

THE INCIDENCE OF DEHISCENCE OF THE TYMPANIC SEGMENT OF THE FACIAL NERVE CANAL ESTIMATED WITH COMPUTED TOMOGRAPHY

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Abstract. *In this study, we aimed to determine the presence and incidence of dehiscence of the tympanic segment of the facial nerve canal using the High Resolution Computed Tomography (HRCT) and to evaluate this variation in relation to gender and age.*

The retrospective-prospective study was performed at the Clinic for Radiology, University Clinical Center of Sarajevo. After the criteria for participation and non-participation in the study were applied, the study included 295 patients (160 women and 135 men) of ages ranging from 5 to 75, with performed computed tomography (CT) of the temporal bone as a part of a standard procedure due to the suspicion of pathological activity in that area. We divided the subjects into seven age groups. Each group included a ten-year period. The presence of dehiscence of the facial nerve canal was recorded and the obtained results were statistically analyzed.

Of the total number of patients included in the study, the dehiscence of the tympanic segment of the facial nerve canal was found in 95 patients (32%). Of 590 temporal bones, there were 118 temporal bones with facial nerve canal dehiscence in the tympanic segment (20%). The dehiscence without stenosis of the oval window was noted in 110 temporal bones (18.6%). The dehiscence with stenosis of the oval window was noted in 8 temporal bones (1.4%). There was no statistically significant difference between age groups ($p=0.245$, Pearson's χ^2 test). Also, there was no statistically significant difference between males and females ($p=0.385$, Pearson's χ^2 test).

The incidence of dehiscence of the facial nerve canal is high and the tympanic segment is the most frequent site of dehiscence localization. Almost one third of the patients with the suspicion of pathological processes on the temporal bone can have dehiscence of the tympanic segment of the facial nerve canal. HRCT is the best visual imaging technique for the evaluation of the facial nerve course within its osseous canal.

Key words: Dehiscence, facial nerve canal, tympanic segment, computed tomography

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1. INTRODUCTION

Facial expression controlled by the facial nerve represents an important means of human social communication [1], [2]. The facial nerve is longer than other nerves and its intraosseal course through the temporal bone is more tortuous. Even though the course of the facial nerve canal represents one of the most constant anatomical relationships, anomalies can occur. Anatomical variations of the facial nerve canal present a significant problem in otologic and neurotologic surgery [3]. One of the basic risks during temporal bone surgical procedures are traumatic injuries of the intratemporal segment of the facial nerve canal which may result in symptoms such as partial or complete paralysis, tics, hemifacial spasms, alterations in hearing and taste and lacrimal gland secretion.

Normally, the facial nerve canal represents a closed bony tube, apart from the sites where nerve branches exit. However, that's not always the case since the canal can be dehiscence and the nerve can herniate into the middle ear cavity [4]. Dehiscence is the most common variation of the facial nerve canal. Baxter [5] reported dehiscence in more than a half of 500 temporal bones studied microscopically. Even though the average dimension of dehiscence is smaller than 1mm, its existence makes the facial nerve vulnerable [6]. Dehiscence usually occurs in the tympanic segment, especially in the region of the oval window, though it can occasionally occur in the mastoid segment or near the region of the geniculate ganglion. Therefore the tympanic segment represents the most common site of iatrogenic injury of the facial nerve during otologic surgical procedure. From a surgical aspect the two most important elements in interpreting temporal

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bone CT scans refer to diagnosing the pathological process and alerting surgeons to a possible anatomical variation whose presence predisposes surgical error [7]. From an anatomical aspect CT scans of bone structures enable visualization of both the temporal bone and its relationships with the surrounding topographic regions which is often impossible on anatomical specimens.

