VIA MEDICA

REVIEW ARTICLE

Folia Morphol.
Vol. 82, No. 2, pp. 242–247
DOI: 10.5603/FM.a2022.0023

ISSN 0015–5659
eISSN 1644–3284
journals.viamedica.pl

Pneumatization of the articular eminence in cone-beam computed tomography: prevalence and characteristics — literature review

M. Wrzosek[1], K. Wilczek[1], J. Tusiewicz[1], M. Piskórz[2], I. Różyło-Kalinowska[2]

[1]*Student Research Group at the Department of Dental and Maxillofacial Radiodiagnostics, Medical University of Lublin, Poland*

[2]*Department of Dental and Maxillofacial Radiodiagnostics, Medical University of Lublin, Poland*

[Received: 20 October 2021; Accepted: 20 January 2022; Early publication date: 8 March 2022]

Background: *The articular tubercle is a site prone to pneumatization within the cranial bones. Knowledge of the anatomical variations of pneumatization adjacent to the temporomandibular joint (TMJ) is an important issue. Air cells exhibit decreased resistance to trauma, facilitate the spread of various pathologies in the TMJ, such as inflammation, tumours or fractures. Articular tubercle pneumatization may cause complications during TMJ surgery. Information of possible location allows to detect and conduct differential diagnosis of pneumatization of the articular tubercle (PAT) during cone-beam computed tomography (CBCT) examinations. The aim of this study is to determine the prevalence and characteristics of PAT, with respect to age, gender, location and type through assessment in CBCT images.*

Materials and methods: *Articles were selected through database search (PubMed, Scopus, Google Scholar), in which the main objective was to assess the prevalence of articular tubercle pneumatization using CBCT. Search strategies included the following keywords: "pneumatized articular eminence" and "CBCT", "pneumatized articular tubercle" and "CBCT" and "zygomatic air cell defect" and "CBCT". A meta-analysis of prevalence using a random effects model was performed.*

Results: *Fifteen studies met the selection criteria. The results showed that an overall prevalence of articular tubercle pneumatization was 25.22% (n = 6393; 95% confidence interval [CI] 15.84–35.94). The occurrence of PAT in females was 25.14% (n = 3064; 95% CI 14.96–36.94). The frequency of PAT in males was 25.81% (n = 2671; 95% CI 15.30–37.99).*

Conclusions: *There was no correlation between the frequency, location or type of PAT with age and gender.* (Folia Morphol 2023; 82, 2: 242–247)

Key words: articular tubercle, pneumatization, air cells, zygomatic air cell defect, pneumatized articular tubercle, pneumatized articular eminence, cone-beam computed tomography

INTRODUCTION

The skull is a bone containing many air-filled cavities. This phenomenon is defined as pneumatization [12]. One of the pneumatized bones is the temporal bone. It contains ten aerated sites, including the zygomatic process of the temporal bone, in which,

Address for correspondence: Dr. M. Piskórz, Department of Dental and Maxillofacial Radiodiagnostics, Medical University of Lublin, ul. Chodzki 6, 20–093 Lublin, Poland, tel: +48 81502 1800, e-mail: magdalena.piskorz@umlub.pl

depending on the location, pneumatization of the articular eminence (PAT) or pneumatization of the roof of the glenoid fossa is classified [3, 17, 23].

The term PAT was first used in 1985 by Tyndall and Matteson [24] to describe an asymptomatic, radiolucent, non-expansive defect in the zygomatic process of the temporal bone and articular process that does not extend beyond the zygomatic-temporal suture and does not destroy the cortical layer of the bone. Pneumatization can occur unilaterally or bilaterally as a single (unicellular) or divided by thin septa (multicellular) radiolucency [24].

Knowledge of the anatomical dissimilarity of the air cells adjacent to the temporomandibular joint is an important issue. The pneumatized articular eminence, by creating less bone resistance, can be a complication during surgical procedures and can lead to unintentional penetration, dura mater rupture and cerebrospinal fluid leakage [13, 17, 22]. In addition, air cells can be an obstacle to surgical procedures in the temporomandibular joint, such as eminectomy or insertion of miniplates [8]. The presence of air cells may facilitate the spread of inflammation, tumours, infections, fractures or other pathological processes deep into the bone and consequently cause fractures of the associated bone or ankylosis of the temporomandibular joint [8, 12, 17, 22]. The development of temporomandibular joint ankylosis at a young age leads to secondary effects in mandibular growth such as malocclusion, facial asymmetry and mandibular retraction [7, 14, 16].

