Dentomaxillofacial Radiology (2006) 35, 365–370

http://dmfr.birjournals.org

RESEARCH

Radiographic evaluation of pneumatized articular eminence in a group of Turkish children

K Orhan*,[1], C Delilbasi[2] and AI Orhan[3]

[1]Department of Oral Diagnosis and Radiology, Faculty of Dentistry, Ankara University, 06500 Besevler, Ankara, Turkey; [2]Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Yeditepe University, 34755, Kadikoy, Istanbul, Turkey; [3]Department of Pediatric Dentistry, Faculty of Dentistry, Ankara University, 06500 Besevler, Ankara, Turkey

Objectives: The purpose of this study was to determine the prevalence and characteristics of patients with pneumatized articular eminence (PAT) in a group of Turkish children in order to make a contribution to pneumatization phenomenon in childhood.
Methods: 1049 panoramic radiographs were retrospectively evaluated. PAT was defined as non-expansile, non-destructive cyst-like radiolucency in the zygomatic process of the temporal bone, which appears similar to the mastoid air cells. It was classified as unilocular or multilocular on the radiograph. Statistical comparison of gender, age and localization was performed using a chi-square test ($P < 0.05$).
Results: Twenty-four pneumatized articular eminences were found in 17 patients, representing a prevalence of 1.62%. Patients with pneumatized articular eminence had a mean age of 11.2 (SD 3.13) years with a range of 7–16 years. Eight cases (47.1%) occurred in girls and nine cases (52.9%) occurred in boys. The results of statistical tests showed no statistically significant differences among the groups with respect to gender, age and localization ($P < 0.05$).
Conclusions: Pneumatization of accessory air cells begins before puberty, contrary to the general opinion and statements. Knowledge about these structures is helpful for the interpretation of imaging such as panoramic radiographs and provides valuable information to understand the spread and differential diagnosis of pathological entities in this region.
Dentomaxillofacial Radiology (2006) **35,** 365–370. doi: 10.1259/dmfr/77401728

Keywords: panoramic radiography; pneumatized articular eminence; children; temporomandibular joint; acute mastoiditis

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 singly or in cluster.[1–3] The phrase of pneumatized articular eminence (PAT) was coined by Tyndall and Matteson[4] in 1985 to describe accessory air cells which occur in the root of the zygomatic arch and in the articular eminence of the temporal bone that is similar to air cells in the mastoid process and ethmoid bone. Carter et al[5] in 1999 re-emphasised the occurrence of this phenomenon and named these air cells as zygomatic air cell defect (ZACD) in a similar fashion. Tyndall and Matteson[4] identified the common characteristics of the pneumatic 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.[6]

Studies about the mastoid air cell system and temporal bone pneumatization have been discussed and the distribution of temporal bone pneumatization has previously been described in the literature.[1–24] Previous studies have stated that the pneumatization of the mastoid process is almost complete when a patient reaches the age of 5 years, but air cells may continue to develop through

*Correspondence to: Kaan Orhan, Ankara University, Faculty of Dentistry, Department of Oral Diagnosis and Radiology, 06500, Besevler, Ankara, Turkey; E-mail: call53@yahoo.com
Received 12 September 2005; revised 14 November 2005; accepted 21 December 2005

adulthood. Pneumatization of the zygomatic process of the maxilla does not begin until the age of 9 years, although it is unknown at what age air cells within the articular eminence begin to develop.[7,21] According to several studies, the accessory air cells begin to pneumatize after puberty and achieve full size several years later, as with mastoid air cells proper.[3,6,7,20] It has been designated that the puberty period commences at 12–13 years of age.[25–27] However, Hofmann et al[19] and Orhan et al[20] detected cases of PAT in children 7 years and 11 years of age.

Hence, it was considered worthwhile to determine the prevalence and characteristics of PAT in a group of Turkish children in order to make a contribution to studies about pneumatization in childhood.

