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# Temporal bone pneumatisation: A computed tomography study of pneumatized articular tubercle☆

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AIM: To determine the prevalence and characteristics of pneumatized articular tubercle (PAT) at computed tomography (CT), and to determine whether the presence of PAT is a predictor of larger pneumatized spaces of temporal bone.

MATERIALS AND METHODS: A retrospective study was performed using axial, sagittal and coronal CT images of 225 patients who attended a private medical imaging centre. Age and gender were recorded for all patients and, for cases of PAT, laterality and types were also recorded. Temporal bone pneumatization was recorded based on three reference structures on axial images. The Chi-square and Mann–Whitney *U*-tests were used.

RESULTS: Of the 225 patients, 43 (9.55%) had PAT, of whom 24 were female and 19 were male. This difference was not statistically significant ($p > 0.05$). The age range of the patients with PAT was 8–67 years. Of the 43 patients, 24 had unilateral and 19 had bilateral PAT. Fifteen cases of PAT were unilocular and 28 were multilocular. Cases of PAT showed larger pneumatized spaces of other parts of the temporal bone ($p = 0.0001$).

CONCLUSION: It is possible that PAT is a more frequent condition than is commonly perceived. The degree of pneumatization of temporal bone can be estimated by the evaluation of the air cells around the articular tubercle. CT is highly recommended in patients with PAT undergoing surgical treatment to determine the exact size and relationship of PAT to other parts of temporal bone.



## Introduction

Pneumatization refers to the development of air-filled cavities in bone. Accessory air cells may develop in numerous locations in the skull, in addition to the major paranasal sinuses, including the temporal bone.[1]

The temporal bone, which is comprised of the petrous bone, the squamous bone, the tympanic bone, the mastoid, and the styloid process, primarily develops through pneumatization of the mastoid process.[2] According to literature, the development of otitis media and formation of cholesteatoma, may be related to the degree of pneumatization of the temporal bone.[3] Although it is not known whether it is the cause or the result of otitis media.

In addition to the pneumatization of the mastoid process, accessory air cells may develop in several regions of the temporal bone, including the root of the zygomatic arch and the articular eminence.[4] Detection of these air cells is not just important from an epidemiological point of view, but

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also from a surgical perspective. Inadvertent penetration through this anatomical region may cause severe intraoperative complications.[1,5]

The distribution of temporal bone pneumatization has been previously discussed in the literature using different imaging methods. Despite the inherent limitations, plain film radiography has, in the past, played an important role in evaluating temporal bone pneumatization. The prevalence of zygomatic air cell defect (ZACD) and pneumatized articular tubercle (PAT) has been studied using panoramic radiography.[1,5,6]

As computed tomography (CT) is now the major imaging method for the ear, more recent studies have been carried out using CT, and recently, using cone beam CT (CBCT) images.[7,8] Among previous reports, few studies used CT to study the pneumatization of the articular eminence,[7–9] and only one study discussed the different classifications of temporal bone pneumatization.[10] Therefore, data on pneumatization in this region are limited. Additionally, no data are available regarding correlation of PAT and degree of pneumatization on other parts of the temporal bone.

Thus, the aim of the present study was to define the distribution and variations of PAT using CT images. In addition, the statistical correlation of pneumatized areas of temporal bone with PAT was evaluated using three-dimensional (3D) reconstruction to determine whether PAT may be used as a prognostic factor to estimate temporal bone pneumatization.

## Materials and methods

Retrospective analysis of temporal CT images of patients who presented to the Taba Radiology Clinic between March 2012 and March 2013 was undertaken. The study design was approved with ID: 8591028, and supported by the International Branch of Shiraz University of Medical Sciences. CT images comprised 450 sides from 225 patients with a mean age of 40.02 years (range 8–85 years), showing normal findings bilaterally. Normal findings on axial-view CT images were defined as no evidence of bony destruction, no fluid retention or mass lesion in any of the mastoid air cells, and sharply demarcated mastoid air cells. Images that were inadequate for the reconstruction of 3D images or those with diagnoses of chronic otitis media or temporal bone fracture, developmental malformations of head and face, those in whom systemic conditions affected growth, those with clinical or radiographic evidence of disease in the head and neck region, and those with a history of trauma to the head and neck region and who had been treated with surgical intervention, were excluded from the study.

The axial views of the high-resolution temporal bone CT images (100 mAs and 120 kV with the thickness of 0.625 mm), which had been taken with a multi-detector row CT machine (VCT 64 sections; GE Healthcare, Waukesha, WI, USA), were evaluated. Sagittal, coronal, and oblique section planes were reformatted using high-resolution multiplanar reconstruction (MPR).

The obtained image information, stored as a DICOM (digital imaging and communication in medicine) file, was transferred to a personal computer and a 3D image was reconstructed using the GE AW 4.1 program (GE Healthcare). The sigmoid sinus, the labyrinth, and the ascending carotid artery were established as reference structures on high-resolution axial-view CT images for the evaluation of temporal bone pneumatization. Unilateral and bilateral involvement of PAT in MPR images was also studied. The images were examined by an experienced radiologist. Forty-five randomly selected images were re-evaluated after a period of 2 weeks to provide diagnostic reproducibility.

The age and gender were recorded for all patients. The extent of the pneumatic spaces of the temporal bone was individually determined using a 1–4 grading system, for each side.

The sagittal and coronal high-resolution MPR reformat images were used and evaluated for the presence of PAT (Fig 1). Detection of air cells in MPR images of articular eminence was classified as grade 1 (to indicate existence of PAT), or grade 0 (to indicate no extension of air cells to articular eminence).

### *Classification of temporal bone pneumatization*

#### *Evaluation using the sigmoid sinus as the reference structure*

On axial sections where the malleoincudal complex appears as an ice-cream-cone shape, three parallel lines angled at 45° in the anterolateral direction were applied. The first line crossed the most anterior point of the sigmoid sinus, the second line passed the most lateral aspect, and the final line crossed the most posterior point of the sigmoid sinus.

Temporal bone pneumatization was classified into four groups according to the degree of pneumatization in relation to the sigmoid sinus as follows: group 1 (hypopneumatization group), the pneumatization remained anteromedial to the line that was drawn at the most anterior point of the sigmoid sinus; group 2 (moderate pneumatization group), the pneumatization was extended to the space between the two arbitrary lines drawn at the most anterior point and at the most lateral aspect of the sigmoid sinus (Fig 2); group 3 (good pneumatization group), the

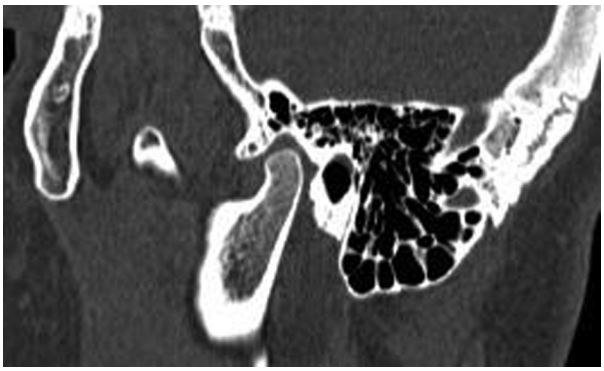

**Figure 1** Sagittal image of the temporal bone CT shows a unilocular PAT.