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Comparative Anatomical Study of the Foramen Magnum of Yankasa Sheep, in Sokoto State: Morphometric Study in Nigeria

Bello A[1]*, Zahraddeen Abubakar[1], Shehu SA[1,5], Sonfada ML[1], Baraya YS[2], Suleiman HM[3], Umar AA[1], Danmaigoro A[1], Dange AI4, Ali MN[3] and Liman YM[4]

[1]*Department of Veterinary Anatomy, Usmanu Danfodiyo University, Sokoto, Nigeria*

[2]*Department of veterinary Pathology, Usmanu Danfodiyo University, Sokoto, Nigeria*

[3]*Department of Veterinary Anatomy, Ahmadu Bello University, Zaria, Nigeria*

[4]*Sokoto State veterinary clinic, Sokoto, Nigeria*

[5]*Department of Veterinary Anatomy, Bayaro University, Kano, Nigeria*

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***Corresponding author:** Bello A, Department of Veterinary Anatomy, Usmanu Danfodiyo University, Sokoto, Nigeria
Email: abccrcfge28@gmail.com

Abtract

This study was conducted in the Veterinary Anatomy Laboratory of Usmanu Danfodiyo University, Sokoto. The aim of this research was to determine dimensions of foramen magnum, occipital condyles, morphometric asymmetry between right and left condyles with respect to foramen magnum age wise. The foramen magnum is the biggest natural foramen of the neurocranium. It is located within occipital bone and connects the posterior cranial fossa with the vertebral canal (base of the skull). The structures are surrounded by various parts of occipital bone. The measurements are helpful for neurosurgeons for performing lateral transcondylar surgical approaches for reaching lesions in the middle and posterior parts of the cranial base, it is also used by radiologist to diagnose craniovertebral abnormalities. Results base on shape and age were shown to have change in shape from pentagonal at 0-6months to hexagonal and egg shape at 1-3 years in relation to sex of the sheep as shown in (Table 1). The variation in the shape with sex of the foramen magnum from tetragonal, egg, hexagonal, round shapes to oval in shape is as shown in (Table 1). The mean and standard error of mean of Yankasa sheep skull bone biometry values were determined. The mean of antero-posterior diameter of foramen magnum (ADPFM) of group 1- 5 were found to be 2.21±0.40, 2.27±0.31, 2.28±0.28, 2.34±0.22 and 2.40±0.16 respectively, and all there were significant difference with all the groups with increase in age.

Keywords: Morphometry; Anatomy; Skulls; Foramen magnum; Occipital bone; Yankasa; sheep; Sokoto state

Abbreviations: ADPFM: Antero-Posterior Diameter of Foramen Magnum; TDFM: Transverse Diameter of Foramen Magnum; AID: Anterior Intercondylar Distance; PID: posterior intercondylar distance; LOC: Length of Occipital Condyle; FMI: Foramen Magnum Index; CI: Condylar Index; TOC: Thickness of Occipital Condyle; EMD: External Mastoid Distance; IMD: Internal Mastoid Distance; HFM: Height of Foramen Magnum; WFM: Width of Foramen Magnum; TD: Transverse Diameter

Introduction

The Yankasa is a meat breed found in North and North central Nigeria. They are thought to cross with the West African Dwarf. The breed is White with black nose and black Patches around the eyes. They are polled or have small horns and semi-loop ears. Rams are usually named [1].

The occipital bone can be described as being perforated by the foramen magnum with the squamous part behind the foramen, the condylar parts lateral and the basilar part in front and carries a great importance in the performance of far lateral approaches due to its localization and the foramina of this region. The anterolateral aspect of the foramen magnum is one of the deepest and most complex areas of the skull base. Exposure of intra- or extra-dural lesions involving the foramen magnum and brainstem poses a significant surgical challenge for neurosurgeons since the foramen magnum is covered by thick bony prominences where many cranial nerves or vascular structures pass through.

The base of the cranium is an important anatomical structure of great importance to study especially for neurosurgeons, orthopedics and radiologists. The foramen magnum is a big hole localized in the posterior part of the cranial base formed by the occipital bone. The lower end of medulla oblongata the vertebral arteries and the spinal accessory nerves pass through it [2]. The surgical and clinical importance of foramen magnum is related possibility of compression of this vital structure in case of foramen magnum herniation, foramen magnum meningioma's and foramen magnum achondroplacia [3]. There are some differences in the sizes of the skull bones and foramen magnum between different ages of sheep [4]. It appears that foramen magnum can be helpful in gender and age determination.

