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Morphometric Analysis of the External Acoustic Meatus and Temporomandibular Joint Proximity

Análisis Morfométrico del Meato Acústico Externo y la Proximidad de la Articulación Temporomandibular

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SUMMARY: We planned this study to create a standard data set to determine the distance between the external acoustic meatus (EAM) and temporomandibular joint (TMJ). In this study, axial CT images of 160 healthy adult individuals with temporal bone integrity were examined. Subjects were evaluated in age groups of 18-30, 31-45, 46-60 and 61-85. The thickness of the anterior wall of the EAM (AWEAM) was measured at the widest and narrowest points of the AWEAM. In addition, the joint spaces between the mandibular head and the AWEAM were measured at these levels. It was observed that women's values were generally lower than men's in all age groups. All values were higher in the 31-45 age group compared to the 18-30 age group. In later age groups, a gradual decline in all parameters was observed with aging. The lower parameters in the older age groups were due to the loss of bone tissue with aging. We believe that our results will contribute both to the literature by creating an average data set and to surgeons in creating safe surgical margins for the protection of this region in TMJ and EAM interventions.

KEY WORDS: External acoustic meatus; Temporomandibular joint; Morphometry; Computed tomography; Proximity.

INTRODUCTION

The temporomandibular joint (TMJ) is a condylar type synovial joint of the skull. It is externally surrounded by a capsule. There is a disc between the bones that form the joint. The TMJ is located anterior to the external acoustic meatus (EAM). The EAM is an S-shaped canal with an average length of 2.5 cm. The lateral 1/3 is cartilage and the medial 2/3 is bone. The anterior part of the bony canal is located in the tympanic part of the temporal bone. The tympanic membrane is located between the middle ear cavity and the EAM (Standring *et al*., 2008). The TMJ is in close proximity to the anterior wall of the EAM (AWEAM) (Anazawa *et al*., 2021). Herniation of the joint from the defect that may be found in AWEAM can lead to clinically significant problems (Park *et al*., 2010; Jin & Park, 2023). Computed tomography (CT) images play an important role in the evaluation of EAM (El-Anwar *et al*., 2023).

In this study, we aimed to create a standard data set according to age and gender by measuring the distance between TMJ and EAM on CT images, thus contributing to the surgeon and the literature, especially in surgical approaches.

MATERIAL AND METHOD

This study was conducted with the approval of Tokat Gaziosmanpasa University Faculty of Medicine Clinical Research Ethics Committee (No: 83116987-272). In our study, taking into account the 95 % confidence level (1-a) and 80 % test power (1-b) with an effect size of d=0.769, it was determined that at least 44 individuals should be present based on the two-way hypothesis (Yu *et al*., 2015). The images of 280 individuals who applied to our University Hospital between January 2019 and April 2024 and underwent temporal CT for any reason were obtained from the Sectra archive system of the Department of Radiology. Images obtained with a 128-slice computed tomography device (GE Healthcare Optima CT660, USA) with a slice thickness of 0.625 mm were used. Those under the age of 18, those whose temporal bone integrity was impaired due to trauma, and those who had TMJ surgery or ear surgery were not included in the study.

After the images that would not be included in our study were eliminated according to the exclusion criteria, axial CT images of 160 adult individuals with normal temporal bone structural integrity were examined. Temporal bone thickness was measured at the widest point (WTT) and

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narrowest point (NTT) of the AWEAM. The joint space between the mandibular head and AWEAM was measured anterior to WTT (JSWTT) and NTT (JSNTT). To calculate the distance from the EAM to the mandibular head, WTT was summed with JSWTT (Total WTT) and NTT was summed with JSNTT (Total NTT).

Male and female individuals were divided into 18-30, 31-45, 46-60 and 61-85 age groups with 20 individuals in each group. Data were stored on Microsoft Excel.

Statistical analysis. SPSS 26 package program was used for statistical evaluation. When the data did not fulfill the parametric assumptions, the groups were evaluated with Kruskal Wallis analysis of variance. In case of statistical significance, post Hoc evaluation was performed with Mann Whitney U test. When p values were less than 0.05, they were considered statistically significant.