Materials and methods

Panoramic radiographs were evaluated retrospectively from files of 1049 children and adolescents, 510 boys (48.6%) and 539 girls (51.5%), who were referred to Pediatric Dental Clinic at Ankara University Faculty of Dentistry from January 2001 to January 2005. All participants were normal healthy children and adolescents. Selection criteria for patients included third molar evaluation, need for extensive restorative dental procedures, swelling, asymmetry, missing or supernumerary teeth, severe generalized caries, mixed dentition analysis and examination for temporomandibular joint (TMJ) disorders. Cases in which the zygomatic arch was not adequately seen for technical or anatomic reasons and cases with history of maxillofacial fracture or maxillofacial anomalies were not included in the study.

All radiographs were taken with a film-based PM 2002 CC Proline (Planmeca, Helsinki, Finland) panoramic radiography imaging unit at machine settings of 62 kVp, 5 mA, and a half-value layer of 2.47 mm of aluminium, using a T-Mat G/Lanex medium film/screen combination (Eastman Kodak Co., Rochester, NY). 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. Blind to the clinical status of the patient, an oral and maxillofacial radiologist examined the radiographs on a standard viewing box in a darkened room. The age and sex were recorded for all patients and, for the cases of PAT, gender, age, localization and radiographic appearance were noted as well. Diagnosis of PAT on the radiographs was made 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 as in the study by 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 comparison of gender, age (before puberty and after puberty) and localization in patients with PAT was performed using the chi-square test and the null hypothesis for comparing two proportions. $P < 0.05$ was considered significant. Statistical analyses were performed using the SPSS 11.0 program (SPSS Inc, Chicago, IL) for Windows.

Results

The average age of the 1049 patients was 10.9 (SD 3.33) years and age range 4–16 years. There were 510 boys (48.6%) and 539 girls (51.5%) in the study population. The mean age of the boys was 10.6 (s.d. 3.38) years with a range of 4–16 years, whilst that for the girls was 11.2 (SD 3.26) years with a range of 4–16 years. The age distribution of the study population is presented in Figure 1.

Twenty-four PATs were found in 17 patients, representing a prevalence of 1.62%. Patients with PAT had a mean age of 11.2 (SD 3.13) years with a range of 7–16 years (Figure 2). All cases were located in the zygomatic process of the temporal bone, did not extend anteriorly beyond the zygomaticotemporal suture, and lacked expansile or destructive characteristics. Eight cases (47.1%) occurred in girls and nine cases (52.9%) occurred in boys. The mean age of boys was 11.3 (SD 2.54) years with a range of 7–15 years while mean age of girls was 11.2 (SD 3.9) years with a range of 7–16 years. Unilateral PAT was found in 10 patients, with 5 cases on the right and 5 cases on the left. Bilateral PAT was found in 7 (41.1%) patients and an example of this finding is shown in Figure 3.

Two subgroups of PAT were examined. Unilocular PAT was identified as single radiolucent oval defect with well-defined bony borders (Figure 4). Ten (41.6%) of the PATs were unilocular type. Multilocular PAT was identified as numerous radiolucent small cavities, which resemble mastoid air cells (Figure 5). Fourteen (58.3%) of the PATs were multilocular type.

In this study, the youngest patients with PAT were a 7-year-old boy and two 7-year-old girls (Figure 6). The number of patients with PAT before puberty was nine (52.9%) with a mean age of 8.8 (SD 1.76) years and an age range of 7–11 years, while the number of patients after puberty was 8 (47.1%) with a mean age of 14 (SD 1.77) years and an age range of 12–16 years. The chi-square tests showed no statistically significant differences with respect to gender ($P = 0.719$), localization ($P = 0.593$) and age (before puberty and after puberty) ($P = 0.761$).

