The Journal of International Advanced Otology

J Int Adv Otol 2018; 14(2): 290-4 • DOI: 10.5152/iao.2018.4428

Original Article

The Predictability Precision of Superior Semicircular Canal Through Radiological Assessment and Microanatomical Dissection

Engin Kara, Kübra Öztürk, Ezgi Oktay, Vural Hamzaoğlu, Deniz Uzmansel, Yusuf Vayisoğlu, Hakan Özalp, Mehmet Farsak, Zeynep Cansu Aladağ, Tuğçe Pütürgeli, Can Mehmet Eti, Ahmet Dağtekin, Merve Türkegün, Derya Ümit Talas

Department of Radiology, Mersin University School of Medicine, Mersin, Turkey (EK)
Mersin University School of Medicine, Mersin, Turkey (KÖ, EO, MF, ZCA)
Department of Neurosurgery, Mersin University School of Medicine, Mersin, Turkey (VH, HÖ, AD)
Department of Anatomy, Mersin University School of Medicine, Mersin, Turkey (DU)
Department of Otorhinolaryngology, Mersin University School of Medicine, Mersin, Turkey (YV, TP, CME, DÜT)
Department of Biostatictics, Mersin University School of Medicine, Mersin, Turkey (MT)

ORCID IDs of the authors: E.K. 0000-0002-5182-0506; V.H. 0000-0003-0249-7711; K.O. 0000-0001-7668-5622; E.O. 0000-0002-5359-125X; D.U. 0000-0003-1657-1388; Y.V. 0000-0002-7132-1317; H.O. 0000-0002-8234-8013; M.F. 0000-0001-8274-3163; Z.C.A. 0000-0002-5313-9773; C.M.E. 0000-0001-8126-3977; A.D. 0000-0001-7368-6937; M.T. 0000-0002-4405-521X; D.U.T. 0000-0002-3402-9229; T.P. 0000-0003-3670-2808

Cite this article as: Kara E, Öztürk K, Oktay E, Hamzaoğlu V, Uzmansel D, Vayisoğlu Y, et al. The Predictability Precision of Superior Semicircular Canal Through Radiological Assessment and Microanatomical Dissection. J Int Adv Otol 2018; 14(2): 290-4.

OBJECTIVE: There is still ongoing research on the relationship of arcuate eminence (AE) and superior semicircular canal (SSC). We aimed to evaluate the precision of predictability of SSC through the morphology of AE via radiological means.

MATERIALS and METHODS: This investigation is performed on 12 dry skulls belonging to Mersin University Medical Faculty department of anatomy. Computed tomography (CT) assessment is performed with 0.5-mm-thin sections temporal bone algorithm on dry skulls which were marked with fixated copper wire by scotch tapes on the most prominent part of the middle fossa floor assuming the location of AE. The data are reformatted on the workstation with vitrea 2.0. The distances of the determined three points including lateral (A), apical (B), and medial (C) of the SSC and the copper wire are measured radiologically. Also, the height between the most apical part of the SSC to the floor of the skullbase (H) is measured. The angles between the placed copper wires and the SSC (E) are calculated. The angle between SSC and the midpoint of the IAC (F) and SSC to the sulcus of the greater GSPN (G) were measured. The nearest distance was measured between the most posterior part of the SSC and the point marked by the perpendicular line drawn from the medial border of the petrous bone to the most posterior part of the internal auditory canal (IAC) (D).

RESULTS: The right and left A, B, and C distances are 2.54+/- 2.75, 3.67+/−3.16, 5.85+/-3.77; 2.92+/-2.24, 3.68+/-2.93, 6.09+/-3.40, respectively. We could not find any statistical significance when the right A, B, and C distances were compared with the left values. Examination of the values revealed that C distance is greater than the A distance of the same side both for right (p=0.040) and left (p=0.022) measurements. The calculated left and right E angles are 30.313+/-12.838, and 35.558+/-18.437 degrees, respectively. Statistical significance was not found between the right and left angles. The right and left F, G angles were 53.17, 47.25; 93.58, 100.92 degrees; and D distances are 8.01, 8.13 millimeters, respectively. Statistical significance was not found when right and left E, F, G angles and D distances were compared. Among 12 left and 12 right sides, the copper wire was found to be nearly overlapping to SSC in two in the right and only one in the left.

