Original Article

Pneumatized Articular Eminence and Assessment of Its Prevalence and Features on Panoramic Radiographs

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Abstract

Objectives: Pneumatized articular eminence or tubercle (PAT) is an air cell cavity in the zygomatic process of the temporal bone. Pneumatization of articular eminence may be seen incidentally on panoramic radiographs (PRs) as a unilocular or multilocular radiolucent defect. The aim of this study was to assess the prevalence and the pattern of PAT on PR in an Iranian population.

Materials and Methods: A total of 3,098 PRs belonging to 1,735 females and 1,363 males were retrospectively investigated for the presence and radiographic features of PAT. All PRs were taken for routine dental examination. Chi-square test, univariate odds ratio (OR) and corresponding 95% confidence interval (95% CI) and binary logistic regression were used for statistical analysis.

Results: Overall, PAT was found in 2.1 % of cases including 41 females and 23 males (with a mean age of 33.23±12.43 and 35.64±13.24 years, respectively, range 19-69 years). There were 40 unilateral and 24 bilateral cases (total: 88 PATs) including 49 unilocular and 39 multilocular cases. There was no significant difference in PAT between males and females or different age groups (P>0.05 and all CIs included 1.00). Binary logistic regression indicated that there was no relationship between the presence of PAT and age or sex.

Conclusion: Knowledge about this anatomical variation is helpful for clinicians who are planning to perform temporomandibular joint surgery. They should assess the radiographic imaging thoroughly before the surgery. It can also provide valuable information to understand the differential diagnosis of pathological entities in this region.

Key words: Articular; Eminence; Tubercle; Temporal Bone

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INTRODUCTION

The temporal bones (temple) form the lateral walls of the cranial vault and contribute to the zygomatic arches. They are derived from five separate ossification centers that fuse after birth. These segments are the squamous, tympanic, mastoid, styloid and petrous (pyramid) [1]. Zygomatic process, which is a part of squamous portion that joins the zygomatic bone, forms the articular tubercle and glenoid fossa [2]. In addition to the paranasal sinuses, air filled (or pneumatized) cavities may be present in various locations in the skull and also in the temporal bones [3,4].

Pneumatization of the temporal bone can be divided into five regions namely the middle ear, mastoid (squamomastoid), perilabyrinthine, petrous apex and accessory.

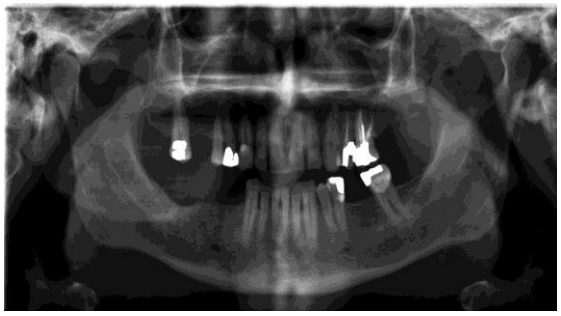

Fig. 1. Unilocular pneumatization of the articular tubercle seen on the left side

Fig. 2. Multilocular pneumatization of the articular eminence seen on the left side

Distribution and pattern of temporal bone pneumatization have been previously discussed in the literature [3,5-9]. The recognition of these air cells is not just important from an epidemiological aspect but also from a surgical perspective [10].

According to Gunnel, the first report of PAT was by Tremble in 1934, whose interest was the examination of the anatomic basis for spread of infections within the temporal bone [3]. He reported 10 locations within the temporal bone where accessory air cells could be found including the zygomatic process of the temporal bone [3]. The term PAT was coined by Tyndall and Matteson in 1985 to describe accessory air cells that occur in the root of zygomatic arch and in the articular eminence of the temporal bone [10].

For the first time, the common characteristics of the PAT of the temporal bone were identified and included:

1) An asymmetric radiolucent defect in the zygomatic process of the temporal bone with the appearance similar to mastoid air cells.

2) Extension of the defect anteriorly as far as the articular tubercle but not beyond the zygomaticotemporal suture and

3) No enlargement or cortical destruction of the zygoma [10].

The purpose of this paper was to determine the prevalence and variation of PAT among Iranian adult patients. Also, we compare other studies from different geographic populations to our results.

MATERIALS AND METHODS

In this cross-sectional study, a total of 3,098 PRs which had been taken for routine dental examination and fulfilled the study criteria belonging to 1,735 females and 1,363 males were retrospectively investigated for the presence and radiographic features of PAT as a unilocular or multilocular radiolucency.

