 83.²² Krespi, in treating 62 cases of lateral skull base malignancy, believes that surgery offers palliation and improvement in the quality of life.²³

Radiotherapy as a primary modality for malignant lateral skull base disease fails to control disease progression and has overall poor results.²⁴ The results of this treatment are comparable to debulking surgery.²⁵ Its value as combined modality treatment with surgery for lateral skull base malignancy has not been proven con-

clusively, although it is frequently employed as adjuvant therapy.²⁶ In selected histopathologic entities, such as chordoma and squamous cell carcinoma, radiotherapy has been shown to be of significant value when used as adjuvant therapy to surgery.²⁷ More recent developments in radiation modalities have included charged particle irradiation for skull base lesions, with promising results.²⁸

In benign lateral skull base disease, radiotherapy as a primary modality is far more controversial. Lack of long-term follow-up, induction of secondary malignancies, and long-term effects on craniofacial growth are still unresolved issues.²⁹

Chemotherapy for lateral skull base malignancy has had limited application. In one of the few such reports, Dreyfuss et al treated 18 patients with recurrent salivary malignancies involving the skull base.³⁰ As with our limited number of patients receiving chemotherapy for malignant disease, the study is biased against this modality and predictably the results are disappointing. Other authors have stressed the outcome and surgical approach to specific disease entities. Desgeorges et al report in their review of 125 petroclival meningiomas a complete tumor removal in 88% of their cases with a mortality of 3.7%.³¹ This is pertinent to this study, which includes a total of 21 such cases managed by similar surgical techniques. Samii et al reports a similar experience with 36 cases of petroclival meningiomas.³² A tumor control rate of 75% was achieved and minimal morbidity is described.

Glomus tumors constitute a substantial proportion of lateral skull base lesions. The complexity of their management relates to their infiltrative nature, involving vital neurovascular structures, and their vascular nature.³³ Many of the refinements in the preoperative preparation of patients, such as embolization of feeding vessels and balloon occlusion studies of the carotid, were first applied for the investigation and management of these lesions and subsequently adapted to other pathologic processes.^{34,35} When glomus tumors are managed inadequately, they recur. The recurrence patterns differ from those of primary tumors because the anatomy has been altered surgically. In addition, symptoms appear late because cranial nerve deficits from the preceding

intervention(s) mask advancing lesions. In a long-term study of an early surgical experience in 231 patients, Brown reports an overall 14% rate of recurrent or residual tumors at 10-year follow-up with a 7% mortality due to disease.³⁶ Glomus tumors account for a significant proportion of the cases in this report. Our criteria for inclusion in this study was preoperative intent and plan to a skull base approach. Therefore, a significant number of glomus cases were excluded from this study, providing a bias toward extensive glomus lesions. With management of increasing numbers of glomus tumors, the awareness of multiple lesions and their significance in the decision-making process became more clear. The proportion of multicentric occurrence is estimated to be 8.6%.³⁷ In the Otology Group series, the multicentric occurrence was 14% and catecholamine-secreting tumors made up 4.2% of all glomus tumors. Preoperative evaluation for such a possibility is important because a life-threatening situation may arise at induction of anesthesia or intraoperatively.

The two classification systems that are in wide use today for glomus tumors are the Fisch and Glasscock-Jackson systems. Fisch classifies the operations for skull base lesions based on extent along the petrous carotid and according to presence and size of intracranial extension.³⁸⁻⁴⁰ The Glasscock-Jackson classification ascribes more emphasis to the medial extent of the tumor. In the Fisch classification system, a more accurate staging is afforded for the petrous carotid. This may be important in selective preoperative use of balloon occlusion studies of the carotid artery. The Fisch classification also allows for a more detailed description of the level of intracranial involvement, making a distinction between extradural or intradural tumor spread. In our patients, balloon occlusion studies are routinely performed if there is suspicion of carotid involvement. In addition, our results have not shown any difference between extradural or intradural involvement unless there is more extensive involvement of cranial nerve root entry zones or the lesion is malignant. Overall, the two classification systems take a slightly different approach but are complementary rather than contradictory. All stageable tumors in this study were classified by both systems. These included a number of non-glomus tumors whose extent could be best described by the above classification systems. No significant difference was noted in the type of operations patients underwent according to the class of tumor ascribed to them by either system.

Our approach, like that of Fisch, is that the primary thrust of the surgical effort at lateral skull base surgery is provided via the infratemporal fossa approach. More recent approaches have focused on extending the exposures to the foramen magnum via an extreme lateral approach.⁴¹ The petrous carotid artery, which has always been a barrier to resectability and safety in skull base surgery, is beginning to yield to ever-safer techniques of

management. The use of saphenous vein grafts to bypass the carotid and microsurgical exposure of the proximal and distal intracavernous segments have allowed this surgical flexibility.^{42,43} In this report, the full gamut of methods of surgical extirpation was utilized. Very often approaches were combined to provide exposure for advanced lesions. This is particularly true in recurrent tumors and in malignancy of the lateral skull base.

Complications were observed frequently in this type of surgery. The overall rate of complications was similar for both benign and malignant lesion groups (22% vs 21%). Wound complication rates were identical in both groups (7.4%), and the CSF leak rate was similar in both groups (10% in benign vs 6.2% in malignant). The operative mortality rate as well as the cerebrovascular complication rate was higher for malignant cases (4% mortality in malignant vs 1.4% in benign, 2.5% stroke rate in malignant vs 0.9% in benign). The majority of these complications, especially those leading to permanent deficits, were observed in cases prior to 1988. Operations done following this year utilized techniques similar to those used today: free flaps for tissue defects, primary phonosurgery, and avoidance of tracheostomy and gastrostomy tubes.

CONCLUSIONS

An overview of one of the largest lateral skull base series is presented in this report. The histopathological features of these cases were varied and approximately one fourth of the cases included malignancies.

Malignancy most commonly presents as otorrhea, whereas benign lesions present as tinnitus. Subtle signs from a carefully taken history and thorough examination will reveal cranial nerve deficits. Hearing loss of increasing severity was more common in the group of patients with benign lesions. Cranial nerve deficits at presentation were also more common in this group.

Surgical approaches were varied and tailored to the individual lesion in order to achieve complete extirpation. The primary operation for malignant lesions was a temporal bone resection; for the benign lesions, it was an infratemporal fossa approach.

The outcome for these groups varied. In the benign lesion group, the failure rate was 17%. Failure in this group was not necessarily related to rapid demise; instead prolonged survivals were observed in recurrent cases. The malignant lesion group had a failure rate of 42%. Failure in this group of patients was equated often with rapid demise from uncontrolled disease progression. Cranial nerve deficits other than those involving the facial nerve were found preoperatively and postoperatively in a smaller proportion of malignant cases than benign cases. The reverse was true for the facial nerve, which was more frequently permanently and totally paralyzed after operations for malignancy.

Complications and permanent deficits were similar in both groups of patients.

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