

Original Article

# Morphometric analysis of hypoglossal canal of the occipital bone in Iranian dry skulls

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## Abstract

**Background:** The hypoglossal canal (HC) is in basal part of cranium that transmits the nerve that supplies the motor innervations to the muscles of tongue. Study on morphometry of (HC) and its variations has been a considerable interest field to neurosurgeons and research workers especially because of their racial and regional. **Material and Methods:** In this retrospective study, 26 adult dry human crania of no sex known were studied for (HC) and its variants. Thirty five skulls were observed for any damage of post cranial fossa and those in good condition (26 skulls) were selected. Sliding Vernier caliper was used for morphometric analysis. **Results:** There were significant difference between distances of: a-(HC) till anterior tip of condyles (right and left), b-(HC) till posterior tip of condyles (right and left), c-(HC) till lower border of occipital condyles (right and left), d-(HC) till external border of foramen jugular (right and left), e-(HC) till opisthion(right and left), f-(HC) till carotid canal (right and left), g-(HC) till jugular tubercle (right and left). There wasn't significant difference in other parameters. **Conclusion:** Detailed morphometric analysis of (HC) will help in planning of surgical intervention of skull base in safer and easier ways.

**Key words:** Cranium base, dry skulls, hypoglossal canal, morphometric analysis

## INTRODUCTION

Hypoglossal canal (HC) is important to anatomists, anthropologists, forensic experts, and clinicians, HC is situated above the occipital condyle at its junction of anterior one-third and posterior two-third.<sup>[1]</sup> HC transmits hypoglossal nerve, meningeal branch of ascending pharyngeal artery and an emissary vein from the basilar plexus.<sup>[1]</sup> Traditionally, lesions located anterior to the craniocervical junction have posed a surgical challenge. Recently, transcondylar approach is being increasingly used to access lesions ventral to the craniocervical junction.<sup>[2]</sup> We conduct this study of morphometric analysis of

the HC as it pertains to transcondylar approach. The HC is a permanent element of human skull.<sup>[2]</sup>

## MATERIALS AND METHODS

Twenty-six dry skulls were chosen from the archives of our department (Department of Anatomy, Arak University of medical sciences, Arak-Iran), thus we provided 52 HCs and 26 foramina magna. By using standard calipers and goniometers, 21 parameters were analyzed. We assessed 13 parameters: The

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length of the HC, diameter of the intra and extracranial ends of the HC, distance of the HC from the posterior, anterior and inferior margins of the occipital condyle, distance of the HC from the basion, opisthion, carotid canal and jugular tubercle, distance of the HC from the jugular foramen intra- and extracranially, anteroposterior, and transverse diameters of the foramen magnum. We have identified the location of the HC according to following Figure 1 and Table 1. In this study, all measurements were made separately for right and left sides.

**Statistical analysis**

To analyze provided data, we used SPSS software version 17 (IBM® SPSS® Statistics) and paired samples *t*-test was used to evaluate the mean differences of the measured parameters of the right and left sides. Comparison was performed between the right and left sides regarding symmetrical structures and *P* < 0.05 was considered as statistically significant.

**RESULTS**

The characteristics of HC are totally determined in Table 2. And separately (right and left) in Table 3. Comparison

**Table 1: Anatomical categorization for HC**

Location on occipital condyle	Definition of location
Location 1	Anterior one-fourth of occipital condyle
Location 2	The junction of first and second one-fourth of occipital condyle
Location 3	Second one-fourth of occipital condyle
Location 4	The junction of second and third one-fourth of occipital condyle
Location 5	Third one-fourth of occipital condyle
Location 6	The junction of third and fourth one-fourth of occipital condyle
Location 7	Fourth one-fourth of occipital condyle

HC: Hypoglossal canal

**Table 2: Characteristics of HC**

Distances and diameters	n	Minimum	Maximum	Mean ± SD
Distances of HC till anterior tip of condyles	46	2.00	11.00	6.91±1.56
Diameter of internal hiatus of HC	46	1.00	5.00	2.99±0.88
Diameter of external hiatus of HC	46	1.00	6.00	3.17±1.05
Distance of HC till posterior border of occipital condyles	46	7.00	20.00	11.43±2.51
Distance of HC till anterior border of occipital condyles	46	2.00	13.00	6.93±2.47
Distance of HC till lower border of occipital condyles	46	1.00	17.00	8.95±4.00
Distance of HC till internal jugular tubercle	36	4.00	15.00	10.36±3.22
Distance of HC till external jugular tubercle	36	1.00	10.00	3.5±1.52
Distance of HC till basion	46	6.00	15.00	12.5±2.35
Distance of HC till opisthion	46	28.00	40.00	33.88±2.82
Distance of HC till carotid canal	38	5.00	16.00	11.66±2.53
HC till jugular tubercle	43	5.00	11.8.00	10.53±3.05
Length of foramen magnum	23	27.00	37.00	31.65±0.854
Width of foramen magnum	23	20.00	29.00	25.45±2.32