Temporal bone scanning represents an extreme challenge considering the fact that a normal anatomical structure includes a larger number of extremely small but clinically significant anatomical structures. The variety of tissues located in this region is evaluated simultaneously, making it practically impossible to develop an optimal radiological technique for the investigation of all of the potential pathological conditions. Magnet resonance imaging (MRI) has advantage in superior soft tissue resolution, whereas Multidetector Computed Tomography (MDCT) enables visualization of very delicate osseous structures, thus representing the basic method for determining developmental anomalies, traumas, acute or chronic infections or the eventual presence of pathologies within a complicated osseous structure such as the temporal bone [8]-[11]. High Resolution Computed Tomography (HRCT) performed in thin layers with a special reconstructive bone algorithm represents the best method for the facial nerve canal visualization [12]. Adequate CT scans in combination with a well-organized protocol and adequate data from the medical history of the patient enable confirming or making an appropriate diagnosis, thus giving otorhinolaryngologists and neurosurgeons the possibility to choose the most optimal surgical approach, which is crucial for timely prevention of eventual intraoperative complications.

The aim of this study is to examine the presence and incidence of dehiscence of the tympanic segment of the facial nerve canal using HRCT temporal bone radiographies and to evaluate this variation in relation to gender and age.

2. MATERIALS AND METHODS

The retrospective-prospective study was carried out at the Clinic for Radiology, University Clinical Center of Sarajevo, during the period from July 2009 to December 2012. The study included 295 patients (590 temporal bones), 160 women and 135 men, ranging in age from 5 to 75, with performed HRCT due to suspicion of pathological processes in that region. Patients with middle ear pathology, with traumatic injuries on the petrosal part of the temporal bone, as well as patients who were undergone the temporal bone surgery were excluded from the study. The patients were divided into seven groups, each group including a ten-year period. The study was approved by the Ethics committee of the University Clinical Center of Sarajevo.

Scanning was performed from the arcuate eminence of temporal bone to the mastoid tip in the transverse plane with the bone window (2300– 2500 Hounsfield units (HU) and the soft tissue window (300–500 HU). The scan image plane was parallel to the hard palate. This way, cornea was not exposed to primary X-ray beams during a CT scan. The analysis of the obtained results was performed with computed

retrospective multiplanar reconstructions (MPR) which enable visualization of the scanned region in all three standard planes, and, if necessary, in additional diagonal planes. For analyzing the osseous structures of the temporal bone and all of the anatomical variations of the facial nerve canal all the scans were visualized with the window center of 700 HU and window width of 4000 HU. Data were analyzed in computer software –GE and Siemens Syngo. Table 1 shows the used scanning protocols, depending on the used CT scanning devices.

The presence of dehiscence of the facial nerve canal was recorded and the obtained results were statistically analyzed in „IBM SPSS Statistics 20“ statistical software.

The statistical analysis included calculation of the basic parameters of descriptive statistics. Statistical significance of the mean values for each of the observed groups was tested with Pearson's χ^2 -test, and the values $p < 0.05$ were considered statistically significant.

Table 1. The scanning protocols, depending on the used CT scanning devices

CT scan	Volume Zoom, Siemens	GE Lightspeed
mAs	100	205 kV
kV	120	120
Scanning direction	Craniocaudal	Craniocaudal
Layer thickness	0.5 mm	0.625 mm
Collimation	0.5 mm	0.625 mm
Scanning line	Axial	Axial
Reconstructive window	Inner Ear spi 90	IAC

3. RESULTS

Based on the radiological diagnostic criteria, dehiscence is defined as the absence of the osseous wall of the facial nerve canal (Figure 1). Of the total number of patients included in the study, dehiscence of the tympanic segment of the facial nerve canal was found in 95 patients (32%). In 79 patients (26.8%) dehiscence was found only in the tympanic segment whereas in 16 patients (5.4%) it was observed both in the tympanic and the mastoid segment.