Pneumatization of the articular eminence can be observed on panoramic radiographs obtained during dental examinations. However, the anatomical complexity of the area and overlap of adjacent structures may prevent accurate assessment of the location and dimensions of the pneumatization [17]. Cone-beam computed tomography (CBCT) may lead to a more accurate diagnosis and better visualization of areas affected by pneumatization [18]. It is a relatively safe imaging modality widely used in dentistry characterised by low radiation exposure compared to computed tomography (CT), precise three-dimensional imaging of the jaws without magnification or distortion [12].

The aim of the study was to conduct the meta-analysis concerning the PAT based on CBCT examinations.

MATERIALS AND METHODS

A systematic literature review was conducted, using electronic databases: PubMed, Scopus and Google Scholar. Search strategies in databases included the following keywords: "pneumatized articular eminence" and "CBCT", "pneumatized articular tubercle" and "CBCT" and "zygomatic air cell defect" and "CBCT". Reference lists of selected articles were searched in an attempt to identify any additional references.

Inclusion criteria

The article selection process was two-phased. In the first phase three authors independently reviewed the titles and abstracts of all publications identified through database searches. Studies, in which the main objective was to assess the prevalence of articular tubercle pneumatization using CBCT were selected. Articles unrelated to this topic were rejected. In the second phase full-text resources were independently reviewed using the following exclusion criteria: (1) reviews, case reports, book excerpts; (2) studies in which the sample included patients with craniofacial deformities, malformations or any maxillofacial fracture history; (3) papers, that did not independently assess the occurrence of PAT and pneumatization of the roof of the glenoid fossa; (4) papers published exclusively in university journals. Finally, 15 papers met the inclusion criteria.

Data synthesis

A meta-analysis of prevalence was performed using MedCalc software, with significance level set at 5%, using a random effects model due to the high heterogeneity of studies included in the meta-analysis. MedCalc 19.8 is a statistical software package for biomedical research, compatible with contemporary Windows desktop editions. It was chosen because of its fully-featured meta-analysis module, which allows for: easy input of individual studies, heterogeneity tests such as Cochran's Q test with I^2 statistic, fixed and random effects model calculations and visualization of statistical data using multiple plots and graphs. A forest plot was selected as a method of displaying results.

RESULTS

From the 369 originally identified articles, 20 remained after the first selection phase. After the second phase 15 studies remained and were included in the meta-analysis. A diagram of the selection process can be found in Figure 1.

Research papers included in the review were conducted in five different countries: India, Turkey, Iran, Brazil, and Egypt. All papers except one [2] were

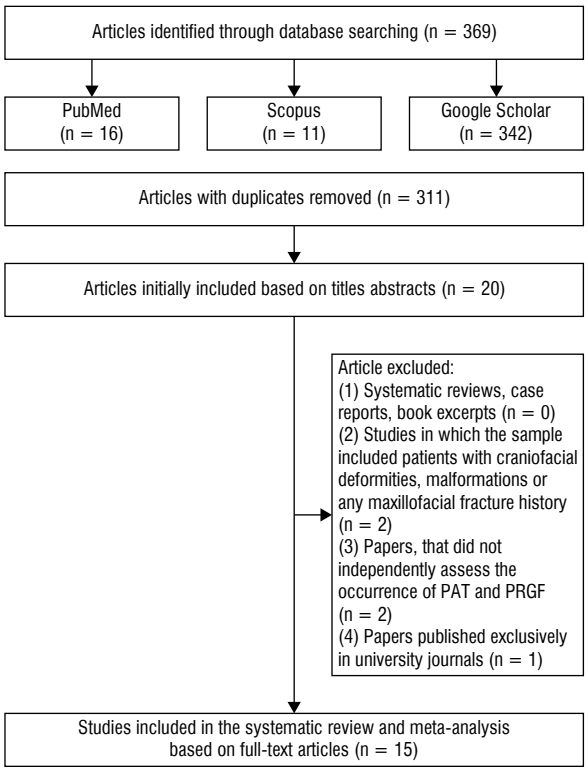

Figure 1. PRISMA diagram for the search strategy and selected studies; PAT — pneumatization of the articular eminence; PRGF — pneumatization of the roof of the glenoid fossa.

published in English. Sample sizes ranged from 111 [12] to 1000 [6, 20] CBCT images. All studies included in the meta-analysis assessed the presence of articular tubercle pneumatization using CBCT. Most studies showed no statistically significant differences in the incidence of PAT between males and females [2, 4–6, 9–11, 15, 17–22]. One study [12] showed a statistically significant difference between the incidence of PAT in females (73.6%) and males (51.3%; $p < 0.05$).

