Anatomical and Morphometrical Study of the Bones of Forelimb of Giraffe

(Giraffa camelopardalis)

A clinical report submitted by

Sadia Jahan

Intern ID– 28

Roll No – 15/30

Reg No – 01445

Report Presented in Partial Fulfillment for the Degree of

Doctor of Veterinary Medicine

Faculty of Veterinary Medicine

Chattogram Veterinary and Animal Sciences University

Khulshi, Chattogram

Anatomical and Morphometrical Study of the Bones of Forelimb of Giraffe

(Giraffa camelopardalis)

A Clinical report submitted as per approved style and contents

....

(Signature of Author)

Sadia Jahan
Intern ID : 28
Roll No : 15/30
Reg. No. : 01445
Session : 2014-2015

....

(Signature of Supervisor)

Dr. Mohammad Lutfur Rahman
Professor
Dept. of Anatomy & Histology
Faculty Of Veterinary Medicine

Chattogram Veterinary and Animal Sciences University

Khulshi, Chattogram.

Contents

Abstract

This work was conducted to study with the aim of studying the gross anatomical features of the bones of thoracic limb of Giraffe *(Giraffa camelopardalis)*. Consequently this study was carried out with the bones of thoracic limb namely scapula, humerus, radius ulna. For this purpose all the bones of thoracic limb were collected, identified and measured after processing. The scapula was a flat bone with a spine in the lateral surface. The humerus was a long bone with two extremities and a spirally twisted shift. The average weight of the humerus was 3687.5 gm. The radius and ulna were articulated at their both proximal and distal extremities. The radius one was smaller and thinner than that of the ulna. The anatomy and morphometric parameters of the bones of Giraffe's forelimb will assist in surgical and radiographic interpretation of skeletal system.

Keywords: Thoracic limb, Scapula, Humerus, Radius Ulna.

Introduction

The giraffe is an African artiodactyl mammal, the tallest living terrestrial animal and the largest ruminant. It is traditionally considered to be one species *Giraffa camelopardalis* with nine subspecies. The giraffe's main distinguishing characteristics are its extremely long neck and legs, it's horn like ossicones and it's distinctive coat patterns. It is classified under the family Giraffidae along with it's closest extant relative, the okapi. Giraffes usually inhabit savannas and woodlands. It's scattered range extend from Chad in the north to South Africa in the south, and from Niger in the west to Somalia in the east. There food sources are leaves, fruits and flowers of woody plants which they browse at heights most other herbivores cannot reach.

Fully grown giraffes stand 4.3-5.7 meter (14.1 -18.7 ft) tall with males taller than females (Nowak, R. M.1999). The average weight is 1192 kg (2628 lb) for adult male and 828 kg (1825 lb) for adult female (Skinner, J. D; Smithers, R. H. M. 1990). Despite of long neck and legs, the giraffe's body is relatively short (Swaby, S. 2010).

Both sexs have prominent horn-like structures called Ossicones, which are formed from ossified cartilage, covered in skin and fused to the skull at the parietal bones. The front and back legs of the giraffe are about the same length. The radius and ulna of the front legs are articulated by the carpus, which structurally equivalent to the human wrist, function as a knee (MacClintock, D; Mochi, U. 1973). It appears that a suspensory ligament allows the lanky legs to support the animal's great weight (Wood, C. 2014). The foot of the giraffe reaches a diameter of 30 cm (12 in), and the hoof is 15 cm (5.9 in) high in males and 10 cm (3.9 in) in females (Williams, E. 2011). The rear of each hoof is low and the fetlock is close to the ground, allowing the foot to provide additional support to the animal's weight (Dagg, A. I. 1971). Giraffes lack of dewclaws and interdigital glands. The giraffe's pelvis, though relatively short, has an ilium that is outspread at the upper ends (Dagg, A. I. 1971).

Many scientists have been studied on the skeletal systems of large animals, for example horse and cattle, small ruminants such as sheep and goat (Sisson et al.1975), carnivores such as dog (Evans and de Lahunta, 2013), wild carnivores such as tiger (Pandit, 1994; Tomar et al. 2018), leopard (Podhade, 2007), Asiatic cheetah (Nazem et al. 2017), Indian wild cat (Palanisamy et al. 2018), guinea pig and rat (Ozkan et al. 1997), and rabbit (Ozkan et al. 1997). Only some literature is available on few bones of the Asiatic lion (Nzalak et al. 2010;

Pandey, 2004), but the morphometrical study of the skeletal system of the Giraffe has not been studied in detail.