Discussion

The development of air cells is preceded by the formation of bone cavities, a normal physiological process related to periosteal activity. Primitive bone marrow in these cavities dedifferentiates into a loose mesenchymal connective tissue. Epithelium invaginates into this connective tissue, producing a mucous membrane which then undergoes atrophy, leaving a thin residual lining membrane attached to the periosteum. Recession of the lining membrane and subepithelial bone resorption then further enlarge air cells.[5,7–9,20] The development of complete adult pneumatization can be divided into three stages: the infantile, from

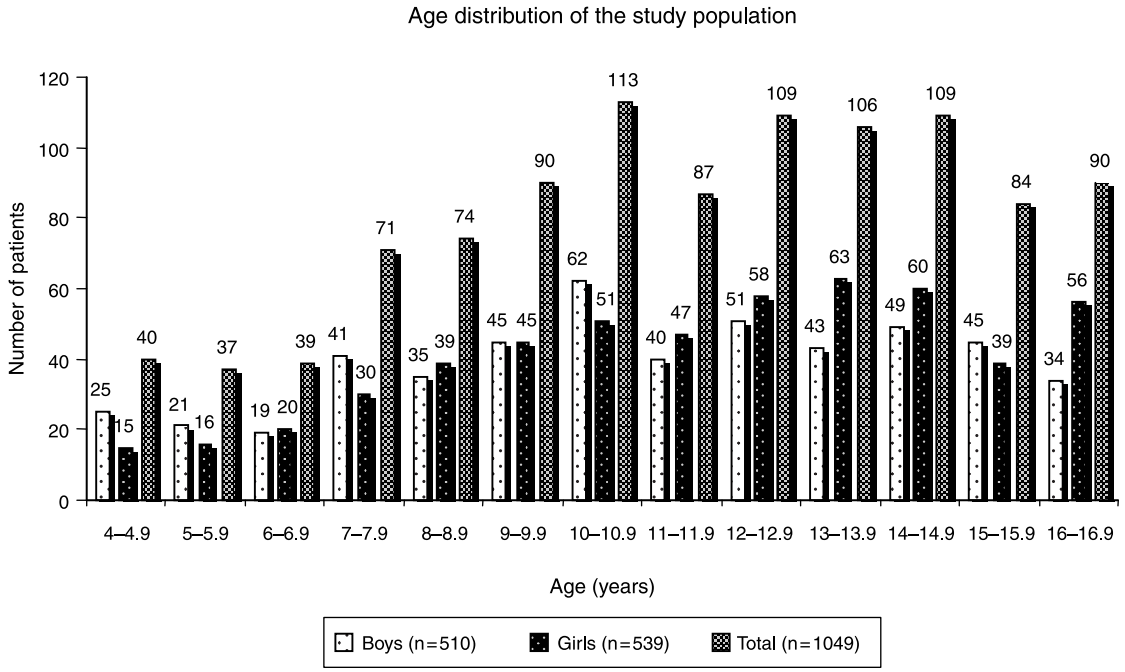

Figure 1 Age distribution of study population of 1049 patients

birth to 2 years of age; the transitional, from 2 years to 5 years; and thereafter the adult. In the infantile stage, air cells begin to appear and are readily visible by 2 years. In the transitional stage, the mastoid (squamomastoid) undergoes gradual enlargement, with migration of air cells toward 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 the adult stage.[7,28] The classification of temporal bone pneumatization is complex. It can be divided into five regions, which in turn are subdivided into areas. The primary regions consist of the middle ear,