Results of the meta-analysis showed that the overall prevalence of articular tubercle pneumatization was 25.22% (n = 6393; 95% confidence interval [CI] 15.84–35.94). The prevalence of PAT in females was 25.14% (n = 3064; 95% CI 14.96–36.94). The prevalence of PAT in males was 25.81% (n = 2671; 95% CI 15.30–37.99) (Table 1, Fig. 2).

Most of the studies [2, 5, 6, 9, 11, 12, 15, 17–22] did not have clearly defined sampling criteria; moreover, most authors used convenience sampling instead of random sampling, thus the samples may not represent the overall population prevalence.

DISCUSSION

The development of air cells within the temporal bone is the result of physiologic periosteal activity [10].

Table 1. Summary of studies included in the meta-analysis

Study	Country	Sample size	Patients, n		Patients with PAT present, n	Patients with PAT present, n		Age of patients	Laterality		Prevalence
			M	F		M	F		Unilateral	Bilateral	
Bhalchim et al. (2018) [4]	India	200	138	62	25	17	8	10–73	11	**14**	12.5%
Şallı et al. (2019) [20]	Turkey	1000	489	511	147	74	73	16–77	**85**	62	14.7%
Khojastepour et al. (2017) [15]	Iran	327	177	150	251	139	112	7–65	76	**175**	76.7%
Miloglu et al. (2010) [18]	Turkey	514	216	298	41	16	25	4–85	**31**	10	8%
İlgüy et al. (2015) [12]	Turkey	111	39	72	73	20	53	17–81	31	**42**	65.8%
Buyuk et al. (2018) [6]	Turkey	1000	423	577	391	165	226	18–86	**215**	176	39.1%
Ladeira et al. (2012) [17]	Brazil	658	257	401	140	–	–	11–85	**76**	64	21.3%
Mosavat and Ahmadi (2015) [19]	Iran	239	111	128	51	25	26	18–81	35	16	21.3%
Shokri (2015) [22]	Iran	377	183	194	59	27	32	8–73	**41**	18	15.6%
Shekhawat et al. (2020) [21]	India	106	50	56	50	24	26	18–80	**44**	14	56%
Demirel et al. (2014) [10]	Turkey	250	127	123	45	23	22	15–82	**29**	16	18%
Borahan et al. (2018) [5]	Turkey	300	134	166	98	55	43	18–85	**56**	42	32%
ElBeshlawy (2020) [11]	Egypt	210	74	136	40	20	20	5–65	20	20	19.1%
Delilbasi et al. (2013) [9]	Turkey	825	377	448	21	11	10	18–91	**14**	**7**	2.54%
Adisen and Misirlioglu (2018) [2]	Turkey	276	133	143	39	17	22	12–85	22	**17**	14.1%