RESULTS

There was no significant difference between the right and left sides in terms of all parameters in both genders and all age groups. (p>0.05). When women and men were compared in each age group, the values of women were generally lower (Tables I and II) (Fig. 1).

In men, all parameters were higher in the 31-45 age group compared to the 18-30 age group. Right Total WTT, right WTT, left Total NTT and left JSNTT values were significantly higher (p<0.05). There was no difference in any parameter between the 18-30 age group and the 46-60 age group. Left Total WTT values were significantly lower in the 61-85 group compared to the 18-30 age group (p<0.05). Right Total WTT, right WTT and left WTT values were significantly lower in the 46-60 age group compared to the 31-45 age group (p<0.05). Right Total WTT, right WTT, left Total WTT, left JSWTT, left WTT, left Total NTT and left JSNTT values were significantly lower in the 61-85 age group compared to the 31-45 age group (p<0.05). There was no difference in any parameter between the 46-60 age group and the 61-85 age group (Table III) (Fig. 2). Figures 3 to 5 show temporal CT images of various parameters of men.

Table I. Comparison of right side measurement parameters between sexes.

	Right Total WTT (mm)		Right JSWTT (mm)		Right WTT (mm)		Right Total NTT (mm)		Right JSNTT (mm)		Right NTT (mm)	
Age (Year)	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
18-30	4.80 (4.20-6.10)	4.35 (3.00-5.70)[a]	2.95 (2.40-4.10)	2.40 (1.60-3.40)[a]	1.90 (1.40-2.60)	1.85 (1.20-2.40)	4.50 (4.10-5.80)	4.00 (2.60-5.30)[a]	3.55 (3.10-4.80)	2.90 (1.80-4.10)[a]	1.00 (0.70-1.20)	1.10 (0.60-1.40)
31-45	5.65 (3.70-7.60)	4.75 (3.60-5.70)[b]	3.15 (2.10-4.90)	2.75 (2.30-3.40)[b]	2.50 (1.60-3.00)	2.00 (1.30-2.60)[b]	5.00 (3.50-7.00)	4.65 (3.20-6.40)	3.75 (2.70-5.70)	3.70 (2.50-4.80)	1.05 (0.70-1.50)	0.95 (0.70-1.60)
46-60	4.80 (4.10-6.30)	4.50 (3.30-6.40)[c]	2.90 (1.90-3.70)	2.65 (1.90-4.20)	1.95 (1.70-2.70)	1.70 (1.30-2.60)[c]	4.85 (2.90-5.60)	4.45 (3.50-6.10)	3.70 (2.20-4.40)	3.45 (2.70-4.90)	1.05 (0.70-1.20)	0.90 (0.80-1.30)[c]
61-85	4.75 (3.70-5.80)	4.30 (3.00-5.70)[d]	2.80 (2.10-3.60)	2.50 (1.70-3.40)[d]	1.90 (1.50-2.60)	1.70 (1.20-2.30)	4.50 (3.50-6.00)	4.15 (2.60-4.90)	3.45 (2.80-4.80)	3.15 (1.90-3.90)	1.00 (0.70-1.30)	0.90 (0.70-1.10)

Mann Whitney U test, Indices a, b, c and d show that the right-sided parameters of women are significantly lower than men in the 18-30, 31-45, 46-60 and 61-85 age groups respectively ($p<0.05$). WTT: Temporal bone thickness at the widest point of the anterior wall of external acoustic meatus (AWEAM). NTT: Temporal bone thickness at the narrowest point of AWEAM. JSWTT: Joint space between the mandibular head and AWEAM at the WTT level. JSNTT: Joint space between the mandibular head and AWEAM at the NTT level. Total WTT: Total distance between the mandibular head and AWEAM at WTT level. Total NTT: Total distance between the mandibular head and AWEAM at NTT level.

Table II. Comparison of left side measurement parameters between sexes.

