Journal of Taibah University Medical Sciences (2022) 17(6), 936–942

Taibah University

Journal of Taibah University Medical Sciences

www.sciencedirect.com

Original Article

Radiologic exploration of the morphometric and morphological features of the carotid canal

Siddharth Tewari, PG [a], Sheela Chinnappan, MBBS, MD [a], Periakaruppan R. Gokulakrishnan, MBBS, MD, FRCR [a] and Chandni Gupta, MBBS, MD [b,*]

[a] *Department of Radiodiagnosis, Sri Ramachandra Medical College and Research Institute, Porur, Chennai, India*
[b] *Department of Anatomy, Kasturba Medical College, Manipal Academy of Higher Education, Manipal, India*

Received 30 December 2021; revised 2 March 2022; accepted 28 April 2022; Available online 13 May 2022

الملخص

أهداف البحث: القناة السباتية عبارة عن ثقبة تقع في الجزء الصخري من العظم الصدغي. تعد المعرفة التفصيلية حول تشريح قاعدة الجمجمة مهمة حيث يتم إجراء العديد من العمليات الجراحية لمختلف الأورام الخبيثة وتمدد الأوعية الدموية. لذلك، فإن الهدف من هذه الدراسة هو جمع القياسات الشكلية المختلفة للقناة السباتية والتي ستساعد جراحي الأعصاب في الأساليب الجراحية المختلفة لتحديد مكان الجزء الثاني من الشريان السباتي الداخلي بسهولة.

طرق البحث: تم إجراء دراسة بأثر رجعي وتحليل 500 مسح بالأشعة المقطعية على جانبي الجماجم. تم قياس العديد من المتغيرات المورفومترية المتعلقة بقناة الشريان السباتي. كما لوحظ شكل القناة السباتية. تم إجراء التحليل الإحصائي لجميع المعلمات.

النتائج: كان متوسط أقطار القناة الأمامية الخلفية وعرض القناة السباتية 0.535 و 0.683 سم. وكان متوسط المسافة للقناة السباتية من الصماخ السمعي الخارجي والقوس الوجني والفك السفلي 2.27 و 3.28 و 2.34 سم على التوالي. كما كان متوسط مسافة القناة السباتية من خط الوسط لقاعدة الجمجمة في الجمجمة 2.97 سم. وكان متوسط الزاوية بين جذر الزيجوما والفتحة الخارجية لقناة الشريان السباتي والصماخ السمعي الخارجي 27.08 درجة. كانت الزاوية بين الصماخ السمعي الخارجي والفتحة الخارجية لقناة الشريان السباتي والقمة فوق الخشائية 26.74 درجة. كانت القناة السباتية دائرية في معظم الحالات (٪50.5).

الاستنتاجات: ستساعد هذه القياسات جراحي الأعصاب على تحديد الأساليب الجراحية المختلفة لتحديد موقع الجزء الثاني بسهولة من الشريان السباتي الداخلي وستساعد أيضا في إجراء العمليات الجراحية في قاعدة الجمجمة.

* Corresponding address: Department of Anatomy, KMC Manipal, 576104, India.

E-mail: chandnipalimar@gmail.com (C. Gupta)

Peer review under responsibility of Taibah University.

Production and hosting by Elsevier

الكلمات المفتاحية: قناة الشريان السباتي؛ قاعدة الجمجمة؛ الشريان السباتي الداخلي؛ العظم الوجنية؛ جراحو الأعصاب

Abstract

Objectives: The carotid canal is a foramen located in the petrous part of the temporal bone. Detailed knowledge about the anatomy of the base of the skull is important, as many surgeries are done there for various malignancies and aneurysms. The aim of this study was to collect various morphometric measurements of the carotid canal to aid neurosurgeons with various surgical approaches to easily locate the second fragment of the internal carotid artery.

Methods: A retrospective study was done, and 500 CT scans on both sides of the skull were analysed. Various morphometric parameters related to the carotid canal were measured. The shape of the carotid canal was also noted. Statistical analysis was done for all the parameters.

Results: The mean anteroposterior diameter and width of the carotid canal was 0.535 and 0.683 cm, respectively. The mean distance of the carotid canal from the external acoustic meatus, zygomatic arch, and mandible was 2.27, 3.28, and 2.34 cm, respectively. The mean distance of the carotid canal from the midline of the base of the skull was 2.97 cm. The mean angle between the zygoma root, external aperture of the carotid canal, and external acoustic meatus was 27.08°. The mean angle between the external acoustic meatus, external aperture of the carotid canal, and supramastoid crest was 26.74°. The carotid canal was round in most cases (50.5%).

