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ORIGINAL ARTICLE

Petrous Apex and Anteriorly Located or Extended Cerebello-Pontine Angle Lesions: Radiological Assessment and the Management Modalities

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Objective: The lesions occupying the petrous apex (PA) and/or the cerebello-pontine angle (CPA) anterior to the internal auditory canal contents are of great concern regarding the surgical choice of access. The decision of the best surgical approach also depends on the nature of the lesion. The thorough radiological assessment is imperative on the precise differential diagnosis leading to the best choice of treatment for this challenging region.

Materials and Methods: A retrospective analysis was planned on thin section high resolution magnetic resonance images of the temporal bone region in the archieves of Radiology Department between April 2007 and October 2010.

Results: Among the 1,860 patients, there were 10 primary PA entities (4 asymmetric bone marrow (ABM), 3 entrapped fluid, 1 cholesterol granuloma, 1 mucocele, 1 internal carotid artery (ICA) dissection) and 8 anteriorly extended or located CPA pathologies neighbouring PA (6 epidermoid tumors, 1 meningioma, 1 neurofibromatosis type-2 (NF 2)). No primary PA cholesteatoma was noted. Of these 18 patients, 11 were female and 7 were male with the mean age of 35 years old, ranging between 18-55.

Conclusion: The radiological evaluation is of utmost importance in the differential diagnosis in PA region due to the great difficulty of direct clinical evaluation. The precise diagnosis is imperative to choose whether to perform surgery or medical therapy. Besides the routine magnetic resonance imaging (MRI) assessment, complementary views including high resolution heavily T2 weighted sequences and diffusion weighted imaging (DWI) might be necessary. Bone algorythm computed tomography (CT) would be essential for the selection of treatment and the best approach to choose.

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Introduction

PA is divided into two major parts by the internal auditory canal. The longer anterior part contains the cochlea, intrapetrous internal carotid artery, fibrocartilage of the foramen lacerum. Posterior portion consists of semicircular canals [1]. The larger anterior portion principally consists of bone marrow or air cells, whereas the posterior part is derived from the dense bone of otic capsule [2] (Figure 1).

PA has a wide variety of pathologies including congenital lesions (epidermoid tumor), infections (petrositis), obstructive processes (entrapped fluid, mucocele, cholesterol granuloma), benign tumors (meningioma, schwannoma), malignant tumors (chondroma, chondrosarcoma, metastasis), and miscellaneous lesions including histiocytosis, Paget disease, fibrous dysplasia and petrous carotid artery pathologies [1-4].

Pneumatization of the PA is seen approximately in 30% of the individuals [3,4]. Asymmetric pneumatization occurs in 4-10% of the population [4]. The cystic lesions of the petrous apex, namely the cholesterol granuloma, epidermoid cyst and mucocele in a descending order, consist of the great majority of the cases [5]. Cholesterol granuloma and mucocele arise in pneumatised PA. All of the above mentioned pathologies are to be differentiated from asymmetric bone marrow, which is not a pathological entity [3], to overcome any unnecessary surgeries. Entrapped fluid may be considered as a pathology that has to be followed-up [3]. Although the asymmetric bone marrow and the entrapped fluid are listed as ‘leave me alone’ lesions, entrapped fluid is, however, condemned as the early developmental stage of cholesterol granuloma [3]. This suggestion is supported by the protein content of the trapped fluid leading to the intermediate to high signal intensity on T1 MRI instead of the characteristic low intensity view of entrapped fluid.

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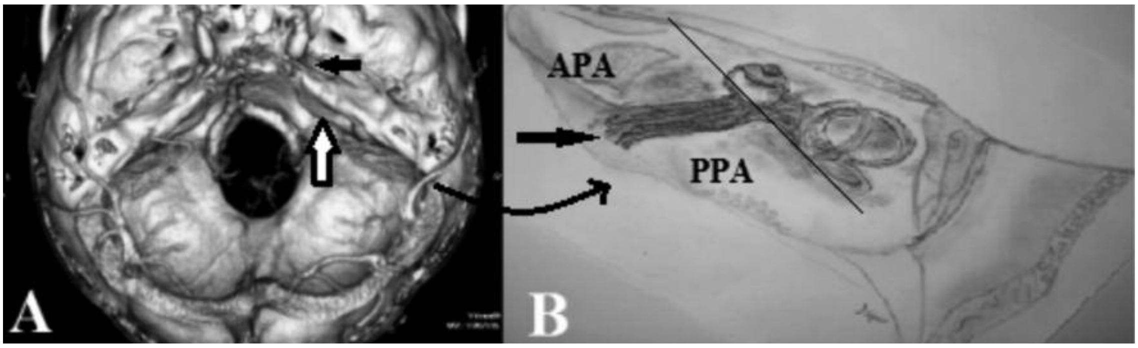

Figure 1. A: Reformatted 3D CT of skull base; white arrow: internal auditory canal, black arrow: intrapetrous part of carotid artery; **B:** Right temporal bone illustration and the boundry of PA. The part anterior to the line of the temporal bone represent PA. PA is divided into anterior and posterior parts by internal auditory canal; APA: anterior PA, PPA: posterior PA, black arrow: internal auditory canal.

There are also various primary and secondary lesions that extend to the petrous apex. The characteristics of the radiological findings of both the primary entities of PA and lesions located medially or extended to PA are summarized in Tables 1 and 2, respectively.

Skull base lesions, particularly in the PA region, that are approached laterally carry significant morbidity due to their medial location to the important neurovascular structures. Therefore, direct midline, anterior approaches gained popularity providing access to the midline lesions without displacement and transgressing these important neurovascular structures. Application of endoscopes made the anterior approaches easier and possible to surgically treat more extensive lesions [6].

Fortunately, most of the pure PA lesions are benign and not so extensive in nature. Therefore, facial and cochlear functions are tried to be preserved in either lateral or anterior approaches to PA for the removal or drainage of the lesions.

PA lesions need a high level of suspicion for the diagnosis. Asymptomatic lesions are usually identified as incidental findings on imaging studies. The cornerstones of accurate diagnosis of the lesions of this area are the modern radiological techniques including MRI and CT.

This retrospective analysis is aimed to investigate the characteristics of the pure PA lesions and pathologies that extend to PA. The importance of radiological assessment in the differential diagnosis is discussed in light of literature, and the choice of surgical approach is reviewed according to the hearing and facial function status, location and extension of the lesion.

Materials and Methods

This study is designed as a retrospective analysis between April 2007 and October 2010 on the archieves of the Radiology Department of Mersin University Medical Faculty. MRI archieves was evaluated and the views of the temporal bone region consisted of totally 1,860 patients. Among these patients, eighteen cases relevant to petrous apex were enrolled. The CT findings were also evaluated for the patients included to the study having PA lesions and anteriorly located or extended CPA entities. The hospital charts of these patients were also reviewed retrospectively.