CONCLUSION: This study reveals that there is a great variability predicting the exact location of SSC through the prominence of AE. Complementary studies are needed with greater number of dry skulls and cadavers. Comparison of different hypothesis including the effect of temporal lobe sulcus is to be discussed to better enlighten the exact relationship of the aforementioned anatomical structures.

KEYWORDS: Arcuate eminence, computed tomography, internal auditory canal, middle cranial fossa approach, superior semicircular canal

This study was presented in the 15th International Meeting of Mediterranean Society of Otology and Audiology (MSOA), 28-30 April 2016, Cappadocia, Turkey.

Corresponding Address: Engin Kara E-mail: renginika@gmail.com

Submitted: 27.09.2017 • **Accepted:** 19.11.2017 • **Available Online Date:** 19.02.2018

INTRODUCTION

Skull base is highly a complex anatomical area containing important neural and vascular structures. Successful surgery needs appropriate technology, surgical experience, thorough anatomical knowledge, and preoperative radiological evaluation [1]. Therefore, landmarks play a crucial role for reaching the targeted area precisely. Arcuate eminence (AE) and great superficial petrosal nerve (GSPN) are important landmarks for identifying the internal auditory canal (IAC) in middle fossa, extended middle fossa, and transpetrosal–transtentorial approaches [2]. AE, which can be described as the arched prominence on the superior surface of the petrous part of the temporal bone, is suggested as a landmark to navigate the position of the superior semicircular canal (SSC) [2]. Although AE is shown to exist in 100% of all neonates, this proportion is reported as 70% in the adult population. This eminence is more often seen on the left side compared with right and reported to be invisible approximately in 25% of cases [3].

There is still an ongoing controversy for precisely locating SSC by AE. High variability between these two anatomic structures is reported by various studies in the related literature [3-5]. Radiological or microanatomical dissection studies are performed to better delineate the relationship of AE and the SSC [6, 7]. To the best of our knowledge, there is a dearth of investigations consisting of both radiological and anatomical assessments. The present study aims to combine the radiological and microanatomical assessments to further contribute to the relationship of AE and SSC for achieving more acceptable surgical success.

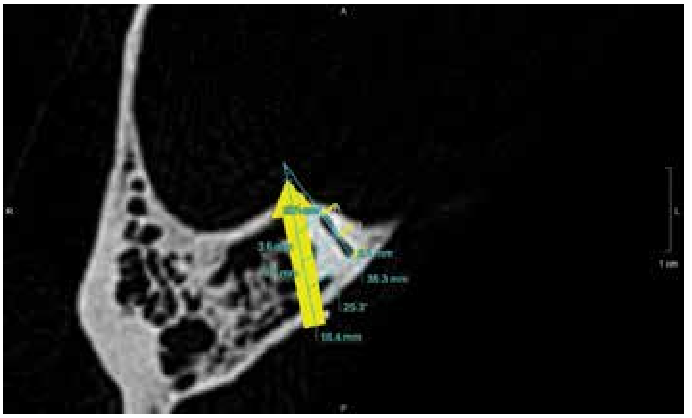

Figure 1. The yellow arrow indicates the fixated copper wire. (a) The distance between the fixated copper wire and the most lateral part of SSC, (b) The distance between the fixated copper wire and the most apical part of SSC, (c) the distance between the fixated copper wire and the most medial part of SSC
SSC: superior semicircular canal

