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DOI: 10.5603/FM.a2017.0078

Article type: ORIGINAL ARTICLES

Submitted: 2017-06-19
Accepted: 2017-07-24
Published online: 2017-08-30

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Examination of foramen tympanicum: cone-beam computed tomography anatomical study

Running head: A CBCT study of foramen tympanicum

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ABSTRACT

Background: The foramen of tympanicum is an osseous dehiscence of the temporal bone and usually close by the age of 5 years. The foramen is located posteromedial to the temporomandibular joint and anteroinferior of the external auditory canal. The aim of this study is to define prevalence, location and size of the foramen.

Materials and methods: We retrospectively examined 200 cone beam computed tomography images (400 ears). We used a CBCT dental imaging system (GALİLEOS, Sirona Dental Systems, Bensheim, Germany) working at 15-30 mA and 98 kV. We noted size and location (unilateral and bilateral) of the presented foramen tympanicums.
Results: Foramen tympanicum was determined in 11.5% of 200 patients had FT at least one side of head. This was bilateral in 5 (2.5%) patients. Prevalence of the FT was significantly higher on females (8%) than males (3.5%). FT was found higher on left side (7.5%) than right side (4%). Mean axial diameter was 1.13 mm (range 0.23-4.43 mm), and mean sagittal diameter was 1.44 mm (range 0.22-3.99 mm).

Conclusions: Because of the defect presents in 11.75% of patients, radiologists and clinicians should be awake to the possible entity of the defect. It is known that this developmental dehiscence may cause herniation of temporomandibular joint, formation of salivary otorrhea, spread of tumor or infection to the infratemporal fossa from external auditory canal. This study showed that CBCT may be preferred for imaging this conditions.

Key words: foramen tympanicum, foramen huschke, cone beam computed tomography, dental volumetric tomography, CBCT

INTRODUCTION

Foramen tympanicum (FT), also called as foramen of Huschke, is an anatomic variation situated in the tympanic portion of the temporal bone. It was determined first by Emil Huschke. FT occurs during the time that embryological development of the viscerocranial bone [1, 2]. When present it is located at the anteroinferior of the external auditory canal (EAC) and external auditory meatus (EAM), posteromedial to the temporomandibular joint (TMJ) [3, 4] (Figure 1,2,3,4).

Development of the EAC begins at eight weeks of pregnancy. A funnel-shaped tube is formed from first branchial cleft. After one week, a solid epidermal lamina develops at the medial of this funnel-shaped tube. This lamina extents to midline of tube until touch first pharyngeal sack. Ossification of this structure develops from four centers around the mesenchyme and forms primordial tympanic ring. Bony prominences of this ring which fuse at the age of 1 year, growing towards each other until they join. This fusion forms a foramen at the inferior of ear canal, foramen tympanicum. The foramen normally become smaller and completely closes throughtout growth, and so is not present.
in adult normally. So, FT is not a true foramen; is a osseous defect or dehiscence [5].

The foramen tympanicum can lead a connection between infratemporal fossa and EAC. It is important because it may provide a route for spreading of tumors and infection. Also FT may cause TMJ herniation into the EAC and salivary secretion flow into the EAC during mastication. The aim of this study is to determine prevalence, location and size of FT on CBCT images in a Turkish sub-population.

MATERIALS AND METHODS

In this study, randomly chosen 200 cone beam computed tomography (CBCT) images (400 ears), which taken for any reason at the Department of Maxillofacial Radiology, Ondokuz Mayıs University were retrospectively examined. The protocol was approved by Ondokuz Mayıs University Clinical Research Ethics Committee.

The images were studied with Galileos Comfort Plus Cone Beam Computed Tomography Unit (Sirona Dental Systems Inc., Bensheim, Germany). GALILEOS (Sirona Dental Systems, Bensheim, Germany), operating at 98 kVp, 15-30 mA. System has 15 mm X 15 mm field of view. Real-time reconstruction was performed using the SIRONA Sidexis XG image viewer. Obtained images were 0.25 mm3 voxel size and consisted of 12 bit grayscale images. Flat panel colored active matrix TFT images were evaluated on the medical display. (Nio Color 3 MP, Barco, Kortrijk, Belgium).

