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Age Related Anatomical Changes in Articular Cartilage of Femoral Head in Buffalo (*Bubalus bubalis*)

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ABSTRACT

Present study was conducted to study the anatomical features of femoral head AC in twenty four intact hip joints of apparently healthy buffaloes procured from GHMC Abbattoir, Hyderabad. They were divided into four groups *viz.,* Group I (prenatal), Group II (Birth - 3yrs), Group III (3 – 6 yrs) and Group IV (6 yrs and above). Morphological features of AC of femoral head revealed that articular surface was covered by a strip of AC made up of hyaline cartilage adjacent to sub-chondral bone in post natal groups, whereas in prenatal stage entire proximal epiphysis of femoral head was purely hyaline cartilage since AC was not yet differentiated. In post natal groups (II, III and IV) a layer of mature AC covered the hemispherical femoral head which blended peripherally with the epiphyseal cartilage. Thickness of femoral head AC reduced marginally with advancing age in various points of articular surface of femoral head *viz.,* lateral surface, at neck and at midpoint. It was 1.89 mm, 1.38 mm and 1.49 mm thick in Gr-II which reduced to 1.64 mm, 1.37 mm and 1.36 mm in Gr-IV respectively. As age advanced, average length and width of femoral head increased fivefold from 2.83 and 2.43 cm in Gr-I (prenatal) to nearly 10.77 and 9.43 cm in Gr-IV (postnatal) specimens respectively. AC surface of young specimens was shiny pink in color in fresh state, whereas aged specimens it showed signs of yellowish discoloration and few indentations around the neck.

HIGHLIGHTS

- Variation in the articular cartilage morphology with the age in buffaloes
- Variation in the thickness of AC femoral head at various points with the age from prenatal to postnatal stages in Buffaloes.

Keywords: Articular cartilage, femoral head, buffalo

Articular cartilage is composed of hyaline cartilage which functions to minimize friction between the articulations of synovial joints and act as a shock absorber of the daily loads applied to the joints: both of these serve to protect the underlying bone (Bauman *et al.* 2019). Therefore, AC plays an important role in joint diseases especially in osteoarthritis where there are specific changes in it and also its repair and remodelling (Taylor *et al*., 2011). They cited that investigations into these treatments should consider the tribology (study of friction, wear and lubrication) of AC wherein simulations using animal joints are a predominate choice. It is proposed that tribology and wear of AC is directly associated with intrinsic mechanical properties. In the literature reviewed so far, many researchers have studied about different joints of bovines and other animals. Most of their research was oriented towards humans and little work has been done on

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hip joint of animals, especially in buffaloes. Hip joint in large animals like buffaloes is an important joint involved in propulsive action in locomotion and also in weight bearing. Therefore present study on the femoral head AC give an idea about the aging changes in the thickness and appearance of articular cartilage at different points.

MATERIALS AND METHODS

The present investigation was carried out in the Department of Veterinary Anatomy, College of Veterinary Science, Rajendranagar, Hyderabad. Intact hip joint specimens of twenty four (24) apparently healthy buffaloes irrespective of their breed, sex and nutritional status were procured from GHMC Modern Abbattoir, Chengicherla and local slaughter houses in and around Hyderabad. Collected specimens were divided into two primary groups *viz.,* one Prenatal stage - Group I (as per the formula of Soliman 1975) and three Post natal stages as per their approximate age based on dentition pattern by FAO (1994) such as Group II (neonatal), Group III (young adult) and Group IV (aged). Samples were collected from both hind limbs by cutting at the level of mid points of femur to secure the femoral head. Hip joint specimens of all groups were carefully dissected to study gross anatomical surface features of articular cartilages (AC) of femoral head in all age groups. Immediately various gross morphological features were studied, noted and photographed accordingly. Morpho-metrical details as detailed below were recorded with a thread, scale and digital Vernier caliper's (Mitutoyo) which ever was necessary:

- ❒ The average thickness of AC on the head of femur taken from various points.
- ❒ The average length and width of the articular surface of femoral head.

