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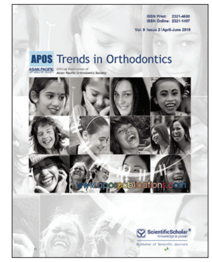

Original Article

Articular eminence pneumatization in patients with different sagittal skeletal patterns: Cone-beam computed tomography study

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ABSTRACT

Objectives: This study objectives to evaluate the type and degree of articular eminence pneumatization in individuals with different sagittal skeletal patterns.

Material and Methods: Cone-beam computed tomography images of 139 patients were included in the study. The population was divided into groups according to their sagittal skeletal anomalies by A point-nasion-B point angle measurement. The laterality, grade, and type of pneumatization were recorded. Pearson Chi-square test and Fisher's exact test were performed to evaluate gender, sagittal skeletal anomalies, pneumatization type, and grade.

Results: A pneumatized articular eminence (PAT) was found in 74.8% of the population. Grade 1 pneumatization and the multilocular type where the most common pneumatization. There were no correlations between sagittal skeletal anomalies and pneumatization grades.

Conclusion: The prevalence of PAT was high concerning the previous studies. However, there were no correlations between the sagittal skeletal anomalies, pneumatization type, and grade. Clinicians must always be aware of the potential for pneumatizations as they may cause untoward complications.

Keywords: Articular eminence, Cone-beam computed tomography, Pneumatization, Sagittal skeletal pattern

INTRODUCTION

The skull bones contain many air-filled cavities, the development of which is known as pneumatizations. These pneumatic fields may appear in different places, such as the temporal bone, in addition to the paranasal sinuses.[1] Within the temporal bone, there are 10 air cell regions, including one in the zygomatic process of the temporal bone,[2] which is called the pneumatized articular eminence (PAT) and the roof of the glenoid fossa.[3] The term PAT was first used by Tyndall and Matteson[4] to describe air cells occurring in the root of the zygomatic arch and in the articular eminence of the temporal bone, which looks similar to air cells in the mastoid process and ethmoid bone. Tyndall and Matteson[4] defined these areas as asymptomatic radiolucent defect sites that do not cause expansion and destruction in the zygomatic process of the temporal bone and do not extend to the zygomaticotemporal suture.

These air cavities near the temporomandibular joint (TMJ) can cause complications during surgical procedures performed on the condyle and articular eminence.[5-8] Penetration may occur, causing a dural rupture and cerebrospinal fluid leakage.[9] Since the pneumatizations have been seen in the bone structures of the TMJ reduce bone resistance, they facilitate fracture formation. They can also facilitate the spread of inflammation, tumor, infection, or other pathological processes into the joints.[5,7,8,10] For example, otitis media and mastoiditis extend into the joint through these pneumatized areas and eventually cause TMJ ankylosis.[10] Therefore, given the potential effects of these factors on surgical procedures, it is important to identify pneumatized areas before surgical planning.

Patients with sagittal skeletal anomalies (class II and III) have a higher frequency of degenerative joint disease and/or temporomandibular disorders than those without these anomalies, and TMJ surgery is more frequently indicated in these individuals.[11-13] The type and degree of PAT in these patients may alert surgeons to the need for more caution during the procedure.[14]

Different imaging methods have been used to evaluate PAT,[1,14,15] including cone-beam computed tomography (CBCT).[7-10] CBCT is an important diagnostic imaging modality in dentistry as it provides high-resolution detailed images of the maxillofacial region and has a lower radiation dose and lower scanning time than computed tomography (CT). CBCT provides three-dimensional cross-sectional imaging that eliminates distortion and superimpositions.[7,9,14]

The present study aimed to evaluate the type and degree of articular eminence pneumatization in individuals with different sagittal skeletal patterns.

MATERIAL AND METHODS

Data collection

This study was approved by the Clinical Research Ethics Committee of the Faculty of Medicine, Aydın Adnan Menderes University and the study was carried out following the ethical rules of the Declaration of Helsinki (the ethics approval number was 2020/33).

