Morphometric Study of the Carotid Canal

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Abstract: A morphometric study of the carotid canal on 150 skulls was done considering their shape, direction, length and diameter both in male and female skulls and the presence of any dehiscence in the canal wall. The anatomical measurements were made in relation to the landmarks previously examined by Lang and Shreiber, 1983 and Calguner et al., 1997.The present study showed that the external opening of the canal appeared as a rounded or an oval-shaped opening in the inferior aspect of the petrous temporal bone and is directed downward in some specimens and downward and slightly medially in the others. The diameters of the external opening of the canal are measured on both sides of the skull in the long and short diameters. The long diameter of the external opening measured 7.96±0.89 mm on the right side, and 6.77±0.8 mm on the left side (in male skulls), while in female skulls, it measured 7.0±0.65 mm on the right side and 6.77±0.6 mm on the left side. The short diameter measured 5.7±0.69 mm on the right side and 5.58±0.67 mm on the left side in male skulls, while in female skulls, it measured 5.0±0.5 mm on the right side and 4.86±0.44 mm on the left side. The carotid canal extends forward and medially inside the petrous temporal bone till it reaches the lateral wall of the foramen lacerum. The internal length of the canal measured (22.56±2.87 mm and 24.4±2.5 mm) in male skulls and (22.5±1.99 mm and 21.5±1.62 mm) in female skulls, on the right and left sides respectively. The distance from the midline to the medial edge of the canal measured (28.78±2.15 mm and 28.19±1.97 mm) in male skulls and (26.4±1.4 mm and 25.99±1.5 mm) in female skulls, on the right and left sides respectively. The distance from lateral edge of the canal to the supramastiod crest measured (31.1±3.1 mm and 30.9±3.06 mm) in male skulls and (28.6±2.0 mm and 28.37±1.99 mm) in female skulls, on the right and left sides respectively. These dimensions of the carotid canal showed highly significant differences among male and female skulls ($P<0.001$). However, no significant differences were found among the canals in the right and left sides of the skull ($P>0.05$).The present study also found dehiscences in the inferior wall of the carotid canal in 5 skulls (3.3%%) and in the superior wall in one skull (0.66%) of the 150 specimens.
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1. Introduction

The foramina and canals of adult skull base were studied by few investigators[1,2,3,4]. They reported that knowledge of the normal and variant positions of the canals and foramina of the skull base was important for radiologists, neurosurgeons and anatomists because of the increasing refined techniques available. Berlis *et al.*,[5] stated that identification of the skull base anatomy was of great importance in cases of aneurysms and clival tumors. Moreover, Gozil *et al.*,[6] described numerous skull base asymmetries concerning their foramina and canals.

The carotid canal was described as a bony canal directed antero-inferiorly, transmitting the internal carotid artery within its internal curvature. Rutz[1]and Gozil *et al.*,[6] studied the internal opening and the size of the canal and the angular measurements of its internal bend.

The carotid canal had a rounded external opening lying at the base of skull in the petrous part of the temporal bone. It extended inside the bone forward and medially to open into the middle of the posterior wall of the foramen lacerum[7,8].

Calguner *et al.*,[9] studied the carotid canal as a landmark for neurosurgeons, who considered the canal the most vital and easily visualized structure on MRI angiography and digital subtraction angiography.

The following study aimed to give accurate measurements about the dimensions and the abnormalities in the carotid canal walls in male and female skulls, also on the right and left sides of the skull.

2.Material and Methods

150 dry adult skulls were used in this study, 75 males and 75 females. The specimens were collected from the anatomy department, faculty of medicine, King Abdulaziz University. The canals of both sides were measured using the caliper. The measured data was done in accordance with Lang & Schreiber,[2] and Calguner, *et al.*[9] This included: (1) the long diameters of the external opening of the canal; (2) the short diameters of the external opening of the canal; (3) the internal length of the canal; (4) the distance from the medial border of the canal to the midsagittal

plane (midline) and (5) the distance from the lateral border of the canal to the supramatoid crest.

The obtained values were collected and statistically analyzed and their mean ± SEM were given and compared with previous researches.

3.Results

The carotid canal is a bony canal inside the petrous temporal bone extending forward and medially from its external opening on the inferior surface of petrous temporal bone to open on the lateral wall of the foramen lacerum **(Fig. 1)**. The external opening of the canal appeared rounded or oval shaped on the inferior surface of the petrous part of temporal bone, slightly toward its lateral part, just in front of the jugular foramen. The direction of the external opening is found variable from one side to another as it is directed downward in some skulls, while in the other is directed downward and slightly medially **(Fig. 2)**.