Conclusion: These measurements will aid neurosurgeons to identify various surgical approaches to easily locate the

1658-3612 © 2022 The Authors.
Production and hosting by Elsevier Ltd on behalf of Taibah University. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/). https://doi.org/10.1016/j.jtumed.2022.04.013

second part of the internal carotid artery, and they can serve as a reference to guide surgeries at the base of the skull.

Keywords: Carotid canal; Internal carotid artery; Neurosurgeons; Skull base; Zygoma

© 2022 The Authors.
Production and hosting by Elsevier Ltd on behalf of Taibah University. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Introduction

The carotid canal (CC) is a foramen located in the petrous part of the temporal bone. The internal carotid artery (ICA) and sympathetic plexus of veins and nerves pass through it. The external orifice of the carotid canal (EOCC) is situated on the inferior surface of the petrous part of the temporal bone. It is located posterior and lateral to the foramen lacerum, and anterior and lateral to the jugular foramen.[1, 2] Initially from the external orifice, it proceeds straight for about 1 cm and then there is a 90° bend. Finally it turns medially and forward for 2–3 cm to the tip of the petrous part of the temporal bone where it ends, leading to the formation of the internal orifice of the carotid canal (IOCC). This orifice lies anterior to the foramen lacerum. The ICA goes inside the cranial cavity through it. The internal carotid venous plexus and some amount of connective tissue lie between the walls of the CC and ICA.[3]

Various measurements of the skull base have been conducted previously. However, most studies have been conducted on skulls using Vernier calipers.[2,3] No study in India has assessed the anatomy of the CC or skull base using CT scans. CT scans can provide more precise and accurate information about skull base anatomy than a dry human skull. Many extracranial and intracranial injuries, as well as intrinsic anomalies like schwannomas, metastatic lesions, and inflammatory lesions of the adjacent structures, can affect the foramina. As such, there is a need to be familiar with the anatomy of the foramina and their variations. In many of these cases surgical resection is the management of choice. Some operations were once thought to be inoperable due to progressive lesions of the foramina. But these are now possible because of advances in microsurgical methods.[2] Detailed knowledge about the anatomy of the skull base and the relations of surgical landmarks is important before beginning any kind of surgery.[4] So, the aim of the study was to collect various morphometric details of the carotid canal and to locate it from various important landmarks. The results can help neurosurgeons identify the best surgical approaches to the ICA (i.e. the petrous part) and they can serve as a reference to facilitate surgeries at the base of the skull.

Materials and Methods

Study design

A retrospective study was done from January 2019 to December 2021. Five hundred (250 male and 250 female) CT scan images on both the right and left sides of the skull were analysed.

The sample size was calculated as follows

Assuming a mean of ang ZA–EACC–EAM (the angle between the zygoma root, EACC, and external acoustic meatus) of 25 with an SD of 4, the sample size was calculated with a confidence level of 95% and with relative precision of 5% of the mean; 39 samples are required for each age group rounded off to 50 samples. In each age group 50 male and 50 female skulls were examined. So 500 samples were studied in total.

We took 100 patients from each age group (50 males and 50 females): 21–30 years, 31–40 years, 41–50 years, 51–60 years, and 60 years and above.

Inclusion criteria

1. Patients who came to the Medical Centre with various complaints and underwent CT head scans.
2. Patients who did not have any malformations, trauma, or pathologic lesions in the skull base, particularly in the temporal bones.

Exclusive criteria

1. Patients with any lesion/haemorrhage/infarct/neoplasm in the brain parenchyma.
2. Patients who had undergone neurosurgical procedures previously

After the CT scan was completed by a radiologist, the images were collected.

Method: The following parameters were measured on both sides of the CC (Figure 1):

1. Anteroposterior length of the CC (L)
2. Horizontal width of the CC (B)
3. Minimum distance of the CC to the external acoustic meatus (EAM).
4. Minimum distance of the CC to the tubercle of root of zygoma (ZA).
5. Minimum distance of the CC to the midline of the skull base (Mid).

