

## Quantitative Study on Some Aspect of Occipital Area in Domestic Cat (*Felis catus*)

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### ABSTRACT

This study was planned to investigate some aspects of the morphometric characteristics of the occipital bone and foramen magnum in domestic cat (*Felis catus*). Twenty adult domestic cat including 10 males and 10 female cats were euthanized using diazepam (@ 20 mg/kg) and their skulls were macerated to give morphometric parameters. Student t-test with level of significance set at 5% ( $p < 0.05$ ) was used to analyze the obtained values. The height of occipital triangle, width of occipital condyles, width of jugular process were significantly larger in male than female. The mean height and width of the foramen magnum were  $1.32 \pm 0.09$  cm and  $1.35 \pm 0.08$  cm, respectively, while the foramen index was below 100 at  $90.72 \pm 4.93$ . Parameters for the foramen magnum index showed significant difference between both sexes at  $p < 0.05$ . The foramen magnum showed shape variations and there were multiple hypoglossal foramina in over 80% of the cats. The morphometric values of the occipital bone and foramen magnum and clinical anatomy of the occipital region of the domestic cats provide an important baseline for further research in this field and could help in the better diagnosis, classification, and treatment of diseases related to this region and serve as a future reference defining an anatomic range.

**Key words:** morphometry, occipital bone, domestic cat, foramen magnum

### INTRODUCTION

The foramen magnum and the occipital bone have been the objects of scientific investigations because of their morphological variability and clinical importance<sup>[1, 2]</sup>. In humans and animals, anomalies of the foramen magnum and the occipital bone can lead to neurological signs<sup>[3, 4]</sup>. The foramen magnum is a fundamental component in the complex interaction of bony, ligamentous, and muscular structures composing the craniovertebral junction<sup>[5]</sup>. Configuration and size of the foramen magnum play an important role in the pathophysiology of various disorders of the craniovertebral junction<sup>[5, 6, 7]</sup>. The foramen magnum is an important landmark of the base of skull and is of particular interest to many fields of medicine<sup>[8]</sup>. Irregularities in the shape of the foramen magnum constitute a crucial problem in veterinary medicine. An irregularly formed foramen magnum can cause plenty of clinical symptoms, for example, convulsions, ataxias, prolapse of the brain to the medullary canal and occipital dysplasia<sup>[9, 10]</sup>. Variations of the shape of foramen magnum have got diagnostic, clinical and radiological importance<sup>[11]</sup>. The dimensions of foramen magnum have clinical importance because the vital structures that pass through it may suffer compression as in cases of foramen magnum achondroplasia<sup>[12]</sup> and foramen magnum brain herniation<sup>[13, 14]</sup>. In neurosurgical practice, the transcondylar approach is commonly used to access the lesions which are ventral to the brainstem and cervicomedullary junction. It was reported that understanding the bony anatomy of the condylar region is important for this approach<sup>[15]</sup>. Thus, a fundamental knowledge of normal

anatomy of this region is important to the clinician for diagnosis and treatment. The aim of our study was to find out various measurements of the occipital bone and foramen magnum of cat. These results could help in the better diagnosis, classification, and treatment of diseases related to this region and serve as a future reference defining an anatomic range.

### MATERIALS AND METHODS

A total of 20 adult native domestic cats (*Felis catus*) of both sexes, equal in number (2-3 years of age) were collected from local fish markets of Chittagong. The live animals were first selected during ante mortem examination based on parameters of apparent good health and no skeletal deformation. The animals were weighed with a standard bathroom scale and euthanized by injecting diazepam (20 mg/kg) in jugular vein. The heads were severed at the atlanto-occipital junction and processed in the Anatomy Laboratory of Chittagong Veterinary and Animal Sciences University using the hot water maceration techniques as described by Simoens et al.<sup>[16]</sup> which briefly were:

- On the working day, frozen cats head were allowed to thaw.
- Skin and most of the muscles were separated and eyes were enucleated.
- Heads were heated to over 80°C for at least 1 hour in solution of polycaboxylate and anionic surfactant [detergent] and soap chips.
- Muscle of boiled heads was separated with the aid of forceps and scalpel in running water.