	Left Total WTT (mm)		Left JSWTT (mm)		Left WTT (mm)		Left Total NTT (mm)		Left JSNTT (mm)		Left NTT (mm)	
Age (Year)	male	female	male	female	male	female	male	female	male	female	male	female
18-30	4.90 (3.90-5.70)	4.35 (3.40-5.40)[a]	2.90 (2.30-3.30)	2.40 (1.70-3.20)[a]	1.95 (1.30-2.70)	1.90 (1.50-2.40)	4.60 (3.80-5.40)	4.10 (2.90-5.50)[a]	3.55 (2.90-4.30)	3.00 (2.10-4.30)[a]	1.00 (0.80-1.30)	1.05 (0.80-1.40)
31-45	5.30 (4.20-7.20)	4.70 (3.70-6.00)[b]	3.20 (2.50-4.60)	2.80 (2.30-3.50)[b]	2.10 (1.70-2.70)	1.90 (1.40-2.50)[b]	5.20 (3.70-7.70)	4.70 (3.60-6.10)[b]	3.95 (2.90-6.40)	3.70 (2.80-4.70)	1.10 (0.80-1.50)	1.05 (0.70-1.40)
46-60	4.95 (4.00-5.80)	4.45 (3.50-6.60)[c]	2.90 (2.00-3.90)	2.60 (2.10-4.60)	1.90 (1.50-2.20)	1.80 (1.20-2.20)[c]	4.80 (3.20-5.60)	4.60 (3.50-6.00)	3.85 (2.40-4.60)	3.70 (2.80-5.10)	1.00 (0.80-1.20)	0.90 (0.70-1.10)
61-85	4.45 (3.30-6.10)	4.25 (3.10-5.40)	2.60 (1.80-4.00)	2.55 (1.40-3.30)	1.80 (1.30-2.20)	1.70 (1.40-2.20)	4.30 (3.00-6.10)	4.15 (2.80-4.80)	3.25 (2.40-5.20)	3.30 (2.10-3.70)	0.95 (0.60-1.10)	0.95 (0.70-1.10)

Man Whitney U test, Indices a, b and c show that the left-sided parameters of women are significantly lower than men in the 18-30, 31-45 and 46-60 age groups respectively ($p<0.05$). WTT :Temporal bone thickness at the widest point of the anterior wall of external acoustic meatus (AWEAM). NTT: Temporal bone thickness at the narrowest point of AWEAM. JSWTT: Joint space between the mandibular head and AWEAM at the WTT level. JSNTT: Joint space between the mandibular head and AWEAM at the NTT level. Total WTT: Total distance between the mandibular head and AWEAM at WTT level. Total NTT: Total distance between the mandibular head and AWEAM at NTT level.

Table III. Comparison of parameters in male and female subjects according to age groups.

