Anterior and Posterior Facial Nerve Rerouting: A Comparative Study

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ABSTRACT

The infratemporal fossa type A (IFT-A) and the modified transcochlear approach are used to remove glomus jugular tumors type C and petroclival tumors extending to the prepontine cistern, respectively. Anterior rerouting is a key step in IFT-A, whereas the modified transcochlear approach involves posterior rerouting. The aim of this study was to analyze facial nerve function after application of the two procedures. One year after surgery, anterior rerouting was associated with excellent to good outcomes (grade I to III) in 94% of the cases, while posterior rerouting was associated with good outcomes (grade III) in 70% of the cases.

KEYWORDS: Anterior rerouting, posterior rerouting, skull base surgery

Both the infratemporal fossa type A (IFT-A) and the modified transcochlear approaches require rerouting of the facial nerve to maximize the surgical exposure. IFT-A was introduced by Fisch¹ in 1978. The intratemporal portion of the facial nerve and the middle ear obstruct complete exposure of the jugular foramen area and the vertical portion of the internal carotid artery (ICA). Consequently, in this procedure, the middle ear contents must be removed, and the nerve must be rerouted. These maneuvers permit wide access to the jugular foramen and the infralabyrinthine and apical compartments of the temporal bone. Control over the intrapetrous verti-

cal segment of the ICA and the posterior fossa dura can also be obtained. The technique is described in detail elsewhere.¹

Two different techniques of anterior rerouting are described in the literature: long and short rerouting.² In the long anterior rerouting technique, the facial nerve is mobilized along its entire mastoid and tympanic course up to the geniculate ganglion. The external auditory canal (EAC), tympanic membrane, and ossicular chain are removed. This technique is used during the IFT-A and is indicated for glomus tumors. In the short rerouting technique, the facial nerve is mobilized from the stylomastoid

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foramen to the second genu, leaving the EAC and middle ear in place.

The transcochlear approach, initially described by House and Hitselberger in 1976³ and modified by Sekhar and Estonillo in 1986,⁴ entails posterior rerouting of the facial nerve. In 1992 Sanna and colleagues^{5,6} proposed further modifications and combinations with other approaches—the system of modified transcochlear approaches, which are detailed elsewhere.^{7,8} In all these procedures the facial nerve is the main obstacle to the anterior extension of the approach. Posterior rerouting is mandatory to achieve the widest access to the clivus up to pre-pontine cistern. The main advantage of the modified transcochlear approaches as compared with the retrolabyrinthine-subtemporal approaches is the ability to obtain a shallower surgical field with direct access to the tumor with minimal cerebellar and temporal lobe retraction.^{9,10}

The modality used to reroute the facial nerve has a direct bearing on the final functional outcome. The results in the literature show that better facial nerve outcomes are associated with the anterior than the posterior technique of rerouting. This study compared the experience of the Gruppo Otologico, Piacenza-Rome, Italy, with anterior and posterior rerouting with the outcomes of other studies in the literature.

MATERIALS AND METHODS

Between March 1986 and December 2001, the facial nerve was anteriorly rerouted in 54 patients (34 females, 20 males; mean age, 46.6 years; range, 17 to 63 years). There were 44 tympanojugular paragangliomas (17 in class C and 27 in class CD), 4 neurinomas of the lower cranial nerves, 2 glomus vagale tumors, 1 meningioma of the foramen lacerum, 1 cholesteatoma of the petrous bone extending to the sphenoid sinus, 1 endolymphatic sac tumor, and 1 neurinoma of the trigeminal nerve. During the same period, the facial nerve was rerouted posteriorly in 17 cases (11 females, 6 males; mean age, 46.3 years;

range, 17 to 66 years). The pathology consisted of 14 petroclival meningiomas, 2 clival chordomas, and 1 posterior fossa epidermoid involving the pre-pontine cistern. Sixteen patients underwent the type A and one underwent the type B modified transcochlear approach.

Facial nerve function was evaluated according to the House-Brackmann grading system¹¹ (H-B) before and at least 1 year after surgery. In all cases facial nerve function was monitored intraoperatively using both pneumatic (Myo Alarm) and electromyographic systems (NIM-2). Patients lacking complete medical records or a minimum follow-up of 1 year were excluded from the study.