In various recently published papers, the foramen is divided into anterior (ventral) and posterior (dorsal) parts [5-7]. The anterior one includes skeleto-motor structures that are important for movement and stabilization of the skull mainly on the level of atlanto-occipital and atlanto-axial joints. It is surrounded by the anterolateral border of the foramen (extending to a line between the bilaterally located anterior intraoccipital synchondroses) and contains the dens of the axis as well as various ligaments-the anterior longitudinal (tectorial membrane), apical, cruciform, alar, and anterior atlanto-occipital membrane. The posterior part (so-called proper foramen magnum) is less involved in head motions since is crossed by various neurovascular structures. It is surrounded by the posterior edge of the foramen magnum and contains the spinal cord (medulla oblongata depends on origin of the first cervical spinal nerves), meninges and subarachnoid space, posterior atlanto-occipital membrane, spinal nerve; known as spinal accessory nerve), lower part of the basilar plexus, marginal sinuses, as well as vertebral, posterior and anterior spinal arteries [8].

Craniovertebral junction refers to the occipital bone that surrounds foramen magnum, atlas and axis vertebrae [9]. Abnormalities of this area can be classified as congenital, developmental, acquired, traumatic, tumors, inflammatory, occurring either alone or in combination. Distance between anatomic landmarks and the sites where a number of vital structures have their entrance or exits are very important for clinical application. One has to be familiar with the anatomical structure of foramen magnum region and the probable variations of the structures in order to achieve the appropriate exposures with the best surgical outcome. A reliable and exact radiological diagnosis require knowledge of the morphologic features of variations and the appearance of the characteristic features in common radiologic procedure. Narrowing as well as widening of foramen magnum is important. The stenosis of the craniovertebral canal may result from congenital underdevelopment or deformity of the skull base. Foramen magnum is small in all individuals with achondroplacia. This is because of markedly diminished growth as a result of abnormal endochondral bone growth and premature fusion of the synchondrosis.

The measurements are helpful for neurosurgeons for performing lateral transcondylar surgical approaches for reaching lesions in the middle and posterior part of cranial base. Therefore, the assessment of morphometrics of foramen magnum and occipital condyle is essential [9]. Knowledge of condylar anatomy helps the surgeon in making important decisions regarding the extent and direction of condylar drilling and minimizing injury and retraction of neural structures [10]. Condylar drilling is an important step in the transcondylar extension of the far lateral approach [11].

Craniovertebral abnormalities have been recorded for many years in morphological and clinico-radiological studies [12]. Anomalies of Cranio-vertebral junction are of interest not only to an anatomist but also to the clinicians because many of these deformities produce clinical symptoms. The occipital bone is the main site of these variations [13]. Abnormalities of this area can be classified as congenital, developmental, acquired, traumatic, tumors, inflammatory, occurring either alone or in combination. Understanding the pathology of these abnormalities and their treatment is simplified if one has the knowledge of bony anatomy, biomechanics, and embryology of this region. To estimate the variation in types and parameters of the foramen magnum (sagittal diameter, transverse diameter, and surface area) and to compare the difference in the parameters of foramen magnum of different age of Yankasa sheep.

The aim of this study is to evaluate the morphology and morphometry of the foramen magnum in yankasa breed of sheep (Ovis aries) while the objectives of the study are,

a) To analyze foramen magnum and occipital condyles morphometrically.

b) To find morphometric asymmetry between right and left occipital condyles.

c) To find the position of occipital condyles with respect to foramen magnum

Materials and Methods

Study area

The study was carried out at the Department of Veterinary anatomy Laboratory of Usmanu Danfodiyo University Sokoto, Sokoto State, Nigeria. The State is located in the North-West political zone of Nigeria. The National Population Commission reported that the State is between longitude 4°8E and 6°54E, and latitude 12°N and 13°58N. The State is bordered by Niger republic to the north, Kebbi state to the west and Zamfara state to the East [14]. The State is made up of 23 Local Government Areas. The State has a total land area of 25,937 square kilometers, with an estimated population of 3,696,999 people [14]. With an estimated population of 3,696,999 people [14]. The vegetation is characterized by tree plantation both within and on the outskirts of Sokoto town, with tolerant shrubs and shorts grasses [15] (Figure 1).

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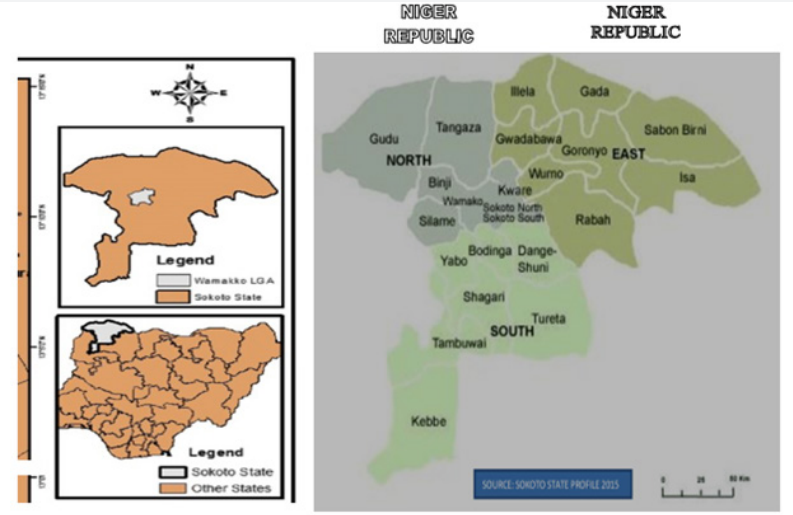

Figure 1: Map of Nigeria Sokoto State Showing the study area.