The following conditions were considered as the exclusion criteria: cases in which the articular tubercle was not adequately seen because of technical errors or anatomical reasons and also cases with positive history of fracture or developmental anomalies. Complete calcification of cortical borders of temporomandibular joint may not be completed until 20 years of age; thus, PRs of patients younger than 19 years were not included in this study [11]. All radiographs were taken with a digital panoramic machine, at exposure settings of 80 kVp and 18 mAs (Proline Planmeca, Helsinki, Finland).

All radiographs were assessed concomitantly by two oral and maxillofacial radiologists in a quiet room with ambient light under standard viewing conditions on a monitor (Flatron 17″, LG, Seoul, South Korea) for the presence and pattern of PAT. Diagnosis of PAT was made if the defect was located in the articular tubercle as well-defined unilocular or multilocular radiolucencies. Unilocular PAT as in the Tyndall and Matteson [10] study was identified as a single radiolucent oval defect with well-defined bony borders.

Multilocular PAT was identified as numerous, radiolucent small cavities (Figs. 1 and 2).

A review for PAT prevalence was done using a Medline search in the English literature between the years 1985 and 2013. Seven prevalence studies and 13 case reports were found [6-10,12-26]. The keywords for this search were "pneumatization", "articular tubercle", "articular eminence", "temporal bone" and "pneumatized articular tubercle".

Statistical analysis

Chi square test, univariate OR and corresponding 95% CI were used to assess the relationship of PAT with sex and age. Binary logistic regression was also applied to compare the adjusted OR (95% CI).

RESULTS

A total of 3,098 PRs belonging to 1,735 females and 1,363 males were retrospectively investigated. The mean age of female patients was 33.23±12.43 years and the mean age of males was 35.64±13.24 years.

The PAT was recorded in 64 patients including 41 females and 23 males with a mean age of 35.11 years ranging from 19 to 69 years; PAT was unilateral in 40 individuals and bilateral in 24 individuals. Most of the PAT cases in this study had a unilocular pattern. Out of 88 recordings of PAT, 49 had unilocular and 39 had multilocular patterns.

Table 1. There was no significant difference in the occurrence of PAT between sexes (P=0.117) or among the various age groups (P=0.952). Univariate analysis (OR) showed that different sexes as well as each age group were as likely as the reference group to develop PAT (all CIs included 1.00). Binary logistic regression was also applied to adjust the effect of sex, which confirmed that there was no relationship between age and sex categories and the presence of PAT.

DISCUSSION

Microscopically, a single flat layer of epithelium separated from bone by subepithelial connective tissue lines an air cell. This subepithelial layer is largely responsible for air cell formation.

The development of air cells preceded by the formation of bone cavities is a normal physiological process related to periosteal activity. The bone cavities contain primitive bone marrow, which differentiates into a loose mesenchymal connective tissue.

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Table 1. Evaluation of the effects of age and sex on prevalence of PAT

Variable	Category	N	Cases with PAT	OR (%95 CI)	Adj. OR* (%95 CI)	P†
Age (years)	**19-29**	1452	29	1	1	0.952
	30-39	682	15	1.10 (0.59-2.07)	1.09 (0.55-2.00)	
	40-49	467	8	0.85 (0.39-1.88)	0.85 (0.40-1.82)	
	50-59	333	8	1.21 (0.55-2.67)	1.25 (0.60-2.61)	
	60-69	164	4	1.23 (0.43-3.53)	1.20 (0.45-3.50)	
Sex	**Male**	1363	23	1	1	0.117
	Female	1735	41	1.41 (0.84-2.36)	1.44 (0.88-2.39)	

* Adjusted OR computed using binary logistic regression

† Chi-Square test.

After the epithelial mucous membrane has invaginated, it in turn undergoes atrophy, leaving a thin residual lining membrane and subepithelial bone resorption; resulting in further enlargement of the air cells [27-31].

Development of complete adult pneumatization can be divided into three stages: the infantile, from birth to two years of age; the transitional, from two to five years and thereafter in adulthood. In the infantile stage, the mastoid (squamomastoid) undergoes gradual enlargement, with migration of air cells towards the periphery.

