

Research Article - Basic and Applied Anatomy

## Incidence of the tympanic foramen in the population of Northeast Brazil

Jalles Dantas de Lucena<sup>1</sup>, Clarice Sampaio Torres<sup>2</sup>, Patricia Karline Rojas<sup>2</sup>, Mateus Francelino Silva<sup>2</sup>, Beatriz Soares Brito<sup>2</sup>, Ana Luíza Viana Pequeno<sup>2</sup>, Paula Emanuele de Lima Bessa<sup>2</sup>, Michelle Guimarães de Lima<sup>3</sup>, Maria Clara Motta Barbosa Valente<sup>4</sup>, Geovani Garcia de Souza<sup>5</sup>, Gilberto Santos Cerqueira<sup>6,\*</sup>

<sup>1</sup> Department of Morphology, Morfofunctional Science Post-Graduation Program, Federal University of Ceara (UFC) - Brazil

<sup>2</sup> Department of Morphology, Medical School - UFC - Brazil

<sup>3</sup> Department of Morphology, Medical School - Federal University of Alagoas (UFAL) - Brazil

<sup>4</sup> Department of Morphology, Medical School - State University of Health Sciences of Alagoas (UNCISAL) - Brazil

<sup>5</sup> Integrated Colleges of Patos (FIP) - Brazil

<sup>6</sup> Department of Morphology, Medical School, Morfofunctional Science Post-Graduation Program - UFC - Brazil

### Abstract

The persistence of the tympanic foramen (or of Huschke) in individuals after second childhood constitutes a failure in the embryological development of the tympanic cavity. When present, it is on the anterior wall of the external acoustic meatus and is associated with important otological complications of the temporomandibular joint and external acoustic meatus. To report on the incidence of tympanic foramen in adult dry skulls, belonging to the population of the Northeast of Brazil, 87 adult skulls obtained from the Human Anatomy Laboratory of 4 universities of the Northeast of Brazil, without knowledge of gender, race and age were analyzed. The 174 temporal bones were examined for presence, morphology and measurements of the longitudinal and transverse diameter of the tympanic foramen. The incidence of tympanic foramen was 24.14%, found in 15 (17.24%) skulls on the right and 18 (20.68%) on the left side. Unilateral tympanic foramen was observed in 10 (11.50%) skulls, bilateral in 9 (10.34%) and multiple in 2 (2.30%). The form of tympanic foramen was mainly irregular. In conclusion, the higher prevalence of tympanic foramen found in the Northeast among other studies carried out in Brazil can be attributed to specific dietary habits in the region that could induce the later foramen occlusion.

### Key words

Foramen of Huschke, external acoustic meatus, tympanic foramen, Northeast of Brazil.

### Introduction

The tympanic foramen (TF), also known as foramen of Huschke, described in 1889 by the German anatomist Emil Huschke (Nakasato et al., 2013), is a structure related to a deficiency in the development of the tympanic portion of the temporal bone, constitutional contributor to the auditory tube and the tympanic cavity (Chauhan and Khanna, 2014). Its persistence in adult individuals is considered an anatomical anomaly, to be found in the antero-inferior wall of the external acoustic meatus

\* Corresponding author. E-mail: giufarmacia@hotmail.com

(Bhanu and Sankar, 2016). Its prevalence ranges from 0.6% to 46% using different methods of analysis (Fusconi et al., 2009; Rezaian et al., 2015), and varies according to age and sex (Hashimoto et al., 2011).

The principle of TF formation is total medial non-obliteration of the ring (Chauhan and Khanna, 2014; Bhanu and Sankar, 2016), a structure that, in birth, is the only portion of the tympanic bone not yet developed completely (Hashimoto et al., 2011). Approximately in the ninth week of intrauterine life, four ossification centers arise around the tympanic membrane. During the tenth week, these centers form the tympanic ring, which continues its growth to join the remaining temporal bone around the 35th week of intrauterine life. At birth, the tympanic ring has two prominences, one anterior and another posterior, which during the first year of life grow toward each other until they merge (Sperber, 1975; Anson and Donaldson, 1981). A small aperture is formed at the melting point of these two prominences, which tends to ossify completely within the fourth or fifth year of life (Humphrey and Scheuer, 2006), but occasionally persists throughout life, being referred to as TF.

Failure to obliterate TF is associated with complications such as herniation of the temporomandibular joint, salivary fistulas and other otologic complications due to passage of the arthroscope into the external acoustic meatus during arthroscopy of the temporo-mandibular joint (Akcam et al., 2011; Tozoglu et al., 2012; Li and Dai, 2015). In addition, the existence of this foramen constitutes a route for the spread of infections, which can occur both from temporo-mandibular joint to external acoustic meatus and vice versa (Silva and Collins, 2012; Tozoglu et al., 2012). Therefore, it is important to observe the presence of TF before performing orthognathic procedures on the temporo-mandibular joint.

