Surgical management of the facial nerve in various skull base pathologies through different lateral skull base approaches

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Objective
The aim of the present study was to demonstrate facial nerve (FN) outcomes in various skull base pathologies managed through different lateral skull base approaches.
Materials and methods
This retrospective study was conducted on 20 patients admitted to the ENT outpatient clinic of a tertiary referral center. All patients presented with different skull base lesions with or without FN involvement. A full preoperative assessment was carried out, including the House–Brackmann (HB) FN grading scale. Surgical techniques used to manage the FN depended on the surgical approach and the extent of the pathological lesion in the form of FN identification and monitoring, decompression, intact fallopian bridge technique, rerouting, anastomosis, or scarification. FN functional integrity was assessed 1 month and 1 year postoperatively using the House–Brackmann scale to assess different surgical techniques used to manage the FN and their effects on postoperative FN function.
Results
Half of the patients had glomus jugulare tumor, which were mostly managed through infratemporal fossa type A approach. At 1 month postoperatively, no great improvement was found in FN function in most of the cases. After 1 year, the improvement was statistically significant.
Conclusion
One year postoperatively could give idea of the FN surgical outcome. Grade III was the best result achieved in cases of FN grafting and anastomosis. In the present study, FN intact techniques were the most useful to yield better results than were grafting and anastomosis when the circumstances and extension of the pathology allow the surgeon to use such techniques.

Keywords:
facial nerve, glomus tumor, House–Brackmann grading scale, lateral skull base approaches

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Introduction

Facial paralysis is a potentially devastating disorder. Little impairment has a more negative effect on socioeconomic capacity and psychology in the individuals' life [1]. Paralysis may result from infection, tumor growth, trauma, and several other causes.

Diagnostic tools, such as electroneurography, high-resolution computerized tomographic scanning, and MRI, provide more precise assessment and localization of nerve injuries in many disorders. This has allowed more accurate preoperative planning and the selection of best surgical approach according to the site of nerve involvement [2].

Indication for facial nerve (FN) exploration and repair in cases of trauma are well defined, in contrast to paralysis to infectious or neoplastic causes [3]. If there is strong evidence after head trauma that the nerve has been transected, including a sudden onset of complete paralysis, loss of electrical activity by electroneurography, surgical exploration, and decompression are warranted [4]. Whereas indication for exploration and decompression in case of neoplastic causes depend on the tumor location and extension, as well as the hearing status in both ears [3].

Refinements of surgical strategies and advancement of surgical instrumentation have enabled the neuro-otologist to expose safely the entire course of the FN from the brain stem to its exit from the temporal bone. However, surgical management of FN disorders continues to be controversial [5].

Many surgical approaches or combination of two or more approaches can be used when full exposure of the entire course of the FN is needed. Each approach has

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specific advantages and disadvantages [6]. The decision to select a surgical approach depends on the anatomic location of the lesion, its extent, and the hearing status in both ears. And still, timing of surgical intervention presents another dilemma [7]. The purpose of the study was to demonstrate FN outcome in various skull base pathologies managed through different lateral skull base approaches.

Materials and methods

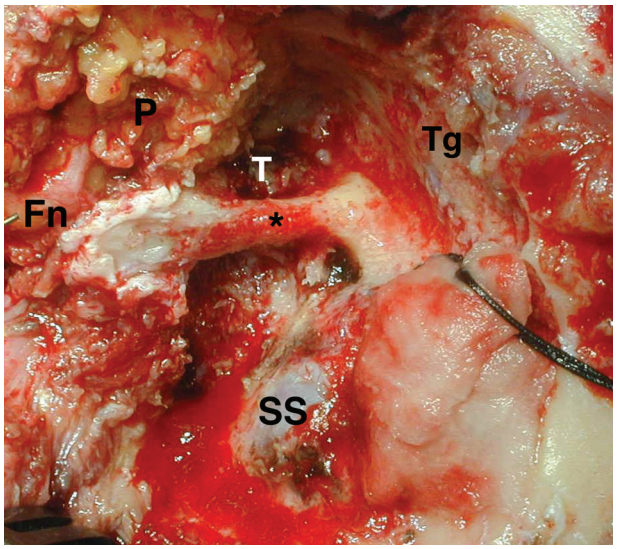
This retrospective study was conducted on the records of 20 patients admitted to the ENT outpatient clinic of a tertiary referral center in the period from October 2010 to January 2012. All patients presented with skull base lesions, either traumatic or neoplastic in origin with or without FN involvement. Inflammatory FN lesions were excluded from the study.