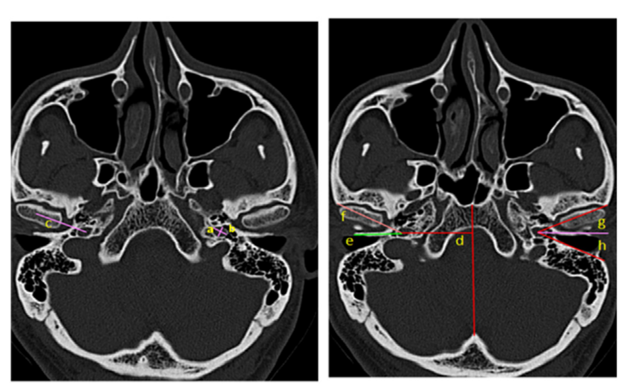

Figure 1: Measurements of the carotid canal: a. length; b. width; c. CC to mandible; d. CC to midline; e. CC-EAM; f. CC-ZR; g. ZR-EACC-EAM angle; h. EAM-EACC-SC angle.

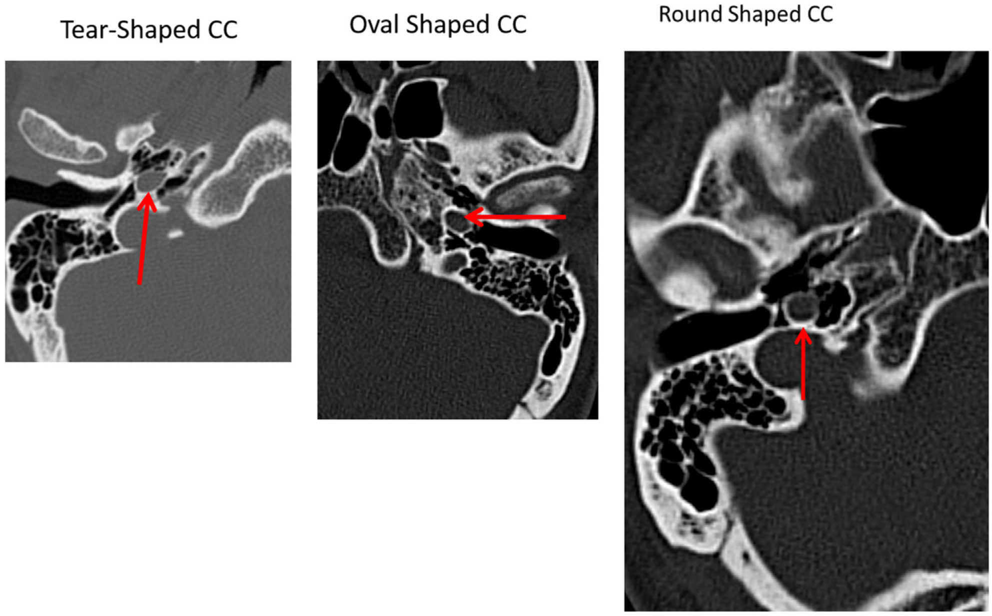

Figure 2: Shapes of the carotid canal.

6. Minimum distance of the CC to the mandible.
7. Angle (ang ZR−EACC−EAM) between the zygoma root, EACC, and external acoustic meatus.
8. Angle (ang EAM−EACC−SC) between the external acoustic meatus, EACC, and supramastoid crest.

The shape of the CC was also noted (Figure 2).

Statistical analysis

The mean, standard deviation, and range (min−max) were calculated from the above measurements. An independent-samples t-test was done to compare the sexes and sides. Tukey's HSD test was done to compare the groups.

Results

The mean AP diameter of the carotid canal was 0.535 cm. The mean width of the carotid canal was 0.683 cm. The mean distance of the carotid canal from the EAM was 2.27 cm. The mean distance of the carotid canal from the ZA was 3.28 cm. The mean distance of the carotid canal from the mandible was 2.34 cm. The mean distance of the carotid canal from the midline of the skull base 2.97 cm. The mean angle (ang ZR−EACC−EAM) was 27.08°. The angle (ang EAM−EACC−SC) was 26.74°.

Descriptive parameters of statistics of the carotid canal in various age groups are shown in Table 1. A comparison of

Table 1: Descriptive parameters of the carotid canal in various age groups.

