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RESEARCH

Foramen tympanicum or foramen of Huschke: anatomical cone beam CT study

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Objective: The foramen of Huschke (foramen tympanicum) represents a developmental defect in the antero-inferior aspect of the bony external auditory meatus. The foramen is located at the antero-inferior aspect of the external auditory canal, posteromedial to the temporomandibular joint. The aim of this study is to define the prevalence and location of the foramen of Huschke.
Methods: We retrospectively examined 207 cone beam CT (CBCT) studies (414 ears). We used flat panel detector (FPD)-based CBCT (New Tom FP; Quantitative Radiology, Verona, Italy) for imaging in our department. We noted the location of the foramen tympanicum and calculated its prevalence as a percentage.
Results: We found a foramen tympanicum in 37 (17.9%) of 207 patients. This was unilateral in 24 patients (11.6%) and bilateral in 13 patients (6.3%). Mean axial diameter was 5 mm and mean sagittal diameter was 2 mm.
Conclusion: The foramen tympanicum is an uncommon disorder and is well demonstrated on CBCT. This is the first study to detect the foramen tympanicum using FPD-based CBCT.
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Keywords: foramen tympanicum; foramen of Huschke; cone beam computed tomography

Introduction

The foramen of Huschke (foramen tympanicum) represents a developmental defect in the antero-inferior aspect of the bony external auditory meatus and is an uncommon disorder.[1,2] The foramen is located at the antero-inferior aspect of the external auditory canal (EAC), posteromedial to the temporomandibular joint (TMJ).[1,3] The foramen of Huschke may predispose individuals to TMJ pathology or it may be associated with salivary discharge into the EAC during mastication.[1]

Cone beam CT (CBCT) is a recently introduced imaging technique that uses a cone beam which moves around the part of the body being examined.[4] CBCT scanners provide smaller effective doses than conventional CT to the patient.[5] In a recent study, the effective (radiation) dose of one particular CBCT scanner was only 8% of the effective dose of a conventional CT scanner.[6] Both CT and CBCT provide data sets that can be converted into DICOM (Digital Imaging and Communications in Medicine) format using appropriate software. It is therefore possible to produce three-dimensional (3D) reformations and slice images that are useful in surgery planning and identifying adjacent anatomical structures.[4] We can use CBCT not only for the oral and maxillofacial area but also for the head and neck area.

There is little research about the foramen of Huschke. Some researchers reported that a foramen tympanicum was found in 6 (4.6%) of 130 ears; mean axial diameter was 4.2 mm and mean sagittal diameter was 3.6 mm. They used high-resolution spiral CT to detect the foramen tympanicum.[1] This is the first study to use flat panel detector (FPD)-based CBCT to detect the foramen tympanicum.

The aim of this study is to define the prevalence and location of the foramen of Huschke using CBCT.

Materials and methods

We retrospectively examined 207 CBCT studies (414 ears) which were taken for reasons such as mandibular fracture, dental implants and paranasal sinusitis in our department.

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Table 1 Location of the foramen tympanicum was noted as unilateral or bilateral and its prevalence was calculated as a percentage

Location	*Frequency*	*Percentage*
None	170	82.1
Unilateral	24	11.6
Bilateral	13	6.3
Total	207	100.0

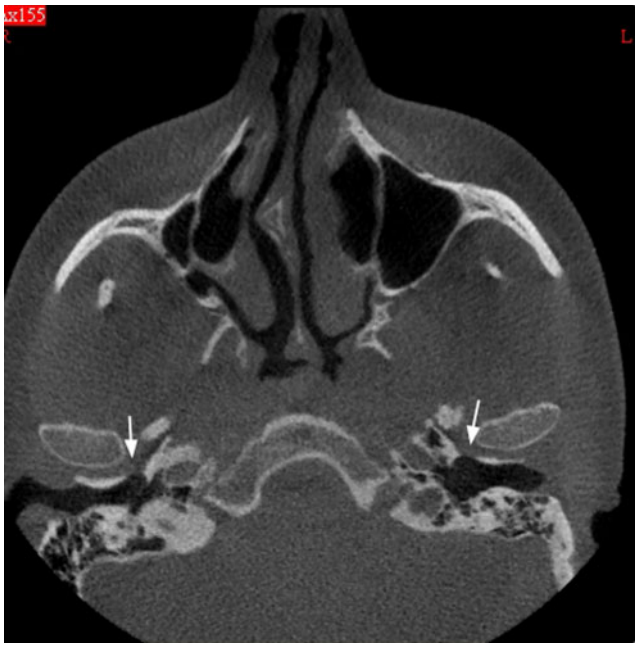


Figure 1 There are foramen tympanicum in two sides, 0.5 mm with thickness axial slice, flat panel detector-based cone beam CT scan (white arrow)