F — female; M — male; PAT — pneumatization of the articular tubercle

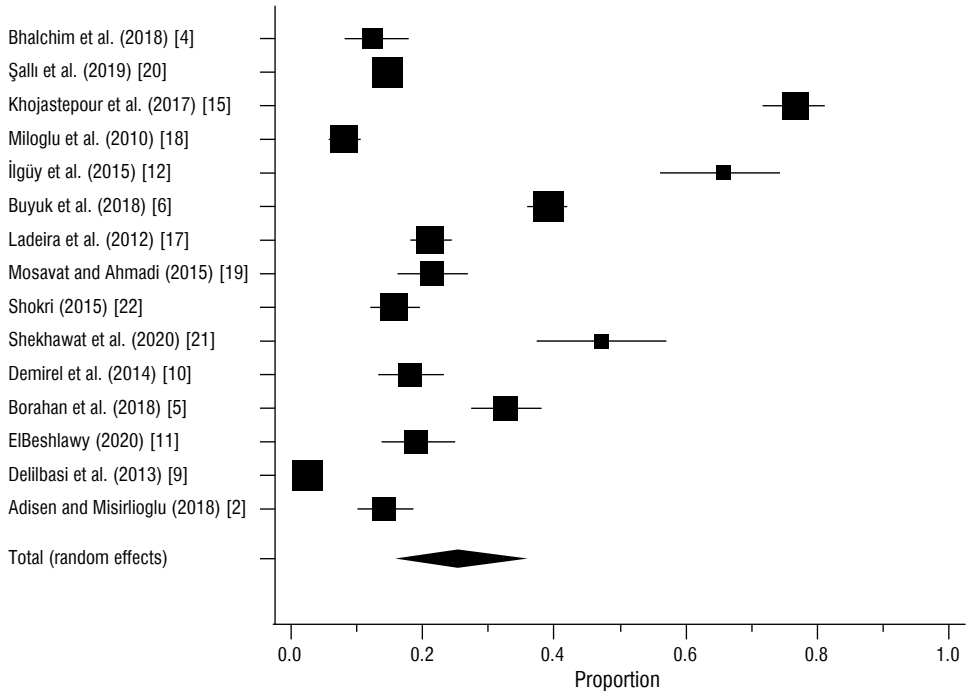

Figure 2. Forest plot of 15 prevalence studies and pooled prevalence using random effects model.

Classification of temporal bone pneumatization is a complex topic. The sites where it occurs include the middle ear, mastoid process, peri-labyrinth, and the apex of the temporal bone pyramid. However, many accessory air-cells can be localised within it, particularly in the region of the squamous area, the styloid process and the zygomatic process, from which it spreads toward the articular tubercle [4, 18].

Pneumatization of the articular tubercle is completely asymptomatic and is usually diagnosed incidentally on radiographs [11] as a well-demarcated translucency within the zygomatic process and the articular tubercle that does not extend beyond the zygomaticotemporal region [18]. Nowadays, three-dimensional imaging methods, such as CT and CBCT, are considered the gold standard for the evaluation of pneumatized cranial air spaces because they provide valuable information for better understanding the nature and character of these rare lesions [11]. These modalities decrease the problem of overlapping structures that is inherent in conventional panoramic radiographs, however this X-ray may be the first to take clinician's notice of the problem of PAT because of the high prevalence of these examinations in dental practice [18].

Pneumatization of the articular tubercle may predispose to the spread of inflammatory processes along the temporomandibular joint, as well as cause complications of surgical procedures in this region and pathological fractures of the bones [18]. Therefore, the ability to diagnose and differentiate these lesions is an important aspect. PAT may resemble some pathological conditions such as aneurysmal bone cyst, vascular malformations, acidophilic granuloma, cancer metastasis, early type of fibrous dysplasia. To facilitate differentiation, clinical and radiographic signs of bone destruction by the above-mentioned lesions should be considered in comparison to asymptomatic pneumatization [11].

Treatment of PAT is not recommended. If a detected pneumatization is not accompanied by any signs and symptoms only follow-up is recommended. The presence of PAT may be a contraindication to eminectomy or articular tubercle plastic surgery for the treatment of recurrent chronic mandibular dislocation [18].

Tyndall and Matteson [24] distinguished three types of articular tubercle pneumatization — unilocular, multilocular and trabecular [18, 24]. In the studies on PAT included in this systematic review, most authors distinguished between two types: unilocular and multilocular [4–6, 11, 12, 15, 17–22]. Demirel et al. [10] did not differentiate between the pneumatization types in their study. In the vast majority of authors who included Tyndall and Matteson's division, the multilocular type occurred more often than the unilocular type

[4, 6, 11, 12, 15, 17–20, 22]. Only in two studies the unilocular type was more prevalent [5, 21].

In the study by ElBeshlawy [11], out of 40 CBCT scans with diagnosed pneumatization, 20 PATs were unilateral (50%) (8 on the right side and 12 on the left side) and 20 (50%) cases had bilateral PATs (1:1 ratio). There was no statistically significant difference between unilateral and bilateral or right/left incidence. Many of the previous studies using CBCT have shown that unilateral pneumatization of the articular tubercle is more common than bilateral [12, 17, 20]. In a study by Miloglu et al. [18], unilateral PAT was observed in 75.6% of cases, while bilateral PAT was found in only 24.4% of cases. Shokri et al. [22] also showed that unilateral lesions were significantly more common than bilateral lesions. Mosavat and Ahmadi [19] described unilateral PAT in 68.6% of cases. On the other hand, three authors, Bhalchim et al. [4], Khojastepour et al. [15] and İlgüy et al. [12], reported a higher incidence of bilateral PAT. The cited literature did not clearly identify the determinants of unilateral or bilateral articular tubercle pneumatization.