The CBCT records of patients who presented to the Faculty of Dentistry Oral and Maxillofacial Radiology Department, Aydın Adnan Menderes University, for a surgical procedure, orthodontic treatment, and prosthetic rehabilitation between December 2015 and December 2019 were retrospectively scanned.

CBCT images of 139 randomly selected patients were included in the study according to the following inclusion and exclusion criteria. The inclusion criteria were as follows: (1) above 18 years, (2) absence of systemic or metabolic diseases affecting bone structure, (3) absence of trauma, pathology, and surgical intervention affecting bone structure which negatively affects the assessment of pneumatization in the articular eminence region, and (4) CBCT images which had a 20 × 17 cm field of view (FOV). CBCT images in which the pneumatization was not visualized, image quality was poor, or there were artifacts were excluded from the study.

The sagittal skeletal relationship of the mandible and maxilla was classified as skeletal class I, II, or III, using A point-nasion-B point (ANB) angle measurements as follows: class I, $0° < ANB < 4°$; class II, $ANB \geq 4°$; and class III, $ANB \leq 0°$. Age, gender, laterality, type, and degree of pneumatization were recorded for all patients.

Images

CBCT images were obtained by one experienced X-ray technician using a Planmeca Promax 3D device (Planmeca, Helsinki, Finland), following the manufacturer's instructions (20 × 17 cm FOV, 94 kVp, 14 mA, and 27 s). All CBCT images were evaluated in a reduced-light room using an LED monitor, approximately 30–40 cm away from the LED monitor by the same investigator who is an expert in dental radiology with 6 years of experience. A maximum of 10 CBCT images were evaluated per day to avoid investigator fatigue. All images were reevaluated to 2 months later by the same investigator and an intraobserver agreement was evaluated.

Assessment of pneumatization

Pneumatization was defined on both sides as a well-defined radiolucent area in the articular eminence and roof of the glenoid fossa, posterior to the zygomaticotemporal suture.[4,16]

The articular eminence pneumatization and the roof of the glenoid fossa were assessed bilaterally on axial, coronal, and sagittal sections in all CBCT images. Pneumatization type was classified as unilocular (well-defined, single, and oval radiolucent defect borders) and multilocular (numerous radiolucent small areas)[7,17,18] [Figure 1], and the degree of pneumatization was divided into four groups according to Al-Faleh and Ekram as follows: [19]

Grade 0: Pneumatization limited to the mastoid process;

Grade 1: Pneumatization between the mastoid process and the glenoid fossa;

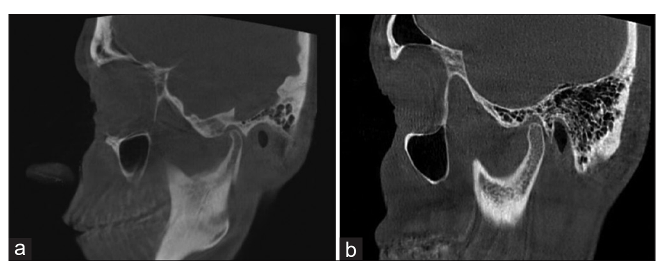

Figure 1: Sagittal CBCT images of pneumatized articular eminence. (a) Unilocular and (b) multilocular. CBCT: Cone-beam computed tomography.

Grade 2: Pneumatization between the deepest point of the glenoid fossa and the tip of the articular eminence;

Grade 3: Pneumatization extending beyond the crest of the articular eminence [Figure 2].

Grade 0 was evaluated as no PAT in our study.

Statistical analysis

Data were statistically analyzed using SPSS (version 23.0, SPSS Chicago, USA). The relationship between the degree of pneumatization and gender was analyzed with the Pearson Chi-square test, and the relationship between pneumatization type and gender were analyzed with Fishers exact testt. The relationship between sagittal skeletal pattern and the type and degree of pneumatization was analyzed with Fisher's exact test. The intraobserver agreements were assessed by kappa coefficients.