MRI was performed on GE Signa 1.5 T MR unit (GE Medical Systems, Milwaukee, WI, USA) using a 8 element phased array surface coil with standart temporal bone region (inner ear) MRI protocol including axial T1 weighted imaging (T1 WI) (spin echo (SE) or fast spin echo (FSE), TR:500 msn, TE:10 msn, FOV:18X18, 3 mm thickness/0.5 mm space, matrix: 256X192, NEX:2); coronal T1 WI (FSE, same protocol as axial T1 WI); axial and coronal T1 WI (same protocol as axial and coronal T1 WI) with contrast; axial T2 WI (FSE, TR:3250, TE:105, FOV:18X18, 3 mm thickness/0.5 mm space, matrix:288X224, NEX:2), FIESTA (flip angle:550, TR:5.2, TE:1.6, FOV:20X20, 0.8 mm thicknes/0.6 mm space, matrix:320X320, NEX:4). If need, fat saturated axial T1 WI (SE, TR:620, TE:19, FOV:22X22, NEX:2, 3 mm thickeness/0.5 mm space); DWI and ADC map (b=1000s/mm2, SE/EPI, TR:8000, TE:97,

Table 1. Imaging characteristics of primary PA lesions

	CT	T1 WI	T2 WI	T1 WI+C	FAT SAT T1 WI	DWI	ADC	FLAIR
Cholesterol granuloma	Well defined, smoothly expansile lesion, destruction of trabeculae	Hyperintense	Hyperintense Peripheral dark hemosiderin ring	No enhancement/peripheral rim enhancement	Fat saturation -			Hyperintense
Mucocele	Smooth expansile lesion, destruction of trabeculae, ovoid shaped	Hypointense Isointense	Hyperintense	No enhancement/peripheral rim enhancement		No diffusion restriction (hypo-isointense)	Hyperintense	
Congenital cholesteatoma (epidermoid tm)	Smooth expansile lesion, destruction of trabaculae, smooth lobuler bone remodeling	Hyperintense	Hypointense	No enhancement Mild rim enhancement (possible) No meningeal enhancement		Restricted diffusion	Hyperintens,	mixed iso- hypointens
Cephalocele	Smooth expansile, noninvasive bony excavation	Hypointense (isointense with CSF in all sequences)	Hyperintense (isointense with CSF in all sequences)	No enhancement (Peripheral enhancement: periganglionic venous plexus)				Hypointense (isointense with CSF in all sequences)
Petrous apicitis or central skull base osteomyelitis	Aggressive bone destruction	Hypointense, isointense	Hyperintense, isointense	Enhancement, rim enhancement with adjacent meninges				
Carotid artery aneurysm	Smooth expansion of carotid canal, heterogeneous contrast enhancement	Hypointense (new thrombus) hyperintense (older thrombus), heterogenous	Heterogenous signal with peripheral hemosiderin ring	Diffuse enhancement				
Entrapped fluid	Unilateral opacification Nonexpansile lesion No destruction of trabeculae	Hypointense to hyperintense	Hyperintense	No enhancement				
Asymmetric bone marrow	No bony destruction	Hyperintense	Hyperintense	No enhancement	Fat saturation +			

***CT:** Computed Tomography, **T1 WI:** T1 Weighted Imaging, **T2 WI:** T2 Weighted Imaging, **+C:** with contrast, **FATSAT T1 WI:** Fat Saturated T1 Weighted Imaging, **DWI:** Difussion Weighted Imaging, **ADC:** Apparent Diffusion Coefficient map, **FLAIR:** Fluid Attenuated Invertion Recovery, **MRA:** MR-Angiography, **PA:** Petrous apex, **CSF:** Cerebrospinal flui*

Table 2. Imaging characteristics of lesions that extend to anterior CPA region or located medially to PA

	CT	T1 WI	T2 WI	T1 WI +C	FLAIR	DWI	ADC
Meningioma	Isodense/hyperdense Calcification 25% Hyperostosis	Isointense/ minimally hyperintense to gray matter	Isointense/hypointense to gray matter	Enhancement Dural tail			
Arachnoid cyst	Isodense Bone indentation	Hypointense (isointense with CSF)	Hyperintense (isointense with CSF)	No enhancement	Hypointense (isointense with CSF)	Diffusion restriction -	Hyperintense
Epidermoid tumor	Isodense or minimally hyperdense to CSF	Hypointense (Isointense/slightly hyperintense to CSF)	Hyperintense (Isointense /hypointense to CSF)	No enhancement is rule (Mild peripheral	Hyperintense to CSF (incomplete or enhancement %25) no attenuation)	Diffusion restriction +	Isointense (with brain)
Chordoma	Lobulated Bone destruction with residual bone fragments	Hypointense/isointense	Hyperintense	Less intense than chondrosarcoma			
Chondrosarcoma	Infiltrative Remnants of eroded bone	Hypointense/isointense homogeneous	Hyperintense/ heterogeneous	Enhancement			
Metastases	Bone erosion	Hypo-hyperintense (depends on primary)	Hypo-hyperintense (depends on primary)	Enhancement			
Langerhans cell histiocytosis	Aggressive bony destruction	Iso/ hypointense	Iso/hyper intense	Enhancement			

CPA: *Cerebello-pontine Angle* ***CT:*** *Computed Tomography,* ***T1 WI:*** *T1 Weighted Imaging,* ***T2 WI:*** *T2 Weighted Imaging,* ***+C:*** *with contrast,* ***FLAIR:*** *Fluid Attenuated Invertion Recovery,* ***DWI:*** *Difussion Weighted Imaging,* ***ADC:*** *Apparent Diffusion Coefficient map,* ***PA:*** *Petrous apex,* ***CSF:****Cerebrospinal Fluid*

FOV:22X22, 3 mm thicknes/0.5 mm space, matrix:128X128) was performed. Transverse temporal CT scans were aquired with 120 kV, 115-120 mAs, rotation time 0.5 sn, 0.5 mm slice thickness, 0.5 mm collimation with 64 detector rows, reconstruction increment 0.3 mm, pitch 0.6, matrix: 512X512, in Toshiba Acquillon 64 slice CT scanner (Toshiba, Japan).

Results

Among the 1,860 patients, 18 patients were included in this retrospective analysis. Of these 18 patients, 11 were female and 7 were male with the mean age of 35 years, ranging between 18-55.

Ten patients were found to have primary petrous apex lesions. One cholesterol granuloma (10%), 3 entrapped fluid (30%), 1 mucocele (10%), 1 internal carotid artery (ICA) dissection (10%) and 4 asymmetric bone marrow (40%) were identified. Eight patients had lesions that extend to anterior CPA region or located medially to the petrous apex. Six epidermoid tumors (75%), one petroclival meningioma (12.5%) and one NF 2 (12.5%) (Right huge calcified meningioma, left small schwannoma) were identified. Clinical presentations with radiological features of the lesions of these two groups are shown in Tables 3 and 4, respectively.

Discussion

Pure petrous apex lesions and the pathologies that extend to or locate at the anterior CPA, neighbouring PA region are difficult to evaluate clinically, and the differential diagnosis by radiological means is crucial to choose the choice of treatment and the best surgical approach. The management of the patient is to be decided both through clinical symptoms and thorough MRI and CT evaluation. Depending on the nature and the extension of the lesion, either medical therapy or various surgical approaches can be selected [7].

Cystic lesions of PA constitute the great majority of the cases and each of these pathological lesions is to be discussed individually.