- Further separation of muscles and ligaments from the skulls was done after left in detergent water at least 20-30 minutes.
- Separation of remaining muscles and ligaments from the skull was done after left in 1% sodium hypochlorite solution for at least 24 hours.
- After that, the skulls were left in the above solution, for 48-72 hours with solution, being changed at least twice and clean in running tap water.
- The skulls were then left to dry.

The following measurements were made as defined by Simoens *et al.* [16] and Onar *et al.* [17] (Fig. 1): major width of occipital condyles, the major width between the bases of the jugular processes, height of the occipital triangle length, major width of the foramen magnum and height of the foramen magnum. The foramen magnum index (height of the foramen magnum  $\times$  100/major width of the foramen magnum) was calculated [16, 17]. The difference between those osteometric indices in the two sexes of cats was evaluated using Student t-test with level of significance set at 5% ( $p < 0.05$ )

Table 1. Morphometric analysis of the occipital bone and foramen megnum of the cat

Measurements	Overall mean	Male	Female	P value
HOT*[cm]	2.42 $\pm$ 0.11	2.48 $\pm$ 0.09	2.37 $\pm$ 0.10	0.0171
HOW*[cm]	1.725 $\pm$ 0.25	1.83 $\pm$ 0.24	1.62 $\pm$ 0.23	0.0567
MOC*[cm]	2.08 $\pm$ 0.19	2.16 $\pm$ 0.20	1.99 $\pm$ 0.15	0.0446
MJP*[cm]	3.57 $\pm$ 0.28	3.70 $\pm$ 0.29	3.44 $\pm$ 0.20	0.0320
HFM [cm]	1.23 $\pm$ 0.09	1.19 $\pm$ 0.08	1.27 $\pm$ 0.09	1.0201
WFM[cm]	1.35 $\pm$ 0.08	1.37 $\pm$ 0.09	1.33 $\pm$ 0.06	0.9503
FMI*[%]	90.72 $\pm$ 4.93	86.98 $\pm$ 2.78	94.42 $\pm$ 3.52	0.0006

## RESULTS

Analysis of the dentition and skull sutures proved that all investigated domestic cats were adults. The occipital bone was well developed and its morphology was characteristic for cats.

There were significant differences in the measurements of the occipital bone between investigated males and females. The foramen magnum in all cats was typical in shape, without dorsal notch occurrence. The value of the osteometric data of the occipital bone and foramen magnum, as well as mean values and Standard deviations, are given in Table 1. The mean value of occipital triangle in male was 2.48 cm, in female, it was 2.37 cm. Height of occipital bone without foramen magnum in males and females were 1.83 cm and 1.62 cm, respectively. The mean value of major width of occipital condyle in males and females were 2.16 cm and 1.99 cm, respectively. The mean value

of major width of jugular process in male was 3.70 cm, in female, it was 3.44 cm. The height of occipital triangle, width of occipital condyles, widths of jugular process were significantly larger in male than female. The height and width of the foramen magnum were 1.23  $\pm$  0.09 cm, 1.35  $\pm$  0.08 cm respectively, while the foramen index was below 100 at 90.72  $\pm$  4.93 (Fig.1). The foramen magnum index was significant between both sexes at  $p < 0.05$ . The occurrence of multiple hypoglossal foramina was observed in 80% of the cats in this study ( $n = 16$ ). Side to side variation with respect to this feature was observed in this study with two hypoglossal foramina on the right side and a single one on the left in 55% ( $n = 11$ ), while 50% ( $n = 10$ ) were actually divided by a bony specule.

HOT = Height of occipital triangle; HOW = Height of occipital without foramen megnum; MOC = Major width of occipital condyle; MJP = Major width of jugular process; HFM = Height of foramen magnum; WFM = Width of foramen magnum; FMI = foramen magnum index; Values presented as mean  $\pm$  SE for 20 cats (10 male and 10 female cats); \*the values differed significantly between the two sexes at  $p < 0.05$ .