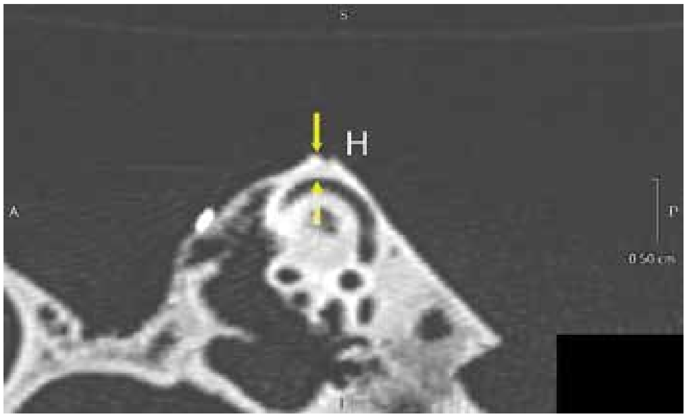

Figure 2. The distance between two yellow arrows indicates the H-distance, which is between the floor of middle fossa and most apical part of SSC
SSC: superior semicircular canal

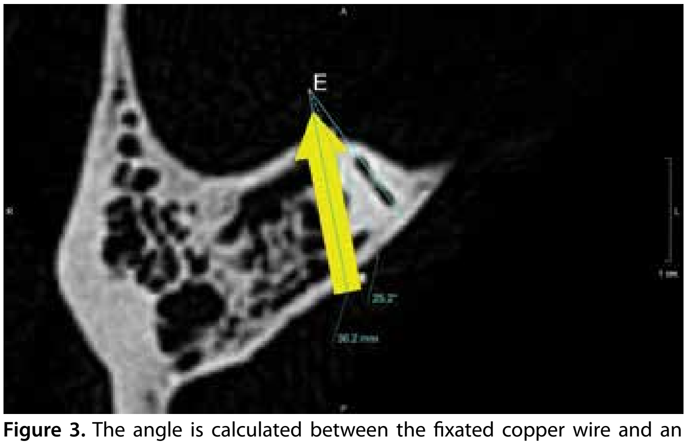

Figure 3. The angle is calculated between the fixated copper wire and an imaginary line drawn according to SSC (E)
SSC: superior semicircular canal

MATERIALS and METHODS

In this study, we used 12 dry skulls that belong to Mersin University Medical Faculty Department of Anatomy. The most prominent part of the temporal bone, which was estimated as the AE was marked with copper wire and fixed with scotch tape. Then, CT assessment was performed with 0.5-mm-thin sections temporal bone algorithm, and the raw data were reformatted with vitrea 2.0 at workstation. The relationship between the AE and SSC was shown by using a 64-slice CT scanner (Aquillion 64, Toshiba Medical Systems Tokyo, Japan).

The distances of the determined three points including: lateral (A), apical (B), medial (C) of the SSC and fixated copper wire were measured radiologically (Figure 1). The distance (H) is the height between the most apical part of the SSC to the surface of the skull base (Figure 2) and it is tried to be measured using the most appropriate vision through lateral oblique and coronal sections. In case an intersection occurred between SSC and copper wire, the angle between them was calculated (E) (Figure 3).

Ethics committee approval was received for this study from Mersin University Clinical Research Ethical Committee.

Statistical Analysis

The minimum and maximum values and mean and standard deviation values from the descriptive statistics for the angle and distance measurements were given. The number and percentage values from the descriptive statistics for categorical variables were also given. The normal distributive control was done by Shapiro-Wilk test for the angle and distance values. The difference between right-left angle and right distance-left distance measurements were evaluated by paired t test among parametric tests. Direct variant analysis method (ANOVA) was used for the investigation of angle and diameters between each other found in the right and the left. Statistical significance value was considered as (p) 0.05 for all statistical comparisons.

Dissection

We drew a line with a pen in accordance with the copper wire. A high-speed drill (Bien Air- Suisse) and operation microscope (C.Z.; OPMI pico, Germany) were used for the dissection of SSC using AE. The distances were measured with electronic caliper (Figure 4), and the angles were measured with a copper wire and goniometer (Figure 5).