So, the aim of this study was follows:

1. to explore the general anatomy and osteomorphometry of scapula, humerus, radius and ulna.
2. to apply the knowledge of osteological features in study of surgery and radiology.

Materials and Methods

The bones of forearm (scapula, humerus, radius and ulna) of Giraffe were collected recently from the Bangladesh National Zoo, Dhaka and subsequently the bones were processed by removing the dirt and mud with a brush and washed under the running tap water. Then the bones were boiled with water and hydrogen peroxide for one hour to remove the remaining muscular structure and associated fat/oil from the bones. After removing the muscular structure through knife all the bones were properly washed with fresh water and finally all the bones were dried under sunlight for a week. Whole processing was done carefully to keep the anatomical structures unchanged. To get the gross anatomical parameters different views of the individual bone was observed. For the gross morphometric study, the length, width, height and circumference were measured by using a metallic calibrated scale and were recorded in centimeter (cm). The weight was also measured by using a digital balance and recorded in gram (gm.).

Result and Discussion

Scapula :

It was a flat bone and the lateral surface with the surface divided into two fossae by the spine of the scapula which extends from the vertebrae to the neck, where it subsided. The two fossae were the supraspinous fossa and the infraspinous fossa. The former one was the smaller, it was smooth and occupied by the supraspinatus muscle. The anatomical observations and morphological measurements of scapula are given below:

Table 1. Morphometrical data for different parameters of scapula, N = 2

SL No.	Parameters	measurements	
		Right	**Left**
1.	Borders (cm)		
	• Cranial border-	56.5	56.7
	• Caudal border-	60.7	59.7
	• Dorsal border-	27.4	27.8
2.	Length of spine (cm)	45.5	46
3.	Max. length of dorsal border to glenoid cavity (cm)	67.5	67.1
4.	Height of supraspinous fossa to spine (cm)	9.9	10.1
5.	Height of infraspinous fossa to spine (cm)	9.8	9.8

The scapula of Giraffe in the present study has been represented 2 surfaces, 3 borders and 3 angles which were found to be similar to those of the horse (Sisson et al., 1975), cattle (McLeod et al., 1958), sheep (Sisson et al.1975), lion (Nzalak et al., 2010) and dog (Miller et al., 1964); the lateral surface was divided into 2 unequal fossae by a well-developed scapular spine. The ratio between the two fossae is 1 to 3. In the medial surfaces of the serratus ventralis muscle, poorly underlined, delimit a wide and shallow subscapular fossa. The subscapular fossa (fossa subscapularis) like horse and human (Sisson et al.) was divided into a larger triangular caudal fossa and a smaller cranial fossa which provides an attachment for the subscapularis muscle.

In the studied individual, the scapular spine rises and descends progressively, without a visible distal continuation of the scapular spine namely acromion process or processus hamatus unlike as cattle (McLeod et al 1958.; Sisson et al 1975) However, the well developed acromion was over hanged to the glenoid notch in human (Williams, 1980), Lion (Nzalak et al. 2010) and African elephant (Smuts & Bezuidenhout, et al 1993). The dorsal border was measured 27.4 cm in right and 27.8cm in left scapula. The cranial border was slightly curved and the caudal border was somewhat smooth.

The glenoid cavity has an ovoid shape, similar to that of cows which found elongated in elephant (Ahasan et al. 2016). The supraglenoid tubercle was simple and tuberous. On the medial side, the scapula presented well developed triangular surfaces for muscle insertion.

Fig 1: Lateral aspect of Scapula,

1= Cranial angle, 2= Caudal angle

3= Spine of scapula, 4= Supraspinous fossa

5= Infraspinous fossa.