Cholesterol granulomas, have thick fibrous capsule, but do not have true epithelial lining. The incidence is reported to be 0.6 per million. Cholesterol granuloma results from hemorrhage due to the obstruction of the aerated space of the PA leading to expansile cyst formation lined by fibrous tissue containing chocolate brown fluid and cholesterol crystals. The expansion of the cyst dilates the involved air cells leading to bony erosion [8,9]. Jackler and Cho proposed an alternative mechanism for the formation of cholesterol granuloma. They suggested that it forms between the dehiscent bony partition and the bone marrow due to the repeated hemorrhages [10]. Cholesterol granuloma is seen typically as hyperintense lesion on TI WI and T2 WI. This view is similar to asymmetric bone marrow. The fatty marrow has high signal on T1 WI and intermeadiate or high signal on T2 WI, however, T2 WI signal is somewhat lower than T1 WI on spin echo imaging technique. Relatively lower signal intensity of T2 WI compared to T1 WI on spin echo imaging technique may be a key for prescence of fat. [3] ABM follows subcutaneous fat in all sequences and can be diagnosed by comparing this entity to subcutaneus or retroorbital fat. Additionally, cholesterol granuloma and ABM can be differentiated from each other with fat saturation. ABM is fully supressed and shows hypointense signal and cholesterol granuloma stays with its hyperintense signal characteristics. If doubt remains, CT can define cholesterol granuloma with its trabecular loss and bony expansion, while ABM has normal trabecular pattern of the bone without any erosion. Once asymmetric bone marrow is correctly identified, no further imaging and follow up is necessary. [3].

PA lesions may be discovered coincidentally in cases with unrelated symptoms. Our cholesterol granuloma case was also found in a coincidental manner with the primary complaint of intentional tremor. Radiological evaluation revealed hyperintense lesion on both T1 WI and T2 WI. CT showed minimally expansile cystic lesion with loss of trabeculation (Figure 2). Periodical radiologic assessment was suggested to the patient. Although minimal expansion was noted on CT examination, no surgical intervention was indicated due to the absence of related symptoms.

Mucocele is a lesion caused by the obstruction of drainage of the aerated PA. These may stay asymptomatic in PA region and should not be overreacted according only to the MRI findings [11]. The common symptoms of PA cystic lesions, including mucocele are headache and aural pressure. Conductive hearing loss can occur in case of Eustachian tube compression, and sensorineural hearing loss may be seen if inner ear or internal auditory canal invasion happens leading also to tinnitus. Vertiginous symptoms

Table 3. Primary lesions of PA region and clinical presentations.

Patient number	Age	Gender	Clinical presentation	CT	MRI	Radiological diagnosis
1	42	F	Headache	Nonexpansile, no destruction of trabeculae	T1 WI: isointense to brain, +C: no contrast enhancement, T2 WI: hyperintense (isointense with CSF),	Left entrapped fluid
2	32	F	Bilateral SNHL, vertigo	The same as case 1	T1 WI: Hypo-isointense, T2 WI: hyperintense (isointense with CSF),	Right entrapped fluid
3	26	M	Incidental	The same as case 1	The same as case 1	Left entrapped fluid
4	18	M	Intentional tremor	Expansile, destruction of trabeculae	T1 WI: hyperintense to brain , +C: no contrast enhancement, T2 WI: hyperintense to brain,	Right cholesterol granuloma
5	50	F	Left SNHL	Smootly expansile, destruction of trabeculae	T1 WI: isointense with brain, +C: no contrast enhancement, T2 WI: hyperintense to brain,	Left mucocele
6	34	M	Sudden left retroorbital pain, Horner Syndrome		FAT SAT T1 WI: hyperintense peripheral ring along intrapetrousal ICA segment	Left internal carotid artery dissection
7	35	F	Right tinnitus, Right SNHL	Nonexpansile, no destruction of trabeculae	T1 WI: hyperintense, T2 WI: hyperintense, FAT SAT T1 WI: fat saturation + (hypointense), FIESTA: isointense with retroorbital fat	Left asymmetric bone marrow
8	24	F	Headache	The same as case 7	The same as case 7	Left asymmetric bone marrow
9	50	M	Right tinnitus	The same as case 7	The same as case 7	Right asymmetric bone marrow
10	15	M	Vertigo	The same as case 7	The same as case 7	Left asymmetric bone marrow

CT: *Computed tomography,* ***MRI:*** *Magnetic Resonance Imaging,* ***T1 WI:*** *T1 Weighted Imaging,* ***+C:*** *TI WI with contrast,* ***T2 WI:*** *T2 Weighted Imaging,* ***FAT SAT T1 WI:*** *Fat Saturated T1 Weighted,* ***SNHL:*** *Sensorineural Hearing Lose,* ***FIESTA:*** *Fast Imaging Employing Steady-State Acquisition,* ***CSF:*** *Cerebro Spinal Fluid,* ***ICA:*** *Internal Carotid Artery,* ***PA:*** *Petrous Apex*

Table 4. Lesions that extend to anterior CPA region or located medially to PA and clinical presentations.

Patient number	Age	Gender	Clinical presentation	CT	MRI	Radiological diagnosis
1	50	F	Right V-XII involvement		T1 WI: hypointense, T2 WI: hyperintense, FIESTA: hypointense to CSF, hyperintense to brain, DWI: diffusion restriction, ADC: isointense with brain, no contrast enhancement	Right epidermoid
2	45	F	Left SNHL, ataxia, left facial paresis		The same as case 1	Left epidermoid
3	38	F	Left facial hypoesthesia, left facial paresis		The same as case 1	Left epidermoid
4	26	F	Vertigo, tinnitus		The same as case 1	Left epidermoid
5	29	F	Headache, diplopia		The same as case 1	Right epidermoid
6	55	F	Vertigo, tinnitus		The same as case 1	Right epidermoid
7	41	M	Right SNHL	Extraaxial, isodense with brain	T1 WI: isointense with brain, T2WI: mildly hyperintense to brain, homogeneous diffuse enhancement	Right petroclival meningioma
8	20	M	Right facial paralysis, Right SNHL	Dense calcifying lesion and hyperostosis	T1 WI: Rigth heterogeneous isointense lesion with hypointense areas heterogeneous diffuse enhancement, T1 W1: Left isointense lesion, diffuse contrast enhancement	NF 2 (Right huge calcified meningioma, left small schwannoma)

***CPA:** Cerebello-pontine Angle, **CT:** Computed tomography, **MRI:** Magnetic Resonance Imaging, **T1 WI**: T1 Weighted Imaging, **T2 WI:** T2 Weighted Imaging, **CSF:** Cerebro Spinal Fluid, **DWI:** Difussion Weighted Imaging, **FLAIR:** Fluid Attenuated Invertion Recovery, **FAT SAT T1 W:** Fat Saturated T1 Weighted, **FIESTA:** Fast Imaging Employing Steady-State Acquisition, **ICA:** Internal Carotid Artery, **NF2:** Neurofibromatosis type 2, **SNHL:** Sensorineural Hearing Lose, **PA:** Petrous Apex*