The normal build of the occipital bone and foramen magnum plays a significant role in correct cerebrospinal fluid (CSF) circulation. The obstruction of cerebrospinal fluid can result in the development of syringomyelia, fluid-containing cavities that develop in the spinal cord. In veterinary medicine, the most common cause of syringomyelia is occipital bone hypoplasia [18]. A dorsal notch (occipital dysplasia) was not observed in any investigated skull of cat. However, occipital dysplasia was observed in some dogs [17,19] and African giant rat [20] which may be physiologic [19] or pathologic [4] in animal. The height of occipital triangle, width of occipital condyles, width of jugular process were significantly larger in male than female which indicate the skull of male was larger than female cat. Comparatively, the skull of cat was larger than African rat [20], rabbit [21] and smaller than dog [17,19]. Variability of skull shape and size related to species.

The mean foramen magnum width and height were 1.35 cm and 1.23 cm, respectively. Comparatively, these values in domestic cats were higher than rabbit<sup>[21]</sup>, mole rat<sup>[22]</sup> and African giant rat<sup>[20]</sup> but lower than dog<sup>[23]</sup>. The foramen magnum index of the domestic cat was 90.72 which was almost similar to that of the mole rat<sup>[22]</sup> and perkingese dog<sup>[24]</sup> and higher than the rabbit<sup>[21]</sup> and African giant rat<sup>[20]</sup>, where the foramen magna were relatively wide. However, the foramen magnum index was relatively higher in the West African Dwarf goat<sup>[25]</sup> and American Staffordshire terrier newborns<sup>[26]</sup>. These above analysis proved that the foramen magnum had large size variability and was related to animal age and species. The foramen magnum width was significantly greater in the male than in the female in our study, although it is speculative whether this translates to the morphometry of the contained spinal cord and meninges. Various authors have stated that irregularities in the shape of the foramen magnum constitute a crucial problem in Veterinary Medicine and can cause a variety of clinical symptoms, for example, convulsions, ataxias, prolapse of the brain to the medullary canal, and occipital dysplasia<sup>[27,28]</sup>. However, Janeczek *et al.*<sup>[23]</sup> considered it an ancient characteristic which is compatible with longevity and the absence of major pathology. However, this occurrence needs be verified to ascertain its effect in the domestic cat.

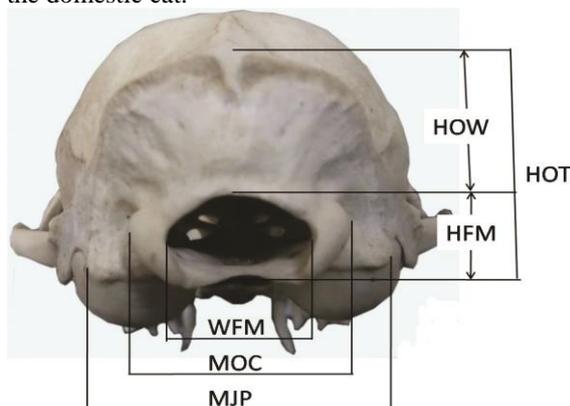


Figure 1. Morphometric measurements of occipital bone and foramen megnum: HOT = Height of occipital triangle; HOW = Height of occipital without foramen megnum; MOC = Major width of occipital condyle; MJP = Major width of jugular process; HFM = Height of foramen magnum; WFM = Width of foramen magnum

A recent study on humans and other mammalian species<sup>[29]</sup> revealed double hypoglossal canals in 43% of cases. In the same study, 28.12% of cases had the hypoglossal canal divided in two by a small bony spicule. The doubling of the hypoglossal canal by a bony spicule is not a rare phenomenon<sup>[30]</sup>. Fifty percent of the cats in this study had the canal divided by a bony spicule. The clinical significance of this has been attached to the variations in the hypoglossal foramen in humans, and knowledge of this anatomical variation could be important for various fields of medicine<sup>[31,32]</sup>.

## CONCLUSION

The morphometric values of the occipital bone and foramen magnum and clinical anatomy of the occipital region of the domestic cats provide an important baseline for further research in this field. Furthermore, these results could help in the better diagnosis, classification, and treatment of diseases related to this region and serve as a future reference defining an anatomic range.

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