Sex	Age (year)	Right Total WTT (mm)	Right JSWTT (mm)	Right WTT (mm)	Right Total NTT (mm)	Right JSNTT (mm)	Right NTT (mm)	Left Total WTT (mm)	Left JSWTT (mm)	Left WTT (mm)	Left Total NTT (mm)	Left JSNTT (mm)	Left NTT (mm)
Male	18-30	4.80 (4.20-6.10)	2.95 (2.40-4.10)	1.90 (1.40-2.60)	4.50 (4.10-5.80)	3.55 (3.10-4.80)	1.00 (0.70-1.20)	4.90 (3.90-5.70)	2.90 (2.30-3.30)	1.95 (1.30-2.70)	4.60 (3.80-5.40)	3.55 (2.90-4.30)	1.00 (0.80-1.30)
	31-45	5.65 (3.70-7.60)[f]	3.15 (2.10-4.90)	2.50 (1.60-3.00)[f]	5.00 (3.50-7.00)	3.75 (2.70-5.70)	1.05 (0.70-1.50)	5.30 (4.20-7.20)	3.20 (2.50-4.60)	2.10 (1.70-2.70)	5.20 (3.70-7.70)[a]	3.95 (2.90-6.40)[f]	1.10 (0.80-1.50)
	46-60	4.80 (4.10-6.30)[f]	2.90 (1.90-3.70)	1.95 (1.70-2.70)[f]	4.85 (2.90-5.60)	3.70 (2.20-4.40)	1.05 (0.70-1.20)	4.95 (4.00-5.80)	2.90 (2.00-3.90)	1.90 (1.50-2.20)[f]	4.80 (3.20-5.60)	3.85 (2.40-4.60)	1.00 (0.80-1.20)
	61-85	4.75 (3.70-5.80)[b]	2.80 (2.10-3.60)	1.90 (1.50-2.60)[b]	4.50 (3.50-6.00)	3.45 (2.80-4.80)	1.00 (0.70-1.30)	4.45 (3.30-6.10)[a,d]	2.60 (1.80-4.00)[b]	1.80 (1.30-2.20)[b]	4.30 (3.00-6.10)	3.25 (2.40-5.20)[b]	0.95 (0.60-1.10)
Female	18-30	4.35 (3.00-5.70)	2.40 (1.60-3.40)	1.85 (1.20-2.40)	4.00 (2.60-5.30)	2.90 (1.80-4.10)[a]	1.10 (0.60-1.40)	4.35 (3.40-5.40)	2.40 (1.70-3.20)	1.90 (1.50-2.40)	4.10 (2.90-5.50)	3.00 (2.10-4.30)	1.05 (0.80-1.40)
	31-45	4.75 (3.60-5.70)[e]	2.75 (2.30-3.40)[e]	2.00 (1.30-2.60)	4.65 (3.20-6.40)[e]	3.70 (2.50-4.80)[e]	0.95 (0.70-1.60)	4.70 (3.70-6.00)	2.80 (2.30-3.50)[e]	1.90 (1.40-2.50)	4.70 (3.60-6.10)[e]	3.70 (2.80-4.70)[e]	1.05 (0.70-1.40)
	46-60	4.50 (3.30-6.40)	2.65 (1.90-4.20)	1.70 (1.30-2.60)	4.45 (3.50-6.10)	3.45 (2.70-4.90)[b]	0.90 (0.80-1.30)	4.45 (3.50-6.60)	2.60 (2.10-4.60)	1.80 (1.20-2.20)	4.60 (3.50-6.00)	3.70 (2.80-5.10)[f]	0.90 (0.70-1.10)
	61-85	4.30 (3.00-5.70)	2.50 (1.70-3.40)	1.70 (1.20-2.30)	4.15 (2.60-4.90)[b]	3.15 (1.90-3.90)	0.90 (0.70-1.10)	4.25 (3.10-5.40)	2.55 (1.40-3.30)	1.70 (1.40-2.20)	4.15 (2.80-4.80)	3.30 (2.10-3.70)[a,e]	0.95 (0.70-1.10)

Mann Whitney U test, a Significantly higher in the 31-45 age group compared to the 18-30 age group. b Significantly lower in the 61-85 age group compared to the 31-45 age group. c Significantly lower in the 46-60 age group compared to the 31-45 age group. d Significantly lower in the 61-85 group compared to the 18-30 age group. e Significantly lower in the 61-85 age group than in the 46-60 age group. f Significantly higher in the 46-60 age group compared to the 18-30 age group. WTT: Temporal bone thickness at the widest point of the anterior wall of external acoustic meatus (AWEAM). NTT: Temporal bone thickness at the narrowest point of AWEAM. JSWTT: Joint space between the mandibular head and AWEAM at the WTT level. JSNTT: Joint space between the mandibular head and AWEAM at the NTT level. Total WTT: Total distance between the mandibular head and AWEAM at WTT level. Total NTT: Total distance between the mandibular head and AWEAM at NTT level.