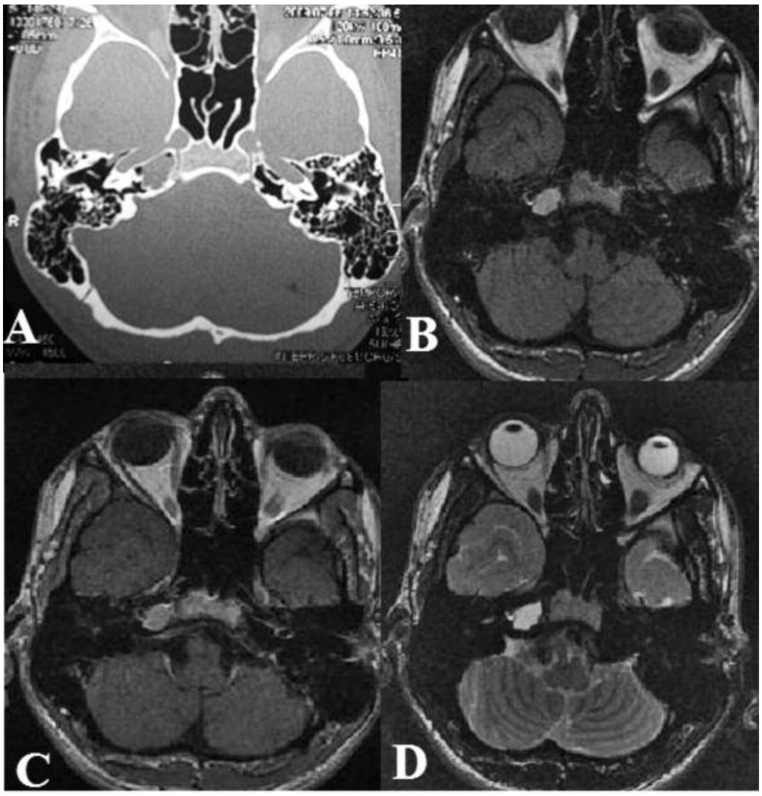

Figure 2. Cholesterol granuloma in right PA. **A:** Axial CT shows a smoothly expansile lesion with the destruction of trabeculae; **B:** Axial T1 WI shows a hyperintense lesion; **C:** Axial T1 WI with contrast shows no enhancement; **D:** Axial T2 WI shows a hyperintense lesion.

occur less often. Symptoms and the imaging characteristics of mucoceles are similar to effusion except smooth bone erosion and loss of septae on CT examination. In symptomatic patients, mucocele can be drained. Asymptomatic cases may be observed by serial imagings [12].

The patient with mucocele was admitted with ipsilateral sudden sensorineural hearing loss on the left side. She had a history of hearing loss during lifting a heavy substance, months ago. The lesion has been found radiologically unchanged up to date and revealed isointense T1 WI, hyperintense T2 WI lesion and smoothly expanded view with trabeculation lysis on CT images (Figure 3). SNHL was not thought to be strongly correlated to the mucocele. As suggested by the literature regarding that coincidentally found cystic lesions may be followed-up by CT evaluation repeated in 6 or 12 months, this patient was included to follow up program [4].

One of the most common cystic lesions of the PA area is the epidermoid cyst or tumors. Epidermoid cyst contains keratin debris surrounded by an epithelial wall with fibrous subepithelium. Osteolytic enzymes at the junction of the epithelium and subepithelium lead to bone erosion around this expansile lesion [13]. Epidermoid (congenital) or cholesteatoma (acquired) consists of 4-9% of all PA lesions [14-16]. It is anatomically classified as supralabyrinthine, infralabyrinthine, massive labyrinthine, infralabyrinthine-apical and apical [17]. Surgical removal is the choice of treatment.

Retrospective analysis revealed 6 epidermoid tumors either located at anterior CPA region or extended to this area. None of these lesions were primary PA epidermoids. However, both the similarity in symptomatology (Table 3) and the difficulty in removal of the lesion located just medially to the PA indicate a somewhat closely related discussion. In our case series, two of the 6 cases had diplopia. Only one case was limited to the anterior CPA region and complained with vertigo and tinnitus. The radiological evaluation showed hypointense T1 WI and

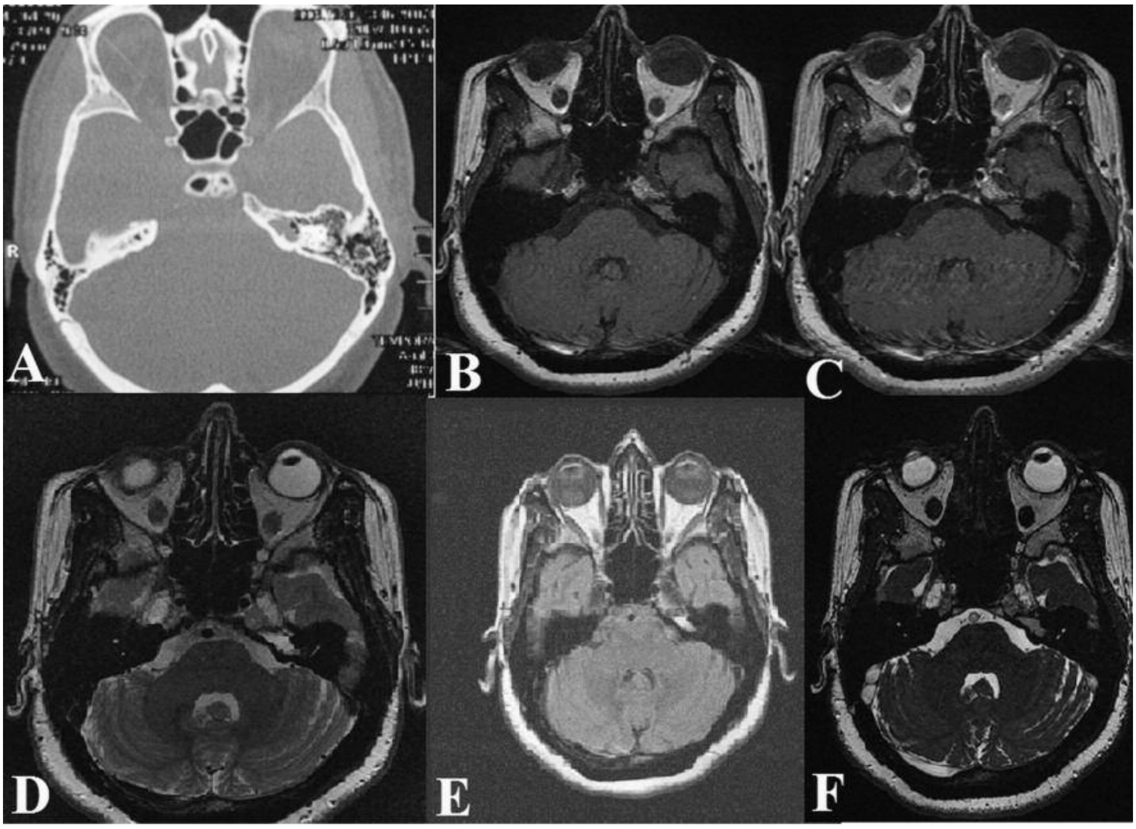

Figure 3. Mucocele in the left PA. **A:** Axial CT shows smoothly expansile isodense lesion with trabecular destruction; **B:** T1 WI shows isointense lesion; **C:** T1 WI with contrast shows an isointense lesion without contrast enhancement; **D:** Axial T2 WI shows a hyperintense lesion; **E:** FLAIR shows a hyperintense lesion; F: FIESTA shows hyperintense lesion (hypointense to retroorbital fat tissue).

hyperintense T2 WI. It should be noted that the contour of the lesion is more striking in FIESTA sequence compared to T1 WI and T2 WI (Figure 4). Epidermoid tumors have the same imaging characteristics with the arachnoid cysts of the CPA on T1 WI and T2 WI. The differential diagnosis can be made by showing the diffusion restriction on DWI. Symptoms were mild and the patient decided to be followed-up radiologically. The patient was advised to be operated should an increase in dimensions of the lesion occur or the symptoms become more severe. Four of the giant epidermoid lesions were operated by retrosigmoid approach (Figure 5) and surgery was also offered to the fifth patient.

