FUDMA Journal of Agriculture and Agricultural Technology
ISSN: 2504-9496
Vol. 8 No. 1, June 2022: Pp.227-231

https://doi.org/10.33003/jaat.2022.0801.088

MORPHOLOGY AND MORPHOMETRY OF THE FORAMEN MAGNUM IN SELECTED NIGERIAN LOCAL BREED DOGS

***[1]Danmaigoro A., and [1,2]Mahmud, M. A.**

[1]*Department of Veterinary Anatomy, Faculty of Veterinary Medicine, Usmanu Danfodiyo University, P.M.B. 2346, Sokoto*
[2]*Department of Animal Health and Production Technology, Niger State College of Agriculture, P.M.B. 109, Mokwa, Niger State, Nigeria*
*Corresponding author: abubakar.danmaigoro@udusok.edu.ng Tel:- +234 803 791 4241

ABSTRACT

The purpose of this study was to evaluate the morphology and morphometry of the foramen magnum of Nigeria local breed of dogs, in order to characterize the morphological features of the foramen magnum which will help in critical analysis of the occipital dysplasia. Occipital dysplasia is associated with dorsal enlargement of the foramen magnum which varies with the structural geometry. The size and shape of the foramen magnum predisposed dogs of different breed to the condition This study provides database indices for the foramen magnum of the Nigeria local dogs, since the knowledge of skull anatomy and morphometry is crucial to the diagnosis and management of some bony disorder. The assessment was done using Vernier caliper, in which from antero-posterio diameter, transverse diameter was assess. The shape of the foramen magnum (FM) was determined according to FM index that was calculated by dividing antero-posterior diameter by transverse diameter. Base on the foramen magnum geometry and morphology, it was possible to classify foramen magnum into different shapes varying from oval and quadrangular with a shallow dorsal notch observed in all the dogs. Of the 30 dogs, 12 (40%) dogs had a dorsal enlargement and 18 (60%) showed normal foramen magnum. This study will provide baseline data on foramen magnum shape, morphometry and variations that occurs in dogs with its application in veterinary forensic medicine and in neurosurgery and anesthesiology.

Key words: Foramen magnum, Occipital bone, Dysplasia, Nigerian local breed dog

INTRODUCTION

Occipital dysplasia is featured by a dorsal midline notch of the foramen magnum into the occipital bone of the skull, which are geometrically and morphologically different in shape and size in assorted breed of the dogs (Janeczek *et al*., 2008). Dog is one of the earlier domesticated animal world-wide (Driscoll *et al*., 2009). However, many years of selective breeding has led to the numerous morphological diversities among different breed of dogs (Driscoll *et al*., 2009). In the recent years, the study of different morphological structure of the skull of the dogs has been elucidated by several scholar in order to document variations in the breed morphology. Nigeria local dogs are characterized by long head (Driscoll *et al.*, 2009). It is the result of the incomplete ossification of the ventromedial part of the supraoccipital bone (Cagle, 2010). Nevertheless, the dorsal notch in the foramen magnum was observed in small-size brachycephalic races (Onar *et al*., 2013). This situation has not been reported in Nigeria local breed of dogs, even though the cranio-metric measurements abounds (Schenecbeck *et al.*, 2013). The irregularities with the shape and size of the foramen magnum and the occipital condyles constitutes a crucial problem in veterinary medicine and human medicine (Girgiri *et al.*, 2015). The foramen magnum can have many shapes: oval (Zdilla *et al*., 1994), rectangular (Zdilla *et al*., 2017) and, in the brachycephalic skulls, can be circular and asymmetric (Zdilla *et al*., 2017). The foramen magnum region of the cranial base consists of the foramen magnum and the laterally placed occipital condyles for articulation with the superior facets of the first cervical vertebra. This region of the skull is covered by a large volume of soft tissue. Hence, the foramen magnum region is in a relatively well-protected anatomical position. The transverse diameter is often larger though equal with vertical diameter in some breeds (Nahkur *et al*., 2011). Occipital bone ataxias, convulsion, prolapse in the brain medullary canal and occipital dystaplasia which causes are unknown, although common in brachycephalic breed of dogs, but also encountered in dolichocephalic breeds of dogs (Fawcett *et al.*, 2019). Some animals have a membranous tissue on the dorsal enlargement covering the caudal portion of the cerebellum (Cantile and Youssef 2016) which may prevent the prolapse of cerebellum or brain stem (Watson *et al*., 1989). The clinical importance of occipital dysplasia is uncertain, because the animals may be asymptomatic and it is rarely associated with neurologic complications (Panayiotopoulos, 2005). Despite its forensic potential in the identification of skeletal remains, only a few morphometric studies of the foramen magnum region have been published so far in dogs. The morphometry of the foramen magnum region is studied both by dry skull measurements, radiography and computed