Parameter	Age	*n*	Mean	SD	Minimum	Maximum
AP (cm)	20−30	200	0.538	0.0887	0.250	0.820
	31−40	200	0.544	0.0779	0.360	0.910
	41−50	200	0.516	0.0799	0.360	0.810
	51−60	200	0.541	0.0833	0.310	0.800
	>60	200	0.535	0.0681	0.350	0.800
Width (cm)	20−30	200	0.705	0.108	0.47	1.25
	31−40	200	0.683	0.094	0.42	0.98
	41−50	200	0.671	0.087	0.35	0.88
	51−60	200	0.675	0.096	0.39	0.99
	>60	200	0.683	0.079	0.50	0.89
CC−EAM (cm)	20−30	200	2.30	0.294	0.28	3.28
	31−40	200	2.28	0.232	1.71	2.95
	41−50	200	2.26	0.271	0.36	3.05
	51−60	200	2.24	0.234	1.67	2.91
	>60	200	2.27	0.220	1.71	2.85
CC−ZA (cm)	21−30	200	3.22	0.235	2.76	4.10
	31−40	200	3.28	0.249	2.51	4.00
	41−50	200	3.30	0.233	2.48	3.95
	51−60	200	3.29	0.251	2.59	4.10
	>60	200	3.31	0.248	2.67	4.21
CC−mandible (cm)	20−30	200	2.14	0.234	1.30	2.76

Table 1 (*continued*)

Parameter	Age	*n*	Mean	SD	Minimum	Maximum
	31–40	200	2.26	0.226	1.76	2.90
	41–50	200	2.48	1.743	1.80	26.80
	51–60	200	2.37	0.236	1.89	3.31
	>60	200	2.44	0.243	1.87	3.39
Angle ZR–EACC–EAM (°)	20–30	200	25.72	4.492	13.00	40.00
	31–40	200	27.230	4.477	17.40	48.00
	41–50	200	27.36	3.595	18.90	36.70
	51–60	200	27.84	3.554	16.80	37.60
	>60	200	27.27	3.663	16.00	35.00
Angle EAM–EACC–SC (°)	20–30	200	28.15	4.477	14.20	38.40
	31–40	200	26.73	3.442	17.60	35.00
	41–50	200	26.80	4.098	2.70	37.80
	51–60	200	26.59	3.548	16.80	35.60
	>60	200	25.46	3.464	16.80	34.00
CC–midline	20–30	200	2.89	0.229	2.32	3.47
	31–40	200	2.94	0.252	2.31	3.80
	41–50	200	2.92	0.213	2.41	3.50
	51–60	200	2.99	0.220	2.45	3.57
	>60	200	3.12	1.794	2.50	28.20

Table 2: Comparison of parameters according to age groups (Tukey's HSD test).

Parameter	20–30 years	30–40 years	40–50 years	50–60 years	>60 years	P-value ANOVA
Length (cm)	0.53815 ± 0.0887	0.54480 ± 0.077983[c]	0.51685 ± 0.079922[b,d]	0.54166 ± 0.083387[c]	0.54166 ± 0.068112	0.005
Width (cm)	0.7058 ± 0.10808[c,d]	0.6834 ± 0.09447	0.6716 ± 0.08734[a]	0.6756 ± 0.09646[a]	0.6831 ± 0.07929	0.003
CC–EAM (cm)	2.3064 ± 0.29449	2.2800 ± 0.23227	2.2638 ± 0.27153	2.2447 ± 0.23414	2.2740 ± 0.22075	0.169
CC–ZA (cm)	3.2292 ± 0.23564[c,e]	3.2842 ± 0.24951	3.3040 ± 0.23359	3.2918 ± 0.25138[a]	3.3111 ± 0.24809[a]	0.007
CC–mandible (cm)	2.1454 ± 0.23439[c,d,e]	2.2635 ± 0.22662[c]	2.4815 ± 1.74396[a,b]	2.3716 ± 0.23620[a]	2.4446 ± 0.24388[a]	<0.001
Angle ZR–EACC–EAM (°)	25.7210 ± 4.49232[b,c,d,e]	27.2300 ± 4.47701[a]	27.3615 ± 3.59502[a]	27.8485 ± 3.55416[a]	27.2784 ± 3.66350[a]	<0.001
Angle EAM–EACC–SC (°)	28.1570 ± 4.47752[b,c,d,e]	26.7320 ± 3.44250[a,e]	26.8028 ± 4.09808[a,e]	26.5900 ± 3.54860[a,e]	25.4615 ± 3.46436[a,b,c,d]	<0.001
CC–midline (cm)	2.8942 ± 0.22997[e]	2.9435 ± 0.25224	2.9289 ± 0.21353	2.9904 ± 0.22062	3.1287 ± 1.79426	0.045

[a] Comparison to 20–30 years.
[b] Comparison to 31–40 years.
[c] Comparison to 41–50 years.
[d] Comparison to 51–60 years.
[e] Comparison to >60 years.