The decision whether to treat or follow the cystic lesions of PA warrants knowledge of anatomical and radiological expertise regarding differential diagnosis. In case of exclusion of probable other causes of ear pain or headache; hearing status, location and size of the cyst are the factors to be considered in selection of the best approach. Infralabyrinthine approach was a commonly used procedure for PA abscess drainage in the preantibiotic era. This procedure is now used for the PA cystic lesion drainage and has the advantages of direct route to this region, avoidance of entrance to the middle ear. This region is also well-known anatomically by the otologists. However, this procedure is limited in high jugular bulb cases and the alternative is the infracochlear approach to petrous apex [18,19]. The advantages of infralabyrinthine approach consist of the preservation of normal middle ear mechanisms, ease of drainage and simplicity of revision, if required [20]. Recurrence rate has been reported as 16% [20]. Infracochlear approach may be chosen for suitable cystic lesions in patients with good hypotympanic pneumatization for drainage. The middle fossa approach is the procedure of choice for excision of the lesion rather than simply to drain. The disadvantages are increased risk of the facial nerve[21-22]

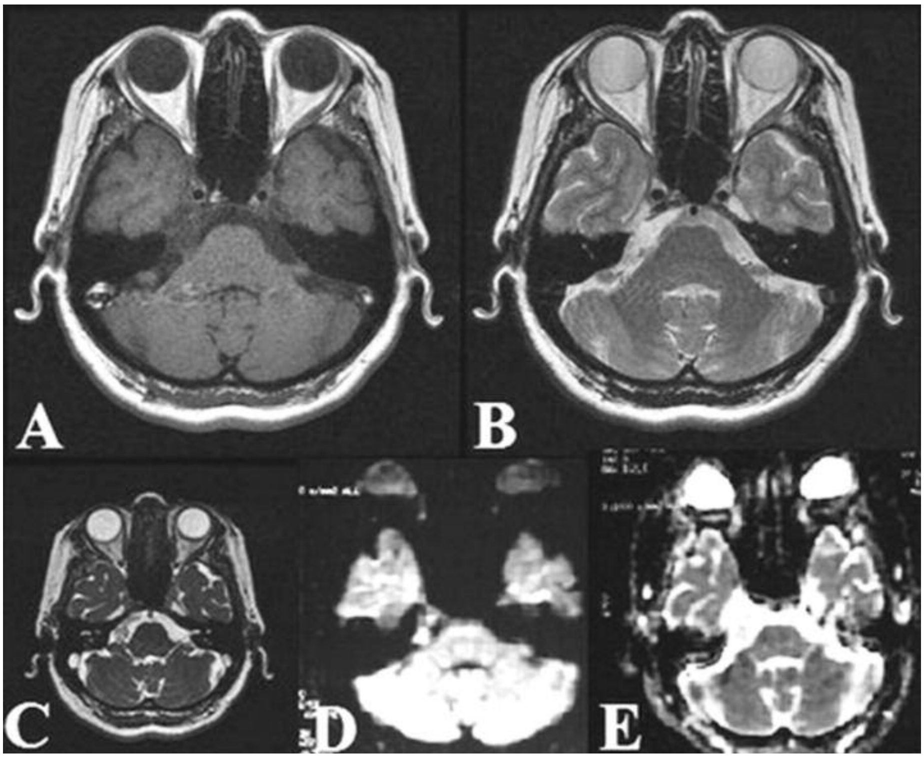

Figure 4. Epidermoid tumor located at right anterior CPA region. **A:** Axial T1 WI shows a hypointense lesion; **B:** Axial T2 WI shows a hyperintense lesion; **C:** FIESTA: demostrates slightly hyperintense lesion **D:** DWI demostrates diffusion restriction; **E:** ADC map shows a isointense lesion.

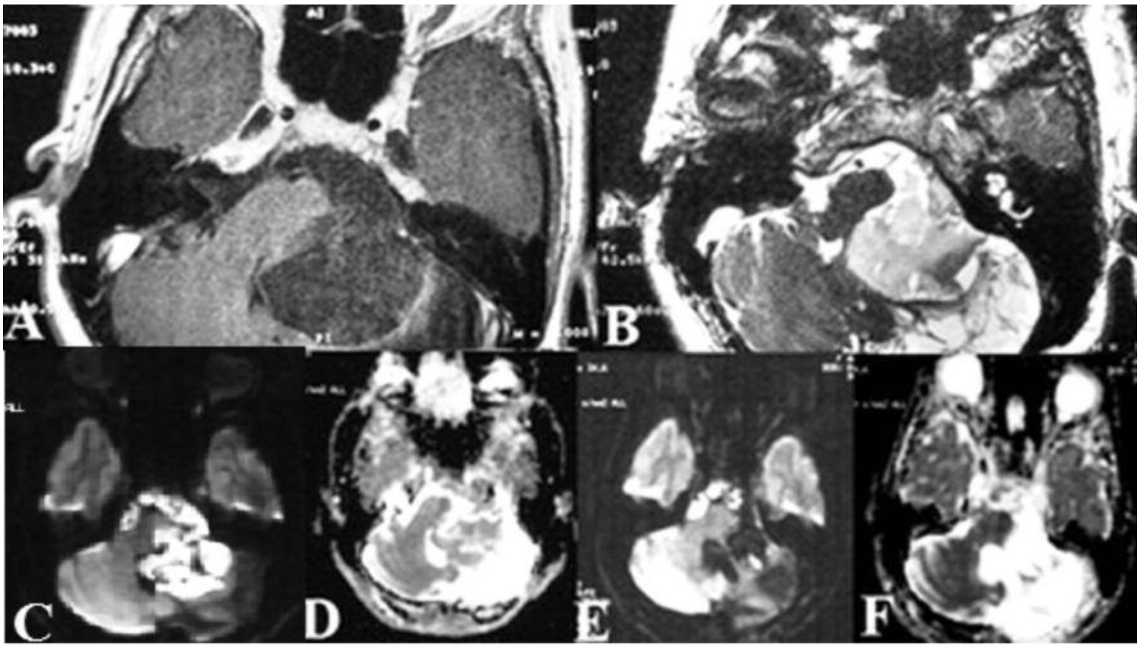

Figure 5. Huge epidermoid tumor extending to left anterior CPA region. **A:** Axial T1 WI shows a hypointense lesion; **B:** Axial T2 WI shows a hyperintense lesion; **C:** Preoperative DWI demostrates diffusion restriction; D: Preoperative ADC map shows an isointense lesion. **E, F:** Residuel epidermoid tumor is seen in the prepontine region on postoperative DWI and ADC map, respectively.

and vein of Labbe injury, temporal lobe damage due to prolonged temporal lobe retraction [23]. Investigation still continues on alternative surgical approaches for PA cystic lesions [24].

There is still controversy in the management of a cystic lesion of PA [3,5,8,9,25,26]. The clinician should be precise in the differential diagnosis of the coincidentally found lesion. Also, it should be bear in mind that symptoms may not be due to the PA lesion.

Usually, MRI findings are sufficient for the diagnosis of a cystic lesion, but CT might be complementary to decide as to whether the lesion is expansile or not. This situation is an important factor for the decision of surgical treatment. Radiation exposure of the repeated CT evaluation should not be underemphasized for the probable future risk of malignancy. Exclusion of other causes also supports surgical intervention for the symptomatic patient.