tomographic measurements (Citardi *et al*., 2001). The conventional methods of reporting dry skull measurements include the use of calipers and calibrated paper strips. In recent times, dry skull measurements involve the use of digital calipers (Citardi *et al.*, 2001). The purpose of this study was to morphologically evaluate the foramen magnum in Nigeria local breed of dogs. The study was on Nigerian local breed of dogs, with dynamic growth in population in Nigeria and to compare it, on the basis of literature, with the foramen magnum of modern breeds dogs. Since, genetic selection through domestication of dogs resulted in the phenotypic variations in the canine breeds, Thus, archaelogical and archaeo-zoological sources clearly indicate the morphological variation which need to be understood. This study is planned to detailed the morphological indices of foramen magnum in Nigeria local dog breed. This study will provide baseline data on foramen magnum shape and morphometry and also find its application in veterinary forensic medicine and applied anatomy specifically in neurosurgery.

MATERIALS AND METHODS

In this study, a total of 30 adult asymptomatic dogs, 15 Male and 15 Female skull of Nigeria local breed of dogs were selected, following individual analysis protocols that included identification. 15 of dogs were positioned and tranquilized with acepromazine (0,1mg kg-1, i.m.) and meperidine (4,0mg kg-1, i.m.) (Kropf and Hughes, 2018). The skin and muscles were dissected from the skulls and the bone were boiled in water and the skull were macerated in accordance to the method of Onuwuama *et al*. (2012). Rostrocaudal projection was chosen to observe the foramen magnum, with the dogs in dorsal decumbency, however, the remaining 15 skull bone were collected from the bone of gross anatomical laboratory, Faculty of Veterinary Medicine, Usmanu Danfodiyo University Sokoto. None of the examined skulls showed signs of prior crania-dissection, malformation, or trauma, and they were photographed with Canon Camera (EOS 850D, China). To analyze the morphometry some variables were checked: height (h), height of dorsal notch (N), total height (H=N+h), and width (W) (Al-Gunaid, 2020) (Figure 1). The shapes of the foramen magnum were all determined according to foramen magnum measurement and index that was calculated by dividing anterior-posterior diameter by transverse diameter of the foramen magnum. If the foramen magnum index is greater than or equal to 1.2, the foramen is accepted to be oval in shape. Whereas when the foramen magnum index is less than 1.2, the foramen is regarded round in shape. For that, the radiographic images were imported into AutoCAD program (AutoCAD, 2006), the perimeters of foramen were re-designed manually with the area of the foramen calculated.

Gross Morphometry

Five parameters related to the foramen magnum, namely length of the right occipital condyle (LROC), length of the left occipital condyle (LLOC), width of the foramen magnum (WFM), area of the foramen magnum (AFM) and length of the foramen magnum (LFM). Maximum width of the foramen magnum, Height of the foramen magnum (basion-opisthion). The shape of the FM was determined according to FM index that was calculated by dividing antero-posterior diameter by transverse diameter.

The height and width of the foramen magnum were measured and its index was calculated (width/height × 100) (Figure. 3). The height of the skull was measured (Figure. 4). The maximum width and maximum height of the condylioccipitalis was measured (Figure 3). Each measurement was repeated three times. The measurements were carried out with the aid of an electronic slide caliper (Sylvac 110-DL India) with 0.1 mm accuracy

$$\textbf{Foramen magnum index} = \frac{\text{Height of the foramen magnum}}{\text{Maximum width of the foramen magnum}} \times 100$$

The difference between the foramen magnum indices in the two groups of dogs was evaluated using student-t test. The examinations were carried out on fourteen skulls of American staff ordshire terrier pups (7 females and 7 males). The pups were of four litters and different parents whose parentage was documented. The pups were one day old. Their heads were macerated and then anatomically prepared with the aid of a magnifying glass. The height and width of the foramen magnum were measured and its index was calculated (width/height × 100) (Figure. 3). The height of the skull was measured (Figure. 4). The maximum width and maximum height of the condylioccipitalis was measured (Figure. 3). Each measurement was repeated three times. The measurements were carried out with the aid of an electronic slide caliper Sylvac 110-DL with 0.1 mm accuracy.