The air cells, which vary in size and shape, become more distinct with time because of progressive calcification of their walls. Pneumatization ceases during adulthood [12,26,31]. The distribution of air cells in the temporal bone was first reported in 1934 when searching for an anatomical basis for the spread of infections within the temporal bone [3]. Ten locations within the temporal bone were identified where accessory air cells could be found [10].

Although some authors do not support the use of PR in the diagnosis of temporomandibular disorders (TMDs) [32-34], its use for the diagnosis of PAT is reasonable, since the posterior aspect of the zygomatic arch and articular tubercle are usually displayed sufficiently [6,10,14].

Transorbital or transmaxillary radiographs can also be adjunctive projections in visualization of PAT [12,10,31]. Although magnetic resonance imaging (MRI) is an excellent tool for evaluation of the soft tissues of the TMJ, high-resolution computed tomography (CT) remains the method of choice for the assessment of bony structures and pneumatized spaces [27,29]. It is obvious that cross sectional imaging such as CT and cone beam computed tomography (CBCT), which are not subjected to superimposition exceed the diagnostic accuracy of plain radiographs in the evaluation of temporal air spaces [10,12,14,27,29]. However, due to their low cost, ease of use and widespread availability and usage, PRs are considered the initial method for the diagnosis of these defects [6]. The paucity of case reports on the PAT suggests that the prevalence of this finding is rare [13-25].

We found seven PAT prevalence studies by searching Medline, namely by Tyndall and Matteson [10] in 1985, Kaugras et al, [12] in 1986, Orhan et al, [6] in 2005, Yavuz et al, [9] in 2009, Miloglu et al, [7] in 2011, Ladeira et al, [8] in 2013 and Shokri et al, [26] in 2013. The results of previous studies are listed in Table 2. There are wide variations in temporal bone aeration, and air cells in the articular eminence may present as an incidental finding by the clinician.

Table 2. Summary of reported prevalence of pneumatized articular eminence.

Imaging modality	Authors	Study sample size	Cases with PAT N (%)	Mean age	Male N (%)	Female N (%)	Unilocular/ Multilocular	Unilateral/ Bilateral
Panoramic	Tyndall and Matteson [10]	1061	28 (2.6)	32.5	13 (46.4)	15 (53.6)	17/16	23/5
	Kaugars et al [12]	784	8 (1.02)	50.5	1 (12.5)	7 (87.5)	Not reported	4/4
	Orhan et al [6]	1006	19 (1.8)	36.6	7 (36)	12 (64%)	10/16	12/7
	Yavuz et al [9]	871	83 (9.5)	26.9	42 (51)	41 (49)	44/66	56/27
	Shokri et al [26]	1563	98 (6.2)	22.8	33 (33.6)	65 (66.4)	52/46	64/34
	Present study	3098	64 (2.1)	35.1	23 (36)	41 (64)	49/39	40/24
CBCT	Miloglu et al [7]	514	39 (8)	15	14 (46)	25 (54)	Not reported	23/16
	Ladeira et al [8]	658	140 (21)	43	129 (63)	75 (37)	7/197	76/64

Knowledge of this phenomenon may be helpful in the interpretation of radiographs and other imaging studies [21].

Tyndall and Matteson reported the first detailed data on population distribution and radiographic appearance of PAT. In their study, 1,061 patients admitted to a dental school outpatient clinic were examined for the presence of PAT; PAT was found in 28 (2.6%) patients with a mean age of 32.5 years and an age range of 15 to 74 years. All cases were located in the zygomatic process of the temporal bone and did not extend anteriorly beyond the zygomaticotemporal bone. There was no gender predilection, and bilateral PAT was found in five patients. There were 17 (53.1%) unilocular cases and 15 (46.9%) multilocular cases. Tyndall and Matteson did not give the mean age, age range, or sex distribution of their sample population [10].

Kaugars et al, in 1986 reported eight (1%) cases of PAT in 784 patients. All of the eight patients were from the adult group. Four cases were unilateral and four were bilateral. Kaugars et al. did not give a mean age for their total population but they provided a mean age for each of the three subpopulations (children, adolescents, and adults). The mean age of their adult group, which comprised 61% of the total patients, was 41.2 years [12].

Orhan et al, in 2005 found 19 cases with PAT in 1,006 patients. The mean age of the cases was 36.6 years. Seven cases were males and 12 cases were females. Twelve cases of PAT were unilateral. Bilateral PAT was found in seven (36.9%) patients. Ten (38.5%) of the PATs were unilocular. Sixteen (61.5%) of the PATs were multilocular. The youngest patient with PAT was an 11-year-old boy [6].