RESULTS

The kappa coefficient was 0.96 for pneumatization type and 0.94 for degree of pneumatization. The study population consisted of 139 patients: 90 females (64.7%) and 49 males (35.3%). The age range was 18–86 years and the patients' mean age was 28.25 years. The mean age of men was 29.46 years and the mean age of women was 27.6 years. We classified patients by their sagittal skeletal pattern and 60 patients were Class I, 36 patients were Class II, and 43 patients were Class III. [Table 1] shows the distribution of patients by sagittal skeletal pattern and gender. There was a significant relationship between sagittal skeletal pattern and gender ($P = 0.012$).

PATs can be seen either unilaterally or bilaterally. A PAT was found in 104 patients (74.8% of the population). The PAT was bilateral in 77 patients (55.4% of the population) and unilateral in 27 patients (19.4%). In our study, 181 PATs were found in 139 patients and 85.1% of these PATs were found bilaterally whereas 14.9% of them were unilateral. Of these, 75.1% were Grade 1 pneumatization, 19.9% were Grade 2 pneumatization, and 5% were Grade 3 pneumatization. Most of the PATs detected were multilocular pneumatization [Tables 2 and 3].

In the present study, we classified patients by their sagittal skeletal patterns. Grade 1 pneumatization was the most commonly found in all the sagittal skeletal patterns whereas grade 3 was the least commonly found. Multilocular PAT was the most frequently found type in all sagittal skeletal patterns. Unilocular PAT was mostly found in the Class III growth pattern. There were no significant relationships between sagittal skeletal patterns and PAT grade or type ($P = 0.335$ and $P = 0.180$, respectively) [Table 4]. In addition, there was no significant relationship between PAT grade or type and gender ($P = 0.339$ and $P = 0.498$, respectively).

The interobserver agreements were assessed by kappa coefficients and the agreement was consistent (>0.94 for PAT type and >0.90 for PAT grade).

DISCUSSION

Pneumatization is the process in which the epithelium infiltrates the developing bone and forms air cell cavities that are lined with epithelium.[20] Pneumatization is a normal physiological process.[21] In human temporal bones, the extent of pneumatization is usually limited to the mastoid process, the perilabyrinthine region, and the petrous apex. In rare cases, epithelium may infiltrate the zygomatic process, articular eminence, squamous and occipital regions, or the area around the TMJ.[20] The process of pneumatization continues until the age of 8–9 and the pattern of pneumatization is typically complete by 10 years

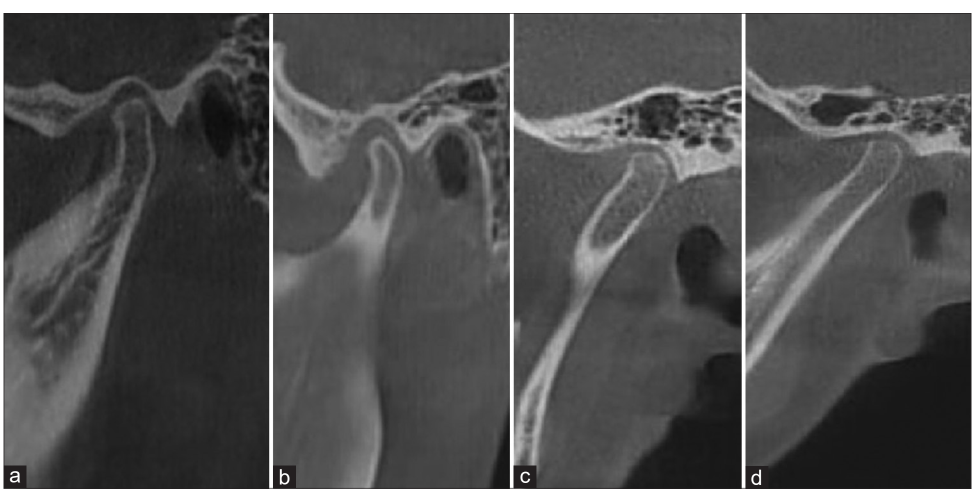

Figure 2: Sagittal CBCT images of different grades of pneumatized articular eminence. (a) Grade 0, (b) Grade 1, (c) Grade 2, and (d) Grade 3. CBCT: Cone-beam computed tomography.