Study design

A cross sectional study design was employed. Purposive sampling (Nonprobability sampling) was applied in this study. The fresh heads from slaughtered Yankasa sheep were picked based on the familiar breed characteristics, good health, and absence of skeletal abnormalities [16].

Twenty-seven (27) sheep recognised as Yankasa sheep aged 0-6months, 6months-1year, 1-2years, 2-3years and 3years and above were collected from Sokoto modern abattoir. The sheep were selected based on apparent good health of animals noting characteristics such as absence of congenital deformities, scars, or trauma on the skulls (heads) [16]. The sampling was arranged according to age, the age was estimated on the basis of the eruption of the permanent teeth as a guide [17]. Following slaughter, samples were severed at the occipito-atlantal joint, and placed in clean polytene bags according to their age. The heads were later processed for morphometric analysis in the anatomy laboratory of the Faculty of Veterinary Medicine at Usmanu Danfodiyo University Sokoto, Sokoto State, Nigeria.

Estimation of age

The ages were estimated using the dental eruption, wear and tear as mentioned by [17].

Sex determination

The sex of the sheep was determined using the presence or absence of horn.

Sample processing

a) Maceration of the Sheep Heads

The hot water maceration techniques as explained by [18] were used in this study. The skin and most of the muscles were separated and eyes were enucleated using knives and scalpel blades from the fresh heads. Samples were heated at over 80°C for 1 hour in solution of polycarboxylate and anionic surfactant (detergent). Muscles of boiled heads were separated with the aid of forceps and scalpel in water following boiling. The boiled heads were left to stand in the detergent water for 30 minutes after which the separation of remaining muscles and ligaments of the heads was done. The heads were then rinsed in clean water [16].

b) Drying of Heads (Skulls)

The heads were sun-dried on the first day but transferred to the anatomy laboratory for completion of the drying process for three (3) days.

c) Gross Anatomy

The shape, size, location/position, contents and relations of the foramen magnums were observed and recorded.

d) Biometry

The sheep were slaughtered and dissected with the purpose of teaching. The heads used for research were removed, the position, location and relations were observed, and various biometric measurements were taken systematically according to the five age categories at the same time. These parameters includes

i. Anteroposterior diameter of foramen magnum: The diameter of the foramen magnum was measured using vernier caliper in millimeter.

ii. Transverse diameter of foramen magnum: The transverse diameter of the foramen magnum was measured using vernier caliper in millimeter.

iii. Anterior intercondylar distance: The distance between anterior intercondyles was measured using tape line.

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iv. Posterior intercondylar distance: distance between posterior tips of right and left occipital condyles was measured using tape line.

v. The length of occipital condyle: The length was measured with tape line.

vi. The width of occipital condyle: maximum distance measured at the right angles to the line joining its anterior and posterior tip using ruler.

vii. Foramen magnum index is calculated by dividing anteroposterior diameter of foramen magnum with transverse diameter of foramen magnum.

viii. Condylar index is calculated for right and left occipital condyle respectively by dividing length of occipital condyle with the width of occipital condyle.

ix. The height (Height of the foramen magnum): Distance between the midpoints of the dorsal and ventral rims of the foramen magnum using tape line.

x. Width (Greatest breadth of the foramen magnum): Maximum breadth between two occipital condyles.

xi. Area (cm^2) = ¼ WH, where W = width and H = height of the foramen magnum. Radinsky's formular (Area = $1/4 \times \pi \times t \times s$).

xii. Circumference: Length of the entire boundary of the foramen magnum was measured using tape line.

xiii. Volume of foramen magnum (cm^3).

xiv. Thickness of occipital condyle.

xv. Internal mastoid distance.

xvi. External mastoid distance

Results and Discussion

Gross observations

Results base on shape, with age was shown to have change in shape from pentagonal at 0-6months to hexagonal and egg shape at 1-3 years in relation to sex of the sheep as shown in (Table 1). The variation in the shape with sex of the foramen magnum from tetragonal, egg, hexagonal, round shapes to oval in shape is as shown in (Table 1).

Table 1: Table showing the variation in age and sex of the foramen magnum of sheep.