The protocol of the study was approved by the Ethical Committee of the Faculty of Medicine, and all patients signed a written consent before participating in the study.

All patients were subjected to the preoperative evaluation including detailed history with special concern of onset, course, and degree of facial paralysis, thorough otoneurological examination, and clinical House–Brackmann (HB) grading scale assessment [8]. Preoperative audiogram and radiological investigations including computed tomography (CT) petrous bone, MRI of posterior fossa, and cerebellopontine angle (CPA) with gadolinium and vascular study for suspected vascular lesions were mandatory with or without a preoperative electrophysiological study. Surgical steps and drawbacks were explained to the patients.

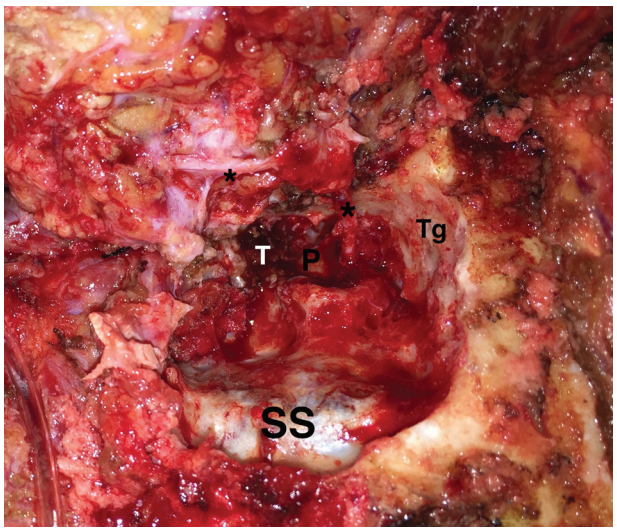
Different lateral skull base approaches were selected according to the type, anatomical location, and extent of the pathology, hearing status, and degree of FN involvement. Glomus jugulare tumors (GJTs) were handled through either infratemporal type A approach [9,10] for large tumors or transmastoid approach for small ones. The FN in such lesions was managed either by intact fallopian bridge technique (Fig. 1) or anterior transposition (Fig. 2) or was being killed [11]. Acoustic neuromas were managed through translabyrinthine approach where FN was identified and monitored [12]. Petrous apex cholesteatomas (PAC) underwent either subtotal petrosectomy [13] with intact fallopian bridge technique or a transcochlear approach for extensive cases [14]. Traumatic cases were managed through either middle cranial fossa [15] or transmastoid approaches [16].

Figure 1



Left infratemporal fossa approach for glomus jugulare tumor (T) showing: intact fallopian bridge technique (*), sigmoid sinus (SS), extratemporal facial nerve (Fn), parotid gland (P), and tegmen (Tg)

Figure 2



Left infratemporal fossa approach for glomus jugulare tumor (T) showing: anterior rerouting of the facial nerve (*), sigmoid sinus (SS), promontory (P), and tegmen (Tg)

In this situation, FN was only decompressed or decompressed and anastomosed using cable graft or end-to-end anastomosis [17]. Parotid adenoid cystic carcinoma was excised using the total parotidectomy approach and FN was killed [18]. Clinical grading of FN surgical outcome [8] was evaluated during the postoperative period.

For statistical analyses of the results, data were fed to the computer using the Predictive Analytics Software [PASW Statistics 18; formerly SPSS Statistics (Hong Kong) Ltd, Quuarry Bay, Hong Kong]. Qualitative

data were described using number and percent. Association between categorical variables was tested using the χ^2-test. When more than 20% of the cells had an expected count less than 5, correction for χ^2 was conducted using Fisher's Exact test or the Monte Carlo correction. Quantitative data were described using median, minimum, and maximum, as well as mean and SD. Significant test results were quoted as two-tailed probabilities. The level of significance was set at 5%.

Results

This work included 20 patients (seven men and 13 women) with different skull base pathologies aged between 16 and 60 years old with mean age of 33 years old.

Patients had different presenting symptoms; the most frequent symptom was facial paralysis in 16 cases (five acute and 11 chronic). Their preoperative HB scale was normal in four patients (grade I), grade II–III in three patients, seven presented with grade IV palsy, whereas the remaining six patients had grade V–VI facial paralysis.