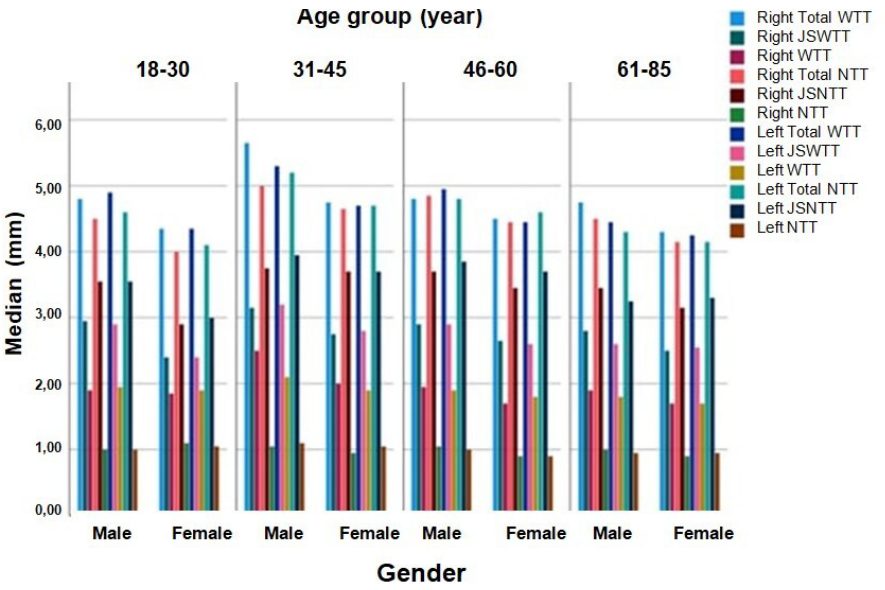

Fig. 1. Evaluation of female and male individuals according to age groups. WTT: Temporal bone thickness at the widest point of the anterior wall of external acoustic meatus (AWEAM). NTT: Temporal bone thickness at the narrowest point of AWEAM. JSWTT: Joint space between the mandibular head and AWEAM at the WTT level. JSNTT: Joint space between the mandibular head and AWEAM at the NTT level. Total WTT: Total distance between the mandibular head and AWEAM at WTT level. Total NTT: Total distance between the mandibular head and AWEAM at NTT level.

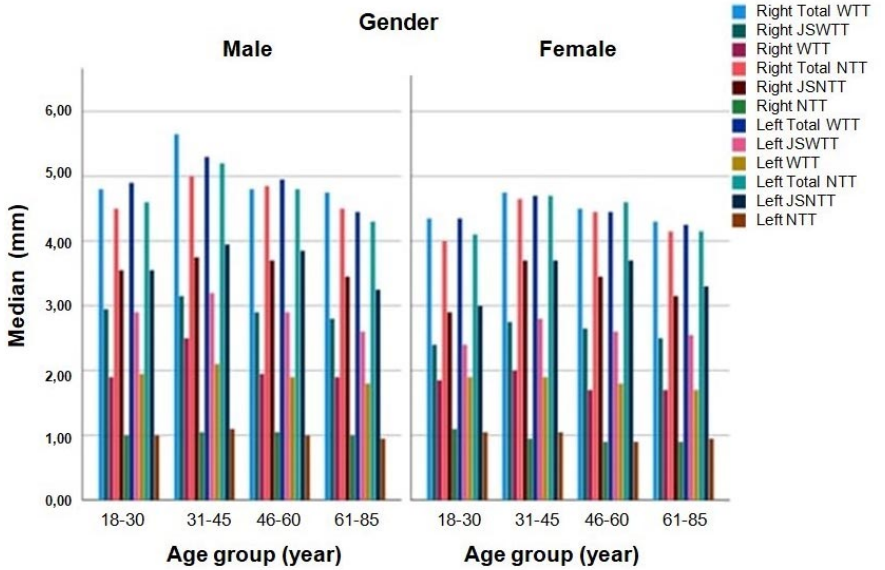

Fig. 2. Comparison of female and male individuals within each age group. WTT: Temporal bone thickness at the widest point of the anterior wall of external acoustic meatus (AWEAM). NTT: Temporal bone thickness at the narrowest point of AWEAM. JSWTT: Joint space between the mandibular head and AWEAM at the WTT level. JSNTT: Joint space between the mandibular head and AWEAM at the NTT level. Total WTT: Total distance between the mandibular head and AWEAM at WTT level. Total NTT: Total distance between the mandibular head and AWEAM at NTT level.

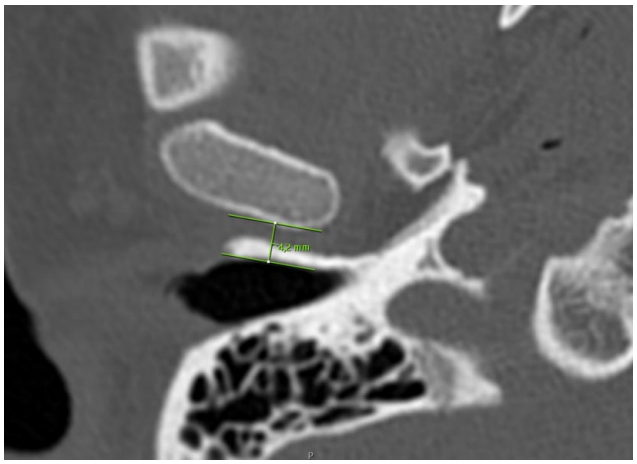

Fig. 3. Temporal CT image of a 23-year-old man (Right Total WTT)