S/N	Parameters	Sex	Shape
1	0-6 months	Male	Pentagonal
		Female	Pentagonal
2	6mon-1year	Male	Hexagonal
		Female	Pentagonal
3	1-2 years	Male	Tetragonal
		Female	Egg
4	2-3 years	Male	Egg
		Female	Hexagonal
5	3-above years	Male	Round
		Female	Oval

The various shapes of foramen magnum observed in this study were shown in plate 1-10 (Figures 2-6). Pentagonal shape were observed in both male and female as seen in plate 1 and plate 2 (Figure 2), while the shape of foramen magnum of male is hexagonal in shape as shown in plate 3 (Figure 3) and that of female is egg shape as shown in plate 4 (Figure 3), tetragonal and pentagonal shapes were observed in both male and females shown in plate 5 and 6 (Figure 4) respectively, in plate 7 (Figure 5) egg shape was seen in male but in plate 8 (Figure 5) hexagonal shape was observed in female, round and oval shapes were seen in male and female in plate 9 and 10 (Figure 6) respectively.

Biometry results

The biometric observation of the foramen magnum in order as shown in (Table 2). The mean and standard error and standard error of mean of yankasa sheep skull bone biometry values were determined. The mean of anteroposterior diameter of foramen magnum (ADPFM) of groups 1, 2, 3, 4 and 5 were found to be 2.21±0.40,2.27±0.31, 2.28±0.28, 2.34±0.22 and 2.40±0.16 respectively. Statistics have shown that there was significant difference with all the groups with increase in age.

The mean transverse diameter of foramen magnum (TDFM) of group 1, 2, 3, 4 and 5 were 1.85±0.21, 1.94±0.17, 1.99±0.28, 2.09±0.06 and 2.13±0.17 respectively, this shows that the values increase with age with significant difference between the 5 groups ($P \leq 0.05$) last group has the highest values while the first group has the lowest values. The anterior intercondylar distance (AID) and posterior intercondylar distance (PID) increase with age with significant difference ($P \leq 0.05$) between all the groups.

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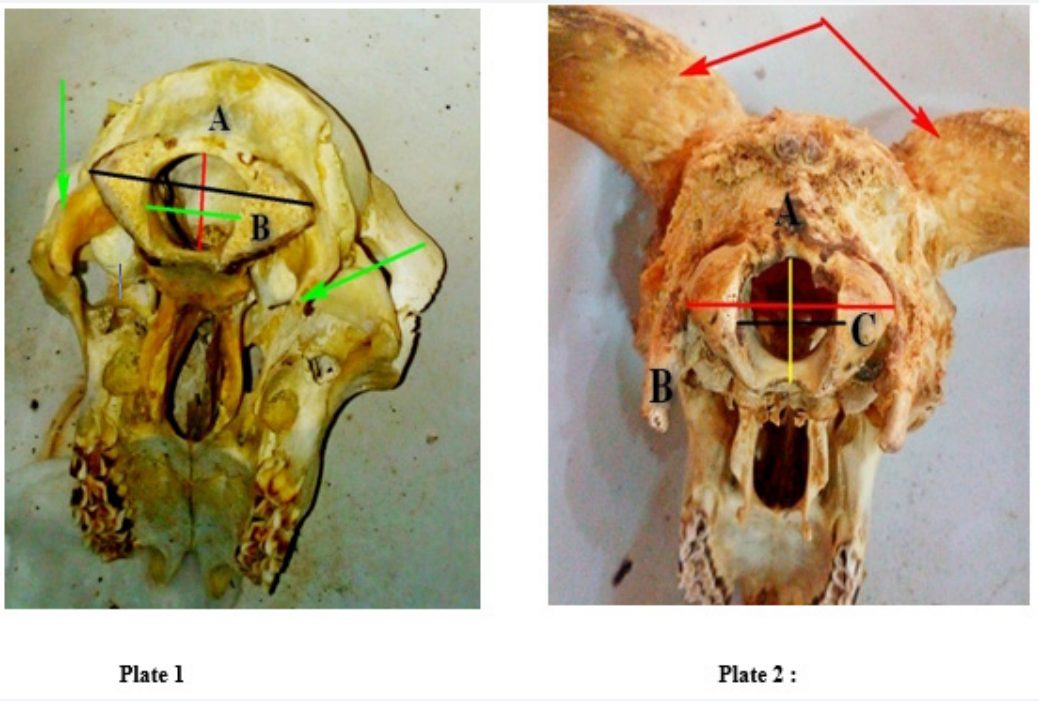

Figure 2: Foramen magnum of male (1) and Female (2) of 0-6months of age.
In plate 1: (A-occipital bone, B-mastoid process, C-occipital condyle, yellow line is height of foramen magnum, black line is width of foramen magnum then the red line is showing distance between basion and opisthion). In plate 2: (A is occipital bone B is occipital condyle C is mastoid process, and the green line is distance between basion and opisthion).