Table 3: Comparison of parameters according to the shape of the carotid canal (Tukey's HSD test).

Parameters		Oval shaped (n = 298)	Round shaped (n = 505)	Teardrop shaped (n = 197)	ANOVA P-value
CC length (cm)	Mean ± SD	0.50497 ± 0.070105[b]	0.56555 ± 0.079375[a,c]	0.50360 ± 0.067103[b]	<0.001
	Range	0.250–0.820	0.300–0.910	0.350–0.690	
CC width (cm)	Mean ± SD	0.6969 ± 0.10111[b,c]	0.6633 ± 0.08625[a,c]	0.7167 ± 0.09033[a,b]	<0.001
	Range	0.35–1.25	0.38–0.93	0.49–1.00	
CC–EAM (cm)	Mean ± SD	2.3037 ± .27590[b]	2.2555 ± .24718[a]	2.2752 ± 0.22415	0.033
	Range	0.36–3.13	0.28–3.28	1.71–2.81	
CC–ZA (cm)	Mean ± SD	3.3047 ± 0.26045	3.2681 ± 0.23839	3.2936 ± 0.23571	0.102
	Range	2.48–4.1	2.60–4.12	2.67–4.21	
CC–mandible (cm)	Mean ± SD	2.3312 ± 0.25851	2.2973 ± 0.25435[c]	2.4691 ± 1.76095[b]	0.042
	Range	1.60–3.4	1.30–3.31	1.64–2.70	
Angle ZR–EACC–EAM (°)	Mean ± SD	26.9570 ± 3.91637	27.0495 ± 4.11594	27.3843 ± 4.01535	0.492
	Range	15–37	13–48	16–36	
Angle EAM–EACC–SC (°)	Mean ± SD	26.5181 ± 3.73690	26.8499 ± 4.03469	26.8379 ± 3.87528	0.479
	Range	14–38.4	15–37.8	14–36.4	
CC–midline (cm)	Mean ± SD	2.9206 ± 0.22954	2.9986 ± 1.14521	3.0075 ± 0.24000	0.371
	Range	2.3–3.8	2.31–3.3	2.45–3.52	

[a] Comparison to oval shape.
[b] Comparison to round shape.
[c] Comparison to teardrop shape.

Table 4: Comparison of descriptive statistics of carotid canal measurements in the sexes.

Parameter	Gender	*n*	Mean	SD	Standard Error Mean	Sig (2-tailed) P-value
CC length (cm)	Male	500	0.54148	0.079443	0.003553	0.015
	Female	500	0.52910	0.080878	0.003617	
CC width (cm)	Male	500	0.7168	0.09182	0.00411	<0.001
	Female	500	0.6509	0.08458	0.00378	
CC−EAM (cm)	Male	500	2.3580	0.27106	0.01212	<0.001
	Female	500	2.1895	0.19977	0.00893	
CC−ZA (cm)	Male	500	3.3643	0.24201	0.01082	<0.001
	Female	500	3.2036	0.22052	0.00987	
CC−mandible (cm)	Male	500	2.4373	1.12342	0.05024	<0.001
	Female	500	2.2452	0.22589	0.01010	
Angle ZR−EACC−EAM (°)	Male	500	26.3746	3.87570	0.17333	<0.001
	Female	500	27.8012	4.07164	0.18209	
Angle EAM−EACC−SC (°)	Male	500	26.2051	3.93254	0.17587	<0.001
	Female	500	27.2922	3.82627	0.17112	
CC−midline (cm)	Male	500	3.0253	0.21844	0.00977	0.067
	Female	500	2.9289	1.15282	0.05156	

P < 0.05 taken as significant.

Table 5: Comparison of descriptive statistics of carotid canal measurements on each side.

