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# SURGICAL MANAGEMENT OF PETROUS APEX CHOLESTEROL GRANULOMAS BY AN INFRALABYRINTHINE APPROACH: OUR EXPERIENCE WITH FOURTEEN CASES

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Short title: Infralabyrinthine approach for petrous apex cholesterol granuloma

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## KEYPOINTS

- Surgical management of cholesterol granuloma of the petrous apex is challenging because of its position, the need to leave an aerated pathway, and because of the high rate of recurrence. It is only required when the lesion is symptomatic.
- The infralabyrinthine approach allows the lesion area to be reached along an axis that is parallel to the petrous apex, and difficult anatomical conditions such as a high jugular bulb can be managed by surgeons experienced in lateral skull base approaches.
- A posterior tympanotomy with drilling of the hypotympanic cells is useful to connect the drained cavity with the middle ear to enhance its aeration without requiring a silicone stent.
- Over the years, computer-assisted navigation and the stimulation burr have allowed improvements in the infralabyrinthine surgical technique. The infralabyrinthine approach is safe and effective, with preservation of hearing and facial function.

Cholesterol granulomas represent 40% of benign lesions developed within the petrous apex.<sup>1</sup> Most of them are asymptomatic and do not require any treatment.<sup>2</sup> When they involve adjacent structures such as the inner ear, the internal auditory meatus, the cranial nerves, or when they are painful, surgical management is required although this is challenging because of the position of the lesion, and the high rate of recurrence. Leaving a permanent aerated pathway is mandatory to avoid closure of the cavity and recurrence, which occurs in, on average, 20% of cases.<sup>3</sup> Though the exact pathogenesis of cholesterol granulomas is unclear, it seems that a chronic inflammatory reaction is caused by a lack of ventilation.<sup>4,5</sup>

The present study aims to report the experiences of a tertiary referral centre in the management of cholesterol granuloma of the petrous apex by an infralabyrinthine approach, focusing on the progress achieved in recent years.

## PATIENTS AND METHODS

### *Ethical considerations*

As the present report was an anonymous retrospective study, it was approved by the institutional board and no permission number was required.

### *Study design*

The medical records of 22 patients surgically treated for cholesterol granuloma of the petrous apex between 1998 and 2015 were collected. Out of the 22 patients, 15 had undergone an infralabyrinthine approach; one patient was excluded owing to loss at follow-up after 2 months.

### *Statistical analysis*

Results are expressed as mean  $\pm$  SD. The paired *t*-test was used to compare preoperative and

postoperative pure tone audiometry;  $p < 0.05$  was considered to be significant.

## RESULTS

### *Demographics and presenting symptoms*

Fourteen patients were included in the study. Demographics and clinical features are presented in Table 1.

INSERT TABLE 1 HERE

At the time of surgery, the mean age of the patients was  $42 \pm 16$  years (range 16–66 years). The main symptoms that led to diagnosis were hearing loss ( $n=4$ , 28.6%), vertigo ( $n=4$ , 28.6%), headache ( $n=2$ , 14.3%), trigeminal pain ( $n=2$ , 14.3%), peripheral facial palsy ( $n=1$ , 7.1%), and hemifacial spasm ( $n=1$ , 7.1%). The mean follow-up time was  $32 \pm 37.6$  months (range 12–144 months).

### *Preoperative assessment*

All patients underwent pure tone audiometry and speech audiometry (measurement of Speech Reception Threshold in a quiet room with headphones); the pure tone audiometry was measured at frequencies of 500, 1000, 2000, 3000 and 4000 Hz.<sup>6</sup> When the 3000 Hz threshold had not been measured, the average of 2000 and 4000 Hz values was used to calculate it. Clinical and audiological evaluations were repeated at 1 month postoperatively. In the absence of recurring symptoms, CT scan and MRI were performed at 1 year postoperatively.

### *Surgery*

The infralabyrinthine approach was performed in the supine position under general anaesthesia with facial nerve monitoring (NIM Response®, Medtronic, Jacksonville, FL, USA). A retroauricular incision was performed 5 cm behind the retroauricular sulcus, with an inferiorly based musculoperiosteal flap. A mastoidectomy was performed, and the inferior

half of the sigmoid sinus was completely skeletonized as well as the posterior cranial fossa dura posteriorly and anteriorly to the sigmoid sinus. The mastoid portion of the facial nerve and the posterior semicircular canal were skeletonized and the sigmoid sinus followed to the jugular bulb: if the latter was situated high up preventing the lesion from being reached, it was lowered using bone wax and haemostatic gauze. The drilling was continued in an upper-medial direction towards the petrous apex to avoid the pyramidal fossa and the pars nervosa of the jugular foramen. The cyst was opened wide.