Fig 2 : Medial aspect of scapula

1= Scapular coller

2= Subscapular fossa

Fig 3: Distal aspect of scapula

1= Glenoid cavity of scapula

2= Supraglenoid tuberocity

Humerus :

The humerus was a long bone in the forelimb that runs from the shoulder to the elbow. It connected the scapula and the two bones of the lower limb, the radius and ulna, and consisted of three sections. The anatomical obsevations and morphometrical measurements of humerus are given below:

Table 2. Morphometrical data for different parameters of humerus. N = 2

SL No.	Parameters	measurements	
		Right	**Left**
1	Weight (gm)	3625	3750
2	Total length (cm)	56	56.35
3	Shaft		
	• Length (cm)	40	40
	• Circumference of upper part (cm)	29.5	31
	• Circumference of middle part (cm)	24	23
	• Circumference of lower part (cm)	23	24
4	Circumference of head (cm)	38	38
5	Proximal extremity		
	• Circumference (cm)	59.8	59.8
	• Width (cm)	22	20
7	Distal extremity		
	• Circumference (cm)	46	47
	• Width (cm)	12.6	12.8

The Humerus of the giraffe was a long bone with a spirally twisted shaft. The body of the humerus was somewhat compressed laterally. The humeral head was long and strongly curved cranio-caudally; the neck was distinctly marked, while the distal end had condyles and epicondyles. The medial condyle was larger than the lateral one. The nutrient foramen of the diaphysis was located on the caudal surface of the distal half of the humerus which was similar to sheep (Sisson et al.1975) and dissimilar to cattle (McLeod et al.1958), where the nutrient foramen was located at distal third of the lateral surface of humerus.

On the diaphysis, we have noticed a poorly developed deltoid tubercle. The spiral groove was also shallow. The general aspect of the distal epiphysis suggests an accentuated projection of the axis of the bone in the caudal direction, so that the trochlea and the condyles had a much more elongated basis compared to the axis of the bone.

The morphometrical data for different parameters of humerus of the giraffe are presented in table 2. The weight of right and left humerus of giraffe measured 3625 gm and 3750 gm, respectively and the length was 56 cm and 56.35 cm, respectively. It possessed a cylindrical shaft (diaphysis/body) and two enlarged extremities (epiphysis) such as proximal extremity and distal extremity.

Fig 4: Humerus (caudal view)

1= head of the humerus.

2= olecranon fossa

3= neck of the humerus.

Fig 5: Humerus (cranial view)

1= cranial part (lesser tubercle)

2= intertubercular groove

3= body of humerus (shaft)

4= deltoid tuberosity

5= radial fossa

6= trochlea of humerus

Redius and Ulna :

These were complete bones in the giraffe but were entirely fused. There were proximal and distal interosseous spaces which were the only two places where the shafts were separated. The ulna's proximal end was caudal to the radius and its distal end formed the lateral styloid process, distal to the radius and articulating with the ulnar carpal bone. The radius was cranio-lateral to the ulna at the cubital articulation (the humeroulnar and humeroradial articulation of the elbow joint are served by the musculocutaneous, radial and ulnar nerves) and cranio-medial to the ulna at the carpal articulation. The rough caudal surface of the radius was the border facing the ulna; this interosseous surface had a nutrient foramen near the proximal end of the radius.

Radius :

Table 3. Morphometrical data for different parameters of Radius. N = 2

SL No.	Parameters	Range	
		Right	Left
1	Total length (cm)	85.4	85
2	Proximal extremity		
	• Circumference (cm)	39.9	38.9
	• Width (cm)	13.8	13.5
3	Distal extremity		
	• Circumference (cm)	37.8	37.2
	• Width (cm)	13.8	13.5
4	Circumference		
	• Upper (cm)	23.3	24.7
	• Middle (cm)	21.4	21.4
	• Lower(cm)	24.8	25.3

The radius presents a widened proximal extremity, with three glenoid surfaces sculpted on it a very large medial one, a deep median one and a narrow lateral one. On its contour there was a well marked coronoid process, laterally flanked by a secondary coronoid process. The body of the radius presented on the lateral edge of the volar surface synostosis with the ulna, interrupted at the level of the arcades. The neck of the radius appeared polished on the medial side by a small tendon, and the bicipital tuberosity was long and faint. On the articular circumference there were two flat surfaces for the ulna. The distal extremity was obliquely cut and presents two glenoid fossae. Two inclined condyles and two small digital fossae situated in the back of the condyles. The tendinous grooves were pooly marked and the styloid process was well developed.