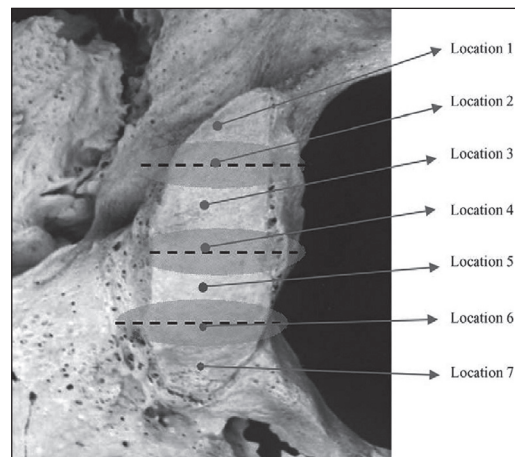
SD: Standard deviation, HC: Hypoglossal canal

between right and left side of parameters of HC is shown in Table 4. There was significant difference between distances of:

- a. HC till anterior tip of condyles (right and left),
- b. HC till posterior tip of condyles (right and left),
- c. Distance of HC till lower border of occipital condyles (right and left),
- d. Distance of HC till external border of foramen jugular (right and left),
- e. Distance of HC till opisthion (right and left),
- f. Distance of HC till carotid canal (right and left),
- g. Distance of HC till jugular tubercle (right and left).

There was no significant difference between internal hiatus diameter of right and left HC (*P* = 0.836) and external hiatus diameter of right and left HC (*P* = 0.163), distance of HC till basion (right and left) (*P* = 0.394).

We have identified the location of the HC in Table 4. In dry skulls, the frequency of location 3 in maximum amount was 60.86% and the frequency of location 1 in minimum was 2.17%.



**Figure 1: The location of intra and extracranial orifices of hypoglossal canal**

**Table 3: Comparison between right and left side parameters of HC**

Pairs	Parameters	Mean ± SD	n	Significant
Pair 1	HC-right condyle anterior tip	6.69±1.98	23	0.000
	HC-left condyle anterior tip	7.13±2.15	23	
Pair 2	Internal hiatus diameter of right HC	3.34±0.93	23	0.836
	Internal hiatus diameter of left HC	2.65±0.83	23	
Pair 3	External hiatus diameter of right HC	3.17±1.07	23	0.163
	External hiatus diameter of left HC	3.17±1.02	23	
Pair 4	Right HC-occipital condyle posterior	11.17±2.34	23	0.002
	Left HC-occipital condyle posterior	11.69±2.68	23	
Pair 5	Right HC-occipital condyle anterior	6.91±2.52	23	0.000
	Left HC-occipital condyle anterior	6.95±2.43	23	
Pair 6	HC-occipital right condyle low border	8.95±4	23	0.000
	HC-occipital left condyle low border	8.95±3.99	23	
Pair 7	HC-foramen jugular (right internal)	9.93±3.06	16	0.000
	HC-foramen jugular (left internal)	10.56±3.42	16	
Pair 8	HC-foramen jugular (right external)	3.37±1.31	16	0.009
	HC-foramen jugular (left external)	3.81±1.93	16	
Pair 9	Right HC-basion	12.21±2.08	23	0.394
	Left HC-basion	12.69±1.57	23	
Pair 10	Right HC-opisthion	33.56±3.07	23	0.001
	Left HC-opisthion	34.21±2.57	23	
Pair 11	Right HC-carotid canal	11.88±2.57	17	0.008
	Left HC-carotid canal	11.58±2.71	17	
Pair 12	HC-jugular tubercle (right)	10.23±2.70	21	0.000
	HC-jugular tubercle (left)	10.85±3.35	21	

SD: Standard deviation, HC: Hypoglossal canal

**Table 4: Frequency of location of intracranial HC**

Location	Left frequency	Right frequency	Total (%)
Part 1	0	1	1 (2.17)
Part 2	7	2	9 (8.7)
Part 3	13	15	28 (60.86)
Part 4	3	5	8 (20)
Total	23	23	46 (100.0)

HC: Hypoglossal canal

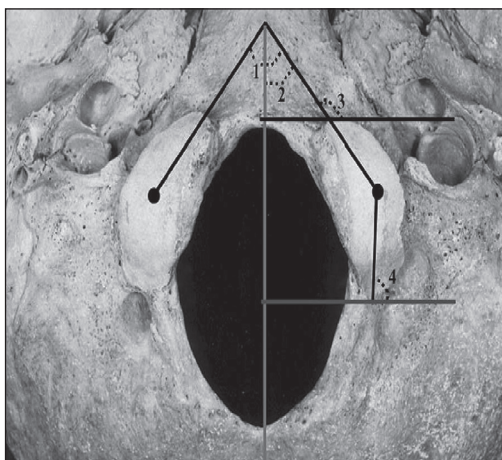
There was a significant difference between locations of right and left intracranial HC ( $P = 0.037$ ).

