ORIGINAL ARTICLE

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Investigation of pneumatized articular eminence in orthodontic malocclusions

Structured Abstract

Authors – Orhan K, Ulas O, Orhan AI, Ulker AE, Delilbasi C, Akcam O **Objectives** – To investigate the prevalence and characteristics of pneumatized articular tubercule (PAT) or eminence in an orthodontic patient population and to examine the possible correlations between different orthodontic malocclusions and pneumatized articular eminence types.

Setting and Sample Population – Department of Orthodontics, Faculty of Dentistry, Ankara University, Turkey.

Material and Methods – Pre-treatment panoramic radiographs were evaluated retrospectively from files of 1405 children and adolescents (459 boys and 946 girls) having various types of malocclusions. Diagnosis of PAT on the radiographs was recorded only if unequivocal pneumatization of the articular eminence could be seen or if the defect was located in the articular eminence posterior to the zygomaticotemporal suture, as a well-defined unilocular- or multilocular radiolucency. PAT was classified as unilocular or multilocular and unilateral or bilateral. Chi-square test was performed to evaluate age, gender, localization, type of malocclusion and prevalence differences.

Results – Sixty-six pneumatized articular eminences were found in 48 patients, representing a prevalence of 3.42%. The results of chi-square test showed no statistically significant differences considering age (p = 0.516), gender (p = 0.719), type of malocclusion (p = 0.155) and localization (p = 0.738).

Conclusions – A relatively high rate of pneumatized articular eminence was observed among patients with orthodontic malocclusions (3.42%) when compared to the general population studies. Knowledge about these structures is helpful for the interpretation of cephalometric and panoramic radiographs and provides valuable information especially prior to temporomandibular joint surgery to avoid intraoperative reconstruction and complications.

Key words: malocclusion; orthodontics; pneumatized articular eminence

Introduction

Pneumatization refers to the development of air-filled cavities in bone. In addition to the major paranasal sinuses, accessory air cells may arise in numerous locations in the skull, including the temporal bone, either single or in cluster (1–3). The term 'pneumatized articular tubercule (PAT)

or eminence' was suggested by Tyndall and Matteson (4) to describe accessory air cells which occur in the root of the zygomatic arch and in the articular eminence of the temporal bone and which are similar to air cells in the mastoid process and ethmoid bone. Carter et al. (5) reemphasized the occurrence of this phenomenon and named these air cells as zygomatic air cell defects in a similar fashion. Tyndall and Matteson (4) identified the common characteristics of the pneumatized articular eminence of the temporal bone as 1) an asymptomatic 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 eminence but not beyond the zygomaticotemporal suture and 3) no enlargement or cortical destruction of the zygoma.

Only few studies about PAT were conducted in children, and data on pneumatization in this region is not clear and well understood. Besides, no data is presented in the literature about the correlation between orthodontic malocclusion and PAT. Patients with orthodontic malocclusions may undergo temporomandibular joint (TMJ) surgery. Hence, it was considered worthwhile to determine the prevalence and characteristics of pneumatized articular eminence in an orthodontic patient population and to examine the possible relationship between orthodontic malocclusion types and pneumatized articular eminence.

Materials and methods

Randomly selected panoramic radiographs were evaluated retrospectively from files of 1405 children and adolescents, 459 boys (32.67%) and 946 girls (67.33%), who were referred to the Department of Orthodontics, Faculty of Dentistry, Ankara University from January 2001 to January 2007. Six hundred and sixty-six patients were skeletal Class I (ANB angle between 0° and 4°), 447 patients were skeletal Class II (ANB angle $>4^{\circ}$), while 292 patients were skeletal Class III (ANB angle $<0^{\circ}$). All participants were normal healthy children and adolescents. Patients in whom the zygomatic arch was not adequately seen because of poor quality of the radiographs or anatomic reasons and those who had a history of maxillofacial fracture or maxillofacial anomalies or syndromes were not included in the study.

All radiographs were taken with a film-based PM 2002 CC Proline (Planmeca, Helsinki, Finland) panoramic\cephalometric radiography imaging unit at machine settings of 62 kVp, 5 mA and a half-value layer of 2.47 mm of aluminum, using a T-Mat G/Lanex medium film/screen combination (Eastman Kodak Co., Rochester, NY, USA). Exposed films were processed according to manufacturer's recommendations using an automatic film processor (XR 24; Dürr Dental GmbH& Co. KG, Bietigheim-Bissingen, Germany) with Kodak ReadyMatic chemistry.