We used FPD-based CBCT for imaging (New Tom FP; Quantitative Radiology, Verona, Italy). The QR-NNT version: 21 software program (Quantitative Radiology, Verona, Italy) was used for this study. All images were recorded at 110 kV and 3–5 mA using a 9-inch field of view (FOV) and total exposure time of 5.4 s. X-ray parameters of kilovolts and milliamperes are automatically determined from scout views by the NewTom 3G. Mean axial diameter was 0.5 mm, mean sagittal diameter was 2 mm and mean coronal diameter was 2 mm. Axial images were acquired in the orbitomeatal plane. For these protocols, two observers analysed the CBCT images independently. We identified the foramina on axial images and confirmed their existence on coronal and sagittal reformatted images. For every patient, we noted location of the foramen tympanicum (unilateral or bilateral), calculated its prevalence as a percentage and noted its size. We measured the size of the foramen in the axial plane as well as on the reconstructed coronal and sagittal planes. We calculated the prevalence of the persistent foramen tympanicum.

Statistical analysis

Statistical analysis was performed using the statistical software package SPSS (version 10.0; SPSS Inc., Chicago, IL). We used frequency and descriptive analysis and the NPar test. Levels of significance were set at $p < 0.05$ and $p < 0.001$.

Results

78 male patients and 129 female patients with an overall mean age of 30.29 years ($\pm$13.79 years) were included in this study. We found a foramen tympanicum in 37 (17.9%) of the 207 patients and 414 ears. We did not find a foramen tympanicum in 170 (82.1%) of the 207 patients and 414 ears (Figures 3 and 4). Of the 37 patients with a foramen tympanicum, it was unilateral in 24 patients (11.6%) and bilateral in 13 patients (6.3%) (Table 1; Figures 1 and 2). The shape of the foramina was considered oval because their dimensions in two planes were slightly different. On the right side their mean size was 2.65 mm (range 1.20–3.60 mm) in the axial plane and 2.55 mm (range 1.20–5.40 mm) in the sagittal plane (Table 2). On the left side their mean size was 2.90 mm (range 2.00–4.20 mm) in the axial plane and 2.71 mm (range 1.20–4.30 mm) in the sagittal plane (Table 2). 3.38% of 414 tympanic bones had decreased thickness (< 1.0 mm) at the antero-inferior portion. Foramen tympanicum was found in 32 (15.5%) of 207 ears in the right side and in 15 (7.2%) of 207 ears in the left side (Table 3). The right side was statistically significantly different compared with the left side ($p < 0.05$) (Table 3).

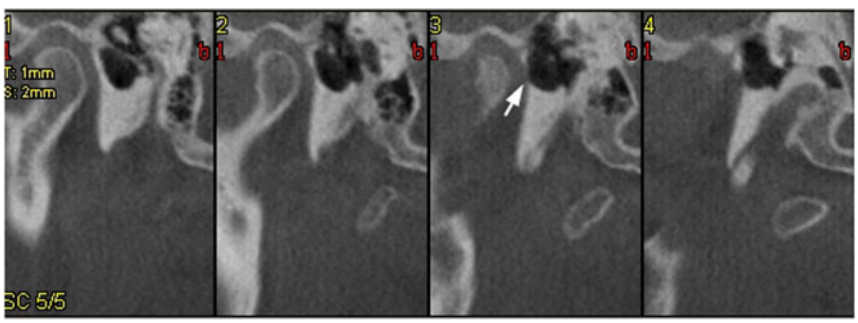


Figure 2 There is foramen tympanicum in the right side, 1 mm with thickness sagittal slice, flat panel detector-based cone beam CT scan (white arrow)