In a study by Yavuz et al, 83 (1.03%) of 8,107 individuals had PAT with 41 females and 42 males; PATs were located on the right side in 60 individuals and on the left side in 50 individuals. Also, PATs were unilateral in 56 cases and bilateral in 27 (total of 110 PATs). Forty-four of the PATs were unilocular, and 66 of the PATs were multilocular [9].

Miloglu et al, in 2011 reported a study of 603 cases; 39 cases had PAT with a mean age of 6-24 years; 19 patients were males and 22 were females. In their study, PAT was found to be unilateral in 23 cases and bilateral in 16 cases; 27 of the PATs were unilocular, and 37 of them were multilocular [7]. Miloglu et al. performed their study using sagittal and coronal CBCT images of patients aged 6-24 years [7].

Ladeira et al, in 2013 reported another CBCT study of 658 cases. They found 204 PATs, in 140 patients and male and female individuals were about 63% and 37%, respectively; PAT was unilateral in 76 cases and bilateral in 64. The mean age of the individuals was 43.02 years; seven PATs were unilocular and 197 were multilocular [8].

Shokri et al, in 2013 reported a large panoramic study on the prevalence of PAT with 1,563 cases. The prevalence that they reported was 6.2%, with a mean age of 22.8 years; 64 PATs were unilateral and 34 of them were bilateral, with 52 unilocular and 46 multilocular types. The results showed no statistically significant differences regarding age (P=0.454), gender (P=0.634), laterality (P=0.252), or locularity (P=0.807) among the samples [26].

The mean age of subjects in the current study (35.11 years) was similar to that of Orhan et al, [6] and Tyndall and Matesson [10] (36.6 and 32.5 years, respectively). It is presumed that the accessory air cells begin to pneumatize after puberty and achieve full size after several years as with mastoid air cells [10,25,29]. In our study, the youngest patient that we had with PAT was 19 years old. Moreover, the puberty period has been designated to commence at 12-13 years of age. But some studies detected cases before the second half of the second decade of life [6,35].

We believe that further studies should be done on accessory pneumatization in children to elucidate this phenomenon.

In our study, female to male ratio was found to be 1:7. The lack of sex predilection like previous studies seems reasonable since there is no basis for this characteristic to be sex-linked.

In the current study, unilateral to bilateral ratio of 1.6 was observed. Previous studies did not mention any predisposing factor for PAT, because most of them were prevalence studies [9].

Orhan et al, and Miloglu et al. studied the relation between malocclusions and presence of PAT, and reported no significant differences between normal and abnormal skeletons [36,37]. Multilocular as well as unilocular radiolucencies such as the aneurysmal bone cyst, osseous hemangioma, chondroblastoma, fibrous dysplasia, giant cell tumor, eosinophilic granuloma and even metastatic tumors could be considered during differential diagnosis of a pneumatized articular eminence. Awareness about this anatomical variation and knowledge about its clinical and radiographic features will help the clinicians. These features include lack of pain, absence of enlargement and bony expansion, and nondestructive characteristic of the lesion in a symptom-free patient. In comparison with the aforementioned lesions, only PAT can be visualized incidentally on radiographs with non-expansile, non-destructive characteristics and with intact cortical borders [10,12,31,35]. Surgical treatment and augmentation of the articular eminence may be indicated in recurrent mandibular dislocation [38]. Although PAT requires no treatment, the presence of PAT can be a contraindication for performing eminoplasty or eminectomy to treat recurrent chronic mandibular dislocation [10,12,14,31,35].

Kaugars et al. [12] recommended the use of tomography before surgical procedures involving the eminence to determine the extent of the pneumatization.

Lindenmuth and Clark [18] indicated that surgeons who are planning to do such surgical procedures should be aware of the details of pneumatized articular eminence.

During surgery, osteotomes or burs should be used carefully to avoid sudden penetration through the defect. Temporal air spaces are potential paths for the spread of various pathological processes. Tumors of the mastoid process and ear may extend into the TMJ while otitis or mastoiditis may involve the TMJ and can even result in ankylosis [35,39,40]. Moreover, fractures of the skull base frequently extend through the pneumatized spaces of the temporal bone and may release air into the glenoid fossa [35,41].

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