Parameter	Side	*n*	Mean	SD	Standard Error Mean	Sig (2-tailed) P-value
CC length (cm)	Right	500	0.53692	0.079915	0.003574	0.522
	Left	500	0.53366	0.080854	0.003616	
CC width (cm)	Right	500	0.6844	0.09191	0.00411	0.869
	Left	500	0.6834	0.09649	0.00432	
CC−EAM (cm)	Right	500	2.2570	0.24923	0.01115	0.036
	Left	500	2.2905	0.25484	0.01140	
CC−ZA (cm)	Right	500	3.2690	0.24124	0.01079	0.053
	Left	500	3.2990	0.24801	0.01110	
CC−mandible (cm)	Right	500	2.3495	0.25421	0.01137	0.750
	Left	500	2.3330	1.12554	0.05034	
Angle ZR−EACC−EAM (°)	Right	500	26.8152	4.04386	0.18085	0.033
	Left	500	27.3606	4.01461	0.17954	
Angle EAM−EACC−SC (°)	Right	500	26.7362	3.74812	0.16762	0.920
	Left	500	26.7611	4.08027	0.18248	
CC−midline (cm)	Right	500	2.9675	0.23781	0.01063	0.716
	Left	500	2.9867	1.15092	0.05147	

P < 0.05 taken as significant.

parameters according to various age groups (Tukey's HSD test) is shown in Table 2. All parameters were found to be clinically significant in various age groups, as the P-value was <0.05 in all but one case, namely the distance of the carotid canal from the EAM (P = 0.169).

A comparison of parameters according to the shape of the carotid canal (Tukey's HSD test) is shown in Table 3. All parameters were found to be clinically significant in various age groups, as the P-value was <0.05 except in the following cases: the distance of the carotid canal from the ZA (P = 0.102), the distance of the carotid canal from the midline of the base of skull (P = 0.492), the mean angle (ang ZR−EACC−EAM) (P = 0.479), and the angle (ang EAM−EACC−SC) (P = 0.371).

A comparison of descriptive statistics of carotid canal measurements in the sexes by independent t-test is shown in Table 4. All parameters were found to be clinically significant in both sexes, as the P-value was <0.05 in all except one case, namely the distance of the carotid canal from the midline of the skull base (P = 0.067).

A comparison of descriptive statistics of the carotid canal measurements on each side and for different sexes by independent t-test is shown in Table 5. Most of the parameters are not significant, as all P-values are >0.05, except in two cases: the distance of the carotid canal from the EAM (P = 0.036), and the angle (ang ZR−EACC−EAM) (P = 0.033).

The most common shape of the carotid canal was round (50.5%, *n* = 505), followed by oval (29.8%, *n* = 298) and teardrop-shaped (19.7%, *n* = 197).

Discussion

The location and measurements of the carotid canal are very significant for surgery at the skull base.[5] The exposure of the internal carotid artery at the carotid canal is the most challenging task.[6]

Ten et al. conducted a study of 200 patients and found that the shape of the EACC is oval, round, and teardrop-shaped in 58.3%, 24%, and 17.8% of cases, respectively.[1] By comparison, in our study we found that it was round in 50.5% of cases, oval in 29.8% of cases, and teardrop-shaped in 19.7% of cases.

Özalp et al. conducted a study of 20 human dry skulls. They also compared the same parameters with computed tomography (CT). They found that the CC was round in 62.5%, oval in 32.5%, and teardrop-shaped in 5% of cases. The length and width of the carotid foramen were found to be 0.789 cm and 0.641 cm, respectively, according to CT scans. The angles between the supramastoid crest-CF-zygoma root and the supramastoid crest-CF-mastoid process were 36.59° and 43.71°, respectively, according to CT scans.[7] In our study, the mean AP diameter of the carotid canal was 0.535 cm. The mean width of the carotid canal was 0.683 cm, similar to the findings of Özalp et al. The mean angle (ang ZR−EACC−EAM) was 27.08°. The angle (ang EAM−EACC−SC) was 26.74°. Both angles were found to less compared to their results. The differences in measurements may be because they conducted the study on a Turkish population, and we conducted it on an Indian population.

Berus et al. conducted a study of 60 adult European skulls. They compared CT and anatomical dimensions to evaluate the precision of the CT illustration of bony structures. They found that the length and width of the extracranial aperture of the carotid canal were 0.588 cm and 0.791 cm, respectively, according to CT scans.[8] Our results were similar: 0.535 cm and 0.683 cm, respectively.