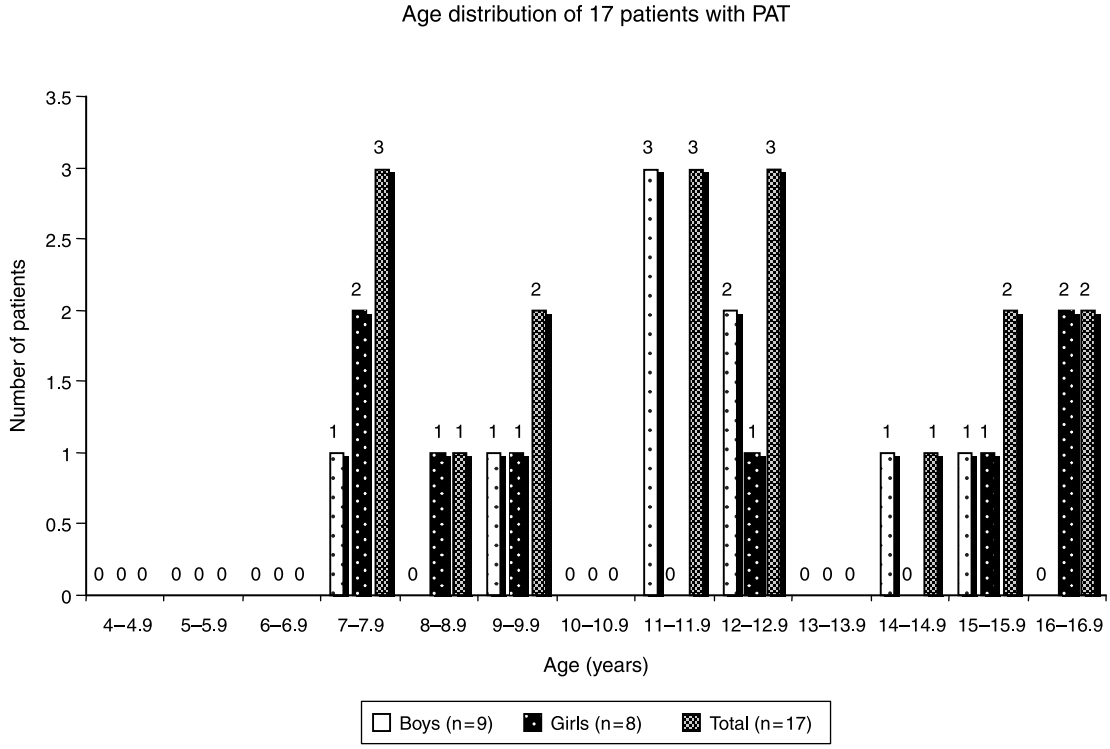

Figure 2 Age distribution of 17 patients with pneumatized articular eminence (PAT)

Figure 3 Panoramic radiograph of bilateral pneumatized articular eminence of the temporal bone in a 14-year-old boy

mastoid (squamomastoid), perilabyrinthine, petrous apex, and accessory. The squamomastoid region is comprised of two key areas of pneumatization, 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.[5,7]

After the first report of extended large mastoid air cell by Roser[13] in 1976, cases and prevalence studies of PAT have been reported in the literature.[4–6,9,10,12–24] Only five series have reported the prevalence of PAT in the general population. Tyndall and Matteson[6] provided the first detailed data on population distribution and radiographic appearance of pneumatized articular eminence. In a series of 1061 panoramic radiographs, PAT was found in 28 (2.6%) patients with a mean age of 32.5 years and an age range of 15–74 years. Kaugars and colleagues[10] reported another study on the prevalence of patients with PAT. They apportioned the patients into one of three groups (children, adolescents and adults). The study group consisted of 100 children with a mean age of 7.2 years, ranging from 4 years to 14 years and 200 adolescents with a mean age of 12.7 years, ranging from 7 years to 15 years, and the rest of the group were adult patients. They described 8 (1%) cases of PAT in 784 patients. All eight patients were from the adult group.[10] Carter et al[5] reported a detailed and wide coverage paper about pneumatized articular eminence. They examined 2734 panoramic radiographs of patients who were admitted to a dental medicine school. Of the

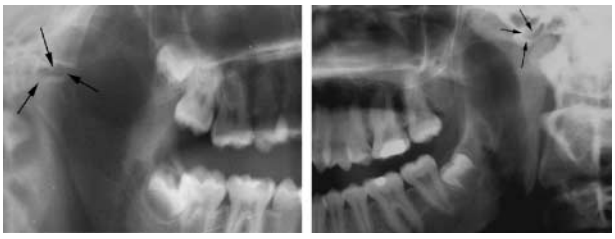

Figure 4 Cropped panoramic images showing unilocular pneumatized articular eminence