of age in females and 15 years of age in males.[9,22,23] The mean age of our study population was 28.25 years which was lower than in some studies in the literature, but the age range was similar.[4,10,18,24]

Pneumatization is considered a potential complicating factor for surgical procedures in the TMJ, and a PAT is a potential pathway for infections such as otitis media, mastoiditis, and pathologies. Knowledge of the pneumatizations involved in the surgical area is important for surgeons and radiologists because of the complications that can occur. A PAT may be a limitation for surgeries involving the articular tubercle and TMJ.[7,14,15,17,25-27] During surgeries such as eminectomy, eminoplasty, or miniplate insertion, a PAT may be found in the surgical area and the existence of a PAT increases the risk of perforation and untoward complications. [4,7,14,27]

PATs are well-defined, asymptomatic, non-expansile, and non-destructive. Some diseases involved in the zygomatic process of the temporal bone can cause cortical enlargements, bone destruction, and symptoms such as fibrous dysplasia, aneurysmal bone cyst, central hemangioma, metastatic tumors, and central giant cell tumor. Clinicians should make the differential diagnosis of PAT with these diseases.[1,4,5,22,28]

The previous studies about articular eminence pneumatization on panoramic radiographs, CT images, and CBCT images[1,3-10,12-18] have reported the prevalence of PAT to be 1–6.2% on panoramic radiographs and 8–76.7% on CBCT images.[9,16,17,28] In studies that used panoramic radiographs as the imaging method, the prevalence was low because of the complexity and superimpositions of the adjacent structures on the examined area.[10,13-16,21] Whereas Bhalchim *et al*.[21] reported a prevalence of 1.96% of PAT on panoramic radiographs from 3000 patients, they found a prevalence of PAT of 12.5% on CBCT images from 200 patients. This difference was linked to the higher diagnostic value of CBCT as the 3D imaging method and the low diagnostic value of panoramic radiography on the TMJ area.[14,21] Even though panoramic radiography has advantages such as low cost, low radiation dose, and being a routinely used imaging method, it has limitations such as superimpositions of adjacent structures.[4,5,7,14,18] On panoramic images, the skull base and zygomatic process are superimposed on the TMJ and this limits the ability to diagnose PAT.[6-8,16] Three-dimensional images are considered the gold standard for diagnosing pneumatized air spaces in the skull.[29] Among the 3D imaging methods, CBCT provides high-quality images with a lower radiation dose, scanning time, and cost.[9,14,16] A higher rate of PAT in studies that used CBCT as the imaging method is unsurprising. Thus, CBCT was used as the imaging method in the present study.

Table 1: The distribution of patients by sagittal skeletal patterns and gender.

Sagittal skeletal patterns	Gender	*n*	%	Total (*n*/%)
Class I	Female	45	32.4	60/43.2
	Male	15	10.8	
Class II	Female	22	15.8	36/25.9
	Male	14	10.1	
Class III	Female	23	16.5	43/30.9
	Male	20	14.4	
Total (n)	Female	90	64.7	134/100
	Male	49	35.3	

n: Number of patients; %: Percent

Table 2: The distribution of PAT existence by sagittal skeletal growth pattern.

Sagittal skeletal patterns	No PAT (*n*/%)	Unilateral PAT (*n*/%)	Bilateral PAT (*n*/%)	Total (*n*/%)
Class I	9/6.5	10/7.2	41/29.5	60/43.2
Class II	10/7.2	7/5	19/13.7	36/25.9
Class III	16/11.5	10/7.2	17/12.2	43/30.9
Total	35/25.2	27/19.4	77/55.4	139/100

PAT: Pneumatized articular eminence, *n*: Number of patients; %: Percent

Table 3: The prevalence of PAT and the distribution of laterality, grades, and types by the number of the PAT.

	Number of PAT	Prevalence of PAT
Laterality		
Unilateral	27	14.9%
Right side	9	4.9%
Left side	18	10%
Bilateral	154	85.1%
Grades		
Grade 1	136	75.1%
Grade 2	36	19.9%
Grade 3	9	5%
Type		
Unilocular	10	5.5%
Multilocular	171	94.5%

PAT: Pneumatized articular eminence

Table 4: The distribution of pneumatization grade and type by the sagittal skeletal patterns.