RESULTS

Of the 54 patients undergoing anterior rerouting of the facial nerve, two patients were lost to follow-up and one was excluded because of preoperative grade IV facial nerve deficit. In the other 51 cases, preoperative facial nerve function was normal (grade I). The postoperative facial nerve function of these 51 patients was as follows: 33 patients (64.7%) had excellent outcomes (H-B grade I or II), 15 patients (29.4%) had grade III outcomes, 2 patients (3.9%) had grade IV and outcomes, and 1 patient (1.9%) had a grade VI outcome (Fig. 1). Gross total tumor removal was achieved in 88% of the cases and subtotal removal was achieved in 12% of the cases.

Preoperative facial nerve function was normal (grade I) in all 17 patients who underwent posterior rerouting, and all had grade VI function at discharge. At their 1-year follow-up examination, 12 patients had grade III (70.5%) function, 3 had grade IV (17.6%) function, 1 had grade V (5.8%) function, and 1 had grade VI (5.8%) function (Fig. 2). Gross total tumor removal was achieved in 56% of the cases and subtotal removal was achieved in 44% of the cases. At another center, one patient had previously undergone partial removal of a clival chordoma through an anterior approach followed by radiotherapy.

Figure 1 Postoperative facial nerve function of 51 patients 1 year after anterior rerouting.

DISCUSSION

Anterior Rerouting

The anterior rerouting of the facial nerve is a fundamental step of the IFT-A. This approach is used to remove type C and type D paragangliomas (Fisch classification¹²). On the basis of data available in the literature (Table 1), it is obvious that the facial nerve function is the same after both short and long

anterior rerouting (and sometimes in favor of short rerouting). This finding, however, does not permit the conclusion that facial nerve rerouting should be limited to its least possible length.

Considering the percentage of total tumor removal alters the picture significantly. Using long anterior rerouting, Fisch¹ achieved total tumor removal in 82% of his cases and maintained excellent facial nerve function in 85%. Using the same method, Moe¹³ and associates reported total tumor removal

Figure 2 Postoperative facial nerve function of 17 patients 1 year after posterior rerouting. *FN involved resection of the perineurium; °preoperative radiotherapy.

Table 1 Comparison of Postoperative Facial Nerve Function in Various Series Using Different Methods of Facial Nerve Rerouting

Author	HB Grade	% Patients	% Patients with Grade I-II
<i>Short Anterior Rerouting</i>			
Spector et al ¹⁵	I-II	82.9	82.9
	VI	14.3	
Farrior [†]	I-II	94.1	94.1
Cece [‡]	I	100.0	100.0
<i>Long Anterior Rerouting</i>			
Brackmann ^{*30}	I	50.0	85.0
	II	35.0	
	III	5.0	
	IV	10.0 (postop radiotherapy)	
Poe [§]	I	15.6	56.2
	II	40.6	
	III	28.1	
	IV	9.4	
Woods	V	6.2	59.4
	I	16.2	
	II	43.2	
	III	29.7	
Green et al ¹⁴	V	2.7	95.0
	I	67.5	
	II	27.5	
	III	5.0	
Moe et al ¹³	I	69.2	88.4
	II	19.2	
	III	9.6	
	IV	2.0	
Russo et al, present study	I	23.5	64.7
	II	41.2	
	III	29.4	
	IV	3.9	
	VI	1.9	

in almost 80% of their patients and maintained grade I to II function in almost 88% of the cases. Green and colleagues¹⁴ achieved total tumor removal in 85% with excellent facial nerve function in 95% of the cases. We achieved total tumor removal in 88% of our cases, but only 64% of the patients were grade I to II. In contrast, Spector et al¹⁵ achieved grade I to II facial nerve function in almost 83% of their cases using short anterior rerouting, but achieved total removal in only 78%.

