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BRIEF REPORT

Radiological diagnostic of the non-pathological conditions of the petrous apex

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KEYWORDS
Petrous apex;
Bone marrow;
Trapped fluid;
Incidental findings

Abstract
Many patients with otological symptoms are remitted to the otolaryngology outpatient clinics every day. These patients commonly undergo imaging studies, generally magnetic resonance imaging (MRI). In some cases, a positive unilateral result is found in the form of a potentially pathological signal that can be observed in the petrous apex region. We present the cases of 6 patients (aged between 26 and 62 years) with asymmetric bone marrow distribution or trapped mucous fluid secretions in the petrous apex, collected over a 6-year period. Diagnosis was made with the use of CT scans and MRI. All of the patients were referred for skull base surgery. In all cases a non-pathologic asymmetry was diagnosed in the petrous apex. Certain non-pathologic conditions of the petrous apex must be treated expectantly without any surgery.

PALABRAS CLAVE
Ápex petroso;
Médula ósea;
Retención mucoide;
Hallazgo casual

Diagnóstico radiológico de las condiciones no patológicas del ápex petroso

Resumen
A menudo se remite a los pacientes con síntomas otológicos a la consulta de otorrinolaringología. En no pocas ocasiones, se realiza a estos pacientes estudios de imagen, habitualmente resonancia magnética. En algunos casos, se evidencia un hallazgo positivo unilateral en forma de señal de posibles características patológicas en el ápex petroso. Presentamos los casos de 6 pacientes (de 26 a 62 años) con médula ósea asimétrica o retención de secreciones mucosas en el ápex petroso a lo largo de 6 años. El diagnóstico se realizó mediante tomografía computarizada y resonancia magnética. Se remitió a todos los pacientes para cirugía basicraneal. En todos los casos, se diagnosticó una asimetría de carácter no patológica en la punta del peñasco. Ciertas condiciones no patológicas de la punta del peñasco deben ser tratadas de forma expectante sin cirugía.

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Introduction

Often patients with otologic or neurological symptoms attend otolaryngology consultation. These patients are usually requested to undergo imaging studies, preferably magnetic resonance imaging (MRI). In some cases, an asymmetric pathological signal is found in the region of the petrous apex or in its tip. These incidental findings usually lead to a diagnosis of inflammatory lesion or tumour that eventually could be an indication for a complex surgical approach of the inner ear, in order to obtain a clear diagnosis and eradicate the condition.

It is very important to adequately diagnose any findings of imaging tests in the region of the petrous apex, as they could correspond to a physiological condition which should be treated in a purely expectant manner.[1,2]

Patients and methods

We retrospectively analyzed medical records of 6 patients between 26 and 62 years of age, with asymmetric distribution of bone marrow or retention of secretions in the petrous apex during the period between 2001 and 2006. The minimum follow-up time was 12 months after the findings. In all cases, the specialist who referred the patient identified a lesion on the tip of the petrous apex in the computed tomography (CT) or MRI images. In all cases where this lesion was not present, the radiological study was complemented with MRI or CT. MRI images were obtained with standard sequence in T1, T2, and T1 with intravenous contrast. CT images were obtained by helical CT with bone algorithm at high resolution.

It is considered that a patient has an asymmetry of the bone marrow of the tip of the petrous apex if an accumulation of fat, with the same radiological features as orbital fat on MRI weighted in T1 and T2, can be observed in the CT of the temporal bones. A pneumatized petrous apex is considered to have retained secretions or mucoid effusion if it shows characteristics of aqueous signal in the T2 images of MRI and the CT scan reveals no signs of bone erosion or extratemporal affectation, opacification of the signal from the filled air cells or alteration or destruction of the bone trabeculae of the tip of the petrous apex.

Results

We identified a total of 6 patients with findings of asymmetry in the tip of the petrous apex, 4 males and 2 females. The average follow-up time was 23 months (range, 12-72).

The diagnosis was made only with the clinical reports and imaging studies, which in all cases were MRI and CT.