Of 590 temporal bones, there were 118 temporal bony with the facial nerve canal dehiscence in the tympanic segment (20%). The dehiscence without stenosis of the oval window was noted in 110 temporal bony (18.6%). The dehiscence with stenosis of the oval window was noted in 8 temporal bony (1.4%). The incidence of dehiscence of the tympanic segment of the facial nerve canal in relation to gender is shown in Table 2, and in relation to age groups in Table 3. Pearson's χ^2 -test showed that there was no statistically significant difference in the incidence of dehiscence of the tympanic segment of the facial nerve canal related to gender ($p = 0.385$). Also, there was no statistically significant difference between age groups ($p = 0.245$).

Table 2. The incidence of dehiscence of the tympanic segment of the facial nerve canal in relation to gender

Gender	The tympanic segment of the facial nerve canal		
	No dehiscence n (%)	Dehiscence of the tympanic segment n (%)	n (%)
Women	105 (35.6)	55 (18.6)	160 (54.2)
Men	95 (32.2)	40 (13.6)	135 (45.8)
Σ	200 (67.8)	95 (32.2)	295 (100.0)

Table 3. The incidence of dehiscence of the tympanic segment of the facial nerve canal in relation to age groups

Age (years)	The tympanic segment of the facial nerve canal		
	No dehiscence n (%)	Dehiscence of the tympanic segment n (%)	n (%)
05-15	23 (7.8)	8 (2.7)	31 (10.5)
16-25	16 (5.4)	9 (3.1)	25 (8.5)
26-35	20 (6.8)	13 (4.4)	33 (11.2)
36-45	39 (13.2)	17 (5.8)	56 (19.0)
46-55	41 (13.9)	28 (9.5)	69 (23.4)
56-65	52 (17.6)	14 (4.7)	66 (22.3)
66-75	9 (3.1)	6 (2.0)	15 (5.1)
Σ	200 (67.8)	95 (32.2)	295 (100.0)

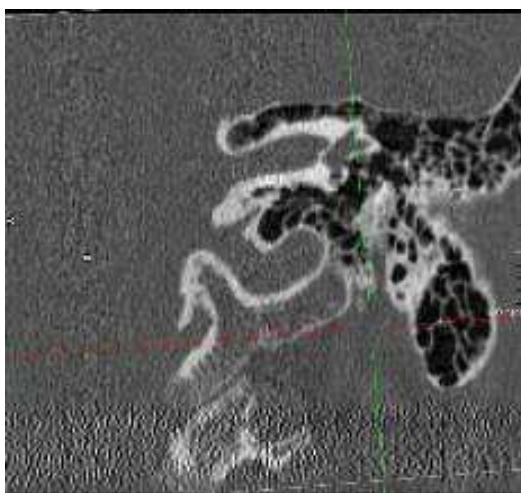


Figure 1. Dehiscence of the tympanic segment of the left facial nerve canal with the correct nerve

4. DISCUSSION

The facial nerve canal represents a complicated radiologic and anatomical whole. Knowing its direction and its relationship with the surrounding soft tissue structures and the eventual presence of variations are the key for success of all diagnostic and surgical procedures. The facial nerve is the most vulnerable structure in otologic surgery. Its injury during surgical procedure is not frequent but if it occurs it represents a serious complication with a very destructive effect on the patient. Since the facial nerve canal variations, especially dehiscence as the most frequent one, can represent very insidious situations for surgeons, their identification is very important for the correct planning of surgical procedures on the temporal bone. Following anatomical

orientation and taking extreme caution during surgery can lead to prevention of iatrogenic injury of the facial nerve [7], [12].