To quote Fisch,¹⁶ "... the larger exposure given by a permanent long anterior rerouting of the facial nerve allows radical resection of often underestimated tumor invasions within spongiotic areas of the temporal bone that appear at first sight to be clear of tumor." This insight automatically sets the priorities for the surgeon as envisaged by Jackson.¹⁷ According to Jackson, surgeons dealing with these tumors have the following goals: (a) the patient's survival, (b) total tumor removal, (c) access to the

Table 1 (Continued)

Author	HB Grade	% Patients	% Patients with Grade I-II
<i>Posterior Rerouting</i>			
Thedinger et al ¹⁰	III	66.7	00.0
	IV	22.2	
	V	11.1	
Arriaga et al ²⁵	I-II	30.0	30.0
	III-IV	40.0	
	V-VI	30.0	
Cass et al ²⁶	I	14.3	21.4
	II	7.1	
	III	50.0	
	IV	21.4	
	V-VI	7.1	
Russo, present study	III	70.5	00.0
	IV	17.6	
	V	5.8	
	VI	5.8	

Some data compiled and modified from Selesnick SH et al.²

*1 patient each of grades V and VI not included because they received preop radiotherapy.

¹Farrior JB. Infratemporal approach to skull base for glomus tumors: anatomic considerations. *Ann Otol Rhinol Laryngol* 1984;93:616-622.

²Ceje JA, Lawson W, Biller HF, Eden AR, Parisier SC. Complications in the management of large glomus jugulare tumors. *Laryngoscope* 1987;97:152-157.

³Poe DS, Jackson CG, Glasscock ME III, Johnson GD. Long-term results after lateral cranial base surgery. *Laryngoscope* 1991;101:372-378.

¹⁰Woods CI, Strasnick B, Jackson CG. Surgery for glomus tumors: the otology group experience. *Laryngoscope* 1993;103:65-70.

ICA, and (d) preservation of normal anatomy and function (lower cranial nerves, facial nerve, and hearing). This ranking of priorities makes it very clear that total tumor removal should receive preference over preservation of cranial nerve function. Another advantage of long anterior rerouting is that if the patient requires a revision surgery, there is no risk of damaging the nerve. In contrast, with short anterior rerouting the mastoid segment of the facial nerve could be stretched. Moreover, when combined with preservation of the posterior wall of the EAC, this approach limits surgical access.

Pensak and Jackler¹⁸ advocate complete removal of class C1 paragangliomas without anterior rerouting of the facial nerve using the fallopian bridge technique. They particularly believe in extending a posterior tympanotomy inferiorly (hypotympanotomy) combined with a subfacial tympanotomy

without transposition of the nerve to obtain adequate control of bleeding and to remove the tumor. In our opinion, the fallopian bridge technique is indicated for the removal of nonvascular pathology of the jugular foramen such as lower cranial nerve schwannomas and meningiomas. These tumors do not infiltrate the surrounding periosteum or adventitia of the ICA and are therefore easy to remove.^{19,20} For class C paragangliomas, we prefer to reroute the facial nerve anteriorly because these tumors have a high tendency to infiltrate bone. Wide bone removal is mandatory to prevent tumor recurrence. Anterior rerouting enables complete control over the entire intrapetrous ICA and jugular bulb. Furthermore, preoperative radiological findings do not always correspond to intraoperative findings.

As advocated by Fisch,¹ our treatment protocol for C1 paragangliomas is to perform an IFT-A.

We prepare for the same approach for tumors that appear to be class B on preoperative evaluation in case they are found to be C1 at surgery. Finally, surgeons must realize the risks involved in changing to an anterior rerouting from a fallopian bridge technique. The facial nerve, skeletonized and left in its cavity during fallopian bridge technique, is particularly delicate and liable to interruption when a shift to anterior rerouting is necessary. The surgical treatment of tympanojugular paragangliomas is quite different from that of cholesterol granulomas of the petrous apex or neurinomas/meningiomas of the lower cranial nerves. Despite prior embolization of these tumors there is a possibility of subtotal removal and excessive intraoperative bleeding. Pensak and Jackler¹⁸ reported the rate of gross total removal with the fallopian bridge technique as 71%, but we achieved gross total removal in 88% of our cases using complete anterior rerouting.

We do not use the above approaches to remove neurinomas arising from the lower cranial nerves and meningiomas limited to the posterior part of the jugular foramen. For such tumors we use the petro-occipital trans-sigmoid approach,²⁰⁻²² which allows the tumor to be removed in one stage without anterior rerouting of the facial nerve. Conductive hearing loss related to blind closure of the EAC is avoided.