In no case was there an extension of the lesions outside the bony confines of the petrous apex. In all cases the CT scans showed occupation of the cells of the tip of the cliff without expansion. None of the studied patients showed bone erosion, cortical destruction or infectious or radiological neoplastic signs. The contralateral side showed normal aeration of the cells in the petrous apex in all patients studied. On the side of interest, an increase of the T1 sequence signal was evidenced in the case of asymmetry in bone marrow (Figure 1) and increased signal on T2 sequence of MRI in the case of retention of mucoid secretions (Figure 2).

With these findings, the 6 patients were referred to our hospital consultation for surgical evaluation. In the cases referred by Gradenigo syndrome, bone erosion or increased signal after intravenous contrast administration were not evident, and although antibiotic and corticosteroid treatment at suppressive doses had been established and maintained for 15 days, the imaging studies with CT were repeated without finding the slightest change after treatment.[3]

All patients studied had previous otologic symptoms for which they underwent the radiological study (cranial neuropathies, hearing loss, aural fullness, nonspecific vertigo, or dizziness) (Table 1).

Discussion

The petrous portion of the temporal bone is a pyramid-shaped structure that extends in the medial and anterior directions towards the geometric centre of the skull base. The body of the temporal bone forms the bony capsule of the membranous labyrinth and includes the seventh and eighth cranial nerves, the internal carotid artery and the bulb of the internal jugular vein. The "petrous apex" is the term used to refer only to the portion of the temporal bone which is medial to the otic capsule or bony and membranous labyrinth.[4]

Any injury or incidental finding evidenced in the petrous apex should be correctly identified in its nature and extent by using radiological techniques.[1,2]

In imaging tests, the appearance of the petrous apex depends on the extent of the migration of air cells. In CT imaging the cortical and air cells margins and the bone marrow are readily visible. If there has been minimal migration of air cells with bone marrow, the fat contained in it creates a characteristic signal with low attenuation. In the MRI, a petrous apex with pneumatization becomes completely black in all sequences. The fat content in a pneumatized petrous apex and with bone marrow shows an increased signal in T1 sequences and a low signal on T2 sequences. A technique of fat suppression could be used in T1 to show a decrease in signal intensity from the adipocyte cells of the bone marrow.[5]

Both CT and MRI are key elements to diagnose potential injuries of the petrous apex, since this anatomical area is not accessible to direct examination without surgery that should be fully justified on the basis of radiographic findings. MRI is not adequate by itself for the differential diagnosis of lesions of the petrous apex.[6] CT can help to distinguish these lesions, as seen in Table 2. Cholesterol granulomas often show expanded boundaries that are often isodense with brain tissue without enhancement of the lesion or with ring enhancement only. When this ring enhancement is present, it is usually almost diagnostic of cholesterol granuloma.[2,7] In the CT, acute or chronic inflammation of the petrous apex or apicitis usually appears as an expansive lesion with irregular margins and erosion or bone destruction, especially in cases of good pneumatization, in which irregular margins of the

Figure 1 Image of asymmetric bone marrow in the right petrous apex of patient number 4. A. Magnetic resonance imaging (MRI) enhanced in T2. B. MRI enhanced in T1. C. CT image showing bone marrow filling the petrous apex. Note the presence of conserved intersepta and normal pneumatization of the left side. D. MRI image enhanced in T1 with fat suppression technique. Note the decreased signal intensity of fat tissue (arrow).

Figure 2 Mucous effusion in the right petrous apex of patient number 5. A. CT scan image of an opacified petrous apex with no evidence of bone remodelling. B. Magnetic resonance imaging (MRI) enhanced in T1. C. MRI enhanced in T2. D. MRI enhanced in T1 with injection of contrast.