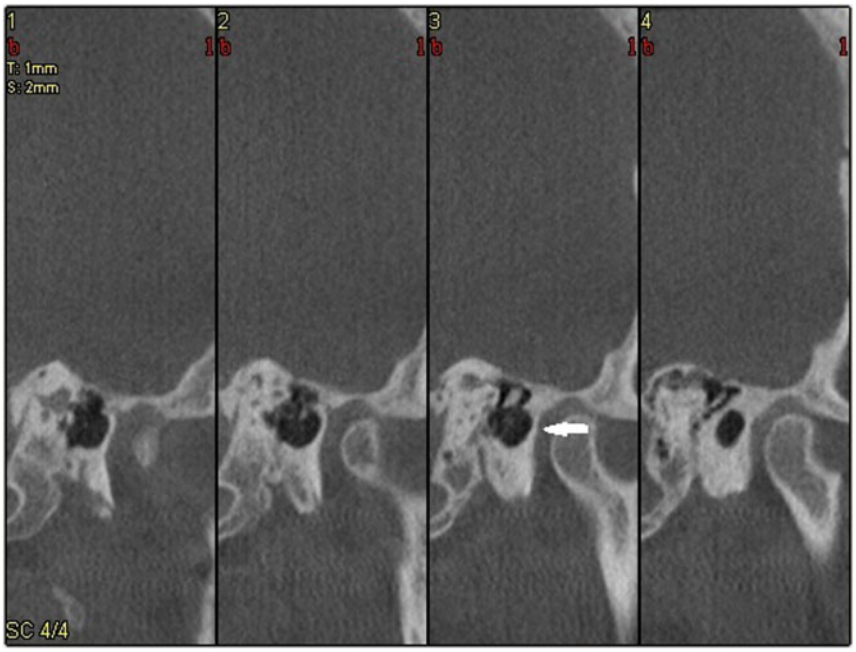


Figure 3 There is no foramen tympanicum in both sides, 1 mm with thickness sagittal slice, flat panel detector-based cone beam CT scan (white arrow)

Discussion

The foramen of Huschke represents a developmental defect in the antero-inferior aspect of the bony external auditory meatus.[3] In a proportion of the population, ranging from 5% to 46%, the foramen of Huschke may persist through life.[3] The foramen of Huschke lies inferior to the external auditory meatus in the first year of life. During skull growth, the foramina of Huschke are luxated anteriorly and usually close by the age of 5 years. They may, however, persist in a few rare cases.[2,3]



Figure 4 There is no foramen tympanicum in both sides, 0.5 mm with thickness axial slice, flat panel detector-based cone beam CT scan (white arrow)

Many factors affect the ossification process of the tympanic bone after birth. The mechanical environment of the mandible such as mastication, deglutition and respiration against the tympanic bone is one factor to consider.[1] Also, a persistent foramen of Huschke has been associated with fistula formation between the parotid gland and the external auditory meatus.[3]

There is little research investigating the prevalence and location of the foramen of Huschke. Wang et al[7] examined the skulls and they found a rate of persistent foramen tympanicum of 7.2% in an osteological study (377 skulls). This is the first study to use FPD-based CBCT to detect the foramen tympanicum. We found a foramen tympanicum in 37 (17.9%) of 207 patients. This was unilateral in 24 patients (11.6%) and bilateral in 13 patients (6.3%).

A persistent foramen of Huschke has been associated with herniation of soft tissues from the TMJ into the external auditory meatus[8,9] and with fistula formation between the parotid gland and the external auditory meatus.[10,11] Researchers stressed the importance of biochemical analysis of the discharge fluid as part of the pre-operative assessment of the patient in order to determine whether the discharge represented a salivary fistula or a synovial fluid leak.[11,12] Clinicians should be aware of the presence of this developmental defect because it may affect diagnosis of the problem and the successful treatment and prognosis.

Moreno et al[13] identified and located the foramen of Huschke using contrast material through extraoral

Table 2 Mean size of axial plane and sagittal plane on the right side and left side

Side	n	*Minimum*	*Maximum*	*Mean*	*Standard deviation*
Right axial	25	1.20	3.60	2.6520	0.71596
Right sagittal	25	1.20	5.40	2.5520	1.05282
Left axial	12	2.00	4.20	2.9083	0.80166
Left sagittal	12	1.20	4.30	2.7167	1.10522

Table 3 Comparing the left and right sides of the foramen tympanicum

Side	*Frequency*	*Per cent*	*Valid per cent*	*Cumulative per cent*
Right	32	15.5	68.1	68.1
Left	15	7.2	31.9	100.0
Total	47	22.7	100.0	

Side	n	*Observed Prop.*	*Test Prop.*	*Asymp. Sig. (two-tailed)*
Right	32	0.68	0.50	0.019
Left	15	0.32		
Total	47	1.00		

Asymp. Sig., asymptotic significance; Prop., proportion.

radiographs, such as panoramic, submental vertex and corrected sagittal linear TMJ tomograms, in four skulls. They reported that linear tomography provides the best results to visualize the foramen of Huschke.[13]

CBCT is a relatively new 3D imaging technique requiring a significantly lower radiation dose than conventional CT. CBCT differs from conventional CT imaging in that the whole volume of data is acquired in the course of a single sweep of the scanner. The exposure time with CBCT scanners is typically less than 20 s and reconstruction of the image takes less than 2 min.[14] Although tomography provides good visualization the foramen of Huschke, CBCT can produce images with high diagnostic quality, high resolution (submillimetre resolution), short scanning time and radiation dose an order of magnitude lower than those of conventional CT scans. CBCT provides 3D localization of various soft-tissue calcifications in the head and neck region[15] which is why we used CBCT to image the foramen tympanicum in this study.

In conclusion, the foramen tympanicum is uncommon but is well demonstrated on CBCT. This is the first study to use FPD-CBCT to detect the foramen tympanicum. Clinicians should be aware of the possible presence of this developmental defect because such a problem may affect the diagnosis, treatment plan and prognosis.

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