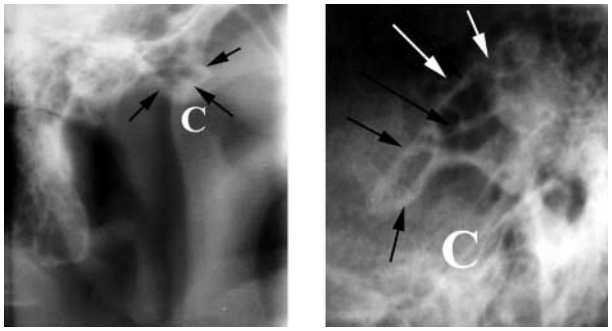

Figure 5 Portion of panoramic radiographies showing extensive multilocular pneumatization of the articular eminence. C, the mandibular condyle

2734 patients, 179 were children under the age of 10 years with a mean age 7.2 years and ranging from 4 years to 9 years. PAT was found in 40 cases (1.5%). The youngest patient reported in their study with PAT was 17 years old. Hofmann et al[19] reported a study on the prevalence and characteristics of PAT. 1084 panoramic radiographs of the patients who admitted to a dental school in Germany were examined for the presence of PAT. The average age of the 1084 patients was 41.9 years and an overall range of 2–96 years. Of all the 1084 patients, 48 were child patients ranging from 2 years to 9 years. PAT was found in 20 (1.85%) cases. The youngest patient with PAT was 7 years old. Orhan et al[20] also reported a study about the prevalence and characteristics of PAT in a series of panoramic radiographs. They described PAT in 19 (1.88%) out of 1006 panoramic radiographs reviewed. Patients with PAT had a mean age of 36.6 years with a range of 11–90 years. The youngest patient with PAT in their study was 11 years of age.

Among these reports, there is not a child-only population presented. In our study, 1049 panoramic

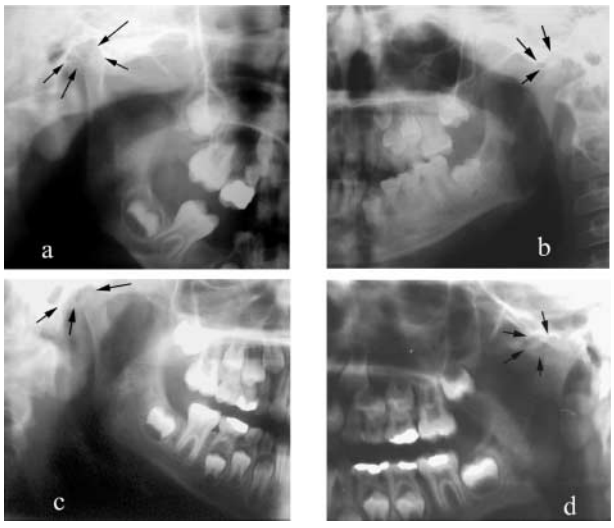

Figure 6 Cropped panoramic images showing pneumatized articular eminence (a) in a 7-year-old boy, (b) a 9-year-old boy and (c,d) 7-year-old girls

radiographs of children were examined with a mean age of 10.9 (SD 3.33) years and age range 4–16 years. The youngest patients with PAT were a 7-year-old boy and two 7-year-old girls. Hollingshead[3] pointed out that the accessory air cells begin to pneumatize after puberty and achieve full size after several years, as with mastoid air cells proper. In contrast to this statement, Hofmann et al[19] and Orhan et al[20] detected cases of PAT in 7 years and 11 years of age before the second half of the second decade of life. In this study the aim is to ascertain whether accessory pneumatization can occur before puberty or not. PAT was found in nine patients (0.85%) before puberty with a mean age of 8.8 (SD 1.76) years, and an age range of 7–11 years, which can be interpreted as the pneumatization of accessory air cells beginning before puberty, opposing of the general opinion and statements. Similar studies have to be conducted in order to support this finding.