One experienced oral and maxillofacial radiologist evaluated the radiographs on a standard viewing box in a darkened room. The observer was blinded for the clinical status of the patient. The age, gender and type of malocclusion were recorded for all patients; localization and radiographic appearance of PAT were noted as well. PAT was diagnosed if unequivocal pneumatization of the articular eminence could be seen or if the defect was located in the articular eminence posterior to the zygomaticotemporal suture as a well-defined unilocular- or multilocular radiolucency. PAT was classified as unilocular or multilocular, referring to the study of Tyndall and Matteson (6). Unilocular PAT was identified as single radiolucent oval defect with well-defined bony borders. Multilocular PAT was identified as numerous radiolucent small cavities.

Statistical analysis

A total of 300 randomly selected films were reevaluated 2 months after the initial examination to test intraobserver reliability, and intra-observer agreement was determined using the Wilcoxon matched-pairs signedranks test. Besides, chi-square test was performed to evaluate age, gender, localization, type of malocclusion and prevalence differences, and p < 0.05 was considered significant. Statistical analyzes were performed using the spss 11.0 program for WINDOWS (SPSS Inc, Chicago, IL, USA).

Results Reliability

Repeated scorings of a subsample of 300 radiographs indicated no significant intra-observer difference

(p > 0.05). Intra-observer consistency was rated at 99.5%.

The average age of the 1405 patients was 10.9 (\pm 3.33) years and age ranged from 5 to 20 years. The mean age of the men was 10.6 (\pm 3.38) years with a range of 5–20 years, while that for the women was 11.2 (\pm 3.26) years with a range of 5–20 years. Sixty-six PATs were found in 48 patients, representing a prevalence of 3.42%. Patients with PAT had a mean age of 11.3 (\pm 3.13) years with a range of 9–20 years.

All PAT were located in the zygomatic process of the temporal bone, did not extend anteriorly beyond the zygomaticotemporal suture and lacked expansive or destructive characteristics. Twelve male patients (33.3%) and 36 female patients (66.6%) had PAT. Unilateral PAT was found in 34 (68.8%) patients, while bilateral PAT was found in 16 (31.2%) patients. The highest PAT frequency was found in Class I (25/666), followed by Class II (15/447) and Class III (10/292 (Fig. 1). Two subgroups of PAT were examined: 13 (25.3%) of the PATs were unilocular (Fig. 2) while 39



Fig. 3. Magnification of panoramic radiograph showing extensive multilocular pneumatization of the articular eminence (arrows).



Fig. 1. The number pneumatized articular tubercule patients according to malocclusion types.



Fig. 2. Cropped panoramic images of two patients showing unilocular pneumatized articular eminence (arrows). C, condyle.



Fig. 4. Bilateral multilocular pneumatized articular tubercule in a patient with Class I malocclusion (arrows).

(74.7%) were multilocular type (Fig. 3). In Fig. 4, Class I orthodontic patient with bilateral multilocular PAT is presented. The result of chi-square test showed no statistically significant differences regarding age (p = 0.516), gender (p = 0.719), type of malocclusion (p = 0.155) and localization (p = 0.738).

Discussion and conclusion

The mastoid air cell system and temporal bone pneumatization as well as the distribution of temporal bone pneumatization have been described earlier

Table 1. Prevalence of pneumatized articular tubercu	Ile (PAT), and age and gender distribution as found in the literature
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Series	Patients	% Prevalence of PAT (no.)	Age range years	% Men (no.)	% Women (no.)	% Bilateral (no.)
Tyndall and Matteson (4)	1061	2.6 (28)	15–74	46.4 (13)	53.6 (15)	17.9 (5)
Kaugars et al. (6)	784	1.0 (8)	32–69	12.5 (1)	87.5 (7)	50.0 (4)
Carter et al. (8)	2734	1.5 (40)	17–83	50.0 (20)	50.0 (20)	20.0 (8)
Hofmann et al. (7)	1084	1.8 (20)	7–87	45.0 (9)	55.0 (11)	20.0 (4)
Orhan et al. (9)	1006	1.88 (19)	11–90	36.9 (7)	63.1 (12)	36.9 (7)
Orhan et al. (10)	1049	1.62 (17)	4–16	52.9 (9)	47.1 (8)	41.1 (7)
Current series	1405	3.42 (48)	5–20	33.3 (12)	66.6 (36)	31.2 (16)
Total	9123	1.97 (180)	4–90	39.44 (71)	60.6 (109)	28.33 (51)