Two major technical advances have been added to the procedure over the years: computer-assisted surgical navigation,<sup>7</sup> used from 2007 on 11 patients (DigiPointeur®, Collin, France), led to improved intraoperative control of the approach and the lesion, especially if bony septa were present; these were drilled using the navigation system to identify them, reaching the medial part of the cyst (Figure 1). Furthermore, the navigation system allowed safe skeletonization of the posterior semicircular canal in cases with sclerotic mastoid bone. The continuous facial nerve stimulating burr,<sup>8</sup> used from 2011 on eight patients, allowed a safer dissection of the third portion of the fallopian canal enhancing the widening of the subfacial route. A silastic draining tube was left in place in three cases operated before 2012. After this time, this technique was abandoned, indeed in the last 4 years (eight cases), to enlarge the drainage pathway towards the Eustachian tube, and to enhance the ventilation from the Eustachian tube, a posterior tympanotomy was performed with drilling of the hypotympanic cells, enhancing the communication between the petrous apex, the mastoid and the middle ear.

No intraoperative complications such as CSF leakage, internal carotid artery or cranial nerve injuries, occurred.

INSERT FIGURE 1 HERE

### *Postoperative outcomes*

One patient experienced retroauricular haematoma in the immediate postoperative period, necessitating drainage under local anaesthesia. There was no postoperative facial nerve palsy. The patient who had House–Brackmann grade II preoperative facial nerve paralysis remained unchanged. Two cases of hemifacial spasm recovered. The disabling symptoms (vertigo, trigeminal pain and headache) recovered.

Six patients showed an unchanged mean pure tone audiometry threshold, and one case a slight decrease in the bone conduction threshold at high frequencies. Among the seven patients presenting moderate hearing loss, six were unchanged, and one patient with preoperative mean pure tone audiometry of 59 dB improved by 20 dB (patient 8). Overall, there was no significant difference between the preoperative and postoperative audiometric thresholds (paired *t*-test).

The mean postoperative Speech Reception Threshold was  $41 \pm 26$  dB. In 12 cases, the Speech Reception Threshold remained unchanged. Two patients showed a Speech Reception Threshold improvement from 95 dB and 80 dB to 47 dB and 48 dB, respectively (patients 8 and 4). As a preoperative radiological finding, both patients showed invasion of the internal auditory meatus, with erosion of the basal turn of the cochlea (Figure 2) in patient 4.

INSERT FIGURE 2 HERE

Three out of 14 patients presented a radiological abnormality suggesting a recurrence. Only two of them presented a reappearance of symptoms and underwent revision surgery (14% of the total, patients 3 and 6). At revision surgery of patient 3, fibrous tissue was found



obstructing the silastic stent left in after previous surgery.

## DISCUSSION

### *Synopsis of key findings*

The infralabyrinthine approach was shown to be a safe technique with a low recurrence rate. It allows the lesion area to be reached along an axis that is parallel to the petrous apex (Figure 3) and with few risks. Over the years, there have been some refinements of this technique, which is reflected in the results: recurrence and residual disease occurred before 2012. The use of image-guided surgical navigation permits the widest pathway to be created with respect to the anatomical structures, and it was shown to be very useful in multiloculated lesions (Figure 1). The facial stimulation burr system allows a safe dissection of the mastoid segment of the fallopian canal to create a greater exposure of the area. More recently (eight patients from 2012 to 2015), a posterior tympanotomy with drilling of the hypotympanic cells was introduced to provide better aeration without the need for a silicone stent, which was found to be obstructed by fibrous tissue in one revision surgery.

INSERT FIGURE 3 HERE

### *Strengths and weaknesses of the study*

The limitation of the study is the variability in the follow-up period, which ranged from 12 to 144 months. However, asymptomatic patients could be lost at follow-up in a tertiary referral centre, because, in France, it is common practice to be followed by a general otolaryngologist in the absence of complications. Concerning the clinical aspects, there was a remission of

symptoms in the majority of cases, and two patients improved their speech audiometry performance.