Table 1 Case reports

Patient, No.	Age	Gender	History	CT	MRI, T1/ T2/ T1 with gandolinium	Original diagnostic	Initial treatment	Final diagnostic	Side of radiological interest
1	26	F	Cephalalgia, right V1 and V2 hypoesthesia, fever	Opaque air cells with no bone alterations	Hyper/ hypo/ no enhancement	Gradenigo syndrome	Antibiotics. Steroids. Remitted for surgery	Asymmetric bone marrow	Right
2	39	M	Long term instability. Vertigo	Opaque air cells with no bone alterations	Hypo/ hyper/ no enhancement	Petrous apicitis	No	Mucoid effusion. Trapped fluid	Left
3	62	F	Right tinnitus. Otic fullness	Opaque air cells with no bone alterations	Hyper/ hypo/ no enhancement	Cholesteatoma or cholesterol granuloma	No. Remitted for surgery	Asymmetric bone marrow	Left
4	35	M	Right V2 neuralgia	Opaque air cells with no bone alterations	Hyper/ hypo-iso/ no enhancement	Petrous apex tumour	No. Remitted for surgery	Asymmetric bone marrow	Right
5	55	M	Left neurosensory hypoacusis	Opaque air cells with no bone alterations	Hypo/ hyper/ no enhancement	Abnormality of bone-petrous tumour	No. Remitted for surgery	Mucoid effusion. Trapped fluid	Right
6	45	M	Left neurosensory hypoacusis	Opaque air cells with no bone alterations	Iso/ hyper/ no enhancement	Cholesteatoma or cholesterol granuloma	No. Remitted for surgery	Asymmetric bone marrow	Right

CT indicates computed tomography; F, female; M, male; MRI, magnetic resonance imaging.
Note that patients 3, 5, and 6 present contralateral symptoms to the side of radiological interest.

lesion are seen; these findings are similar to those obtained in osteomyelitis of the base of the skull.[8,9] When there is not a good visualization of the thin walls separating one cell from another, it must be considered as a sign of bone destruction.[10,11]

Pneumatization of the petrous tip and asymmetry of the apical bone marrow

Several anatomical studies have determined a frequency of petrous apex pneumatization of 30%[12] In several series an incidence of 4% of asymmetric pneumatization of the petrous tip is shown. Stelter et al[13] determined that the trajectory of the petrous apex air cells is caused by medial extension of air cells from the mastoid antrum, the middle ear or the peritubal cells. The fat content of bone marrow in a non pneumatized apex produces an image with signal hyperintensity on a T1 sequence without contrast. This finding should be distinguished from a neoplasm by the absence of bone erosion or expansion in the CT images, in the case of bone marrow even the thin walls separating air cells from each other are well preserved. After intravenous gadolinium injection, a lack of enhancement is evident, and the intensity of T2 images is less than those of cerebral tissue.[2]

Retention of secretions from the mucosa in a pneumatized petrous apex

As explained above, almost one third of adults have some degree of pneumatization of the petrous apex. It is logical to assume that a low percentage of these individuals will develop effusion or collection of mucosa in these air spaces. With increasing use of diagnostic imaging, such as MRI, it is not surprising that some clinicians and radiologists are finding a considerable number of asymptomatic or symptomatic patients with apparent abnormalities in the petrous apex. Simple effusion is not associated with any bone erosion or alteration and the content just takes the shape and pattern

Table 2 Differential diagnosis of findings on computed tomography (CT) and magnetic resonance imaging (MRI) in the region of petrous apex

Diagnostic	CT	MRI T1	MRI T2	MRI T1 with gadolinium
Assymetric bone marrow	Isodense with no expansion or erosion	Hyperintense (fat)	Hypointense	No enhancement
Retention of secretions	Isodense with no expansion or erosion	Hypointense	Hyperintense (water)	No enhancement or only mucosa
Cholesteatoma	Isodense. Bone erosion	Hypointense	Hyperintense	No enhancement
Mucocele	Isodense. Bone expansion	Any intensity	Hyperintense	Enhancement
Petrous apicitis	Isodense. Enhancement with contrast/ normal bone	Hypointense	Mixed, hiperintense	Ring enhancement
Apex giant cell	Aerial density/ no erosion or expansion	Air	Air	No enhancement
Cholesterol granuloma	sodense. Bone erosion/ normal lin early stage	Hyperintense	Very hyperintense	No enhancement
Neoplasm	Isodense. Bone erosion	Hypointense	Mixed	Enhancement or ring enhancement
Carotid aneurism	Isodense. Bone erosion	Hypointense	Hyperintense	Enhancement