The angles between SSC and the midpoint of the IAC (F) (Figure 6) and SSC to the sulcus of the GSPN (G) (Figure 7) were measured. The nearest distance was measured between the most posterior part of the SSC and the point marked by the perpendicular line drawn from the medial border of the petrous bone to the most posterior part of the IAC (D) (Figure 8).

RESULTS

The mean values of radiological evaluation parameters (A, B, C, and H distances) regarding right–left comparison are given in Table 1. The values and the comparison of right-left E angles are given in Table 2.

Figure 4. Electronic caliper

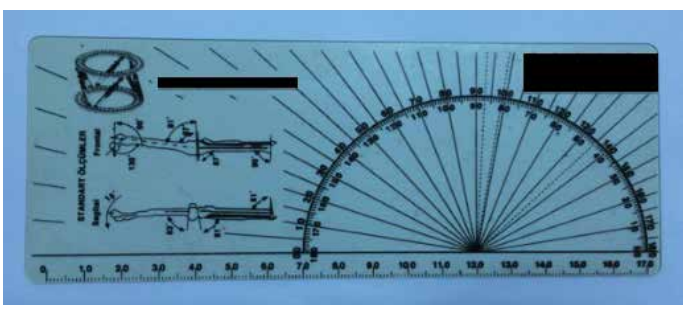

Figure 5. Goniometer

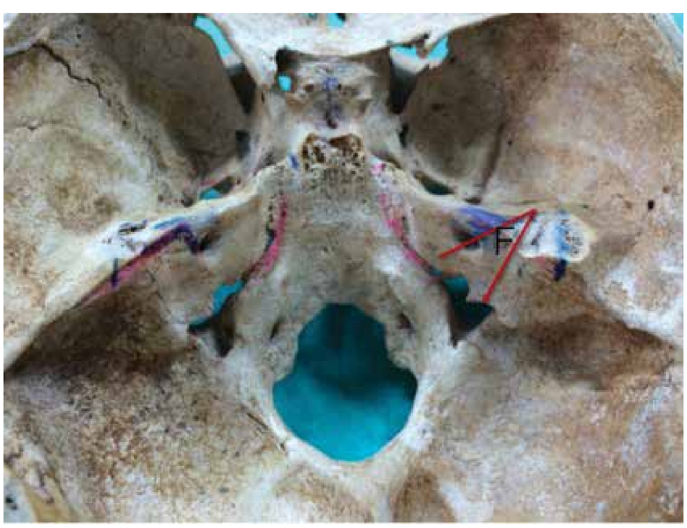

Figure 6. The angle between SSC and the midpoint of the internal auditory canal (IAC) is shown in as (F)
SSC: superior semicircular canal

The same anatomic evaluation parameters regarding the comparison of the same side are given in Table 3. The total number of intersections are given in Table 4 showing the relationship of the copper wire and the SSC. Table 5 shows the mean values of F, G, and D. The attached copper wire was found to be intersected to SSC in three cas-

Figure 7. The angle between SSC and the sulcus of the greater superficial petrosal nerve (GSPN) is shown as (G)
SSC: superior semicircular canal

Figure 8. The nearest distance (D) between the most posterior part of the SSC is shown by red arrow and the point marked by the perpendicular line drawn from the medial border of the petrous bone to the most posterior part of the IAC
SSC: superior semicircular canal; IAC: internal auditory canal

Table 1. The right and left comparison of A, B, C and H distances

N=12	MIN-MAX	MEAN±SD †	p
Right-A	0.01-9.40	2.549-2.756	0.73
Left-A	0.01-6.85	2.922-2.40	
Right-B	0.01-11	3.667-3.158	0.972
Left-B	0.01-8.50	3.627-2.935	
Right-C	0.01-12.50	5.855-3.769	0.871
Left-C	1.10-11.80	6.087-3.401	
Right-H	0.60-2.80	1.325-0.655	0.783
Left-H	0.40-2.20	1.266-0.540	

†: Standard deviation

Table 2. The right and left comparison of E angles

N=12	MIN-MAX	MEAN±SD†	p
Right-E	13.80-65.20	30.313-12.84	0.369
Left-E	4.40-61.85	35.558-18.44	0.369