The superior and inferior walls of the canal show variable degrees of bone dehiscence. The inferior wall is seen defected in 5 skulls of all specimens (3.3%) **(Fig. 3),** while the superior wall is found defected only in one skull (0.66%) **(Fig. 4)**. The defected superior wall is found bilaterally and is associated with defects in the superior wall of the petrous bone laterally on both sides.

The dimension of the canals showed highly significant differences among the male and female skulls (P<0.001) **{Tables 1-4}**. On the other hand there were no significant difference between the left and right sides in the male and female skulls (P>0.05) except the internal length of the canal that showed significant differences between right and left sides (P<0.05) **{Table 5}**.

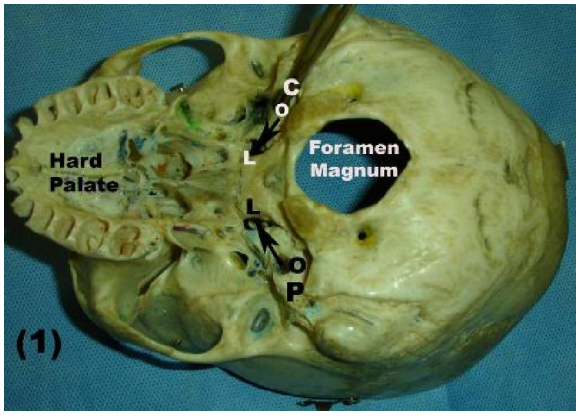

Fig (1): Shows the external aspect of the base of the skull. The carotid canal (C) extending forward and medially (arrow) inside the petrous temporal bone (P) from its external opening (O) to the lateral wall of the foramen lacerum (L). The external opening (O) appeared rounded and is directed downward and slightly medially.

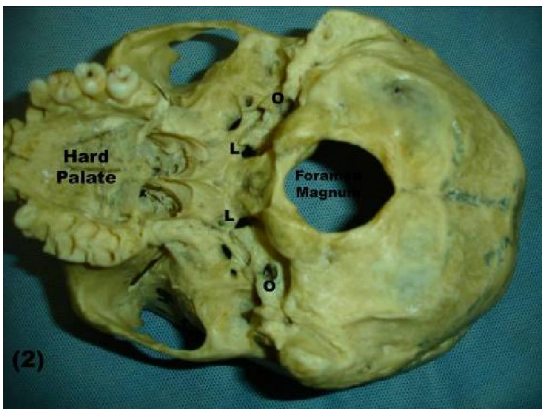

Fig (2): Shows that the external opening (O) is directed downward and slightly medially in the left side while it is directed downward in the right side.

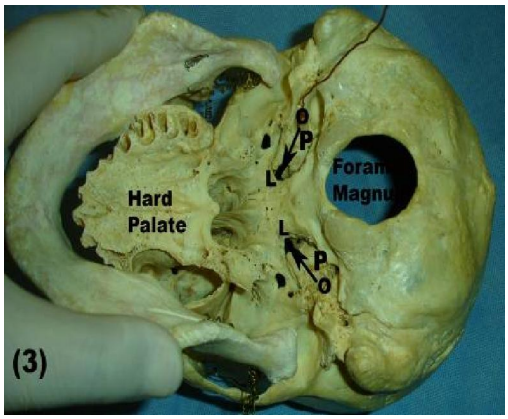

Fig (3): Shows the inferior wall of the carotid canal that shows an apparent cleft (arrow) along its length from the external opening (O) till the foramen lacerum (L) within the petrous part of temporal bone (P).

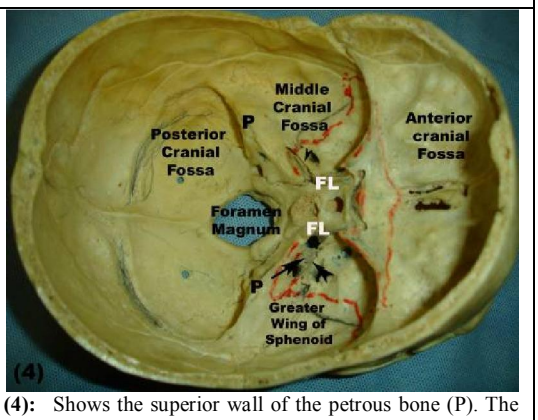

Fig (4): Shows the superior wall of the petrous bone (P). The roof of the carotid canal shows marked dehescences (arrow) along most of its length. The superior aspect of the petrous bone shows also marked defect at its lateral part (arrow head). FL: foramen lacerum.