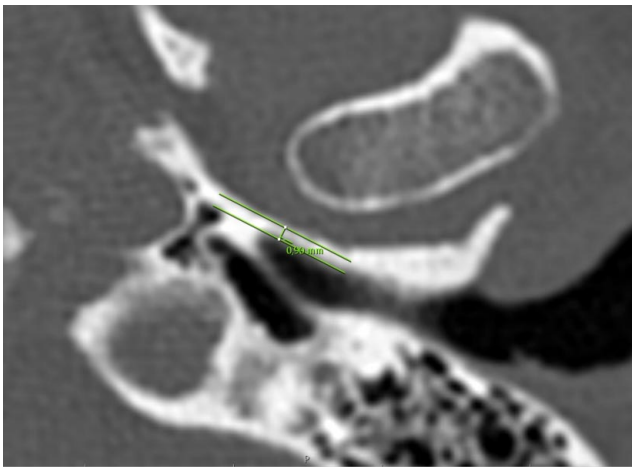

Fig. 5. Temporal CT image of a 71-year-old man (Left NTT).

In female subjects, right Total WTT, right JSWTT, right Total NTT, right Total NTT, right JSNTT, left JSWTT, left Total NTT and left JSNTT values were significantly higher in the 31-45 age group compared to the 18-30 age group ($p<0.05$). Right JSNTT and left JSNTT values were significantly higher in the 46-60 age group compared to the 18-30 age group ($p<0.05$) There was no difference in any parameter between the 18-30 age group and the 61-85 age group. There was no difference in any parameter between women in the 31-45 and 46-60 age groups. Right Total WTT, right Total NTT, right JSNTT, left Total NTT and left JSNTT values were significantly lower in the 61-85 age group compared to the 31-45 age group ($p<0.05$) Left JSNTT was lower in the 61-85 age group than in the 46-60 age group ($p<0.05$). The left JSNTT value was higher in the 46-60 age group compared to the 18-30 age group ($p<0.05$) (Table III) (Fig. 2). Figures 6 to 8 show temporal CT images of various parameters of women.

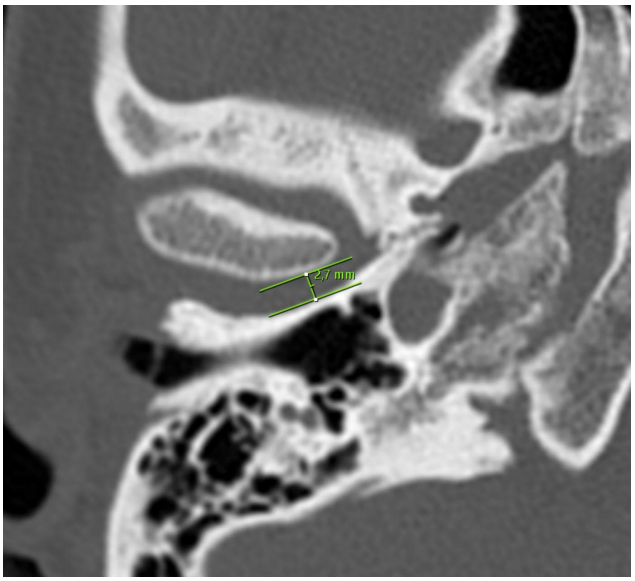

Fig. 6. Temporal CT image of a 24-year-old woman (Right JSNTT).