The images of the patients with bone disease, skeletal asymmetries or trauma, congenital disorders, pathological disorders of the temporal bone and mandible were excluded from the study. In addition, low-quality images, such as containing scattering were excluded.

Sagittal, axial, and cross-sectional CBCT images of 200 patients were retrospectively evaluated to determine the size and position of the FT. Distinguishing characteristics of size and location (unilateral and bilateral) of the FT noted and its prevalence calculated twice by two observers. Observers examined all images twice
promptly in different times of a week. For measurements, we used “distance tool bar” feature of image analysis program (SIDEXIS XG 2.56, Sirona Dental Inc., Bensheim, Germany).

The study was carried out according to the principles described in Declaration of Helsinki. Images were randomly selected, regardless of age and sex. In this retrospective study using randomly chosen 200 cone beam computed tomography (CBCT) images, there is only 10 patient CBCT image under 18 age. So statistical evaluation could not be performed especially for children.

**RESULTS**

Inter-observers and intra-observers’ compatibility were estimated by weighted Kappa statistics using SPSS 15.0 program. It was seen quite harmonious in intra-observer compliance and between researcher 1 and researcher 2. In this study, 116 female (%58) and 84 male (%42) patients were observed. FT was determined in 23 (11.5%) of 200 patients had FT at least on one side of head. This was bilateral in 5 (2.5%) patients.

We determined 8 FT (4%) on the right side and 15 FT (7.5%) on the left side. McNemar test showed that FT was found to be significantly higher on left side (p<0.05). Fisher’s exact test showed that prevalence of the FT was significantly higher on females (8%) than males (3.5%). We found relationship between sex and FT (p< 0.05).

On the right side FT was observed in 2.5% of female and 1.5% of male. Chi-Square Test showed any statictical relationship between sex and right side FT. On the left side FT was observed in 5.25% of female and 2.25% of male. Chi-Square Test showed that prevalence of the FT on left side higher on females (p<0.05).

Mean axial diameter was 1.13 mm (range 0.23-4.43 mm), and mean sagittal diameter was 1.44 mm (range 0.22-3.99 mm). On the right side, mean diameter was 1.32 mm (range 0.23-2.52 mm) in the axial plane, and mean diameter was 1.33 mm (range 0.42-3.77 mm) in the sagittal plane. On the left side mean diameter was 1.04 mm (range 0.22-3.99 mm) in the axial plane, and mean diameter was 1.33 mm (range 0.42-3.77 mm) in the sagittal plane. No correlation between location and FT diameter was found by one-way analysis of variance (p > 0.05).
In female, on the right side mean diameter was 1.33 mm in saggittal plane, and mean diameter was 1.24 mm in axial plane, on the left side mean diameter was 1.47 mm in saggittal plane, and mean diameter was 0.92 mm in axial plane. In male on the right side mean diameter was 1.33 mm in saggittal plane, and mean diameter was 1.48 mm in axial plane, on the left side mean diameter was 1.39 mm in saggittal plane, and mean diameter was 1.24 mm in axial plane. Measurements were evaluated using one-way analysis of variance. Mean sizes did not differ significantly by sex but were found to be greater in males on left side axial plane (p > 0.05).

**DISCUSSION**

CBCT imaging is an effective three-dimensional diagnostic imaging technology with a smaller radiation field than MDCT. CBCT has a better spatial resolution than MDCT and also more easy to perform technically. Dalchow and co-workers [6] showed that small pathological processes can be well analyzing and anatomical process can be well visualizing with CBCT by their temporal bone study. Also the same science workers compared CBCT scans of 25 patients with suffered conductive hearing loss. And they defined CBCT could be proven in the diagnosis of temporal bone pathologies and anatomical landmarks [7].

FT is a developmental defect presents at antero-inferior aspect of EAC. Before 5 years, it gradually narrows and completely closes, but sometimes it may not close. Persistent tympanic bone dehiscence arises at the region where fusion of the two prominences [8, 9]. In a sub-population, ranging from 4.6% to 22.7% FT may persist through life [1, 4, 10].