Temporal air spaces have been recognized as an important contributor and path in suppuration of various pathological processes. Tumours of the mastoid process and ear may extend into the TMJ whereas otitis media or otomastoiditis may involve the TMJ and can even result in ankylosis.[29–35] The very young are most at risk for suppurative otologic infections due to immature Eustachian tube function, and they have not yet undergone complete bony development of the temporal bone, glenoid fossa and TMJ.[33,36] Because of these factors, this age group is at high risk for spread of infections between these two anatomically distinct regions. Acute otitis media (AOM) is one of these infections and remains the most common infection in childhood for the mastoid area. It is estimated that 30 million cases occurred in 1996.[37,38] Acute otomastoiditis is an infrequent complication of AOM with potentially life-threatening consequences.[39–41] The classic description of acute otomastoiditis involves a child with antecedent AOM who develops high fever, severe otolgia, post-auricular erythema, and tenderness.[39–44] Because of the close anatomic relationship between middle ear mastoid cavity, glenoid fossa and TMJ, it is critical that this relationship be appreciated in order to correctly diagnose otomastoiditis when the presenting symptoms, physical examination or radiographic evaluation implicate TMJ disorders (TMD).[33] TMD was generally presumed to be a condition affecting adults; however, epidemiological studies have reported signs and symptoms in children to be as frequent as in adults.[45–48] Among the more common signs and symptoms of TMD, TMJ sounds, impaired movement of the mandible, limitation in mouth opening, pre-auricular pain, facial pain, headache and earache (otalgia) have been reported alone or in combination.[46,47,49–51] Therefore, professionals have to be aware of this disease and should keep in mind that children who are admitted for TMJ symptoms can be affected with otitis media or otomastoiditis. Hence, certain patients with ear symptoms have to be examined by an otolaryngologist meticulously in order to avoid misdiagnosis and mistreatment.[46]

In conclusion, this study shows that the pneumatization of accessory air cells begins before puberty, contrary to the general opinion and statements. Knowledge about these structures is helpful for the interpretation of imaging such as panoramic radiographs and provides valuable information to understand the spread and differential diagnosis of pathological entities in this region.