Table (1) Shows the average dimensions of the external opening of carotid canal.

	Male X ± SD (Range)	**Female** X ± SD (Range)	**T**	***p***
Right long diameter	7.96 ± 0.89 (6.5-9.5)	7.0 ± 0.65 (6-8.4)	5.5	<0.001 HS
Left long diameter	6.77 ± 0.8 (6.4-9.4)	6.77 ± 0.6 (5.2-8.2)	6.02	<0.001 HS
Right short diameter	5.7 ± 0.69 (4.5-7.0)	5.0 ± 0.5 (4-6.5)	5.1	<0001 HS
Left short diameter	5.58 ± 0.67 (4.4-6.8)	4.86 ± 0.44 (4-6)	5.89	< 0.001 HS

Table (2) Shows the average dimensions of the internal length of carotid canal.

	Male X±SD (Range)	**Female** X ± SD (Range)	**t**	***p***
Right	22.56 ± 2.87 (20.4-30.2)	22.5 ± 1.99 (19.5-26.7)	6.57	<0.001 HS
Left	24.4 ± 2.5 (19.2-28.8)	21.5 ± 1.62 (19.0-25.5)	6.98	<0.001 HS

Table (3) Shows the average distances between the medial edge of the carotid canal and the midline.

	Male X ± SD (Range)	**Female** X ± SD (Range)	**t**	***p***
Right	28.78 ± 2.15 (24.9-32.5)	26.4 ± 1.4 (23-28.2)	6.35	<0.001 HS
Left	28.19 ± 1.97 (24.4-32.0)	25.99 ± 1.5 (23.5-28.2)	6.1	<0.001 HS

Table (4) Shows the average distances between the lateral edge of the carotid canal and the supra mastoid crest**.**

	Male X ± SD (Range)	**Female** X ± SD (Range)	**T**	***p***
Right	31.1 ± 3.1 (25.8-36.2)	28.6 ± 2.0 (25.6-33.4)	4.95	<0.001 HS
Left	30.9 ± 3.06 (26.0-36.0)	28.37 ± 1.99 (25.5-33)	5.04	<0.001 HS

Table (5) Shows the relation between dimensions of the carotid canal (between right and left sides) among male and female skulls**.**

	Right		**Left**	
External opening of the canal	$P > 0.05$	NS	$P > 0.05$	NS
Internal length of the canal	$P < 0.05$	S	$P < 0.05$	S
Medial edge of the canal / midline	$P > 0.05$	NS	$P > 0.05$	NS
Lateral edge of the canal / supra-mastoid crest	$P > 0.05$	NS	$P > 0.05$	NS

4.Discussion

The position, dimensions and extensions of the carotid canal become of vital importance in cases of skull base surgery as in the identification and isolation of the internal carotid artery throughout its petrous course (Leonetti *et al.*,[(10)]).

On the level of the carotid canal, the exposure of the internal carotid artery is the most difficult manipulation (Rosset *et al.*,[(11)]).

Ziyal et al. described five segments: the cervical, the petrous, the cavernous, the clinoid and the cisternal segment (Ziyal *et al.*,[(12)]).

The measurements of the present study showed highly significant differences among the various dimensions of the carotid canal between male and female skulls (P<0.001). These results were in contrast with Lang's series who described non significant sex differences among all diameters of the carotid canal. The possible source of such differences could be attributed to the fact that their study included pediatric and newborn groups in comparison to the present adult material. On the other hand there were no significant differences among the right and left sides in both sexes (P>0.05) in the present series. This were similar to Lang's and Calguner's series.

Dehiscence of the inferior wall of the carotid canal was found in 5 (3.3%) of the 150 skulls. This was in accordance with the observations of Hasebe, et al.,[(13)] who found dehiscence of the wall in 4.9%. In addition, carotid canal wall was found to be very thin in some cases, rendering the internal carotid artery vulnerable during surgery around the clival region. Absence of the floor of the carotid canal was described by Lang and Hack,[(2)]**;** Quint *et al.*,[(14)] and Sharma et al.,[(15)] as being attributed to developmental defects. This defect was considered to make exposure of the internal carotid artery to be vulnerable during surgical approaches and may give rise to complications during skull base surgeries. The defect in the floor of the canal is also described by Patsor Vazquez *et al.*,[(16)] either due to abnormality of the internal carotid artery or due to deficiencies in ossification of the skull bone.

In the present study, defects were described in the superior wall of the canal associated with defects in the superior wall of the petrous bone on both side. Such abnormalities were not described before upon the examination of the canal.

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