## DISCUSSION

Microsurgical anatomy is the foundation of neurosurgery. Studies on cadavers have been conducted to find the anatomical variability's of the HC.<sup>[3]</sup> The HC is a region of the skull base which is involved in many pathological entities that most often are ignored. Adequate knowledge of the anatomy of the HC and its related bony, neural, and vascular structures is essential for surgery of lesions involving this area. The canal is surrounded superiorly by the jugular tubercle, superolaterally by the jugular foramen, laterally by the sigmoid sinus and inferiorly by occipital condyle.<sup>[4]</sup>

The relation between occipital condyle and HC is important for the transcondylar approaches. As mentioned above, HC

is surrounded inferiorly by the occipital condyle. Intracranial orifice of HC is located medial to occipital condyle and extracranial orifice is located lateral to occipital condyle. The HC runs its way posteromedially and anterolaterally into the occipital condyle. In this study, the distance between HC and the posterior border of the occipital condyle is about  $11.43 \pm 2.51$  mm ( $P = 0.002$ ). There was a significant difference between right and left side. Avci *et al.* in their study showed that in 60 cases, right ( $n = 30$ ) and left ( $n = 30$ ), mean distance of HC till posterior border of occipital condyle according to anatomical measurement is 10.09 mm and  $P = 0.859$ , and no significant difference has been seen between right and left side.<sup>[5]</sup> Ozer *et al.* have reported that the distance between the HC and the posterior border of the occipital condyle is about 12.2 mm. That means the drilling bone 12 mm from the posterior border of the occipital condyle does not harm the HC.<sup>[6]</sup> In this study, the distance between HC and anterior tip of occipital condyle is about  $6.91 \pm 1.56$  mm totally, right range:  $6.69 \pm 1.98$  mm, left range:  $7.13 \pm 2.15$  mm. According to Naderi *et al.* the range of distance between HC and anterior tip of ipsilateral occipital condyle has been  $10.6 \pm 1.9$  in right and  $9.6 \pm 2.0$  mm in left.<sup>[7]</sup> All parameters measured by Naderi report are greater than this study. Detection of the location of the intracranial and extracranial orifices of the HC is an important step in surgical approaches. In this study, locations of the intracranial orifices of the HC in relation to the occipital condyle are present in location 1, 2, 3, and 4, respectively, 2.17%, 8.7%, 60.86%, and



**Figure 2: The depiction of measured angles: (1) Sagittal intercondylar angle and (2) anterior sagittal condylar angle. Sait Naderia**

20%. Fathi *et al.* found that the intracranial orifice of the HC was located principally at locations 4 and 5 with a total percentage of 65% (35% and 30%, respectively) and the other locations were less frequent, respectively.<sup>[8]</sup> Fathi *et al.* reports that the locations of the intracranial orifices of the HC in relation to the occipital condyle are present in location 1, 2, 3, 4, 5, 6, and 7, respectively, 10%, 16%, 35%, 30%, 18%, and 0%. It was found that the intracranial orifice of HC is present from location 2 to the location 6 with the maximum percentage for location 4 and 5. The total percentage for location 4 and 5 was 65% (35% +30%).<sup>[8]</sup> Wen *et al.* HT found the intracranial orifice in location 4 in more, than 55% of specimens, in the junction of second and third quarter of the HC.<sup>[9]</sup> This study revealed that the location of intracranial orifices of the HC might vary. The location of intracranial orifices of the HC is important during condylectomy.<sup>[10]</sup> Too dorsally located intracranial orifice of the HC may complicate and limit the condylectomy procedure.<sup>[11]</sup> To avoid hypoglossal nerve injury, the location of the HC should be determined in preoperative imaging stage. Furthermore, the direction and the location of the extracranial orifice of the HC should be also detected. We found anterior sagittal condylar angle 58.38° and sagittal intercondylar angle 69.86° in dry skulls [Figure 2] but, Naderi *et al.* reported the canal is directed ventrally and laterally at a 45° angle with the sagittal plane.<sup>[7]</sup> Several anatomical parameters such as shape, size, orientation of occipital condyle, and the location of HC should be taken into consideration during posterior and lateral approaches to the craniovertebral junction.<sup>[12,13]</sup> The determined variabilities

reported in this study require a careful radiological analysis of occipital HC before craniovertebral junction surgery. The major limitation of this study is the lack of knowledge regarding the age and gender of the subjects whose canal was studied.

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### Conflicts of interest

There are no conflicts of interest.

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