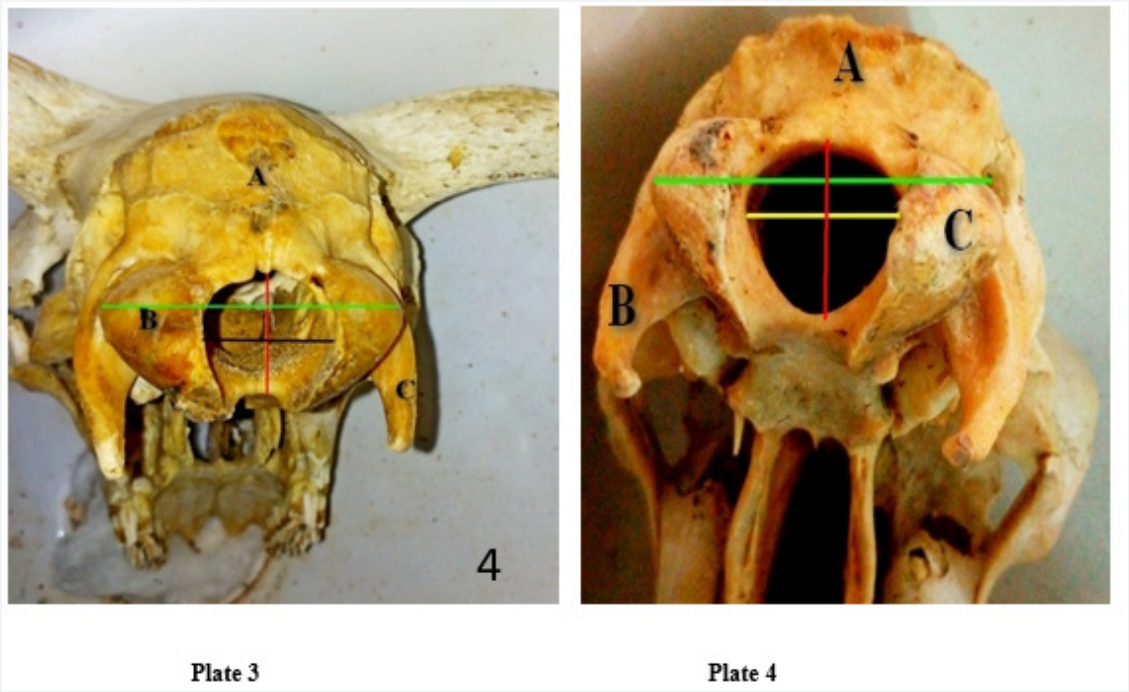

Figure 3: Foramen magnum of male (3) and Female (4) of 6 months - 1 year of age.
In plate 3: (A-occipital bone, B-occipital condyle, C-mastoid process) red line is height of foramen magnum, black line is width of foramen magnum then the green line is showing distance between basion and opisthion). In plate 4: (A is occipital bone B is mastoid process C is occipital condyle, red line is height of foramen magnum, yellow is width of foramen magnum and the green line is distance basion and opisthion).

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The length of occipital condyle (LOC) showed gradual increase with statistical difference (P ≤ 0.05) between group 1, 2, 3, 4 and 5 and the right part is little bigger than the left part. The mean foramen magnum index (FMI) of group 1, group 2, group 3, group 4 and group 5 were found to be 1.58±0.24, 1.17±0.02, 1.15±0.01, 1.14±0.02 and 1.13±0.01 respectively, this shows that values increase with age among the groups. The condylar index (CI) mean of both right and left sides condyles showed significant increase in values from group 1 to 5 accordingly.

The mean thickness of occipital condyle (TOC) of right and left condyles were also increased with age been the right side thicker than left side. The mean values of external mastoid distance (EMD) of group 1 to group 5 were found to be 4.16±0.1, 4.42±0.24, 4.37±0.25, 4.53±0.15 and 4.60±0.10 respectively, this shows that the values increased with age. The mean values of internal mastoid distance (IMD) of group 1 to group 5 were also increased with age as all shown in (Table 2).

Some biometrical values of foramen magnum of yankasa sheep were measured. The height of foramen magnum (HFM) from group 1 to group 5 were 2.08±0.21, 2.2±0.25, 2.29±0.40, 2.34±0.52 and 2.41±0.55 were increasing accordingly whereas the mean width of foramen magnum (WFM) of group 1 to group 5 were also increasing with age been the width bigger than the height in all the groups as shown in (Table 3). In (Table 4) the mean of area, circumference and volume of group 1 to group 5 were also increased significantly with age as the values shown above in the mentioned table.

Length parameters

Anteroposterior diameter of foramen magnum (ADPFM), Transverse diameter of foramen magnum (TDFM), Anterior intercondylar distance (AID), Posterior intercondylar distance (PID) and Foramen magnum index (FMI) were found to be in order arithmetically with advancement in age from 0-6months to above 3years as shown in (Table 2).

Table 2: Table showing the biometric values of foramen magnum of sheep in relation to the age.