The second symptom was hearing loss in 16 cases (eight sensorineural hearing loss, four conductive hearing loss, and four mixed hearing loss). The four cases with normal hearing presented with early glomus jugulare (two cases), one had adenoid cystic parotid carcinoma, and the last one presented with traumatic longitudinal fracture. Other clinical presentations included tinnitus (13 cases), middle ear mass by otoscopy (five cases), and lower cranial nerves deficit (four cases).

All cases underwent radiological evaluation in the form of multislice CT scan petrous bone with or without MRI CPA, posterior fossa and inner ears with or without gadolinium, to know the exact location, type of pathology, size, and extension of the disease. According to the previous clinical presentation and radiological findings, variable skull base pathologies affecting the FN were diagnosed and the most appropriate surgical approach was selected.

Ten cases had GJT with different pathological extensions, as described in Table 1, in light of the radiological evaluation and Fisch classification of GJT [19]. The four traumatic cases distributed as follows; three had longitudinal fracture; two of them passing through external auditory canal and the tegmen toward the perigeniculate area, and in the third one the fracture line passed through the tympanic segment. The fourth patient presented with a transverse fracture passing through geniculate ganglion. The last six cases had different pathological lesions; two had intracanalicular acoustic neuroma, two cases had congenital PAC eroding the internal auditory canal and superior semicircular canal, a case of adenoid cystic parotid gland carcinoma with perineural invasion, and the last one was FN neuroma case involving the tympanic segment.

Regarding the appropriate surgical approach, Fisch infratemporal fossa type A approach was the most commonly used (other approaches are demonstrated in Table 2). Different surgical strategies were used to manage FN according to the different pathological lesions (Table 3).

Table 1 Description of the glomus cases' pathological extension in light of radiological findings and Fish's classification [19]

Glomus jugulare	*n* (%)
C_2	3 (30.0)
C_2 De_1	1 (10.0)
C_3	2 (20.0)
C_3 Di_1	1 (10.0)
C_3 De_1 Di_2	2 (20.0)
C_3 De_2 Di_1	1 (10.0)

Table 2 Surgical approaches used in the studied cases

Approaches	*n* (%)
Infratemporal fossa type A	9 (45.0)
Translabryinthine tumor excision	3 (15.0)
MCF FN decompression	2 (10.0)
Transmastoid FN decompression	2 (10.0)
Transchoclear excision	1 (5.0)
Transmastoid tumor excision	1 (5.0)
Subtotal petrosectomy	1 (5.0)
Total parotidectomy	1 (5.0)

FN, facial nerve; MCF, middle cranial fossa.

Table 3 Surgical management of facial nerve according to type of pathology

Surgical management of FN	*n* (%)	Type of pathology
Left intact	9 (45)	
Intact fallopian bridge	5 (25)	GJT (4)+PAC
Identified and monitored	2 (10)	Acoustic neuroma
Decompressed	2 (10)	Longitudinal F of TB
Anastomosed	5 (25)	
Graft anastomosed	4 (20)	GJT (2)+transverse F+FN neuroma
End-to-end anastomosed	1 (5)	Longitudinal F of TB
FN killed	4 (20)	GJT (2)+parotid cancer+PAC
Anterior transposed	2 (10)	GJT

F, fracture; FN, facial nerve; GJT, glomus jugulare tumor; PAC, petrous apex cholesteatoma; TB, temporal bone.

FN functional integrity was assessed 1 month and 1 year postoperatively using the HB grading scale to evaluate and compare different surgical techniques used to manage the FN and their effect on the postoperative function. At 1 month postoperatively, there was no great improvement in FN function as most cases had grade IV–VI on the HB scale (14 cases) and the remaining cases (six cases) were between grade II and IV, whereas at 1 year postoperatively, FN function greatly improved as five cases had grade I, five cases had grade II, four cases had grade III, two cases had grade IV, and the remaining four cases had grade VI, in which FN was already killed. This improvement after 1 year was statistically significant in relation to the surgical approach used to manage the FN (Table 4).

Discussion

Most surgeries of the skull base lesions require extensive posterolateral dissection. Effective management of the FN and major vessels of the petroccipital skull base is indispensable to obtain a successful surgical outcome after effective management of skull base lesions [20].

The FN represents an anatomic obstacle to surgical exposure of these lesions and their complete resection. The management options for the FN include a simple exposure, partial or complete mobilization, and segmental resection. Lesion size and control of the distal internal carotid artery are the main factors that determine FN management [21].