Posterior Rerouting

Posterior rerouting of the facial nerve is a key step in modified transcochlear approaches. All the tumors treated with these approaches were intradural and located in the prepontine cistern. Because of their deep location in the median skull base, access has been the main problem in their management. The modified transcochlear approach offers the most direct route to the central skull base in addition to a flat working angle and a wide surgical field. This approach provides excellent visibility and hence safer tumor resection. With intradural tumors this approach enables the surgeon to obtain optimal con-

trol of the prepontine cistern, without cerebellar or brain retraction.^{5,6,10,23,24} Posterior rerouting of the facial nerve is an important step because the nerve represents an obstacle to the anterior extension and total control of the ICA. The disadvantages of the procedure are hearing loss and facial nerve palsy.^{8,10,23,25}

After 1 year in our series, 70.5% of patients had grade III facial nerve function. Despite these inevitable consequences, gross total tumor removal was possible in 56% of the cases while subtotal removal was achieved in 44%. Although none of our patients obtained grade I or II facial nerve function, some exceptional cases have been reported^{25,26} (Table 1). Cass et al²⁶ achieved total tumor removal in 53% of the cases using total petrosectomy and posterior rerouting of the nerve, and 71% of the patients had grade III or better facial nerve function. Thedinger and colleagues¹⁰ achieved complete tumor removal in 89% of their cases, and 66.7% had grade III facial nerve function. Finally, Arriaga and associates²⁵ completely resected 80% of the tumors in their series, and 70% obtained a grade IV or better.

To protect the delicate intrameatal part of the nerve and its vascularization, we suggest rerouting the nerve with the dura and all the contents of the internal auditory canal. The dissection of the mastoid segment of the nerve is also important. Intraoperative monitoring of the facial nerve is an essential tool that enables the surgeon to manage the nerve during these delicate procedures. Electromyographic potentials in the form of spikes, bursts, and trains are transformed into sounds that immediately alert the surgeon regarding the condition of the nerve.^{27,28} Despite these precautions, the final outcome of the facial nerve is typically poor after posterior rerouting because the blood supply to the geniculate ganglion is compromised.

A surgical alternative to the modified transcochlear approach might be the retrolabyrinthine-subtemporal-transtentorial approach.²⁹ However, this alternative offers limited exposure due to the presence of an intact middle ear, otic capsule, and inter-

nal auditory canal. Other drawbacks of this approach are the need for cerebellar and temporal lobe retraction, the potential of damaging the vein of Labbé, the sharp angle of view to the midclivus, and the difficulty visualizing the dissection plane between the brainstem and the tumor.

Any study of this type is constrained by the subjective nature of evaluating the function of the facial nerve as highlighted by previous reports.² This limitation should be considered when evaluating these studies.

CONCLUSION

The IFT-A is the best approach for resecting tympanojugular class C paragangliomas. Anterior rerouting of the facial nerve, the key step in this approach, gives the surgeon good control of the intrapetrous portion of the ICA and allows bone infiltrated by the pathology of the jugular foramen to be removed. Furthermore, it enables any bleeding that might occur despite preoperative embolization to be controlled. Complete anterior rerouting, especially if performed competently, can be expected to ensure an excellent or good functional outcome (grade I to III) in 94% of the cases.

The modified transcochlear approach with posterior rerouting of the facial nerve offers the most direct access to the central skull base. It enables the surgeon to work in a shallow and wide surgical field associated with an excellent view of the region to ensure safe tumor removal. It provides optimal control over the prepontine cistern without necessitating cerebellar or brain retraction. Posterior rerouting of the facial nerve is associated with an immediate postoperative function of grade VI. One year after surgery, however, function may be expected to recover to grade III in 70% of cases. Facial palsy and hearing loss are considered the minimal price that must be paid for a safe removal of the tumor while minimizing overall morbidity and mortality.

Overall, the rerouting technique makes it possible to remove skull base tumors previously considered inoperable and to obtain excellent or good results with anterior rerouting and good results with posterior rerouting of the facial nerve.

FUNDING

This paper was supported by a grant from A.S.A.B. (Associazione Studio Aggiornamento Basicranio).

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