(1-4). Previous studies have stated that the pneumatization of the mastoid process is almost complete at age 5, but air cells may continue to develop through adulthood (1-5). Pneumatization of the zygomatic process of the maxilla does not begin until 9 years of age, although it is unknown at which age air cells within the articular eminence begin to develop (6). According to several studies, the accessory air cells begin to pneumatize after puberty and achieve full size several years later as mastoid air cells (3, 5-7). It has been designated that the puberty period commences approximately at 12-13 years of age; however, several studies detected PAT before puberty (8, 9). In a previous study among a Turkish population, we concluded that the pneumatization of accessory air cells begin before puberty opposite to the general opinions and statements (10). In our study, the average age and prevalence of PAT in women are higher than that of men. Because pneumatization commences during maturation or post-natal growth, girls who are chronologically older than boys are also biologically further advanced. This may be reason for higher PAT prevalence in women.

The classification of temporal bone pneumatization is a complex issue. It can be divided into five regions, which in turn are subdivided into areas. The primary regions consist of the middle ear, mastoid (squamomastoid), perilabyrinthine, petrous apex and accessory. The squamomastoid region is comprised of two key areas, the mastoid antrum (including the central tract) and the periantral area. The tegmental periantral cells lie superior to the mastoid antrum and may pass upward into the squamotemporal region or extend into the zygomatic arch producing the PAT. In addition to the current series, we found in the literature six large case series by Tyndall and Matteson in 1985 (6), Kaugars et al. in 1986 (7), Carter et al. in 1999 (5), Hofmann et al. in 2001 (8), Orhan et al. (11) in 2005 and again by Orhan et al. (10) in 2006.

Only six series have reported the prevalence of PAT in the general population, and the prevalence found was between 1.0 and 2.6% (Table 1). However, the current study revealed a prevalence of 3.42% in individuals with orthodontic malocclusions which is quite high when compared to general population studies. Distribution of individuals with PAT revealed the highest number/rate in Class I (25/666), followed by Class II (15/447) and Class III (10/292. Similar studies with a larger sample size are needed to clarify the relation between malocclusion type and PAT. In this study, we did not form a control group, because we did not find it ethical to have panoramic radiographs from non-orthodontic individuals. Besides, Class I patients are used as control group in many investigations.

In this study, we did not find a correlation between pneumatization and a specific orthodontic malocclusion. Eman (9) reported a high rate of PAT (12.5%, four patients out of 32) in patients with TMJ disorders with an age range between 16 and 38 years. The author mentioned that the presence of PAT should be considered as a possible complicating factor if surgical manipulation of the articular eminence is required, thus, a thorough radiographic examination of the articular eminence is recommended prior to surgical treatment.

Moreover, it should be noted that pathologic processes; such as acute otitis media and otomastoiditis, which occur in this region, may cause destruction of the bony barriers and resulting the spread of the infections through surrounding areas. The differential diagnosis of radiolucencies in cephalometric and panoramic radiographies within the zygomatic arch includes aneurismal bone cyst, osseous hemangioma, chondroblastoma, fibrous dysplasia, giant cell tumor, eosinophilic granuloma, metastatic tumor and PAT. Only PAT can be visualized incidentally on radiographs without non-expansive, non-destructive characteristics. The other pathology would be characterized by enlarging and usually painful, bony expansions with cortical destruction. PAT requires no treatment but the presence of PAT can be a contraindication for performing eminoplasty or eminectomy to treat recurrent chronic mandibular dislocation (4–8). Kaugars et al. (7) stated that PAT is not necessarily a contraindication for performing eminoplasty or eminectomy unless the pneumatization is large but they did not mention a size. Lindenmuth and Clark (12) indicated that surgeons who are planning to do such surgical procedures should be aware of the details about pneumatized articular eminence. During the operation, care must be taken while using osteotomes or burs to avoid sudden penetration through the defect.

In consequence, knowledge about these structures is helpful for the interpretation of imaging such as cephalometric and panoramic radiographs and provides valuable information especially before TMJ surgery to avoid intra-operative reconstruction and complications. Moreover, additional studies such as morphometric and volumetric analysis in different orthodontic malocclusions or different orthodontic treatment modalities must be conducted with larger population series to understand the relationship between PAT and malocclusions. lometric radiographs thoroughly to determine pneumatization of the articular eminence in patients with orthodontic malocclusions particularly for those who are planned to undergo TMJ surgery to avoid intraoperative complications and reconstruction.

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Clinical relevance

Orthodontists, pediatric dentists and maxillofacial surgeons are advised to assess panoramic and cepha-

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