This retrospective study included 20 patients of various skull base pathologies with or without FN palsy. Half of them had GJT, followed by 20% with traumatic temporal bone fractures, 10% with acoustic neuroma, 10% with congenital cholesteatoma, a case of FN neuroma, and, lastly, parotid carcinoma case. Similar retrospective studies were also conducted by other authors on variable skull base pathologies [22–24]. Leonetti [22] had 44 cases; 40% were parotid carcinomas, 27% temporal bone tumors, and 20% glomus jugulare. El Shazly *et al.* [23] had 36 cases; 78% were glomus jugulare, 11% glomus tympanicum, and 11% congenital cholesteatoma. Gierek *et al.* [24] had 31 cases; 58% were congenital cholesteatoma and 42% traumatic temporal bone fractures. On the other hand, Pareschi *et al.* [20] and Hato *et al.* [25] advocated the same issue in their retrospective studies but they had chosen one lesion for their cases. Pareschi *et al.* [22] worked on glomus cases (80% glomus jugulare), whereas Hato *et al.* [25] conducted the study on patients suffering from different types of temporal bone fractures.

For the presenting symptoms we agreed with Leonetti [22], Gierek *et al.* [24], Hato *et al.* [25], and Shulev *et al.* [26] that facial palsy had been the most frequent presenting symptom. On the other hand, Pareschi *et al.* [20] stated that middle ear mass by otoscopy was the most frequent finding. Whereas El Shazly *et al.* [23] found that prevalence of hearing loss among included cases was the rule.

High-resolution multislice CT petrous bone and/or MRI CPA, posterior fossa and inner ears with or without gadolinium were the rule to evaluate our patients. Other authors [20,27] added a digital subtraction angiography study to complete their assessment. When we applied Fisch classification of glomus tumors [19] on the radiological findings of 10 cases of glomus jugulare we found that 60% were C_3 and the remaining were C_2. In contrast, Pareschi *et al.* [20] found that 76% of their glomus jugulare cases (42 cases) were $C_{1–2}$ and only 24% were $C_{3–4}$.

Management of different skull base lesions was carried out through various lateral skull base approaches. Overall, 45% of our patients underwent infratemporal fossa type A approach for GJTs, 15% were managed through translabyrinthine approach for acoustic neuroma and FN neuroma, 10% had middle cranial fossa FN decompression, whereas transmastoid FN decompression was applied in 10% of traumatic cases. Similarly, Pareschi *et al.* [20] and El Shazly *et al.* [23]

Table 4 Relation between surgical management of facial nerve and postoperative House–Brackmann scale at 1 year

HB scale postoperative 1 year	Surgical techniques				^{MC}P
	Left intact (n=9) [n (%)]	Transposed (n=2) [n (%)]	Anastomosed (n=5) [n (%)]	FN killed (n=4) [n (%)]	
I	5 (55.6)	0 (0.0)	0 (0.0)	0 (0.0)	0.001*
II	2 (22.2)	1 (50.0)	0 (0.0)	0 (0.0)	
III	2 (22.2)	1 (50.0)	1 (20.0)	0 (0.0)	
IV	0 (0.0)	0 (0.0)	4 (80.0)	0 (0.0)	
V	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
VI	0 (0.0)	0 (0.0)	0 (0.0)	4 (100.0)	

FN, facial nerve; HB, House–Brackmann scale; ^{MC}P, P value for Monte Carlo test. *$P \leq 0.05$; statistically significant.

used infratemporal fossa type A approach to manage most of their glomus cases (78 and 76%, respectively). On the other hand, Leonetti [22] managed their parotid cancer cases (40%) by subtotal petrosectomy with total parotidectomy, whereas Gierek *et al.* [24] used subtotal petrosectomy and transmastoid FN decompression for congenital petrous cholesteatoma and traumatic facial paralysis, respectively. Other authors [26,27] advocated only FN decompression through different lateral skull base approaches as the management strategy for either tumor or traumatic lesions. Hato *et al.* [25] stated that the most frequent surgical approach used to manage traumatic facial paralysis was middle cranial fossa FN decompression in 62% of cases, followed by transmastoid FN decompression.