In 7 of the 15 studies reviewed, PAT was found more often in women [2, 6, 12, 18, 19, 21, 22] while in 6 men [4, 5, 9, 10, 15, 20]. The authors of one of the studies included in the current review did not include the gender of the subjects as a factor determining the possibility of PAT [17]. In ElBeshlawy's study [11], PAT occurred in an equal number of female and male subjects.

In a study by Adisen and Misirlioglu [2] conducted on 276 patients aged 12–85 years, pneumatization was most commonly observed in subjects aged 20–29 years, with the lowest in the age range 50–59 years. Similarly, in a study of ElBeshlawy [11] conducted on 210 patients between 5, and 65 years of age, the highest percentage of PAT cases occurred in subjects aged 10–20 years (10.5%), and the lowest in the age range 60–70 years (0%).

Bhalchim et al. [4], whose study included 200 subjects in the age range of 10–73 had the highest rate of pneumatization of the articular eminence in subjects aged 21–30 years. Delilbasi et al. [9] conducted a study on 825 individuals, among which the highest percentage of positive findings is observed in individuals between the ages of 20–29. A similar result was obtained by Miloglu et al. [18] where among the 514 individuals studied, the highest percentage of positive findings was in individuals between the ages of 21–40. Şallı et al. [20] in their study included 1000 CBCT scans, where PAT was confirmed in 147 individuals and the highest prevalence was in patients between the ages of 30–39. On the other hand, in a study conducted by Borahan et al. [5] on 300 patients, as many as 103 or 34.3% were over the age of 55. The quoted authors did not clearly demonstrate a relationship between age and the incidence of PAT in the patients studied [2, 4–6, 9–12, 15, 17–22].

CONCLUSIONS

The articular eminence is a predisposed site for pneumatization within the cranial bone. Knowledge of the possible location of this anatomical variation allows to detect and differentiate PAT during evaluation CBCT examinations. In the reviewed studies, no correlation was found between the frequency, location, as well as type of PAT and age and gender.

Conflict of interest: None declared

REFERENCES

1. Abramovitch K, Rice DD. Basic principles of cone beam computed tomography. Dent Clin North Am. 2014; 58(3): 463–484, doi: 10.1016/j.cden.2014.03.002, indexed in Pubmed: 24993919.
2. Adisen M, Misirlioglu M. Konik ışınlı bilgisayarlı tomografi görüntülerinde pnömatize artiküler tüberkül prevalansı ve karakteristik özelliklerinin değerlendirilmesi. Turkish J Clin Laboratory. 2018, doi: 10.18663/tjcl.336158.
3. Allam AF. Pneumatization of the temporal bone. Ann Otol Rhinol Laryngol. 1969; 78(1): 49–64, doi: 10.1177/000348946907800105, indexed in Pubmed: 5763190.
4. Bhalchim SG, Jugade SC, Ramaswami E, et al. Prevalence of pneumatized articular tubercle using panoramic radiography and cone beam-computed tomography: a retrospective study. Contemp Clin Dent. 2018; 9(Suppl 2): S221–S226, doi: 10.4103/ccd.ccd_64_18, indexed in Pubmed: 30294148.
5. Borahan M, Sadıkoğlu AY, Ulay G, et al. A preliminary study of prevalence and characteristics of pneumatization of articular eminence on cone beam computed tomography. Marmara Dental Journal. 2018; 2(1): 1–6, doi: 10.12990/mdj.2018.11.
6. Buyuk C, Gunduz K, Avsever H. Prevalence and characteristics of pneumatizations of the articular eminence and roof of the glenoid fossa on cone-beam computed tomography. Oral Radiol. 2019; 35(2): 171–176, doi: 10.1007/s11282-018-0334-z, indexed in Pubmed: 30484191.
7. Chidzonga MM. Temporomandibular joint ankylosis: review of thirty-two cases. Br J Oral Maxillofac Surg. 1999; 37(2): 123–126, doi: 10.1054/bjom.1997.0089, indexed in Pubmed: 10371317.
8. da Costa Ribeiro R, dos Santos BJ, Provenzano N, et al. Dautrey's procedure: an alternative for the treatment of recurrent mandibular dislocation in patients with pneumatization of the articular eminence. Int J Oral Maxillofac Surg.