Naidoo et al. conducted a study of 81 dry skulls. They found that the external orifice of the CC was round, oval, and teardrop-shaped in 28.4%, 49.4%, and 22.2% of the skulls, respectively. The mean width and AP diameter were 0.752 and 0.541 cm, respectively.[9] In our study, teardrop-shaped CCs were the least common, but round CCs were seen more often in our study than in the study by Naidoo et al. This may be because of racial differences, as they studied African and Caucasian skulls, and we conducted our study on Indian people. The mean AP diameter of the carotid canal was 0.535 cm, which was similar to their results. But the mean width of the carotid canal was 0.683 cm, which was not similar to their results. This difference might also be because they conducted their study on dry skulls, and we used CT scans of skulls.

Aoun et al. conducted a study of 150 skulls. They noted the shape of the external orifice of the canal as round or oval. But in our study, we found teardrop-shaped CCs as well. The distance from the midline to the carotid canal was 2.878 and 2.819 cm in male skulls and 2.64 and 2.599 cm in female skulls, on the right and left sides, respectively.[3] In our study we found that the distance from the midline to the carotid canal was 3.0253 cm in male skulls and 2.9289 cm in female skulls. This was similar to their results.

Somesh et al. conducted a study of 82 dry adult human skulls. They found that the mean length of the external aperture of the carotid canal was 0.812 and 0.815 cm on the right and left sides, respectively. The mean width of the external aperture of the carotid canal was 0.631 and 0.619 cm on right and left sides, respectively. Also, they found that the most common shape of the aperture was round (51.83%).[10] In our study, we found that the CC was round in 50.5% of cases, similar to their study. We found that the mean length of the external aperture of the carotid canal was 0.536 and 0.533 cm on right and left sides, respectively. The mean width of the external aperture of the carotid canal was 0.684 and 0.683 cm on the right and left sides, respectively. Our width was similar to these.

Harini et al. conducted a study of 30 dry human skulls. They found that the most common shape of the carotid canal was oval, in 48.33% of skulls.[11] In our study, we found that majority had a round carotid canal (50.5%).

Nikolina et al. conducted a study of 24 skulls and 36 temporal bones. They found that the mean AP diameter of the external orifice of the carotid canal on the right and left sides was 0.731 and 0.771 cm, respectively. The mean transverse diameter of the external orifice of the carotid canal on the right and left sides was 0.582 and 0.620 cm, respectively. The shape of the external aperture of the carotid canal noted was round, oval, and almond-shaped in 53.57%, 29.76%, and 15.47% of cases, respectively.[12] In our study we found that the mean length of the external aperture of the carotid canal was 0.536 and 0.533 cm on the right and left sides, respectively. The mean width of the external aperture of carotid canal was 0.684 and 0.683 cm on the right and left sides, respectively. The difference in measurements might be because of racial differences, as they conducted the study on a Serbian population and we conducted our study on an Indian population.

Kanna et al. conducted a study of 200 Indian craniums. They found that the shape of the carotid canal was round in 54%, oval in 28%, and almond-shaped in 18% of cases. They found that the mean length of the external orifice of the carotid canal on the right and left sides was 0.68 and 0.677 cm, respectively. The mean width of the external orifice of the carotid canal on the right and left sides was 0.594 and 0.60 cm, respectively.[13] In our study we found that the mean length of the external aperture of carotid canal was 0.536 and 0.533 cm on the right and left sides, respectively. The mean width of the external aperture of the carotid canal was 0.684 and 0.683 cm on the right and left sides, respectively.

EACC morphology is vital for surgeons to prevent iatrogenic damage to the internal carotid artery passing through the carotid canal when managing pathologies like aneurysms, malignancies, fractures, and stenosis. It is also important to locate the carotid canal from other anatomical landmarks because this will help surgeons to select a suitable surgical approach (e.g., lateral surgical approaches). So, the results of this study will help surgeons locate the carotid canal accurately.

Conclusion

This study was conducted on 500 CT scans. Various morphometric parameters related to the carotid canal were measured. The shape of the carotid canal was also noted. According to the results, the mean AP diameter and width of the carotid canal were 0.535 and 0.683 cm, respectively.