S/N	Parameters	Group 1	Group 2	Group 3	Group 4	Group 5
1	ADPFM	2.21±0.40	2.27±0.31	2.28±0.28	2.34±0.22	2.40±0.16
2	TDFM	1.85±0.21	1.94±0.17	1.99±0.28	2.09±0.06	2.13±0.17
3	AID	1.68±0.49	1.95±0.65	2.03±0.34	2.03 ±0.33	2.09 ±0.33
4	PID	1.050.22	1.09±0.25	1.15±0.27	1.16 ±0.32	1.18 ±0.29
5	FMI	1.58 ±0.24	1.17± 0.02	1.15 ±0.01	1.14 ±0.02	1.13 ±0.01
			LOC			
6	Right	5.12 ±0.45	5.39 ±0.37	5.6±0.75	5.69±0.91	5.83±0.97
	Left	5.04±0.61	5.31±0.62	5.56±0.79	5.72±0.90	5.83±0.52
			CI			
7	Right	2.21 ±0.05	2.28 ±0.13	2.23 ±0.09	2.12 ±0.04	2.08 ±0.06
	Left	2.22 ±0.06	2.21 ±0.04	2.21 ±0.03	2.14 ±0.04	2.11 ±0.04
			TOC			
8	Right	3.63±0.2	3.7±0.19	3.93±0.17	4.78±0.31	5.15±0.06
	Left	3.34±0.12	3.63±12	3.98±0.13	4.50±0.16	5.05±0.10
9	EMD	4.16±0.19	4.24±0.28	4.37±0.25	4.53±0.15	4.60±0.10
10	IMD	4.03±0.77	4.07±0.66	4.13±0.57	4.23±0.61	4.28±0.59

KEY: ADPFM: Anteroposterior diameter of foramen magnum(cm), TDFM: Transverse diameter of foramen magnum(cm), AID: Anterior intercondylar distance(cm), PID: Posterior intercondylar distance(cm), FMI: Foramen magnum index(cm) LOC (Right): Length of occipital condyle right side(cm), LOC (Left): Length of occipital condyle left side(cm), CI (R): Condylar index right side(cm), CI (L): Condylar index left side(cm), TOC (R): Thickness of occipital condyle right side(cm), TOC (L): Thickness of occipital condyle Left side(cm), EMD: external mastoid diameter(cm), IMD: Internal mastoid diameter(cm).

The Length of occipital condyle LOC (Right), length of occipital condyle LOC (Left), Condylar index CI (Right), condylar index (Left), and thickness of occipital condyle TOC (Right), thickness of occipital condyle (Left) were found to be in order arithmetically with advancement in age from 0-6months to above 3years with right side being bigger than the left side respectively as shown in (Table 2). The external mastoid diameter (EMD) and Internal mastoid diameter (IMD) were found to be in order arithmetically with advancement in age from 0-6months to above 3years as shown in (Table 2).

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Height

The height of foramen magnum was found to be in order arithmetically with advancement in age from 0-6months to above 3years as shown in (Table 3).

Area, circumference and volume

These parameters were found to be in order arithmetically with advancement in age from 0-6months to above 3years as shown in (Table 4).

Table 3: Table showing the height of foramen magnum in relation to age.

S/N	Parameters	Group 1	Group 2	Group 3	Group 4	Group 5
1	HFM	2.08±0.21	2.2±0.25	2.29±0.40	2.34±0.52	2.41±0.55
2	WFM	2.12±1.9	2.38±1.16	2.42±1.19	2.47±1.17	2.51±1.15

KEY: HFM: Height of foramen Magnum (cm), WFM: Width of foramen magnum (cm) Group 1= 0-6months, Group 2=6months-1year, Group 3=1 year-2years, Group 4=2years-3years, Group 5=3years above.

Table 4: showing Area, Circumference and Volume of foramen magnum at different age groups.

S/N	Parameters	Group 1	Group 2	Group 3	Group 4	Group 5
1	Area (cm^2)	3.49±2.84	4.45±2.50	4.63±3.26	4.73±2.92	4.94±3.42
2	Circumference (cm)	4.57±0.28	4.79±0.44	4.86±0.46	4.98±0.62	5.17±0.72
3	Volume (cm^3)	7.30±3.36	9.82±3.16	10.56±4.29	11.02±4.20	11.79±48.63