Surgical treatment of a cystic lesion may be managed by either drainage or resection (total or near total). The management modality of such cystic lesions is widely discussed especially for cholesterol granulomas. Although subcochlear drainage is safe, it may have a disadvantage to recur. Resection through middle fossa offers better long term control in terms of recurrence. Transnasal endoscopic approaches to posterior, middle and anterior fossae including the PA, have been developed from the experience and knowledge of the more classic endoscopic assisted pituitary surgery. Endoscopic transnasal approaches to PA are performed for selected cystic lesions that expand well into the sphenoid sinus [27]. In the postoperative follow-up, the lack of pneumatization is not alone an indication for reoperation. Recurrence of symptoms and bone expansion-erosion warrant reoperation in cholesterol granuloma and mucocele patients. For the cholesterol granuloma cases, hyperintensity in T1 WI MRI supports the postoperative recurrence of the lesion, while hypointensity may mean fluid retention. Total removal is the choice of treatment for the epidermoid cyst [28].

PA effusion is also named as retained or entrapped fluid and discovered as an incidental finding in almost 1% of all cranial MRI studies [29]. It is thought to be the result of a preexisting middle ear or mastoid infection and can only be found in pneumatised PA [30]. The patients with symptoms including hearing loss, positional vertigo, headache, aural pressure are suggested to be treated by antibiotics and steroids. In case of persistence of the symptoms, surgical drainage is offered with the most appropriate approach regarding the location of the effusion. Asymptomatic patients are followed with imaging studies [30]. Entrapped fluid is seen with hyperintense signal on T2 WI, may have hypointense, isointense or hyperintense on T1 WI. Hyper-hypointense T1 WI signal of the EF may cause diagnostical problem with cholesterol granuloma, cholesteatoma, mucocele. In that case, CT imaging provides differential diagnosis of the EF by demonstrating no destruction of the bony trabeculae. In our series, one of the entrapped fluid cases was found incidentally on the left side. The patient complaining about vertigo and bilateral sensorineural hearing loss had entrapped fluid on the right side. The patient with headache had left entrapped fluid. MRI assessment showed isointense T1 WI and hyperintense T2 WI. There was no contrast enhancement (Figure 6). CT evaluation revealed isodense lesion without loss of trabeculae and no expansion. The symptoms were considered irrelevant to effusion, and no therapy was suggested to the patients.

Retroorbital pain is commonly known as a sign of petrous apicitis. However, carotid artery pathology is to be also taken into consideration in the differential diagnosis. In one of our cases, intrapetrous carotid artery dissection was shown as the causative lesion in the patient admitted with sudden retroorbital pain and Horner Syndrome on the left side. Antiaggregant medical therapy was prescribed and periodical follow-up was suggested (Figure 7).

There were four patients radiologically diagnosed with asymmetric bone marrow. The diagnosis was incidental in the headache and vertigo patients. Asmmetric bone marrow was diagnosed on the opposite side in the right sensorineural hearing loss and tinnitus patient. This entity is seen isointense to retroorbital fat in all MRI sequences and is suppressed by fat saturation (Figure 8). It was diagnosed at the same side in the patients complaining about right sided tinnitus only. No intervention or medical therapy was planned for the asymmetric bone marrow patients.

Hearing loss is noted to be the most common symptom of the primary and secondary neoplastic cases of the PA [5,9,25].

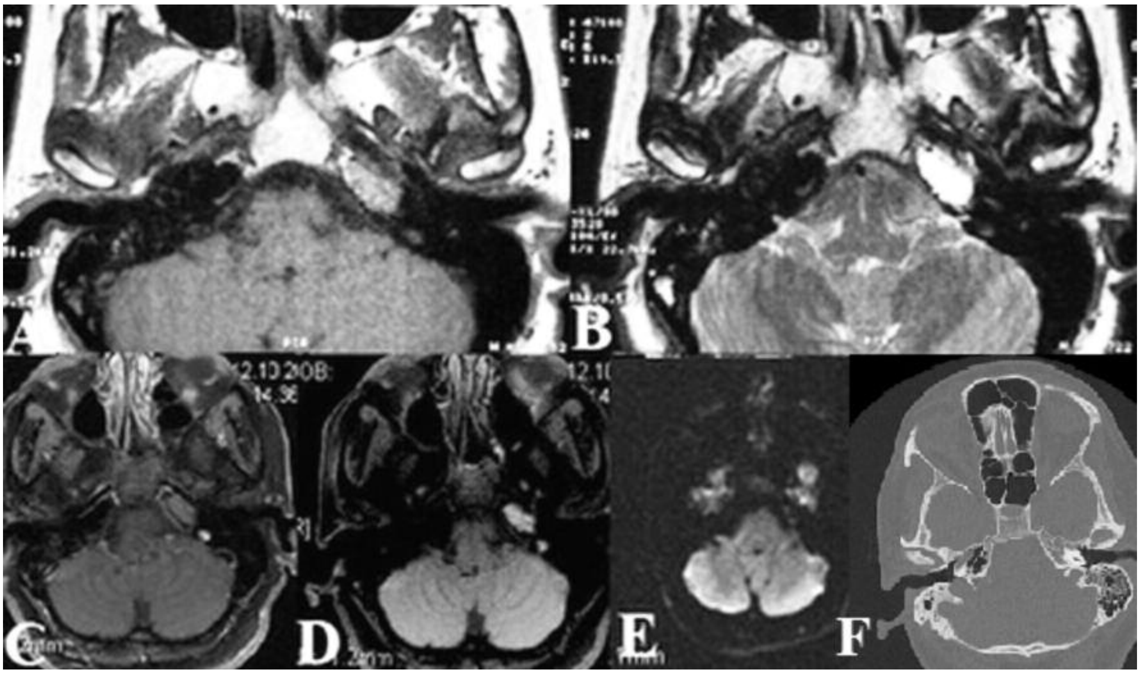

Figure 6. Entrapped fluid centered in the left PA. **A:** Axial T1 WI shows an isointense lesion; **B:** Axial T2 WI shows a hyperintense lesion; **C:** Axial T1 WI with contrast shows no enhancement; **D:** FLAIR shows an isointense lesion with hyperintense area; **E:** DWI shows no diffusion restriction; **F:** Axial CT shows isodense lesion without expansion and destruction of trabeculae.

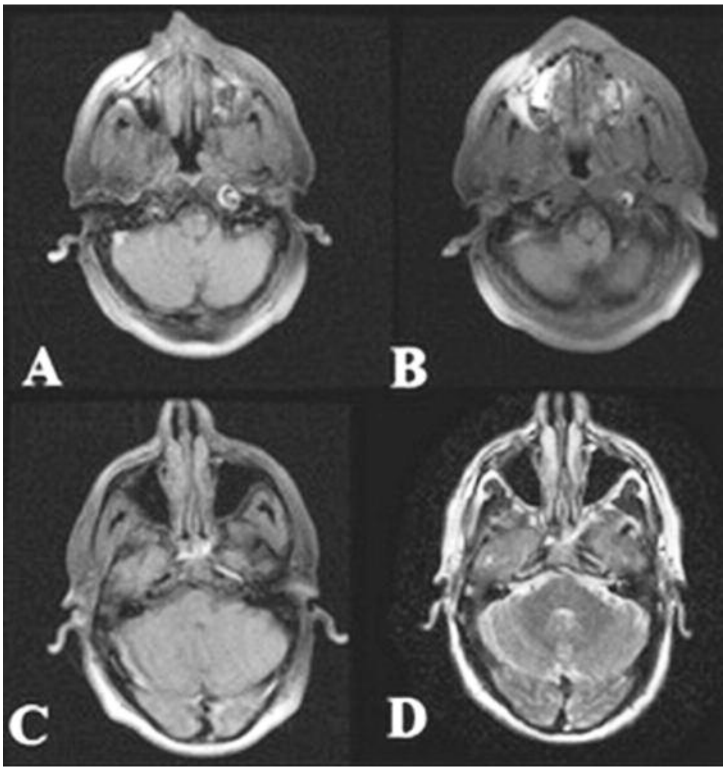

Figure 7. A-C: Axial FAT SAT T1 WI shows hyperintense signal (mural thrombus) adjacent to hypointense distal cervical and intrapetrosal ICA lumen. **D:** Axial T2 WI shows hyperintense signal adjacent to hypointense intrapetrosal ICA lumen.