The mean distance of the carotid canal from the EAM, ZA, and mandible was 2.27, 3.28, and 2.34 cm, respectively. The mean distance of the carotid canal from the midline of the base of the skull was 2.97 cm. The mean angle between the zygoma root, EACC, and external acoustic meatus was 27.08°. The mean angle between the external acoustic meatus, EACC, and supramastoid crest was 26.74°. The carotid canal was round in most cases (50.5%). The results of this study will help neurosurgeons to identify various surgical approaches to easily locate the second part of the ICA, and they can serve as a reference to guide surgeries at the base of the skull.

Source of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

Ethical clearance was granted by the institutional ethics committee. Date: 6 October 2021; IEC no. CSP-MED/21/SEP/71/136.

Authors contributions

ST conceived and designed the study, conducted research, and collected and organized data. PRG conducted research, wrote material, and provided logistic support. CG wrote the initial and final drafts of the article. SC analysed and interpreted the data. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

Acknowledgment

The authors acknowledge Dr. P. M Venkata Sai and Dr. R. Rajeshwaran in the Department of Radiodiagnosis, Sri Ramachandra Medical College and Research Institute, Porur, Chennai for allowing the authors to conduct the study in the department.

References

1. Ten B, Beger O, Direk MO, Balcı Y, Çiçek F, Özalp H, Hamzaoğlu V, Temel G, Vayisoğlu Y, Bağdatoğlu C, Talas DM. Radiologic analysis of the location, shape and size of the external aperture of the carotid canal in children. **Surg Radiol Anat 2020**; 42(7): 749−759.
2. Ahmed MM, Jeelani M, Tarnum A. Anthropometry: a comparative study of right and left sided foramen ovale, jugular foramen and carotid canal. **Int J Sci Stud 2015**; 3: 88−94.
3. Aoun MA, Nasr AY, Aziz AMA. Morphometric study of the carotid canal. **Life Sci J 2013**; 10: 2559−2562.
4. Aslan A, Balyan FR, Taibah A, Sanna M. Anatomic relationships between surgical landmarks in type b and type c infratemporal fossa approaches. **Eur Arch Oto-Rhino-Laryngol 1998**; 255: 259−264.
5. Leonitti JP, Mith PG, Linthicu FH. The petrous carotid artery: an anatomic relationship in skull base surgery. **Otolaryngol Head Neck Surg 1990**; 102(1): 3−12.
6. Rosset E, Albertini J, Magnan P, Ede B, Thomassin J, Branchereau A. Surgical treatment of extracranial internal carotid artery aneurysms. **J Vasc Surg 2000**; 31: 713−723.
7. Özalp H, Beger O, Erdoğan O, Koç T, Kayan G, Hamzaoğlu V, et al. Morphometric assessment of the carotid foramen for lateral surgical approach. **J Int Adv Otol 2019**; 15(2): 222−228.
8. Berlis A, Putz R, Schumacher M. Direct and CT measurements of canals and foramina of the skull base. **Br J Radiol 1992**; 65: 653−661.
9. Naidoo N, Lazarus L, Ajayi NO, Satyapal KS. An anatomical investigation of the carotid canal. **Folia Morphol 2017**; 76(2): 289−294.
10. Somesh MS, Sridevi HB, Murlimanju BV, Pai SR. Morphological and Morphometric study of carotid canal in Indian Population. **IJBR 2014**; 5(7): 455−460.
11. Harini M, Lavanya P, Preetha S. Morphology and morphometry of carotid canal in South Indian skulls. **Int J Pharmaceut Res 2020**; 12(1). https://doi.org/10.31838/ijpr/2020.12.01.363.
12. Nikolina P, Mirela E, Slobodan S, Nikola K, Angelina V, Dragica H, et al. Morphological and morphometric analysis of the external aperture of the carotid canal in Serbian population. **Int J Morphol 2020**; 38: 1026−1031.
13. Kanna N, Vidya L, Vivekanand G. Morphometric & morphological analysis of carotid canal external aperture in human adult neurocranium. **Int J Scient Res 2019**; 8(7): 23−24.

How to cite this article: Tewari S, Chinnappan S, Gokulakrishnan PR, Gupta C. Radiologic exploration of the morphometric and morphological features of the carotid canal. J Taibah Univ Med Sc 2022;17(6):936−942.