The radius of the giraffe had an elongated linear shape, compared to its proportions in the cow radius. On its proximal epiphysis there were 3 articular surfaces. The medial one was L shaped, different from that of the bovines. The bicipital groove is shallow, which was also encountered in the large ruminants (a longer and poorly underlined groove). On the distal articular surface, there was a similitude of the placement of articular elements, in the sense of similar entities being present in both species: two glenoid fossae and two condyles obliquely placed. It also presented two small fossae placed towards the exterior, in a latero-medial direction, erasing the elongated aspect seen in bovines, and giving them the appearance of squarely shaped grouped surfaces.

Ulna :

Table 4. Morphometrical data for different parameters of ulna. N = 2

SL No.	Parameters	Range	
		Right	Left
1	Total length (cm)	93	93
2	Circumference (cm)		
	• Upper extremity	8.3	8.8
	• middle extremity	4	4
	• Lower extremity	2.5	2.2
3	Proximal Extremity(cm)		
	• Circumference	27.9	28.2
	• Width	11.3	11.5
4	Distal Extremity(cm)		
	• Circumference	4.1	4.2
	• Width	2.2	2.5

The ulna articulated to the radius on all of its length, forming two radioulnar arches-proximal and distal – united on the lateral face through a groove. The olecranon was massive, long, with more pronounced tuberosity and its summit was medially deviated. The styloid process was very well marked and exceeds the length of the radius.

Because of the incomplete ossification of the tuberosity, we cannot distinguish the particular aspects of the ulna. The articular surface of the olecranon was similar to that of the bovines. The two surfaces corresponding to the olecranon fossa appeared slightly different, in the sense that the lateral surface was much more broadened in the latero-medial direction (where we encounter an ovoid surface). This aspect conveyed to it a rectangular aspect.

Fig 7: Radius and ulna of a giraffe, 1= Head of radius bone, 2= neck of radius,

3= body of radius bone, 4= Olecramon tuber, 5= Body of ulnar bone.

Fig 8: 1= Olecranon tuber, 2= Troclear notch

3= Olecranon process

Fig 9: 1= Antebrachial

interosseous space

Conclusion:

The scapula of the giraffe had a triangular appearance, with its body and its thoracic and dorsal edges were elongated. Its edges were not linear, and furthermore, the cervical edge was concave.

The proximal epiphysis of **the humerus** with its non-articular elements was poorly outlined and small. The bicipital groove was less evident. The deltoid tuberosity and the tubercle of the diaphysis, were poorly developed, almost wiped. The distal epiphysis presents a caudal pronounced projection of the humeral axis, so that the trochlea and the condyle had a much wider base.

In the radius, the proximo-caudal articular surface is L shaped in the giraffe. The bicipital tuberosity is small. Distally, there were present two non-articular fossae with a latero-medial direction. **The ulna** of the giraffe presented a lateral diarthrodial surface, corresponding to the olecranon fossa, was extended latero-medially and gives it a rectangular aspect.

The precise anatomical knowledge and morphometric data of this study will be important tools for diagnostic, radiographic and surgical interpretation.

Limitation:

1. There were no sufficient samples due to shortage of animals. Collection of bones of wild animals like Giraffe was very difficult in our country.

2. The information of the bones of Giraffe was not available due to lack of osteological research in our country as well as in abroad.

3. The comparison with closely similar type of species was not possible due to insufficient references.

Future Plan:

My future plan is to achieve the depth knowledge in form and structure of wild animals to develop my career in the field of veterinary science specifically in radiography and surgery. I am also interested to gain a comprehensive knowledge on animal locomotion (osteology associated with myology, tendon, ligaments, blood and nerve supply) for future research in wildlife conservation and in eco-health.

Acknowledgement

First of all, I would like to thank the **Almighty Allah** for being able to complete this clinical report.

I am thankful to the authorities of **Bangladesh National Zoo**, Dhaka, Bangladesh for giving permission to collect the bones of Giraffe in the Anatomy museum of CVASU and allowed me for this study. I would like to express my gratitude and thanks to **Dr. Mohammad Lutfur Rahman**, Professor, Department of Anatomy and Histology, Faculty of Veterinary Medicine, CVASU for his skillful supervision and guidance to make this report successfully.

I am also thankful to **Dr. Shahariar Hasan Sohel** and **other members** of Anatomy laboratory for their supports and help during conducting this study. I am grateful to my classmate and friend **Md. Kabir Hossain** for his kind co-operation and help specially during taking morphometric parameters of bones to complete this research work.