†: Standard deviation

Table 3. The same anatomic evaluation parameters regarding the comparison of the same side

		N	MIN-MAX	MEAN ± SD†	p
RIGHT	A	12	0.01-9.40	2.549-2.756	
	B	12	0.01-11	3.667-3.158	0.04
	C	12	0.01-12.50	5.855-3.769	
LEFT	A	12	0.01-6.85	2.922-2.240	
	B	12	0.01-8.5	3.627-2.935	0.022
	C	12	1.10-11.80	6.087-3.401	

†: Standard deviation

Table 4. The relationship between the copper wire and the SSC

	Right	Left
Nearly Overlap	2	1
Intersected	3	5
Posterolateral	7	6

SSC: superior semicircular canal

Table 5. The mean values of right-left F, G, and D

N=12	MIN-MAX	MEAN ± SD†	p
Right-F	37.00-90.00	53.17-17.83	0.4
Left-F	28.00-80.00	47.25-14.524	
Right-G	75.00-115.00	93.58-13.01	0.25
Left-G	85.00-130.00	100.92-15.54	
Right-D	4.36-10.59	8.01-1.61	0.76
Left-D	5.48-10.67	8.13-1.80	

†: Standard deviation

es for the right and five for the left. Posterolateral location of the wire to the SSC was found in seven cases in the right and sic cases in the left. Meanwhile, the wire near overlaps was observed in two cases in the right and just one in the left.

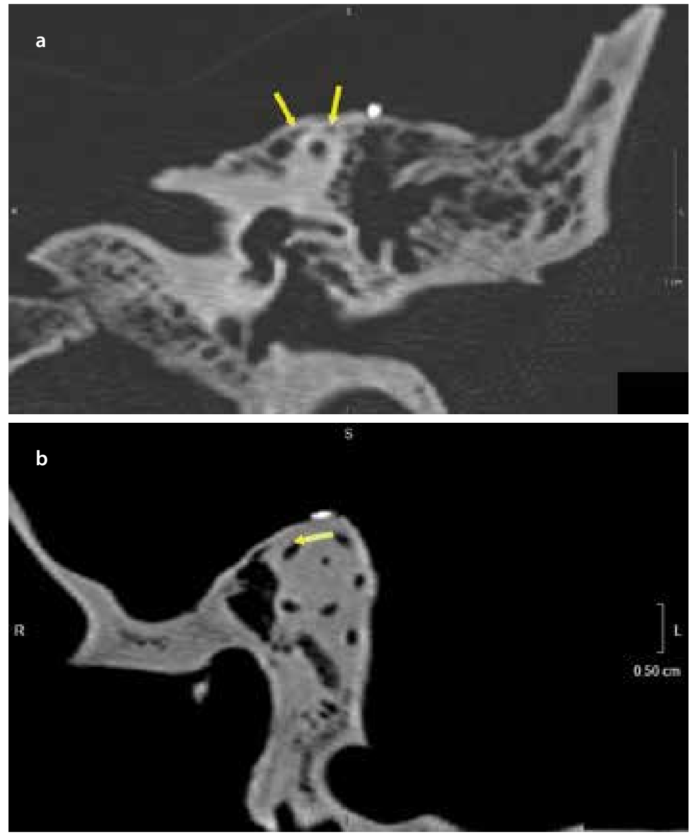

Figure. 9 a, b. Lateral oblique CT view showing (a) air cells between apex of SSC and floor of the cranial fossa and (b) just cortical bone without air cells between the copper wire and yellow arrow

DISCUSSION

There are three well-defined methods to localize the IAC in middle fossa surgeries [1]. The House Method consists of tracing the GSPN to find the facial nerve and the fundus of IAC [2]. Garcia-Ibanez method aims to drill between GSPN and the AE by bisecting the area between these two structures [2].