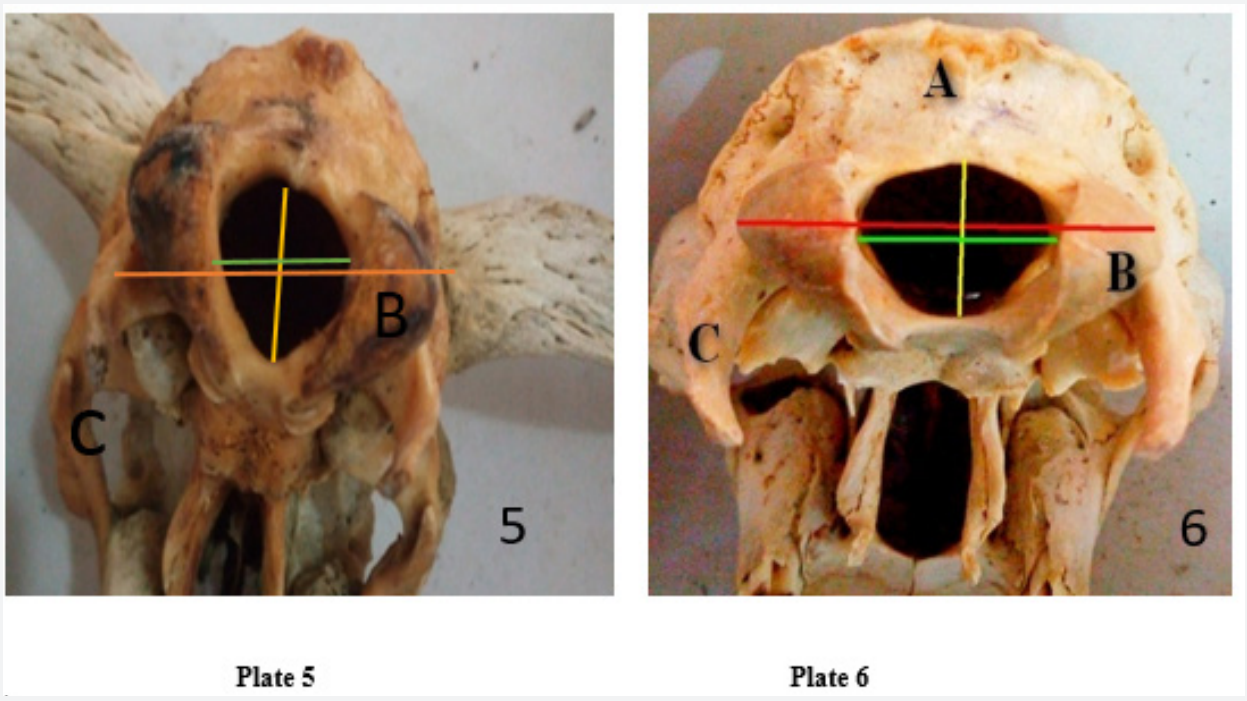

Figure 4: Foramen magnum of male (5) and Female (6) of 1-2 years of age.
In plate 5: (A-occipital bone, B-occipital condyle, C-mastoid process)Yellow line indicate height of foramen magnum, while green line is width of foramen magnum and red line is distance between basion and opisthion.

This study has recorded the age-related changes in some parameters of Yankasa sheep skull. Due to insufficient information in the areas of the subject matter on Yankasa sheep, the results obtained in this study is to form a data base for Yankasa sheep skull. It is real that this study will be useful for feature studies in the ovine species of domestic animals in Nigeria.

The morphometry of foramen magnum is clinically important as large number of significant structures pass through it. In this

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study the mean anterior posterior diameter of foramen magnum (APDFM) in group 1-5 were found to be 2.21±0.40, 2.27±0.31, 2.28±0.28, 2.34±0.22 and 2.40±0.16 respectively and mean transverse diameter (TD) of foramen magnum in group 1-5 were found to be 1.85±0.21, 1.94±0.17, 1.99±0.28, 2.09±0.06 and 2.13±0.17 respectively, in previous study conducted by (Roma et al., 2014), mean ADP of foramen magnum was measured at 3.37cm for human skull (greater than value of present study) while mean transverse diameter (TD) was measured as 3.33cm. The mean diameter measured by [19] were greater than present study.