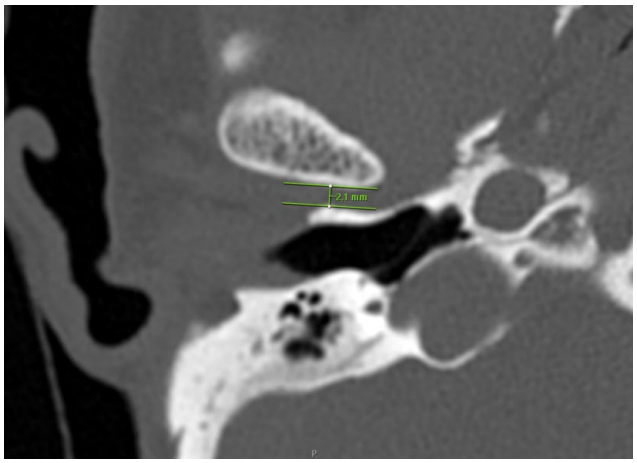

Fig. 4. Temporal CT image of a 31-year-old man (Right JSWTT)

Fig. 7. Temporal CT image of a 48-year-old woman (Right WTT).

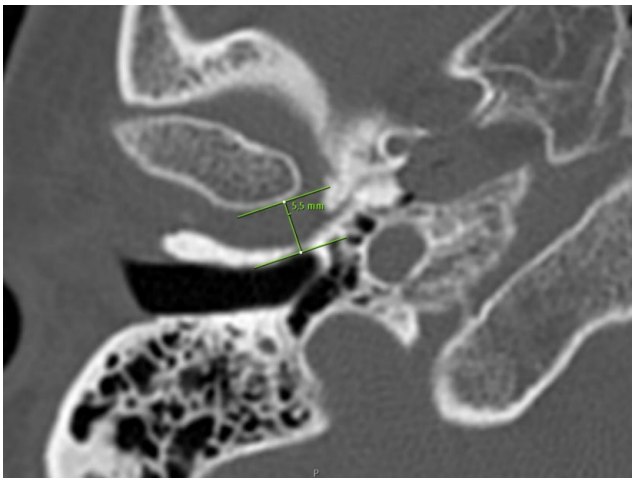

Fig. 8. Temporal CT image of a 58-year-old woman (Right Total NTT).

DISCUSSION

The neighborhood of the EAM and TMJ is very important in surgical interventions in and from this area. When we look at the literature, it is seen that a detailed morphometric study measuring the thickness of the AWEAM and the joint space between the mandibular head and the AWEAM has not been done before.

In an anthropometric study conducted by Yu *et al*. (2015), on CT images, it was reported that the transverse section of the external auditory canal was elliptical in both sexes and the difference between the height and width was approximately 40 %. Hennig *et al*. (2025), measured the height and width of the EAM bilaterally on magnetic resonance images of 870 individuals. They found that the mean cross-sectional area of the EAM was higher in men than in women. In general, the EAM has an oval shape, but there are strong individual differences in morphology when different EAMs are compared in three dimensions. In a CT study measuring the lengths and surface areas of bone and cartilage fragments of the EAM, all parameters were found to be higher in men than in women (Polat *et al*., 2023). Ayyıldız *et al*. (2021), measured the TMJ joint space in the sagittal plane at the distance between the most posterior point of the mandibular head and the mandibular fossa in a morphometric study performed on cone-beam computed tomography (CBCT) images of 171 individuals aged 18-65 years. They found that there was no difference between the right and left sides, and the joint space was significantly wider in males (right 3.31±0.80 and left 3.40±0.89 mm) than females (right 2.85±0.72 and left 2.74±0.72 mm).

Kinniburgh *et al*. (2000), evaluated the TMJ of 109 individuals aged 7-20 years with MR and CT. They measured the joint space as higher in males (3.03±0.88 mm) than females (2.86±0.74 mm). Similarly, Dalili *et al*. (2012), found joint space in CBCT images of 40 individuals aged 12-59 years to be greater in males (2.4±0.9 mm) than females (2.2±0.5 mm). They also found that the joint space was significantly wider on the left side (2.4±0.8 mm) than on the right side (2.1±0.7 mm). In our study, similar to the literature, the joint space was wider in males than females. However, we did not observe any difference between right and left side values. We think that the differences in data between the studies may be due to the measurement in different populations, differences in the image plane and also in the slice thickness between CT and CBCT, as well as personal differences between the researchers who performed the measurements.