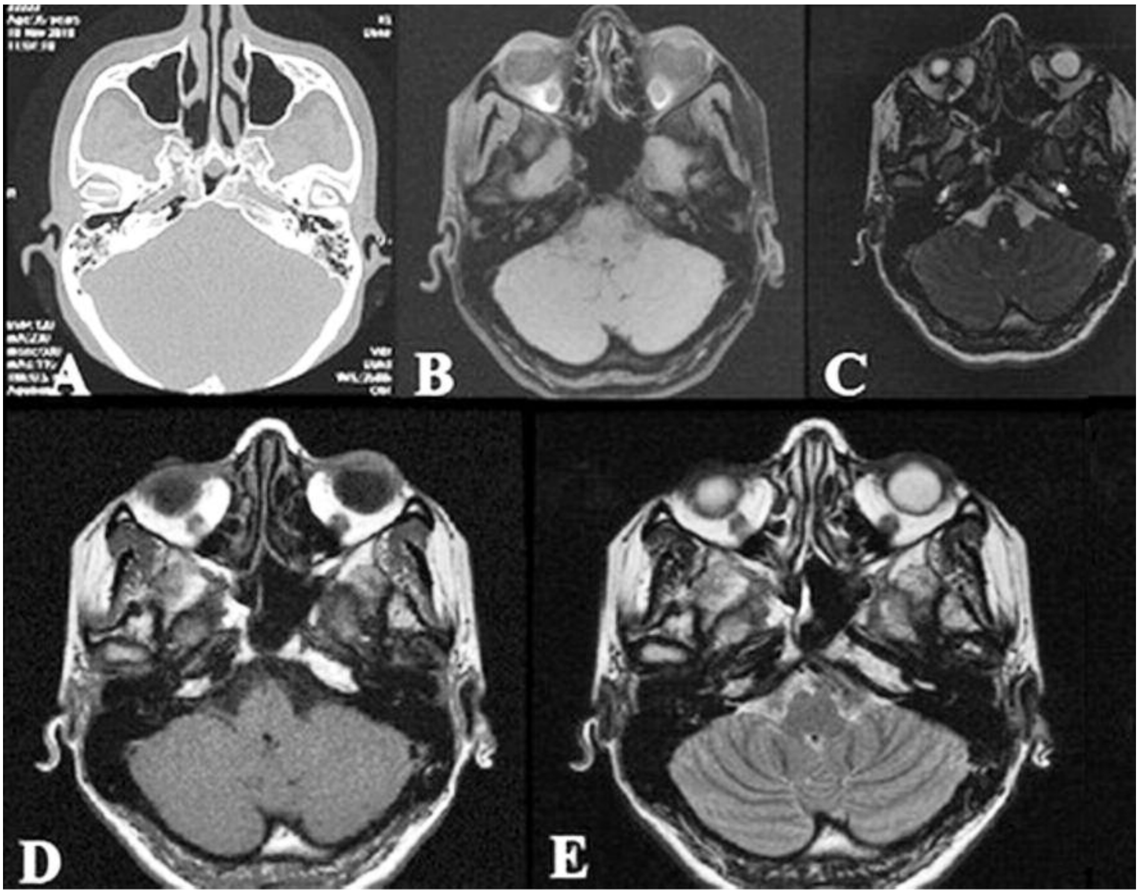

Figure 8. Asymmetric bone marrow in the left PA. **A:** Axial CT shows nonexpansile isodens lesion without any trabeculation lost; **B:** FAT SAT T1 WI shows loss of hyperintense characteristic after fat saturation; **C:** FIESTA shows lesion isointens with retroorbital fat tissue; **D:** Axial T1 WI shows a hyperintense lesion; **E:** Axial T2 WI shows hyperintense lesion.

Our two tumor cases extending to the petrous apex had been admitted with the complaint of hearing loss. NF2 case had also facial paralysis.

The petroclival meningioma patient was informed for her lesion and decided to be involved in the follow-up program due primarily to her collagen tissue disorder (Figure 9).

The NF2 case was operated by transcochlear approach due to brainstem compression for the meningioma. He is in the follow-up program for the contralateral schwannoma and multiple medulla spinalis lesions. The preoperative MRI and CT findings show bilateral CPA lesions (Figure 10).

Conclusion

Petrous apex region needs special attention and experience for the differential diagnosis and selection of the best management modality. Thorough knowledge regarding the different MRI sequences and the contrast involvement is essential for differential diagnosis. Also, MRI assessment is crucial for some of the ‘leave me alone’ lesions in which surgical intervention might be hazardous and classified as overtreatment. Besides the conventional techniques, additional diagnostic means including fat saturated, diffusion weighted and/or heavily T2 weighted steady-state sequences are of paramount importance for better defining and distinguishing the lesion with its surrounding tissue. CT is a complementary tool for the cystic lesions for the better delineation of bony changes including destruction of septae and expansion. However, radiation exposure is not to be underestimated for serial CT imaging for follow-up of the patients.

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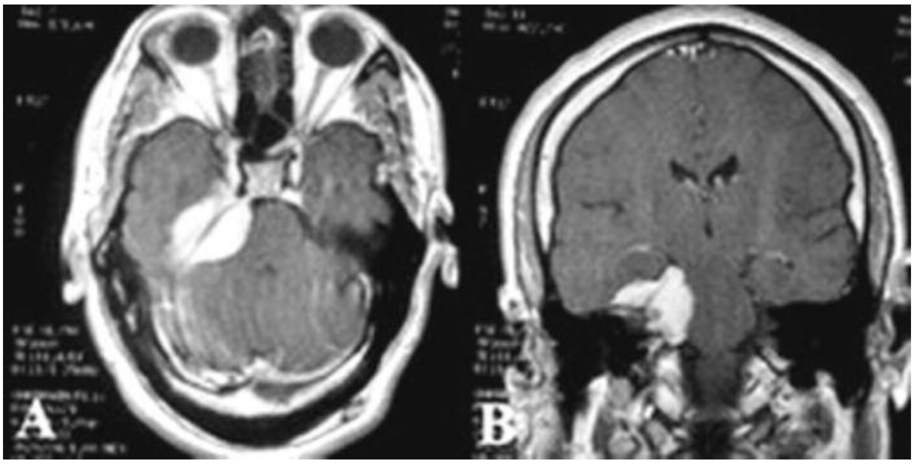

Figure 9. Right petro-clival meningioma. **A, B:** Axial and coronal T1 WI with contrast shows homogeneous diffuse enhancement.