RESULTS AND DISCUSSION

In the present study, the articular bony surface of buffalo femoral head was covered by AC in post natal groups. These observations are consistent with the description of articular surfaces and anatomy of hip joint in domestic animals by Getty (1984), Dyce *et al.* (2010), Konig and Leibich (2012) and Supriya *et al*. (2014). Round ligament of hip joint noticed from pre to post natal stages of buffalo in this study extended from fovea capitis of femoral head to centre of acetabulum, which was also reported by Supriya *et al*. (2014) in buffalo calves.

AC of femoral head in prenatal group (Gr-I) was unclear and not yet differentiated at this age which was evident in sagittal sections of entire femoral head. Right from its articular surface to its depth, the tissue was typical hyaline cartilage (Fig. 1).

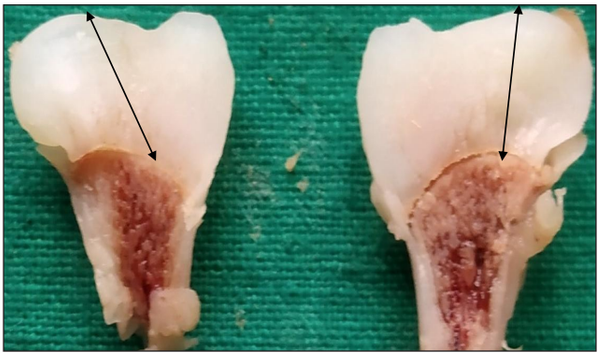

Fig. 1: Photograph of sagittal section of proximal extremity of femoral head in 3 months old buffalo calf (Group – I) showing entire cartilaginous structure (double sided arrow) without any differentiation of AC

Femoral head was hemispherical and merged into cartilaginous part of greater trochanter on the outside presenting a saddle shaped surface which was also reported by Supriya *et al.* (2014) in buffalo calves who stated that the femoral head was nearly hemispherical with smooth articular saddle shaped surface extending on to the dorsal part of the neck closer to trochanter. Cartilaginous femoral head seen in 3 and 4 month old fetuses in this study is akin to studies of morphogenesis of human femur by Suzuki *et al.* (2019). They stated that entire proximal epiphysis of femur was cartilaginous with growth plates and cartilage canals in early weeks (8 – 10 wks) of development.

A layer of mature AC adapted and covered the hemispherical femoral head entirely in specimens of all three postnatal groups (II, III and IV) in this study. It was clearly appreciable and was smooth and hard to touch when compared to prenatal specimens. AC was spherical at the tip of proximal extremity of femoral head and it sloped down towards the neck region (Fig. 2). These observations are in concurrence to the description of femoral head AC in various domestic animals by several authors such as Friend (1959) in domestic animals like

dog, ox and horse; Kobrynczuk (1976) in European bison; Dyce *et al.* (2010) in domestic animals and Supriya *et al.* (2014) in buffalo calves. They opined that femoral head AC blended peripherally with epiphyseal cartilage and it covered the surface of the neck, merging into cartilaginous structure of the trochanter on the outside in fetuses and newborns, whereas in adults it covered only the surface of head except for its fovea.

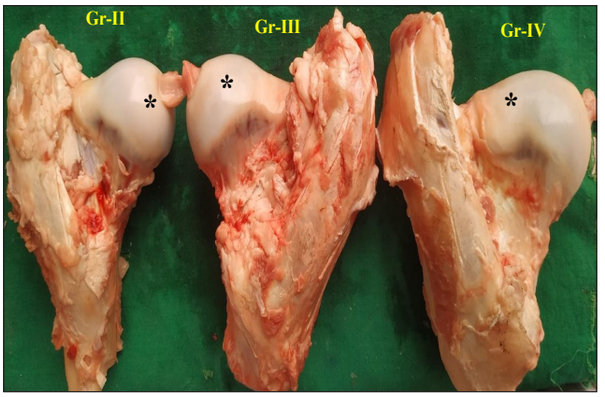

Fig. 2: Photograph showing saddle shaped AC (*) on the femoral head in Groups – II, III and IV buffalo specimens

Slight variation in thickness of femoral head AC observed in post natal groups (II, III and IV) of this study is in agreement with many authors who reported that the AC on femoral head varied in its thickness across various animal species. However, in European Bison Kobrynczuk (1976) stated that AC had no great variation in its thickness near the margin and at the centre.