	Class I (*n*/%)	Class II (*n*/%)	Class III (*n*/%)	Total (*n*/%)
Grade 1 (*n*/%)	70/76	36/80	30/68.2	136/75.1
Grade 2 (*n*/%)	19/20.7	8/17.8	9/20.4	36/19.9
Grade 3 (*n*/%)	3/3.3	1/2.2	5/11.4	9/5
Unilocular (*n*/%)	3/3.3	2/4.4	5/11.4	10/5.5
Multilocular (*n*/%)	89/96.7	43/95.6	39/88.6	171/94.5

n: Number of patients; %: Percent

The prevalence of PAT in the present study was 74.8%. Khojastepour *et al.*[16] reported a prevalence of 76.7% on CBCT, which was higher than the present study. The prevalence of PAT reported in other studies ranged from 8%,[14] 14.7%,[18] 16.4%,[17] and 21.3%[7] to 65.8%[10] on CBCT. This wide range of prevalence in the literature can be attributed to the variety and size of the populations studied.

In the previous studies, there was no significant correlation between gender and PAT prevalence[6-8,15] except in Ilgüy *et al.*'s study. Ilgüy *et al.*[10] found a significantly higher prevalence of PAT in females than in males. PAT was classified into four groups according to the pneumatization extension point. In the present study, the authors used the classification of Al-Faleh and Ekram.[19] Grade 1 pneumatization was found the most frequently and Grade 3 pneumatization was found the least frequently in both males and females. There were no significant correlations between pneumatization grade, pneumatization type, and gender. Al-Faleh and Ekram[19] also found no correlation between pneumatization grade and gender.

Bhalchim *et al.*[21] found unilocular PAT to be more prevalent on panoramic radiographs and multilocular PAT to be more prevalent on CBCT scans. This difference may be attributed to the fact that CBCT provides more detailed images of the temporal bone and panoramic radiographs are negatively affected from superimpositions and distortion of the evaluated area. CBCT images do not affect from superimpositions, thus the higher prevalence of multilocular PAT might be related to the use of CBCT images.[7,10,14,21] At the present study, the prevalence of multilocular PAT was higher than unilocular PAT in studies by Akyol and Orug,[28] Khojastepour *et al.*,[16] Chicarelli *et al.*,[17] Orhan *et al.*,[13] Ladeira *et al.*,[7] Sallı *et al.*,[18] and Ilgüy *et al.*[10] In the present study, multilocular pneumatization (94.5%) was more frequent than the unilocular type (5.5%), similarly to other studies.

Sagittal skeletal patterns and the relationship between the articular fossa, condyle, and prevalence of TMJ disorders have been studied previously.[11,12] Patients with dentofacial abnormalities are more likely to have TMJ disorders and require surgery.[17] In the present study, the authors found the highest prevalence of PAT in Class I followed by Class II and Class III. There was no correlation between the sagittal skeletal patterns, pneumatization grade, and type in the present study. Orhan *et al.*[13] detected PATs on panoramic radiographs and divided the population into groups by their sagittal skeletal anomalies. They found the highest PAT frequency in Class I patients followed by Class II and Class III. They found the multilocular type of PAT more often than the unilocular type. In their study, there was no significant correlation between sagittal skeletal anomaly and the existence of PAT. Chicarelli *et al.*[17] compared the existence, type, and laterality with the skeletal anomalies on CBCT and found a statistically significant correlation between PAT and Class I patients. They speculated that no abnormal forces are directed onto the TMJ in Class I patients, and hence, bone remodeling would be avoided and the dissemination of pneumatization would be facilitated.[17]

CONCLUSION

Before any surgical treatment is being planned on the TMJ area, PAT existence should be evaluated. There was no correlation between sagittal skeletal anomalies and grade or type of PAT in the present study. Even though the authors did not find any correlation, additional studies should be done with a larger population series to determine the relationship between PAT and malocclusions.

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Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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