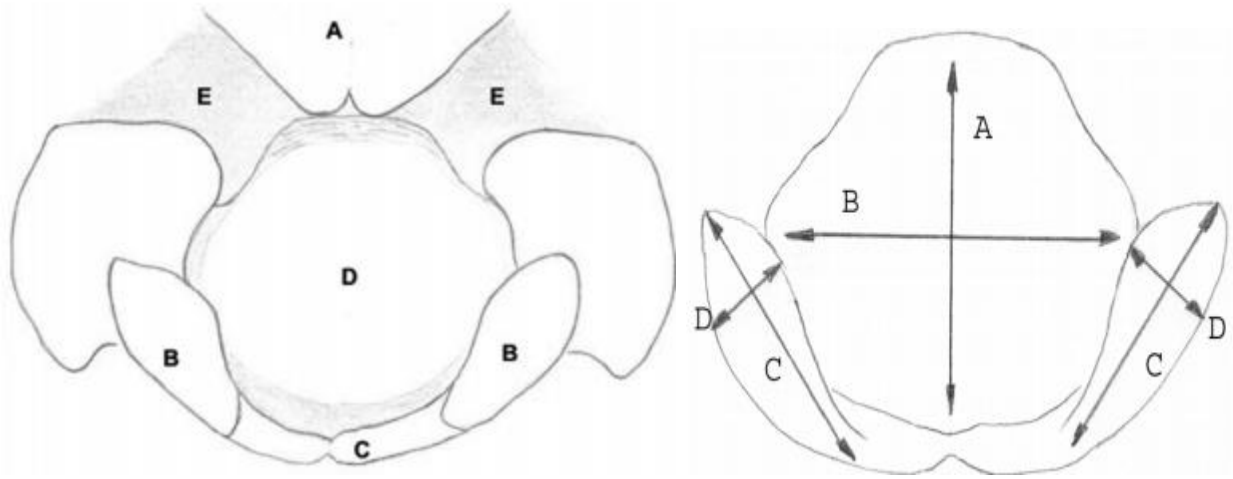

Figure 1. a: Morphology of the foramen magnum and it parts A squamous part (supraoccipital), B lateral part (exoccipital), C basiliar part (basioccipital), D foramen magnum, E synchondrosis.

b. The length of the right occipital condyle (LROC), length of the left occipital condyle (LLOC), width of the foramen magnum (WFM), area of the foramen magnum (AFM) and length of the foramen magnum (LFM) Maximum width of the foramen magnum, Height of the foramen magnum (*basion-opisthion*).

RESULTS

Analysis of the Shape of the Foramen Magnum

The characteristics of the shape vary with the foramen magnum index. The two major shapes of foramen magnum were 22 dogs with oval shape, and 5 dogs presented round shape foramen magnum and 3 dogs presenting a pentagonal shape foramen as shown on Plate 1 and Table 1.

Plate 1: Qualitative description of Foramen Magnum in local breed of Dogs

The foramen magnum observed in all the dogs evaluated with an oval to round shape were found between the occipital's squam and basal part of the occipitals. The Cranio-metric results are presented in the Table 2 below, reveals that the width of the foramen magnum is higher than its height in all the dogs. The average anterior posterior diameter of the dogs was 22.3±1.3 mm, while the transverse diameter was 17.3 ± 2.3 mm, with height, width and height of the skull recorded as 5.86 ± 0.42 mm, 6.23 ± 1.10 mm and 15.0 ± 0.35 mm. respectively. However, average height and width of the occipital condyle were 4.20 ± 0.20 mm and 2.33 ± 0.30 mm. respectively as shown on Table 2.

Table 1: Qualitative Description of the Foramen Magnum Shape in Local Breed of Dogs

Shapes	Oval	Rounded	Pentagon
Number of Foramen Magnum	22	5	3

Table 2: Descriptive Results of the Examined Foramen Magnums

Parameters	Mean± SD
AP diameter (mm)	22.3 ± 1.30
TD (mm)	17.23 ± 2.30
Height of the foramen magnum (mm)	5.86 ± 0.42
Width of the foramen magnum (mm)	6.23 ± 1.10
Height of the skull (mm)	15.0 ± 0.35
Average height of the occipital condyle (mm)	4.20 ± 0.20
Average width of the occipital condyle (mm)	2.33 ± 0.30