With advancing age the average length and width of femoral head increased fivefold from 2.83 and 2.43 cm in Gr-I (prenatal) to nearly 10.77 and 9.43 cm in Gr-IV (postnatal) specimens respectively (Table 1). These observation are akin to the reports of Fermor *et al.* (2015) who stated bovine femoral head measured 8 cm from teres ligament to femoral neck. They also reported that porcine femoral head was 4.0 cm and that of ovine was 2.0 cm which is lesser than the bovine. They further stated that the bovine AC appeared white, glossy and healthy with exception of ovine species aged more than 4 years which had yellowish appearance in most cases. Similarly in young specimens of groups II and III in this study the articular surface of femoral head was shiny pink in color in fresh state whereas in aged specimens of Gr – IV it showed slight signs of discoloration such as yellowish appearance in spots near fovea capitis along with few indentations around femoral neck which establishes that with advancing age femoral head articular surface changes are possible due to wear and tear in aged bovines (Fig. 3).

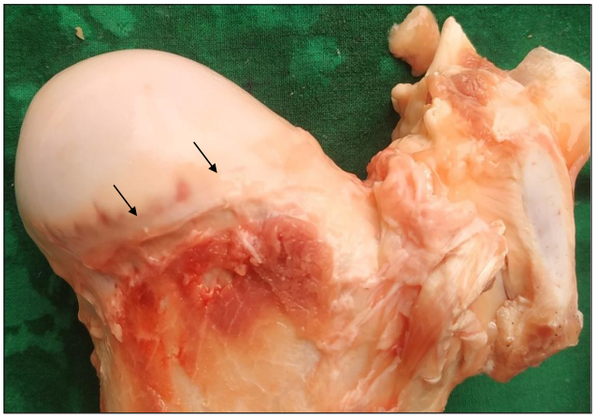

Fig. 3: Photograph of femoral head AC showing indentations (black arrows) at level of neck of femur in Group-IV specimen (aged approximately 8 years)

This study confirms the that femoral head in large ruminants is bulkier part of hip joint, because the latter bears a significant portion of body weight and it helps the animal in its forward propulsive motion. AC covered the entire femoral head going beyond the limit of acetabular rim to support all possible moments of locomotion. These findings are similar to reports of Byrne *et al.* (2010) who stated that human femoral head was covered approximately 60 to 70% of the sphere with corresponding AC beyond the reaches of acetabular brim to accommodate full range of motion.

Variation in thickness of femoral head AC recorded in this study reduced marginally with advancing age in various points of articular surface *viz.,* lateral surface, at neck and at midpoint of femoral head. Average thickness of AC at these points was 1.89 mm, 1.38 mm and 1.49 mm in Gr-II which reduced to 1.64 mm, 1.37 mm and 1.36 mm in aged specimens of Gr-IV respectively (Table 2). These findings are akin to reports of Kobrynczuk (1976) who stated that thickness of femoral head AC in European bison showed variation such as it was 4 mm in youngest specimens at fovea capitis, 5 – 6 mm in the periphery and in adults it was 1.0 to 1.5 mm.

In domestic pig and wild boar Caprinisan (2007) revealed that thickness of AC of femoral head varied with the area and maximum mechanical stress.

Table 1: Morphometrical measurements of Articular surface area of femoral head

Sl. No.	Femoral head – articular surface area (covered by AC)		
	Group	**Length (in cm)**	**Width (in cm)**
1		2.5	2.3
2		2.1	2.0
3	I	2.8	2.3
4	(n = 6)	3.0	2.5
5		3.1	2.5
6		3.5	3.0
	Average (Gr- I)	2.83 cm	2.43 cm
7		8.0	6.9
8		8.2	7.2
9	II	7.9	7.2
10	(n = 6)	8.4	7.6
11		8.0	6.7
12		8.8	7.6
	Average (Gr- II)	8.22 cm	7.20 cm
13		10.4	9.9
14		9.5	8.3
15	III	8.9	8.2
16	(n = 6)	9.1	8.3
17		10.4	9.8
18		10.6	9.3
	Average (Gr-III)	9.82 cm	8.97 cm
19		11.0	9.9
20		10.7	9.5
21	IV	11.0	9.5
22	(n = 6)	10.6	9.2
23		10.5	9.1
24		10.8	9.4
	Average (Gr- IV)	10.77 cm	9.43 cm