However, in our study, a more detailed data set was obtained, since not only the joint space but also the AWEAM was measured from the thin and thick areas of the bone. This data is especially important in EAM surgical interventions. In this respect, we think that our study is superior to other studies (Kinniburgh *et al*., 2000; Dalili *et al*., 2012; Ayyıldız *et al*., 2021). In young individuals, bone growth takes from puberty until the early 20s to complete and ends earlier in girls than boys (Kvist *et al*., 2021). According to the data we obtained, the higher AWEAM thickness in the 31-45 age group compared to the 18-30 age group in both genders may be explained by the fact that bone development is completed in the older group. However, the fact that the difference between the 18-30 and 31-45 age groups is slightly smaller in women compared to men may be related to the earlier completion of puberty in women. There is a progressive loss of bone tissue with advancing age (Beranger *et al*., 2016). In our study, the lower values in the 46-60 age group compared to the 31-45 age group and the much lower values in the 61-85 group can be explained by the loss of bone tissue with aging.

It is reported in the literature that TMJ may be affected in temporal bone surgery (House & Wilkinson, 2008; de Casso *et al*., 2010; Mat *et al*., 2021). Osteomas can be seen in various parts of the temporal bone. When performing surgery on osteomas located in the EAM, care should be taken not to damage the adjacent TMJ (Mat *et al*., 2021). It has been reported that the joint may also be affected in the surgery of external auditory exostosis (House & Wilkinson, 2008). A decrease in TMJ function may occur after temporal bone surgery. In a study in the literature, 13 of 30 patients who underwent tumor-related temporal bone resection were alive 5 years after surgery and these individuals had TMJ dysfunction manifested by restricted jaw movements (de Casso *et al*., 2010).

In a case report, an AWEAM fracture was observed in a patient with itching and bleeding in the ear after molar extraction in the lower jaw. It was stated that the fracture occurred with the stress that reached the EAM when the mouth was closed after the mouth was wide open for a long time during the intervention to the tooth, and the soft tissue damage increased more as long as it was kept closed after the procedure. When the patient's previous CT image was examined, it was found that the distance between the mandibular condyle and AWEAM was narrow. However, it was reported that this short distance could not be seen clearly in the panoramic radiograph requested from each patient before dental intervention (Kim *et al*., 2016).

Our aim is to create a dataset to determine the safe average morphometric margin in ear surgeries, especially tympanoplasty, meatoplasties, and tumor resection from the EAM, and especially in procedures performed to widen the canal in patients with narrow EAM, without damaging the TMJ capsule. We believe that our results will contribute to the literature and clinical practice.

IRMAK SAPMAZ, H.; ÖDER, M.; KAYA ÇELIK, E. & GÖKÇE, E. Análisis morfométrico del meato acústico externo y la proximidad de la articulación temporomandibular. *Int. J. Morphol., 43(4)*:1140-1145, 2025.

RESUMEN: Este estudio fue programado para crear un conjunto de datos estándar que determinara la distancia entre el meato acústico externo y la articulación témporomandibular. En este análisis se examinaron imágenes axiales de TC de 160 adultos sanos con integridad ósea temporal. Los sujetos fueron evaluados en grupos de edad de 18 a 30 años, 31 a 45 años, 46 a 60 años y 61 a 85 años. Se midió el grosor de la pared anterior del meato acústico externo en sus puntos más anchos y más estrechos. Además, se midieron los espacios articulares entre la cabeza mandibular y el pared anterior del meato acústico externo a estos niveles. Se observó que los valores en mujeres fueron, en general, inferiores a los de los hombres en todos los grupos de edad. Todos los valores fueron superiores en el grupo de 31 a 45 años, en comparación con el de 18 a 30 años. En grupos de edad más avanzada, se observó una disminución gradual de todos los parámetros con el envejecimiento. Los parámetros más bajos en los grupos de mayor edad se debieron a la pérdida de tejido óseo con el envejecimiento. Creemos que nuestros resultados contribuirán tanto a la literatura, creando un conjunto de datos promedio, como a la creación de márgenes quirúrgicos seguros para la protección de esta región en intervenciones de articulación temporomandibular y meato acústico externo.

PALABRAS CLAVE: Meato acústico externo; Articulación temporomandibular; Morfometría; Tomografía computarizada; Proximidad.

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