2014; 43(4): 465–469, doi: 10.1016/j.ijom.2013.10.007, indexed in Pubmed: 24239140.
9. Delilbaşı BÇ, Orhan K, İçen M, et al. Evaluation of articular eminence pneumatization using cone beam computed tomography. Minerva Stomatologica. 2013; 62(10): 349–354.
10. Demirel O, Kaya E, Üçok C. Evaluation of mastoid pneumatization using cone-beam computed tomography. Oral Radiol. 2013; 30(1): 92–97, doi: 10.1007/s11282-013-0150-4.
11. ElBeshlawy D. CBCT assessment of pneumatization of the articular tubercle and the roof of the glenoid fossa: a retrospective study. Egyptian Dental J. 2020; 66(3): 1553–1562, doi: 10.21608/edj.2020.27346.1098.
12. İlgüy M, Dölekoğlu S, Fişekçioğlu E, et al. Evaluation of pneumatization in the articular eminence and roof of the glenoid fossa with cone-beam computed tomography. Balkan Med J. 2015; 32(1): 64–68, doi: 10.5152/balkanmedj.2015.15193, indexed in Pubmed: 25759774.
13. Jadhav AB, Fellows D, Hand AR, et al. Classification and volumetric analysis of temporal bone pneumatization using cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol. 2014; 117(3): 376–384, doi: 10.1016/j.oooo.2013.12.398, indexed in Pubmed: 24528795.
14. Kaban LB, Perrott DH, Fisher K. A protocol for management of temporomandibular joint ankylosis. J Oral Maxillofac Surg. 1990; 48(11): 1145–1152, doi: 10.1016/0278-2391(90)90529-b, indexed in Pubmed: 2213309.
15. Khojastepour L, Paknahad M, Abdalipur V, et al. Prevalence and characteristics of articular eminence pneumatization: a cone-beam computed tomographic study. J Maxillofac Oral Surg. 2018; 17(3): 339–344, doi: 10.1007/s12663-017-1033-8, indexed in Pubmed: 30034152.
16. Kumar R, Hota A, Sikka K, et al. Temporomandibular joint ankylosis consequent to ear suppuration. Indian J Otolaryngol Head Neck Surg. 2013; 65(Suppl 3): 627–630, doi: 10.1007/s12070-013-0666-2, indexed in Pubmed: 24427727.
17. Ladeira DBS, Barbosa GLR, Nascimento MCC, et al. Prevalence and characteristics of pneumatization of the temporal bone evaluated by cone beam computed tomography. Int J Oral Maxillofac Surg. 2013; 42(6): 771–775, doi: 10.1016/j.ijom.2012.12.001, indexed in Pubmed: 23290566.
18. Miloglu O, Yilmaz AB, Yildirim E, et al. Pneumatization of the articular eminence on cone beam computed tomography: prevalence, characteristics and a review of the literature. Dentomaxillofac Radiol. 2011; 40(2): 110–114, doi: 10.1259/dmfr/75842018, indexed in Pubmed: 21239574.
19. Mosavat F, Ahmadi A. Pneumatized articular tubercle and pneumatized roof of glenoid fossa on cone beam computed tomography: prevalence and characteristics in selected iranian population. J Dentomaxillofacial Radiol, Pathol Surg. 2015; 4(3): 10–14, doi: 10.18869/acadpub.3dj.4.3.10.
20. Şallı GA, Özcan İ, Pekiner FN. Prevalence of pneumatization of the articular eminence and glenoid fossa viewed on cone-beam computed tomography examinations in a Turkish sample. Oral Radiol. 2020; 36(1): 40–46, doi: 10.1007/s11282-019-00378-1, indexed in Pubmed: 30796675.
21. Shekhawat C, Sobti G, Sundaragiri KS, et al. Evaluation of Pneumatization in Articular Tubercle and Roof of the Glenoid Fossa with Cone-Beam Computed Tomography. RUHS J Health Sci. 2020; 5(2), doi: 10.37821/ruhsjhs.5.2.2020.255.
22. Shokri A, Noruzi-Gangachin M, Baharvand M, et al. Prevalence and characteristics of pneumatized articular tubercle: First large series in Iranian people. Imaging Sci Dent. 2013; 43(4): 283–287, doi: 10.5624/isd.2013.43.4.283, indexed in Pubmed: 24380068.
23. Tremble GE. Pneumatization of the temporal bone. Arch Otolaryngol - Head and Neck Surgery. 1934; 19(2): 172–182, doi: 10.1001/archotol.1934.03790020018002.
24. Tyndall DA, Matteson SR. Radiographic appearance and population distribution of the pneumatized articular eminence of the temporal bone. J Oral Maxillofac Surg. 1985; 43(7): 493–497, doi: 10.1016/s0278-2391(85)80026-4, indexed in Pubmed: 3859592.