However, in human femoral heads Armstrong and Gardner (1977) stated that radiographic studies identified that femoral head AC was thickest at anterior to zenith. They opined that it increased in this zone between the age 20 and 45 years and was not related to femoral head diameter, femur length or body weight. Kurrat and Oberlander (1978) and Sheperd and Seedhom (1999) stated that human femoral head AC was thickest around axis point of head *i.e.,* ventro-lateral area of head of femur beyond which it decreased concentrically. This feature is similar to the distribution of AC thickness in post natal groups in this study wherein it was slightly higher at lateral surface of femoral head.

Table 2: Thickness of Articular Cartilage (AC) on femoral head surface

Sl. No.	Femoral head – Articular Cartilage thickness (in mm)				
	Group	Pt. 1 (fovea capitis)	Pt. 2 (lateral surf.)	Pt. 3 (at neck)	Pt. 4 (mid point)
	I	AC not yet			
	(n = 6)	differentiated	—	—	—
1		1.66	1.96	1.44	1.49
2		1.72	1.79	1.55	1.54
3	II	1.85	2.07	1.23	1.62
4	(n = 6)	1.86	2.01	1.25	1.56
5		1.78	1.86	1.35	1.32
6		1.64	1.65	1.44	1.42
	Average (Gr- II)	1.75 mm	1.89 mm	1.38 mm	1.49 mm
7		1.73	2.21	1.55	1.53
8		2.33	2.85	1.75	1.64
9	III	2.22	2.75	1.67	1.56
10	(n = 6)	2.01	2.59	1.72	1.45
11		1.64	2.12	1.56	1.48
12		1.78	2.31	1.69	1.34
	Average (Gr-III)	1.95 mm	2.47 mm	1.66 mm	1.49 mm
13		2.07	1.59	1.33	1.42
14		2.01	1.65	1.42	1.32
15	IV	1.95	1.45	1.35	1.23
16	(n = 6)	1.82	1.69	1.29	1.45
17		1.75	1.82	1.53	1.35
18		1.81	1.62	1.36	1.42
	Average (Gr- IV)	1.90 mm	1.64 mm	1.37 mm	1.36 mm

There was little change in femoral head AC thickness from young to adult stages in this study which is akin to the reports of Venn (1978) and Adam *et al.* (1998) who opined that human femoral head cartilage had greater thickness in young tissue which in later years rapidly decreased in early years and it showed little change after maturity.

Lothe *et al.* (1979) recorded the cartilage thickness in normal femoral head in humans aged from 6 to 90 years and stated that AC thickness from 6 to 25 years of age was 1.76 ± 0.36 mm while that of 30 to 90 years of age was 1.84 ± 0.43 mm, the difference being very minimal. Taylor *et al.* (2011 and 2018) reported that human femoral head AC was significantly thicker than all quadruped hips. They stated AC thickness of 1.32 ± 0.13 mm in bovine was more than porcine *i.e.,* 1.22 ± 0.05 mm, which they felt was insignificant. However, they noticed a significant difference in average femoral head diameter (FHD) amongst human, bovine, porcine and ovine species. They concluded that FHD was largest in bovine followed by human, porcine and ovine species.

CONCLUSION

Present study showed variation in thickness of femoral head AC which reduced marginally with advancing age in various points of articular surface *viz.,* lateral surface, at neck and at midpoint of femoral head. It was 1.89 mm, 1.38 mm and 1.49 mm thick in Gr-II which reduced to 1.64 mm, 1.37 mm and 1.36 mm thick in Gr-IV respectively. With advancing age the average length and width of femoral head increased fivefold from 2.83 and 2.43 cm in Gr-I (prenatal) to nearly 10.77 and 9.43 cm in Gr-IV (postnatal) specimens respectively. In specimens of groups II and III the articular surface of femoral head was shiny pink in color in fresh state whereas in specimens of Gr – IV it showed signs of discoloration such as yellowish spots nearer to fovea capitis along with few indentations around the neck. This feature establishes that with advancing age joint articular surface changes are possible due to wear and tear.

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