In this study, FT was present in 11.5% of the 200 patient had FT at least one side of head. While Akbulut et al. [1] investigated FT in 22.7% of patients on CBCT images; Lacout et al. [4] identified FT in 4.6% of patients on high-resolution spiral CT images. Tozoğlu et al. [10] observed frequency of FT 17.9% on CBCT images. Afghari et al. [11] reported frequency of FT 6.9% on CBCT images. CBCT has a better spatial
resolution and contrast resolution is much better with conventional CT. These technical advantages of CBCT clarify obtained different ranges of FT between CT and CBCT studies. So CBCT may be more effectable from MDCT to investigate FT radiologically.

Akbulut et al. [1] found frequency of FT on the right side (17.8%) was significantly different from the left side (14.05%) (p<0.05). Tozoğlu et al. [10] revealed frequency of FT significantly higher on the right side (15.5%) from the left side (7.2%) (p<0.05). Akbulut et al. [1] reported that FT presents unilateral 59.5% and bilateral 40.5% of patients with FT. Tozoğlu et al. [10] observed it was unilateral 11.6% and bilateral 6.3% of patients. In this study, we determined 4% of FT on the right side and 7.5% of FT on the left side (p<0.05). This was bilateral 2.5% of patients. The relationship between side and FT can be responsible from mastication habits and genetic factors of study populations.

In literature, researchers reported female predominance of FT [4, 12-18]. Akbulut et al. [1] found no difference between sexes (p>0.05), but it was seen that more bilateral in women. (p<0.05). Lacout et al. [4] reported female predominance (p<0.05). Afghari et.al. [11] found FT prevalence was higher in females (p<0.05). We found relationship between sex and persistent FT; compatible with previous studies female predominance was determined. This female predominance of FT might have been based on growth and development differences of osseous structures between genders. Studies performed on the temporal bones taken from different human populations described effects of sex on growth and development of temporal bone [12, 19].

In this study, we found mean diameter was 1.32 mm (range 0.23 - 2.52 mm) on the right side in the axial plane and 1.33 mm (range 0.42 - 3.77 mm) on the sagittal plane. On the left side, mean diameter was reported 1.04 mm (range 0.22-3.99 mm) on the axial plane and 1.33 mm (range 0.42 - 3.77 mm) on the sagittal plane. Researchers estimated that shape of the foramina is oval because FT’s dimensions on axial plane are slightly bigger than sagittal planes in their studies [1,4,13]. We investigated that shape of the foramina was oval like previous studies; mean sagittal size of FT was bigger than
axial size of FT. But unlike the previous studies mean sagittal size dimension of FT was very close to mean axial size dimension of FT.

Pathologies associated with FT were reported in the literature. An unhealthy condition associated with FT is soft tissue migration from TME to EAC and this situation can lead to TME pain and dysfunction [9, 17]. The origin of this migration is uncertain, but reported as a complication of TMJ arthritis and external otitis [20, 21, 22]. FT may facilitate ear injury during TMJ arthroscopy. Endoscope may penetrate into the EAC accidently owing to FT [17]. Other reported pathologies are salivary-gland fistulas and synovial TMJ fistulas [13, 14, 21]. FT form an anatomic way between the EAC and the infratemporal fossa [22]. Because of this infection or tumor may spread into the infratemporal fossa from the EAC or into the EAC from the infratemporal fossa [6,16,23].

CONCLUSIONS

In conclusion, the FT is an uncommon developmental defect and also very well demonstrated on CBCT. CBCT imaging system may be preferred to CT imaging system to examine these anatomical variations. Clinicians and radiologists should be aware of the possible presence of this developmental defect because may affect the diagnosis, treatment plan and prognosis. CBCT may be preferred imaging modality for evaluation of anatomical structures in the near future than other imaging modalities.

ACKNOWLEDGEMENTS

The authors report no conflicts of interest related to this study.

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FIGURE LEGENDS

**Figure 1:** There is a FT on the posteromedial aspect of right temporomandibular joint on coronal plane of CBCT scan (arrowhead) and external auditory canal is seen adjacent to FT (star).

**Figure 2:** There is no FT on the right side, coronal plane of CBCT scan (white arrow) and external auditory canal is showed (star).

**Figure 3:** There is a FT (arrowhead) on the anterior aspect of the right external auditory meatus (thin arrow) on sagittal plane of CBCT scan.

**Figure 4:** There is no FT (white thick arrow) on the anterior aspect of the right external auditory meatus (thin arrow), sagittal plane of CBCT scan.