Variations of the facial nerve canal have been investigated for a long period of time. The greatest number of analyses was conducted by using classical anatomical methods. The findings of the available radiologic studies seem to be uneven considering the fact that different diagnostic and radiologic criteria were used. The complete absence of the osseous wall of the facial nerve canal is usually located in the region around the oval window, in the medial 2/3 of the tympanic segment. In the study of Jäger et al. [9] dehiscence was 60%. According to Kim et al. [13] the incidence of dehiscence of the facial nerve canal varies from 0.5% do 74%. Wang et al. [14] conducted a study on 155 temporal bones with mastoidectomy with cholesteatoma which showed incidence of dehiscence of the facial nerve canal in 29.7%. Baxter [5] reported dehiscence of the facial nerve canal in 55% out of 535 temporal bones, out of which in 91% the canal was dehiscent in the tympanic segment and in 9% in the mastoid segment. Bucak et al. [3] determined intraoperatively that the incidence of dehiscence of the facial nerve canal was 28,1%. The most frequent site of dehiscence (82.8%) was the tympanic segment ($p < 0.001$). Comparing the pediatric group of patients aged under 16 with the adult group, it was reported that 10.5% had dehiscence in the pediatric group and 31.6% in the adult group. The incidence of dehiscence was more common in women but the results were not statistically significant. Nomiya et al. [15] reported the high incidence of facial nerve canal dehiscence in chronic otitis media. The incidence was 88.2% in the group of subjects aged under four years, and was 68.9% in the group of subjects aged four years and older. There was not statistically different compared to the normal controls. In our study, the incidence of dehiscence in the tympanic segment of the facial nerve canal was 20%, in relation to the total number of the examined temporal bones; that is, dehiscence was observed in 32.2% of patients. There wasn't statistically significant difference in the number of dehiscence of the tympanic segment of the facial nerve canal in relation to either the gender or the age groups.

Bucak et al. [3] stated that the percentage of dehiscence of the facial nerve canal is lower in surgical than in histological studies, which can be a consequence of the osseous destruction of the facial nerve canal during the sample preparation of the cadaveric temporal bone. The other possible explanation is the presence of microdehiscence located under the facial nerve in the region of the oval window; therefore, it cannot affect microdissection that occurs intraoperatively over the lateral surface of the tympanic segment of the facial nerve canal.

Modern diagnostic techniques, such as a CT scan which presents a standard in temporal bone scanning because of its high resolution, enable visualization of quite subtle anatomical temporal bone structures. A combined analysis of axial, coronal and sagittal planes increases a positive rate in diagnosing dehiscence of the facial nerve canal. Yu et al. [16] evaluated the diagnostic value of HRCT during scanning of the tympanic segment of the facial nerve canal in patients with chronic otitis media. According to these authors, out of 76 patients with chronic suppurative otitis

media, in 88.1% of the cases the HRCT and the surgical findings were the same. In our study, the cases with middle ear inflammation were not included in the comparative statistical analysis. We think that in such cases CT scans of all the three planes are significant only for determining the correct nerve position and not the precise determination of eventual dehiscence. However, transverse scans clearly showed the position and length of dehiscence of the lateral wall of the facial nerve. Coronal scans were better in visualizing osseous circumference of the canal and their use presents absolute imperative for determination of the absence of osseous wall of the canal especially in the area of the oval window. Sagittal layers enable better visualization of the inferior wall.

Based on the radiological and diagnostic criteria described in literature, dehiscence is defined as the absence of the osseous wall of the facial nerve canal. When the canal wall is very thin, especially in the tympanic segment where it has multiplanar and tortuous course so that it is not visible when using radiological methods of choice for the facial nerve canal analysis, the case is defined as dehiscence. For this reason some authors believe that diagnostic values of CT scans in determining dehiscence are limited [6], [14], [17], [18]. The lack of our study is the absence of comparing radiological findings with the surgical ones, considering that the patients who underwent surgery were not included in the study. However, radiological image of a substantial bone loss in any part of the facial nerve must be considered abnormal and imply dehiscence of the facial nerve canal. Because of that, a CT scan, as the best method for visualization of the osseous wall of the facial nerve canal, is necessary for documenting the presence or absence of variations in the position of the facial nerve.

5. CONCLUSION

The incidence of dehiscence of the facial nerve canal is high and the tympanic segment is the most frequent site of dehiscence localization. Almost one third of patients with suspicion of pathological processes on the temporal bone can have dehiscence of the tympanic segment of the facial nerve canal. HRCT is the best visual imaging technique for the evaluation of the facial nerve course within its osseous canal.

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