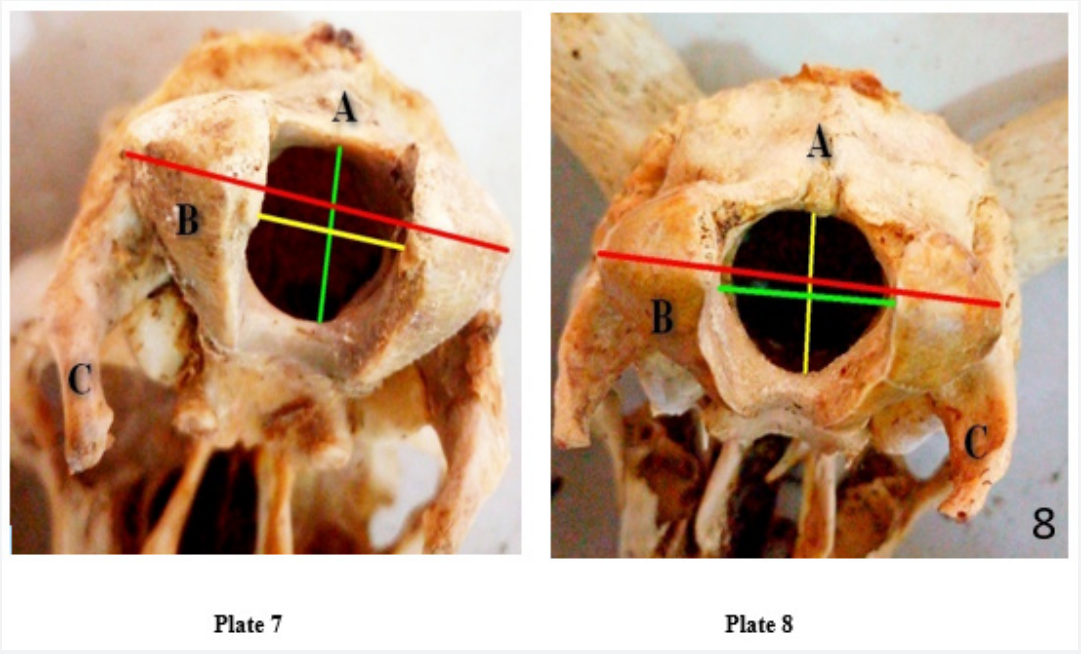

Figure 5: Foramen magnum of male (7) and Female (8) of 2-3 years of age.
In plate 7: (A-occipital bone, B-occipital condyle, C-mastoid process) Yellow line indicate height of foramen magnum, while green line is width of foramen magnum and red line is distance between basion and opisthion. In plate 8: (A-occipital bone, B-occipital condyle, C-mastoid process, green line is height of foramen magnum, yellow line is width of foramen magnum and red line is distance between basion and opisthion.

Anatomy of occipital condyles play an important role in decision making regarding degree and direction of condylar drilling with minimal injury, condylar drilling is an important step in the transcondylar extension of the far lateral approach [10]. Mean length of right and left occipital condyles as displayed in the (Table 2) were greater than the results found by [20] 2.75cm and 2.36cm respectively who worked on pan Arab skulls.

The mean width and height of foramen magnum obtained in this study as shown in all the groups in (Table 3) is bigger than 1.67±0.16cm and 1.72±0.11cm respectively as recorded by [21] who worked on West African Dwarf goats from Southwest Nigeria. This means that the foramen magnum is relatively higher and wider in Yankasa sheep than in West African Dwarf goat.

The disparity observed in the morphometric measurements of the Yankasa sheep with other animals including goats could be due to adaptation of skull structures to the environmental factors [16], but the increase in values of the parameters within the Yankasa sheep is due to age variations. The mean length of Area of the foramen magnum in group 1-5 were 3.49±2.84, 4.45±2.50, 4.63±3.26, 4.73±2.92 and 4.94±3.42 its higher than area of foramen magnum of Indian black buck 0.86±0.004cm2 and 0.89±0.04cm2 in female and male respectively by [22].

The mean Circumference of this study were 4.57±0.28, 4.79±0.44, 4.86±0.46, 4.98±0.62 and 5.17±0.72 is indicate that as the animal ages the circumference of foramen magnum also increases, but the study conducted by [23] in Indian black buck of female and male were 8.19±0.01 and 8.26±0.01 respectively, this showed that the circumference of foramen magnum is larger in male than in female according to the findings of [24]. The mean volume of the current study of group 1-5 were 7.30±3.36, 9.82±3.16, 10.556±4.29, 11.02±4.20 and 11.79±48.63 this shows that the volume of foramen magnum is increasing with age according to the findings of [25] (Table 5).

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In this study, the mean of foramen magnum index of group 1-5 was 1.58±0.24, 1.17±0.02, 1.15±0.01, 1.14±0.02 and 1.13±0.01 the index is decreasing with age. In the present study, the mean thickness of both right and left occipital condyles from group 1-5 respectively were 3.63±0.2, 3.7±0.19, 3.93±0.17, 4.78±0.31, 5.15±0.06 and 3.34±0.1, 3.63±0.12, 3.98±0.13, 4.50±0.16 and 5.05±0.10 this shows that the thickness of the occipital condyle is increasing with age and is thicker in right than in left sides. This is in accordance with the findings of [25].

Table 5: Categorization of the samples.

S/N	Age	No. of Sample
1	0-6months	5
2	6months-1year	5
3	1year-2years	5
4	2years-3years	5
5	3years above	7
Total = 27		

Age group classification.

The mean length of external and internal mastoid diameter of group 1-5 were 4.16±0.19, 4.24±0.28, 4.37±0.25, 4.53±0.15, 4.60±0.10 and 4.03±0.77, 4.07±0.66, 4.13±0.57, 4.23±0.61 and 4.28±0.59 respectively. In this study it signified that external mastoid distance is more than internal distance. This is in accordance with the findings of [26].

Conclusion

It is concluded that the study on osteometry of Yankasa sheep is comparable to goat, variation could be due to age, sex and breed. Additionally results revealed that foramen magnum parameters were increasing in both males and females. Furthermore, types and parameters of foramen magnum should be taken into consideration during radiographical reports and during surgical interventions [27-45].

Recommendation

Normally, the foramen magnum is oval shape, but this study shows different shapes and variation of foramen magnum. The present study reported that, as the animals aging both male and female shows more variation with the help of mean values. Further studies using a larger sample size to enable us to generalize the findings for the Yankasa sheep in Sokoto state.

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