Considering the clinical findings that can be involved with the presence of TF and the absence of data in the literature on the presence of this foramen in the adult population in the Northeast region of Brazil, the present study analyzed adult dry skulls of Northeast Brazil regarding the presence of TF. The anatomical knowledge of TF is important for anatomists, anthropologists, radiologists and surgeons.

## Methods and material

We analyzed 87 adult skulls from the Human Anatomy Laboratory of the Federal University of Ceara (UFC), State University of Health Sciences of Alagoas (UNCIS-AL), Federal University of Alagoas (UFAL) and Integrated Colleges of Patos (FIP), all located in the Northeast region of Brazil. There were 174 temporal bones, which have been closely monitored for the presence of pathologies or by bone degradation, especially in the tympanic region. Gender, race and age of the skulls studied were unknown.

Temporal bones were examined for the presence of TF. The foramina found were classified according to the form: fissure, oval, round and irregular. Laterality was recorded and the longitudinal and transverse diameter of the TF were measured with the aid of a digital caliper with an accuracy of 0.01 mm. Data analysis was performed using SPSS statistical software (Version 20.0, SPSS Inc., Chicago, IL). We used descriptive analysis for the presentation of the results.

**Results**

Of the 87 skulls analyzed, TF was found in 21 (24.14%). Among these, TF was unilateral in 10 skulls (11.50%), bilateral in 9 (10.34%) and multiple in two (2.30%) (Table 1). Among unilateral cases, 50% TF were on the right side and 50% on the left side (Table 1). In the 21 skulls with TF, we found 33 (37.92%) foramina, 17.24% on the right side and 20.68% on the left side (Table 2). On the right side, the mean longitudinal diameter of the TF was  $4.21 \pm 0.80$  mm, and the mean transverse diameter was  $5.38 \pm 1.68$  mm. On the left side, the mean longitudinal diameter of the TF was  $4.51 \pm 1.50$  mm, and the mean transverse diameter was  $4.59 \pm 1.35$  mm (Table 3). The shape of the TF was mainly irregular (16.10%), but sometimes was in the form of a fissure (5.74%), oval (6.89%) and round (9.19%) (Table 4). Table 5 presents data from previous and present studies on the TF prevalence and measures.

**Table 1.** Distribution of tympanic foramen according to location and side.

Location	Number of skulls	Right side	Left side	Percentage (%)
None	66	-	-	75.86
Unilateral	10	5	5	11.50
Bilateral	9	9	9	10.34
Multiple	2	1	4*	2.30
Total	87	15	18	100.0

\*Each skull had two foramina on the left side.

**Table 2.** Distribution and prevalence of tympanic foramen according to side.

Side	Number	Percentage of examined skulls (%)	Percentage of tympanic foramina (%)
Right	15	17.24	45.45
Left	18	20.68	54.55
Total	33	37.92	100.0

**Table 3.** Size of tympanic foramen on either side.

Side and diameter	Number of cases	Minimum (mm)	Maximum (mm)	Mean	Standard deviation
Right longitudinal	15	3.03	5.40	4.21	0.80
Right transverse	15	2.12	7.21	5.38	1.68
Left longitudinal	18	1.60	7.18	4.51	1.50
Left transverse	18	1.12	7.08	4.59	1.35

**Table 4.** Distribution of tympanic foramen according to its shape.

Foramen shape	Number	Percentage of skulls (%)	Percentage of foramina (%)
Fissure	5	5.74	15.16
Oval	6	6.89	18.18
Round	8	9.19	24.24
Irregular	14	16.10	42.42
Total	33	37.92	100.0

**Table 5.** Comparative analysis of different studies on the tympanic foramen.

Studies	Country	Prevalence (%)
Present study	Brazil	24.14
Faig-Leite and Horta, 1998	Brazil	9.93
Lacout et al., 2005	Netherlands	4.6
Reis et al., 2006	Brazil	11.3
Hashimoto et al., 2011	Japan	14.5
Tozoglu et al., 2012	Turkey	17.9
Chauhan et al., 2014	North India	23.34
Bhanu and Sankar, 2016	South India	38.2

## Discussion

Several studies on the persistence of TF found marked variation in number (Faig-Leite and Horta-Júnior, 1998; Lacout et al., 2005; Tozoglu et al., 2012; Rezaian et al., 2015; Bhanu and Sankar, 2016). The data from this study revealed a prevalence of 24.14%, higher than that reported in two other studies conducted in Brazil with prevalence of 9.93% and 11.3 % respectively (Faig-Leite and Horta-Júnior, 1998; Reis et al., 2006). This difference can be attributed to different eating habits between the population of the Northeast region and that of the previous studies. The Northeast has a food with dense foods, which are offered in the first years of the child's life. Thus, the tympanic part of the temporal bone, which continues to grow even after birth, is influenced by the pressure caused by chewing and swallowing (Akcem et al., 2011; Lee and Park, 2018) and, therefore, TF occlusion tends to occur later in life (Afghari et al., 2016).