Key: AP, antero-posterior; TD, transverse diameter ;mm, Millimeter; SD, Standard Deviation

DISCUSSION

The evaluation of foremen magnum morphology was done on euthanized dogs since only macerated skill give reliable assessment of the morphology of the foramen magnum, which is reported to have regular to ellipsoidal shape, bounded by the occipital squama, occipitalis lateralis, and occipital bases (Simoens *et al*., 1994). The width of the foremen is usually greater than the diameter although, in contrary to the finding of Zdilla *et al.* (2017), who reported higher height than width diameter on foramen magnum. However, the difference observed in their work were not statistically significant by sex in dogs. The shape and foramen magnum index did not change with body weight of the dogs in this study which was similar to the report of the foramen magnum index puppies (Zdila *et al*., 2017). Zdilla *et al.* (2017) reported that there was a positive correlation between the mean width and height of the foramen magnum and the occipital condyle and jugular processes of the occipital bone. The irregularity observed on the foramen magnum is very rare in small animal but serve of the major reason of Chiari's syndrome due to underdevelopment and shape irregularity in human (Bosemani *et al*., 2015). However, in the dog's dorsal notch abrasion is very rare since numerous occipital foramina are observed on the occipital squama, although dorsal notch were observed in 33 dogs in the works of Janeczek *et al*. (2008), and in the works of Simoens *et al*. (1994) where some cases of dorsal notch in the Pekingese was reported. Janeczek *et al*., (2008) reported that all dorsal notch in the dogs should be considered as variation not as anomaly. Although, dorsal notch was not evaluated in this work. The shape of the foramen magnum was only evaluated to the level of the lower border of the dorsal notch. It is emphasized that in evaluating shape and size of foramen magnum in breed of dogs conditioning could account for some difference that might occur. However, studies have shown that the presence of the dorsal notch in the beagle dogs could be as a result of abrasion as it not usually part of the morphological structure of the foramen magnum but as an abnormality although, the attribute to its appearance is unknown (Janeczek *et al*., 2008). Even though, endocrine system plays a vital role in the formation of the foramen magnum. The absence of the dorsal notch in the beagle dogs could have strengthen the occipital bone from avulsion dislocation at the atlanto-occipital joint. It was further deduced that foramen magnum size and age of the dogs are not correlated as reported by Knowler *et al*. (2018). Morphologically, dorsal notch of the foramen magnum in most breed of dogs lacks of ossification of the ventromedial part of the supra-occipital one (Knowler *et al.*, 2018).

The average total height, width and area of the foramen magnum were lower when compared to than that of Toy Poodle (Baroni *et al*. 2011) Total height of foramen magnum was divided by width and this measurement demonstrated the contribution of the total height in the variability of its aspects. The subjective analyses of the foramen magnum were difficult radiographically, so procedures are important in order to establish the size of the foramen magnum and the final radiographic diagnosis in different breeds of dogs. Though, the dogs used in these studies were free from neurologic signs, the grading classification doesn't seem to have connection with clinical signs.

CONCLUSION

Base on the foramen magnum geometry and morphology, it was possible to classify foramen magnum into different shapes varying from oval to quadrangular with a shallow dorsal notch observed in all the dogs. Twelve (40%) dogs had a dorsal enlargement and 18 (60%) showed normal foramen magnum. This study will provide baseline data on foramen magnum shape, morphometry and variations that occurs in local breed of dogs and may also find its application in veterinary forensic medicine and applied anatomy specifically in neurosurgery and anesthesiology,

Ethical approval

The research was approved by Institutional Animal Care and Use Committee of Usmanu Danfodiyo University, Sokoto, Nigeria. IACUC/UDUS/AUP20-RO04.

Conflicts of Interests

The authors have no conflicts of interests to declare.

Acknowledgements

We would like to thank the Gross Laboratory and Radiology Unit, Department of Veterinary Anatomy & Department of Surgery and Radiology, Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto, for their technical support in the laboratory

REFERENCES

Al-Gunaid, T. H. (2020). Sex-related variation in the dimensions of the mandibular ramus and its relationship with lower third molar impaction. *Journal of Taibah University Medical Sciences*, *15*(4), 298-304.

Baroni, C. O., Pinto, A. C., Matera, J. M., Chamone, C. M. K., & Hayashi, A. M. (2011). Morphology and morphometry of the foramen magnum in Toy Poodle and Yorkshire terrier dogs. *Ciência Rural*, *41*, 1239-1244.