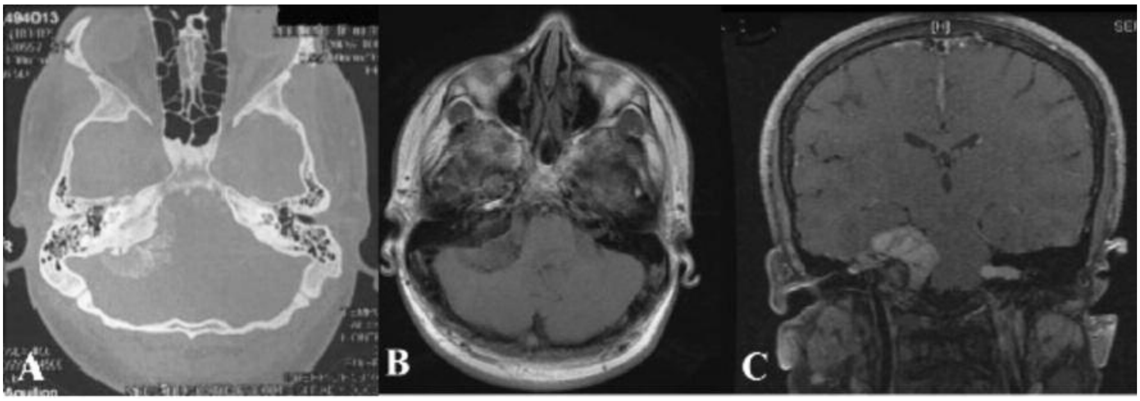

Figure 10. Right meningioma and left schwannoma in NF 2 case**. A:** Axial CT shows calcification in the lesion and hyperostosis in right temporal bone; **B:** Axial T1 WI shows a heterogeneous iso-hypointense lesion on the right side and isointense lesion on the left side; C: Coronal T1 WI shows contrast enhancement on both space occupying lesions.

References

1. Blevins NH, Heilman CB: Lesions of the petrous apex. In: Jackler RK, Brackmann DE (Eds). Neurotology. Philadelphia: Elsevier Mosby; 2005. p. 1107-1124.

2. Connor SEJ, Leung R, Natas S. Imaging of the petrous apex: a pictorial review. The British J Radiology 2008; 81: 427-435.

3. Moore KR, Harnsberger HR, Shelton C, Davidson HC. 'Leave me alone' lesions of the petrous apex. AJNR Am J Neuroradiol 1998;19:733-738.

4. Isaacson B, Kutz JW, Roland PS. Lesions of the petrous apex: diagnosis and management. Otolaryngol Clin North Am 2007; 40(3): 479-519.

5. Muckle RP, De La Cruz A, Lo W. Petrous apex lesions. Am J Otol 1998;19:219-25.

6. PA, Kassam AB, Snyderman CH, Carrau RL, and Prevedello DM. Endoscopic Endonasal Approaches to the Skull Base and Paranasal Sinuses. In: Brackmann DE, Shelton C, Arriaga MA, editors. Otologic Surgery. 3. edition, Saunders, Elsevier, Philedelphia, 2010. p. 667-680

7. Jackler RK: Atlas of neurotology and skull base surgery.Elsevier Mosby; 1996.

8. Curtin HD, Som PM. The petrous apex. Otolaryngol Clin North Am 1995;28: 473-496.

9. Flood LM, Kemink JL. Surgery in lesions of the petrous apex. Otolaryngol Clin North Am 1984; 17: 565-574.

10. Jackler RK, Cho M. A new theory to explain the genesis of petrous apex cholesterol granuloma, Otol Neurotol 2003; 24: 96-106.

11. Leonetti JP, Shownkeen H, Marzo SJ. Incidental petrous apex findings on magnetic resonance imaging. Ear Nose Throat J 2001; 80:200-206.

12. Nugent GR, Sprinkle P and Bloor BM. Sphenoid sinus mucoceles, J Neurosurg 1970; 32: 443-451.

13. Gacek RR. Diagnosis and management of primary tumors of the petrous apex. Ann Otol Rhinol Laryngol Suppl 1975; 84(18): 1-20.

14. King TT, Benjamin JC and Morrison AW. Epidermoid and cholesterol cysts in the apex of the petrous bone, Br J Neurosurg 1989; 3: 451-461.

15. de Souza CE, Sperling NM, da Costa SS, et al. Congenital cholesteatomas of the cerebellopontine angle, Am J Otol 1989; 10: 358-363.

16. Axon PR, Fergie N, Saeed SR, et al. Petrosal cholesteatoma: management considerations for minimizing morbidity. Am J Otol 1999; 20: 505-510.

17.Sanna M, Zini C, Gamoletti R, et al. Petrous bone cholesteatoma, Skull Base Surgery 1993; 3: 201-213.

18. Ghorayeb YB, Jahrsdoerfer RA. Subcochlear approach for cholesterol granulomas of the inferior petrous apex. Otolaryngol Head Neck Surg 1990; 103: 60-65.

19. Giddings NA, Brackmann DE, Kwartler JA. Transcanal infracochlear approach to the petrous apex. Otolaryngol Head Neck Surg 1991; 104: 29-36.

20. Brackmann DE, Toh EH. Surgical management of petrous apex cholesterol granulomas. Otol Neurotol 2002; 23: 529-533.

21. Isaacson B, Telian SA and El-Kashlan HK. Facial nerve outcomes in middle cranial fossa vs translabyrinthine approaches, Otolaryngol Head Neck Surg 2005: 133: 906-910.

22. Satar B, Jackler RK, Oghalai J. Risk-benefit analysis of using the middle fossa approach for acoustic neuromas with >10 mm cerebellopontine angle component, Laryngoscope 2002; 112: 1500-1506.

23. Lustig LR, Jackler RK. The vulnerability of the vein of Labbe' during combined craniotomies of the posterior and middle fossae. Skull Base Surgery 1998; 8: 1-9.

24. Gerek M, Satar B, Yazar F, Ozan H, Ozkaptan Y. Transcanal anterior approach for cystic lesions of the petrous apex. Otol Neurotol 2004; 25(6): 973-6.

25. Amedee RG, Gianoli GJ, Mann WJ. Petrous apex lesions. Skull Base Surg 1994;4(1): 10-4.

26. Franklin DJ, Jenkins HA, Horowitz BL, Coker NJ. Management of petrous apex lesions. Arch Otolaryngol Head Neck Surg 1989; 115: 1121-1125.

27. Zanation AM, Synderman CH, Carrau RL, gardner PA, Prevedello DM, Kassam AB. Endoscobic endonasal surgery for petrous apex lesion. Laryngoscope 2009; 119: 19-25.

28. Hughes BG, Lee J, Ruggieri PM. Surgery for Cystic Lesions of the Petrous Apex. In: Glasscock ME, Gulya AJ, editors. Surgery of the ear. PB Saunders, Hamilton, 2003. p. 698-711.

29. Harnsberger HR. Trapped fluid, petrous apex. In: H.R. Harnsberger, R.H. Wiggins and P.A. Hudgins, editors, Diagnostic imaging: head and neck, Elsevier, Oxford, 2004. p. 162-5.

30. Arriaga MA. Petrous apex effusion: a clinical disorder. Laryngoscope 2006; 116:1349-1356.