Faig-Leite and Horta (1998) and Reis et al. (2006) found TF unilaterally in 5.29% and 4.0% of subjects, respectively. The prevalence in this study of unilateral foramen was 11.50%, which corresponds to double and almost triple the values of previous studies (Faig-Leite and Horta, 1998; Reis et al., 2006). Also regarding bilateral TF the results of this study (10.34%) are higher than those of Faig-Leite and Horta (1998) and

Reis et al. (2006), 4.64% and 7.3%, respectively. This type of foramen distribution can be due to differences in the growth and development of the mandible in the different regions of the country, and also to differences in the ossification mechanics among the sides of the face (Afghari et al., 2016).

The study by Faig-Leite and Horta (1998) found a mean longitudinal diameter of 2.48 mm and mean transverse diameter of 2.35 mm, in 776 skulls analyzed, and therefore the morphology of TF was mainly irregular (64.60%) and more rarely oval (17.70%). The current study, however, found mean longitudinal and transverse diameters of 4.21 mm (range 3.03 to 5.40 mm) and 5.38 mm (range 2.12 to 7.21 mm), respectively, on the right, and 4.51 mm (range 1.60 to 7.18 mm) and 4.59 mm (range 1.12 to 7.08 mm), respectively, on the left, which were all higher than the values found by Faig-Leite and Horta (1998). In the present study, TF shape was mainly irregular (42.42%), followed by round (24.24%), which too diverges from the study of Faig-Leite and Horta (1998). This information had not been given by Reis et al. (2006).

The persistence of TF has also been described in some international studies, such as those carried out by Lacout et al. (2005), who examined 65 patients with high-resolution computed tomography, and by Tozoglu et al. (2012), who performed cone beam computed tomography of 207 patients. While the persistence of TF found by Lacout et al. (2005) was from only 4.6%, Tozoglu et al. (2012) found a frequency of TF in the Turkish population of 17.9%. The prevalence of TF found by Hashimoto et al. (2011) in 997 skulls of Japanese origin was 14.5%. All these figures were lower than that found in this study (24.14%). Recently, Bhanu and Sankar (2016) analyzed 93 skulls and 34 temporal bones from South India, and found a TF persistence rate of 38.2%, higher than that of the present study, which can be due to ethnic differences. In turn, the data that is closest to that found in the present study was reported by Chauhan et al. (2014), North India, which presented a prevalence of 23.34%, corroborating the hypothesis of a possible ethnic variation between the populations of North and South India.

Although most cases are asymptomatic (Olarinoye-Akorede et al., 2014; Kayahan et al., 2014; Lee and Park, 2018), TF is indicated by several authors as a possible risk factor for several changes, disorders and pathologies related to temporo-mandibular joint, ears and adjacent structures (Fusconi et al., 2009; Akcam et al., 2011; Chauhan and Khanna, 2014; Cascone et al., 2015). Spontaneous temporo-mandibular joint herniation into the external acoustic meatus has been described by several authors (Tae et al., 2013; Olarinoye-Akorede et al., 2014; Ryu et al., 2017), and the main symptoms are otalgia and tinnitus.

There is also the report of the spread of infections or neoplasia from the infratemporal fossa to external acoustic meatus, or vice versa (Silva and Collins, 2012; Tozoglu et al., 2012; Nakasato et al., 2013); these patients are usually affected by pain and hearing loss (Chauhan and Khanna, 2014; Olarinoye-Akorede et al., 2014; Bernstein et al., 2015). Another possible consequence is the formation of salivary fistula between the parotid gland and the external acoustic meatus (De Zoysa et al., 2009; Akcam et al., 2011; Cascone et al., 2015; Rezaian et al., 2015).

The persistence of this foramen is a factor that determines vulnerability of the middle and external ear, increasing the risks of possible perforating lesions in temporo-mandibular joint arthroscopy (Srimani et al., 2013; Li and Dai, 2015; Cascone et al., 2015), which can also affect the chewing of affected individuals, having a relation

with changes in the parotid gland or in the temporo-mandibular joint itself (Chauhan and Khanna, 2014; Olarinoye-Akorede et al., 2014).

## Conclusion

The prevalence of TF in the present study, 24.14%, was higher than that found in other regions of the country, and can be explained by the influence of food and regional differences of the Brazilian population. Although it is a study of dry skulls, the anatomical knowledge of TF is clinically and surgically important for surgeons, dentists, radiologists, and anatomists. The data obtained from this study can also be added to the existing anatomical and medical literature, providing TF information from the population of Northeast of Brazil.

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