References

I. Skinner, J. D. & Smithers R. H. N. (1990). The mammals of the Southern African sub region. 2nd edn. Pretoria: University of Pretoria.

II. Slijper, E. J. (1946). Comparative biological-anatomical investigation on the vertebral column and spinal musculature of mammals. Verh. K. Ned. Akad. Wet. Afd. Nat. 42: 1–128.

III. Hall-Martin, A. J., Von la Chevallerie, M. & Skinner, J. D. (1977). Carcass composition of the giraffe *Giraffa camelopardalis giraffa*. S. Afr. J. Anim. Sci. 7: 55-64.

IV. Alexander, R. McN., Jayes, A. S., Maloij, G. M. O. & Wathuta, E. M. (1979). Alometry of the limb bones of mammals from shrews (Sorex) to elephants (Loxodonta). J. Zool. (Lond.) 189: 305-314.

V. Skinner, J. D. & Smithers R. H. N. (1990). The mammals of the Southern African sub region. 2nd edn. Pretoria: University of Pretoria.

VI. Nzalak, J. O., Eki, M. M., Sulaiman, M. H., Umosen, A. D., SaLami, S. O., Maidawa, S. M. & Ibe, C. S. (2010). Gross anatomical studies of the bones of the thoracic limbs of the Lion *(Panthera leo)*. J. Vet. Anat., 3(2):65-71.

VII. David, E. D., Dagg A. I., FosterCoţofan, J. B., V., Palicica, R., Valentina, H. & Ienciu, V. (1999). Anatomia animalelor domestice, Vol. I, Ed. Orizonturi Universitare Timişoara.

VIII. Damian, A., Popovici, N. & Chirilean, I. (2001). Anatomie comparată: sistemul de sustinere şi mişcare. Ed. Academic Press, Cluj-Napoca.

IX. Savage, R. J. G. & Long, M. R. (1986). Mammal Evolution: an illustrated guide, New York: Facts on File, 228-229.

X. Stevens, J. (1993). Familiar Strangers, International Wildlife, 23, 6-10.

XI. Sisson, S., Grossman, J. D. & Getty, R. (1975). Sisson and Grossman's The Anatomy of the Domestic Animals. 5th ed. Philadelphia, Saunders, 2019-2066.

XII. Smuts, M. M. & Bezuidenhout, A. J. (1993). Osteology of the thoracic limb of the African elephant *(Loxodonta africana).* Onderstepoort. J. Vet. Res., 60(1):1-14.

XIII. Williams, P. L. (1980). Gray's anatomy. London Churchill Livingstone.

XIV. Miller, C. E., Basu, C., Fritsch, G., Hildebrandt, T. & Hutchinson, J. R. (2008). Ontogenetic scaling of foot musculoskeletal anatomy in elephants. J. R. Soc. Interface, 5(21):465-75.

XV. Miller, M. E., Christensen, G. & Evans, H. E. (1964). Anatomy of the Dog. 9th ed. Philadelphia, W. B. Saunders.

XVI. Nazem, M. N., Sajjadian, S. M. & Nakhaei, A. (2017). Anatomy, functional anatomy and morphometrical study of forelimb column in Asiatic cheetah (Acinonyx jubatus venaticus). Italian Journal of Anatomy and Embryology, *122*(3), 157-172.

XVII. Evans, H. E. & De Lahunta, A. (2013). *Miller's anatomy of the dog-E-Book*. Elsevier Health Science.

XVIII. Skinner, J. D. & Smithers, R. H. M. (1990). The mammals of the southern African subregion. University of Pretoria. 616–620.

XIX. Dagg, A. I. and Foster J. B. (1982). The Giraffe. Its Biology, Behavior, and Ecology. Krieger Publishing Company, Malabar, Florida.

XX. Nowak, R. M. (1999). Giraffe in Walker's Mammals of the World. The Johns Hopkins University Press, Baltimore, USA and London, UK. Volume 1.1086–1089.

XXI. Mitchell, G. & Skinner, J. D. (2004). Giraffe thermoregulation: a review, Transactions of the Royal Society of South Africa: Proceedings of a Colloquium on Adaptations in Desert Fauna and Flora. 59 (2): 49–57.