References

1. Tremble GJ. Pneumatization of the temporal bone. *Arch Otolaryngol* 1934; **19:** 172.
2. Allam AF. Pneumatization of the temporal bone. *Ann Otol Rhinol Laryngol* 1969; **78:** 48–64.
3. Hollinshead WH. *Anatomy for surgeons: The head and neck*, (2nd edn). New York: Harper and Row, 1968.
4. Tyndall D, Matteson S. The appearance of the zygomatic air cell defect (ZACD) on panoramic radiographs. *Oral Surg Oral Med Oral Pathol* 1987; **64:** 373–376.
5. Carter LC, Haller AD, Calamel AD, Pfaffenbach AC. Zygomatic air cell defect (ZACD). Prevalence and characteristics in a dental clinic outpatient population. *Dentomaxillofac Radiol* 1999; **28:** 116–122.
6. Tyndall D, Matteson S. Radiographic appearance and population distribution of the pneumatized articular eminence of the temporal bone. *J Oral Maxillofac Surg* 1985; **43:** 493–497.
7. Virapongse C, Sarwar M, Bhimani S, Sasaki C, Shapiro R. Computed tomography of temporal bone pneumatization: 1. Normal pattern morphology. *AJNR Am J Neuroradiol* 1995; **6:** 551–559.
8. Ojala L. Pneumatization of the bone and environmental factors: experimental studies in chick humerus. *Acta Otolaryngol* 1957; **133:** 1–28.
9. Groell R, Fleischmann B. The pneumatic spaces of the temporal bone: relationship to the temporomandibular joint. *Dentomaxillofac Radiol* 1999; **28:** 69–72.
10. Kaugars G, Mercuri L, Laskin D. Pneumatization of the articular eminence of the temporal bone: prevalence, development and surgical treatment. *J Am Dent Assoc* 1986; **113:** 55–57.
11. Tos M, Stangerup SE, Hvid G. Mastoid pneumatization: evidence of the environmental theory. *Arch Otolaryngol* 1984; **110:** 502–507.
12. Deluke DM. Pneumatization of the articular eminence of the temporal bone. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1995; **79:** 3–4.
13. Roser SM, Rudin DE, Brady FA. Unusual bony lesion of the zygomatic arc. *J Oral Med* 1976; **31:** 72–73.
14. Kulikowski BM, Schow SR, Kraut RA. Surgical management of a pneumatized articular eminence of the temporal bone. *J Oral Maxillofac Surg* 1982; **40:** 311–313.
15. Yurosko JJ. Pneumatized articular eminence. *Oral Surg Oral Med Oral Pathol* 1985; **60:** 346.
16. Lindenmuth JE, Clark MS. Pneumatization of the articular eminence. *Cranio* 1986; **4:** 86–87.
17. Piette E. La pneumatisation du tubercule zygomatique antérieur de l'os temporal. *Rev Stomatol Chir Maxillofac* 1986; **87:** 223–226.
18. Hasnaini M, Ng SY. Extensive bone pneumatization: incidental finding in a patient with TMJ dysfunction. *Dent Update* 2000; **27:** 187–189.
19. Hofmann T, Friedrich RE, Wedl JS, Schmelzle R. Pneumatization of the zygomatic arch on pantomography. *Mund Kiefer Gesichtschir* 2001; **5:** 173–179.
20. Orhan K, Delilbasi C, Cebeci I, Paksoy C. Prevalence and variations of pneumatized articular eminence: a study from Turkey. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2005; **99:** 349–354.
21. Stoopler ET, Pinto A, Stanton DC, Mupparapu M, Sollecito TP. Extensive pneumatization of the temporal bone and articular eminence: an incidental finding in a patient with facial pain. Case report and review of literature. *Quintessence Int* 2003; **34:** 211–214.