of existing air cells. Typically, even the delicate septa that divide the apex are completely conserved in the CT image. The contralateral apex usually has a similar pneumatization to the side of interest and it is usually aired. In the MRI image, the petrous apex with retention of mucoid secretions appears hypointense on the T1 sequence and with a marked hyperintensity on the T2 sequence, with no enhancement after gadolinium injection. A persistent mucoid collection can, in a considerably long time, evolve into an expansive lesion such as a mucocele or cholesterol granuloma, depending on the nature of the material trapped in it.[9] The appropriate monitoring for such patients is not clearly defined,[14] but Moore et al[15] suggest waiting for a period of approximately 3 years before repeating the CT and exclude an early degeneration towards a cholesterol granuloma in the case of mucoid fluid entrapment. This time should be shortened if there are concurring symptoms pertaining to the area of radiological interest.

Conclusions

Petrous apex lesions are rare. The asymmetric bone marrow and mucous effusion, usually found incidentally in MRI studies, may not be related to the clinical symptoms and they should be studied radiologically but not necessarily intervened. Both conditions have sufficient radiographic features in CT and MRI images to facilitate a correct diagnosis. In these cases a monitoring by CT or MRI is warranted to confirm the stability of the findings.

Conflict of interests

The authors have indicated there is no conflict of interests.

References

1. Muckle RP, de la Cruz A, Lo WM. Petrous apex lesions. Am J Otol. 1998;19:219-25.
2. Arriaga MA, Brackmann DE. Differencial diagnosis of primary petrous apex lesions. Am J Otol. 1991;12:470-4.
3. Gradenigo G. Uber die Paralyse des N. Abduzens bei Otitis. Arch Ohrenkeilk. 1907;74:149-58.
4. Leonetti JP, Shownkeen H, Marzo SJ. Incidental petrous apex findings on magnetic resonance imaging. Ear Nose Throat J. 2001;80:200-2. 205-6.
5. Curtin HD, Som PM. The petrous apex. Otolaryngol Clin North Am. 1995;28:473-96.
6. Moore KR, Fischbein NJ, Hansberger HR, Shelton C, Glastonbury CM, White DK, et al. Petrous apex cephaloceles. AJNR Am J Neuroradiol. 2001;22:1867-71.
7. Greenberg JJ, Oot RF, Wismer GL, et al. Cholesterol granuloma of the petrous apex. MR and CT evaluation. Am J Neuroradiol 1998;9:1205-14.
8. Jackler RK, Parker DA, Davis KR, Goodman ML, Weber AE. Radiographic differential diagnosis of petrous apex lesions. Am J Otol. 1992;13:561.74.
9. Koral K, Dowlingb M. Petrous apicitis in a child: computed tomography and magnetic resonance imaging findings. Clin imaging. 2006;30:137-9.

10. Chang P, Fagan PA, Atlas MD, Roche J. Imaging destructive lesions of the petrous apex. Laryngoscope. 1998;108:599–604.
11. Profant M, Steno J. Petrous apex cholesteatoma. Acta Otolaryngol. 2000;120:164–7.
12. Myerson MC, Rubin J, Gilbert JG. Anatomic studies of the petrous portion of the temporal bone. Arch Otolaryngol. 1934;20:195–210.
13. Stelter GP, Bast TH, Anson BJ. The developmental and adult anatomy of the air cells in the petrous part of the temporal bone. Buarterly Bill of Northwestern University Medical School. 1960;34:23–36.
14. Thorne MC, Gebarski SS, Telian SA. Rapid expansion in a previously indolent cholesterol cyst: a need for lifelong follow-up. Otol Neurotol. 2005;27:124–6.
15. Moore KR, Harnsberger HR, Shelton C, Davidson HC. "Leave me alone" lesions of the petrous apex. AJNR Am J Neuroradiol. 1998;19:733–8.