Fisch method explains blue lining the SSC and localizing the IAC using a fairly constant angle 45-60 degrees [2]. The angle found in our study was 47 degrees for the left side and 53 degrees for the right side. Our measurement was performed between SSC and midpoint of IAC. Statistical significance was not found between right and left angles. The average angle was reported as 61 degrees by Rhoton in their microsurgical anatomical study.

Wigand technique finds the IAC by bisecting the angle between GSPN and SSC instead of AE [8]. This angle shown by the present study may help the surgeon drill the roof of the IAC, if the dissection is decided to be performed between these two structures. The distance between the cortical petrous bone and the apex of the SSC is another important point to deal with. This depth and the presence of air cells between the SSC and the floor of the temporal bone is of great importance during drilling of this area for the preservation of hearing in middle fossa surgeries (Figure 9 a, b). The authors want to emphasize upon the technique of measurement when one wants to compare the angles. Therefore, our findings were concordant with the related literature with the mean angle of 52 degrees in range of 34-75 degrees. The mean angle between the sulcus of the GSPN and

SSC is measured as 93.58 in the right and 100.92 in the left. A similar measurement was performed by Maina et al. [9] between GSPN and AE reported as 122.92 in the range of 96.29-158.90.

The apex of the SSC to the floor of the temporal bone was 1.33 mm for the right and 1.27 for the left side. This distance was given as 2 mm by Katsuta et al. [7] with a range of 0.2 mm to 4.2 mm [6].

Correspondence between the AE and SSC was also examined by CT evaluation. The distances between the SSC and the most prominent part of the petrous part of the temporal bone, which is thought as the AE, were measured at three positions including medial, lateral, and apical points. Statistical significance was not found between the right and left values of A, B, and C distances. On the other hand, distance A was found to be significantly greater when compared to the other two distances. This fact points out that the predictability of the SSC by AE diminishes toward the midline. These data might indicate to the skull base surgeons a greater caution toward the medial border of the petrous ridge to prevent sensorineural hearing loss due to SSC drilling. In the present study, a great majority of the attached copper wires (13 of 24) was found to be localized posterolateral to the SSC. Seo et al. [3] reported lateral location as 25/52 in their series [2]. High variability of AE with respect to SSC is documented by very low percentages of complete correspondence of these two anatomic structures. In our study, near overlap was found in two cases for the right whereas just one for the left side. Seo et al. [3] reported complete correspondence as 2/52 [3].

Therefore, preoperative CT imaging and/or navigation systems are to be cautiously evaluated to find out the precise relationship between AE and SSC for successful middle fossa approaches and prevent any important complications including hear loss.

CONCLUSION

Various structures had been reported to play the role on the formation of AE other than SSC. Elevation or depression on the cerebral surface cannot be excluded for supporting the formation of AE by the gyrus or a sulcus on the inferior aspect of temporal lobe [10]. On behalf of that majority of cases, AE did not correspond with SSC and temporo-occipital sulci participation is blamed in its formation with an inconstant fashion [5, 11]. This is also emphasized in Djallian's et al. [12] reporte that the angle was 42.3 degrees between SSC and the posterior wall of the IAC, whereas this angle was 60.8 degrees when measured between SSC and anterior wall of the IAC.

The hypotheses mentioned above are to be studied with greater number of dry skulls and cadavers to better enlighten the precise relationship of the aforementioned anatomical structures. MRI and CT scanning of the temporal bone and mentioned structures may give valuable information.

Ethics Committee Approval: Ethics committee approval was received for this study from Mersin University Clinical Research Ethical Committee (Approval Date: 10.08.2017).

Informed Consent: N/A.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - E.K., D.Ü.T.; Design - E.K.;Supervision - D.Ü.T., Y.V., A.D.; Resource - D.U., C.M.E.; Materials - K.Ö., E.O.; Data Collection and/or Processing - E.K., M.F., Z.C.A., T.P.; Analysis and/or Interpretation - E.K., M.T.; Literature Search - V.H., H.Ö.; Writing - E.K.; Critical Reviews - E.K., D.Ü.T.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

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