22. Wong K, Munk PL. Magnetic resonance imaging of the temporomandibular joint: diagnostic difficulty caused by extensive pneumatization of the mastoid air cells. *Skeletal Radiol* 1999; **28:** 577–580.
23. Koudstaal MJ, van der Wal KG. A radiolucency in the articular eminence of the temporal bone: an air bubble? *Ned Tijdschr Tandheelkd* 2003; **11:** 193–194.
24. Randzio J, Vogl T, Kellermann O, Geisemeyer W. Pneumatization of the articular eminence of the TMJ. A case report. *Dtsch Z Mund Kiefer Gesichtschir* 1989; **13:** 283–285.
25. Lowrey GH. *Growth and development of children*. Chicago: Year Book Medical Publishers Inc; 1973, p 13.
26. Stone LJ, Church J. *Childhood and adolescence*, (3rd edn). New York: Random House Inc; 1975.
27. Mathewson RJ, Primosch RE. *Fundamentals of pediatric dentistry*, (3rd edn). St Louis, MO: Quintessence Publishing Co Inc; 1995, p 14, 19.
28. Shapiro R. *Radiology of the normal skull*. Chicago: Year Book Medical Publishers; 1981, pp 326–340.
29. Thomson HG. Septic arthritis of the temporomandibular joint complicating otitis externa. *J Laryngol Otol* 1989; **103:** 319–321.
30. Faerber TH, Ennis RL, Allen GA. Temporomandibular joint ankylosis following mastoiditis: a report of a case. *J Oral Maxillofac Surg* 1990; **48:** 866–870.
31. Dingle AF. Fistula between the external auditory canal and the temporomandibular joint: a rare complication of otitis externa. *J Laryngology Otol* 1992; **106:** 994–995.
32. Youniss S. The relationship between craniomandibular disorders and otitis media in children. *Cranio* 1991; **9:** 169–173.
33. Hadlock TA, Ferraro NF, Rahbar R. Acute mastoiditis with temporomandibular joint effusion. *Otolaryngol Head Neck Surg* 2001; **125:** 111–112.
34. Weissman JL, Hirsch BE, Chan K, Tabor EK, Curtin HD. Dehiscent temporomandibular joint. *Radiology* 1991; **180:** 211–213.
35. Orhan K, Nishiyama H, Tadashi S, Shumei M, Furukawa S. MR of 2270 TMJs: prevalence of radiographic presence of otomastoiditis in temporomandibular joint disorders. *Eur J Radiol* 2005; **55:** 102–107.
36. Keith DA. Development of the human temporomandibular joint. *Br J Oral Surg* 1982; **20:** 217–224.
37. Hoberman A, Paradise JL. Acute otitis media: diagnosis and management in the year 2000. *Pediatr Ann* 2000; **29:** 609–620.
38. American Academy of Pediatrics Subcommittee on Management of Acute Otitis Media, Diagnosis and management of acute otitis media. *Pediatrics* 2004; **113:** 1451–1465.
39. Vazquez E, Castellote A, Piqueras J, Mauleon S, Creixell S, Pumarola F, et al. Imaging of complications of acute mastoiditis in children. *Radiographics* 2003; **23:** 359–372.
40. Tarantino V, D'Agostino R, Taborelli G, Melagrana A, Porcu A, Stura M. Acute mastoiditis: a 10 year retrospective study. *Int J Pediatr Otorhinolaryngol* 2002; **66:** 143–148.
41. Penido Nde O, Borin A, Iha LC, Suguri VM, Onishi E, Fukuda Y, et al. Intracranial complications of otitis media: 15 years of experience in 33 patients. *Otolaryngol Head Neck Surg* 2005; **132:** 37–42.
42. Niv A, Nash M, Peiser J, Dagan R, Einhorn M, Leiberman A, et al. Outpatient management of acute mastoiditis with periosteitis in children. *Int J Pediatr Otorhinolaryngol* 1998; **46:** 9–13.
43. Bahadori RS, Schwartz RH, Ziai M. Acute mastoiditis in children: an increase in frequency in Northern Virginia. *Pediatr Infect Dis J* 2000; **19:** 212–215.
44. Gliklich RE, Eavey RD, Iannuzzi RA, Camacho AE. A contemporary analysis of acute mastoiditis. *Arch Otolaryngol Head Neck Surg* 1996; **122:** 135–139.
45. Farsi NM. Symptoms and signs of temporomandibular disorders and oral parafunctions among Saudi children. *J Oral Rehabil* 2003; **30:** 1200–1208.
46. Bonjardim LR, Gaviao MB, Carmagnani FG, Pereira LJ, Castelo PM. Signs and symptoms of temporomandibular joint dysfunction in children with primary dentition. *J Clin Pediatr Dent* 2003; **28:** 53–58.
47. Castelo PM, Gaviao MB, Pereira LJ, Bonjardim LR. Relationship between oral parafunctional/nutritive sucking habits and temporomandibular joint dysfunction in primary dentition. *Int J Paediatr Dent* 2005; **15:** 29–36.
48. Alamoudi N, Farsi N, Salako NO, Feteih R. Temporomandibular disorders among school children. *J Clin Pediatr Dent* 1998; **22:** 323–328.
49. Dworkin SF, Huggins KH, LeResche L, Von Korff M, Howard J, Truelove E, et al. Epidemiology of signs and symptoms in temporomandibular disorders: clinical signs in cases and controls. *J Am Dent Assoc* 1990; **120:** 273–281.
50. Bernal M, Tsamtsouris A. Signs and symptoms of temporomandibular joint dysfunction in 3 to 5 year old children. *J Pedod* 1986; **10:** 127–140.
51. Ash CM, Pinto OF. The TMJ and the middle ear: structural and functional correlates for aural symptoms associated with temporomandibular joint dysfunction. *Int J Prosthodont* 1991; **4:** 51–57.