Four different surgical techniques were used to manage the FN in this study: first, FN was left intact in 45% of the cases (25% intact fallopian bridge technique for GJT and PAC, 10% FN identified and monitored in acoustic neuroma cases, and 10% FN was decompressed in longitudinal temporal bone fracture); second, FN was grafted and anastomosed in 25% of the cases (20% cable graft anastomosis in GJT, transverse temporal bone fracture and FN neuroma tumor, the remaining 5% underwent end-to-end anastomosis for longitudinal fracture of the temporal bone); third, FN was killed in 20% (GJT, parotid carcinoma, and PAC); and fourth, FN was anteriorly transposed in 10% of GJT cases. Pareschi *et al.* [20] and El Shazly *et al.* [23] advocated the same techniques that we adopted but with prevalence of anterior transposition of the FN in ~50% of their cases. On the other hand, Ozmen *et al.* [27], Shulev *et al.* [26], and Gierek *et al.* [24] had chosen FN grafting and anastomosis to manage most of their cases. Leonetti *et al.* [22] preferred to use FN grafting and anastomosis in 60% of their cases for traumatic temporal fractures and parotid carcinomas.

In respect to evaluation of FN 1 month postoperatively using the HB scale we found that 70% of cases scored between grade V and VI, whereas the other 30% scored between grade II and IV. On the other hand, 1 year postoperatively the results improved, where 25% of cases scored grade I, 15% grade II, 30% grade III, 10% grade IV, and the last 20% scored grade VI as the nerve was killed in them. Other authors [20,23–27] used the HB scale only 1 year postoperatively to evaluate FN surgical outcome except for Leonetti [22] who used the same scale but 2 years postoperatively. For the FN outcome, Pareschi *et al.* [20] found that 84% of cases scored between grade I and II, also the findings of Gierek *et al.* [24] revealed that 60% of cases scored between grade I and II. Similarly, the findings of Hato *et al.* [25] showed that 50% of cases scored grade I and all the remaining cases scored between grade II and III. In contrast, El Shazly *et al.* [23] found that 71% the of cases scored grade III or worse. Whereas Leonetti [22] and Shulev *et al.* [26] found that all the cases included in their studies scored between grade II and IV with no cases scored grade I or VI and added that grade III had the highest percentages in their results (29 and 44%, respectively).

From the obtained findings we found that 1-month postoperative FN surgical outcome evaluation was not enough to evaluate the surgical techniques used. Whereas 1-year postoperative FN surgical outcome evaluation showed significant improvement. FN intact technique (45% of cases) revealed to have the best results 1 year postoperatively using the HB scale, as 55.6% scored grade I, 22.2% scored grade II, and 22.2% scored grade III. FN anterior transposition scored grade II–III. Whereas FN grafting and anastomosis (25% of cases) scored less grades, as the best achievement was grade III in case of end-to-end anastomosis and grade III–IV in cases of cable graft anastomosis. FN sacrifice led to complete dysfunction score (grade VI). Therefore, overall achievement was 70% grade III or better and 35% grade I–II. Pareschi *et al.* [20] concluded that 1 year postoperatively FN surgical outcome evaluation gives better results as it scored 52% grade I–II for early glomus lesions. In contrast, El Shazly *et al.* [23] concluded that total anterior rerouting of FN carries a high risk for FN paralysis postoperatively even if the anatomical integrity of the nerve is preserved; this is possibly due to excessive handling or devascularization procedure or due to fibrosis in the mastoid cavity, advising to preserve this technique for cases of excessive extensions or great adhesions. Concerning authors [22,24,26,27] advocating FN grafting and anastomosis as the main technique, they all agreed that 1–2 years postoperatively yield the best result that could be scored on the HB scale, which were between grade II and III. But there is controversy on the factors implicated to achieve these results, as Leonetti [22] concluded that 2-year postoperative FN function did not appear to be related to the surgical approach, the tumor histology, and the graft length. Ozmen *et al.* [27] concluded that in cases of traumatic temporal bone fractures, a number of factors were implicated to affect success rate of FN outcome but only the duration of preoperative FN deficit was found to be significant. Thus, the timing of management is critical to achieve optimal results. They advocated that 6 months or less of

preoperative FN deficit gives best results. Similarly, Shulev *et al.* [26] concluded that in cases of total loss of FN function, only early decompression and early grafting yield the best functional outcome results. Furthermore, Gierek *et al.* [24] stated that best FN surgical outcome depended on the rehabilitation before and after surgery.

Conclusion

From the above studies and literature we gain that most authors assumed that at least a period of 1 year postoperatively could give us idea of the FN surgical outcome. But there was great controversy on which type of approach or which surgical technique should be used to yield the best surgical FN outcome, but most of the authors assumed that grade III could be the most great result achieved when adopting FN grafting and anastomosis as the main technique. On the other hand, we found that the FN intact techniques were the most useful to yield better results than were grafting and anastomosis when the circumstances and extension of the pathology allow the surgeon to use such techniques.

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Conflicts of interest

There are no conflicts of interest.

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