#### *Comparisons with other studies*

When hearing preservation is the goal, the infralabyrinthine and infracochlear approaches are more commonly used. The findings in the present series concur with those of Goldofsky et al<sup>9</sup> and Sanna et al,<sup>10</sup> in which the infralabyrinthine approach led to the complete removal of the lesions with preservation of the hearing function. In a series of 29 cases, Sanna described 9 patients treated surgically by infralabyrinthine approach, with a preserved hearing in all cases and no recurrence of disease. In 2002 Brackmann and Toh<sup>11</sup> described a large series of 34 CG; all the patients with a good hearing function were treated by infralabyrinthine or infracochlear approach (7 and 18 patients respectively). In all them the hearing preservation was achieved, and a recurrence occurred in 3 cases for the infracochlear approach and 1 case for the infralabyrinthine approach, in all cases for the obstruction of the silicone stent. The infracochlear approach is performed through a transcanal route that avoids mastoidectomy, although controlling the position of the jugular bulb is more difficult through a transcanal approach,<sup>12</sup> and the opening for drainage and aeration is smaller than that obtained with an infralabyrinthine approach because of the close proximity of the basal turn of the cochlea, the internal carotid artery and the jugular bulb.

The transsphenoidal approach could be indicated in cholesterol granulomas extending more medially toward the clivus, with a favourable anatomy of the petroclival region and the internal carotid artery.<sup>13</sup> In this technique, placement of a silicone tube and/or nasoseptal flap is always appropriate to avoid fibrosis and recurrences, but exposes the patient to donor-site morbidity.

#### *Clinical applicability of the study*

Given the rarity of this pathology, this case series is one of the largest in the literature treated with one single approach. The infralabyrinthine approach seems to be a safe and effective procedure for the treatment of symptomatic cholesterol granuloma of the petrous apex with very low morbidity and a low rate of recurrence.

Conflicts of Interest: None declared

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Figure 1 CT scan of patient 13 presenting cholesterol granulomas of the right petrous apex with multiple bony septa (\*\*). This patient was previously operated in another centre with an endoscopic and infralabyrinthine approach, and presented a recurrence of disease that was treated with an infralabyrinthine approach with computer-assisted navigation. Note the anatomical difficulties and the pitfalls of the first infralabyrinthine approach: a high jugular bulb, insufficient drilling of the sigmoid sinus and of the posterior fossa dura anteriorly and posteriorly to the sigmoid sinus (\*), the lack of posterior tympanotomy and the drilling of the hypotympanum.

Figure 2 Patient 15, cholesterol granuloma of the left petrous apex invading the internal auditory meatus with erosion of the basal turn of the cochlea (\*). (A) Preoperative axial MRI T2-weighted image. (B) Postoperative axial MRI T2-weighted image.

Figure 3 Patient 17, infralabyrinthine approach. (A) Preoperative axial MRI T1-weighted image. (B) Postoperative CT scan shows a well-aerated pathway to the petrous apex without silastic drainage.

Table 1. Preoperative features of the 14 patients

<i>Case/year</i>	<i>Age (years) sex</i>	<i>Initial symptoms</i>	<i>Mean PTA (dB)</i>	<i>Radiological features</i>
1/ 1998	46/M	HL, tinnitus, vertigo	40	Invasion of IAM
2/ 1998	33/F	Headache	10	–
3/ 2001	47/F	Vertigo	20	Invasion of IAM
4/ 2007	47/M	HL, otalgia, tinnitus	53	Invasion of IAM
5/ 2010	33/F	Vertigo, headache, HL	18	Invasion of IAM
6/ 2010	16/F	FP, headache, TP, HL	52	Invasion of IAM and CC
7/ 2012	44/F	TP, headache	17	Invasion of IAM, erosion of CC
8/ 2012	56/M	HL, otalgia, tinnitus, vertigo	59	Erosion of cochlea, IAM, and CC
9/ 2013	62/F	HL, TP, vertigo	40	Invasion of IAM, erosion of CC
10/ 2013	64/M	Vertigo, headache	18	Invasion of IAM
11/ 2014	16/F	TP, headache	15	–
12/ 2014	66/F	Vertigo, facial spasm, HL	43	Invasion of IAM, erosion of CC
13/ 2015	27/M	Headache, vertigo	5	Erosion of cochlea
14/ 2015	49/M	Facial spasm	30	Invasion of IAM

FP, facial paralysis; CC, carotid canal; IAM, internal auditory meatus; TP, trigeminal pain; HL, hearing loss; PTA, pure tone audiometry.