Bosemani, T., Orman, G., Boltshauser, E., Tekes, A., Huisman, T. A., & Poretti, A. (2015). Congenital abnormalities of the posterior fossa. *Radiographics*, *35*(1), 200-220.

Cagle L. (2010). Concurrent occipital hypoplasia, occipital dysplasia, syringohydromyelia, and hydrocephalus in a Yorkshire terrier. *The Canadian Veterinary Journal La revue Veterinairecanadienne*, *51*(8), 904–908.

Citardi, M. J., Herrmann, B., Hollenbeak, C. S., Stack, B. C., Cooper, M., & Bucholz, R. D. (2001). Comparison of scientific calipers and computer-enabled CT review for the measurement of skull base and craniomaxillofacial dimensions. *Skull Base*, *11*(1), 005-012.

Driscoll, C. A., Macdonald, D. W., & O'Brien, S. J. (2009). From wild animals to domestic pets, an evolutionary view of domestication. *Proceedings of the National Academy of Sciences*, *106* (1), 9971-9978.

Cantile C, Youssef S. (2016) Nervous System. Jubb, Kennedy & Palmer's In: *Pathology of Domestic Animals*: *1* :250–406

Fawcett, A., Barrs, V., Awad, M., Child, G., Brunel, L., Mooney, E., & McGreevy, P. (2019). Consequences and management of canine brachycephaly in veterinary practice: perspectives from Australian veterinarians and veterinary specialists. *Animals*, *9*(1), 3.

Girgiri, I., Olopade, J. O., & Yahaya, A. (2015). Morphometrics of foramen magnum in African four-toed hedgehog (Atelerixalbiventris). *Folia morphologica*, *74*(2), 188-191.

Janeczek M, Chrószcz A, Onar V, Pazvant G, Pospieszny N. (2008). Morphological analysis of the foramen magnum of dogs from the Iron Age. *Anatomia, Histologia, Embryologia 37*(5):359-61.

Knowler, S. P., Galea, G. L., & Rusbridge, C. (2018). Morphogenesis of canine chiari malformation and secondary syringomyelia: disorders of cerebrospinal fluid circulation. *Frontiers in Veterinary Science*, *5*, 171.

Kupczyńska, M., Czubaj, N., Barszcz, K., Sokołowski, W., Czopowicz, M., Purzyc, H., & Kiełbowicz, Z. (2017). Prevalence of dorsal notch and variations in the foramen magnum shape in dogs of different breeds and morphotypes. *Biologia*, *72*(2), 230-237.

Nahkur, E., Ernits, E., Jalakas, M., & Järv, E. (2011). Morphological characteristics of pelves of Estonian Holstein and Estonian native breed cows from the perspective of calving. *Anatomia, Histologia, Embryologia*, *40*(5), 379-388.

Onwuama, K. T., Salami, S. O., Ali, M., & Nzalak, J. O. (2012). Effect of Different Methods of Bone Preparation on the Skeleton of the African Giant Pouched Rat (*Cricetomys gambianus*). *International Journal of Morphology*, *30*(2). 425 – 427.

Onar, V., Pazvant, G., Ince, N. G., Alpak, H., Janeczek, M., & Kızıltan, Z. (2013). Morphometric analysis of the foramen magnum of byzantine dogs excavated in Istanbul Yenikapi at the site of theodosius harbour. *Mediterranean Archaeology & Archaeometry*, *13*(1). 135 – 142.

Panayiotopoulos, C. (2005). Symptomatic and probably symptomatic focal epilepsies: Topographical symptomatology and classification. *The epilepsies: Blandon Medical Publishing, Oxfordshire (UK)*. PMID: 20821848

Schoenebeck, J. J., & Ostrander, E. A. (2013). The genetics of canine skull shape variation. *Genetics*, *193*(2), 317-325.

Simoens, P., Poels, P., & Lauwers, H. (1994). Morphometric analysis of the foramen magnum in Pekingese dogs. *American Journal of Veterinary Research*, *55*(1), 34-39.

Watson, A. D., De Lahunta, A., & Evans, H. E. (1989). Dorsal notch of foramen magnum due to incomplete ossification of supraoccipital bone in dogs. *Journal of Small Animal Practice*, *30*(12), 666-673.

Zdilla, M. J., Russell, M. L., Bliss, K. N., Mangus, K. R., & Koons, A. W. (2017). The size and shape of the foramen magnum in man. *Journal of Craniovertebral Junction & Spine*, *8*(3), 205.