www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(11): 241-245

www.thepharmajournal.com
Received: 08-08-2023
Accepted: 13-09-2023

Sandeep Singh
MVSc Scholar, Division of Surgery, Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh, India

Rohit Kumar
Scientist, Division of Surgery, Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh, India

Corresponding Author:
Sandeep Singh
MVSc Scholar, Division of Surgery, Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh, India

Comparative evaluation of radiographic morphometry of femur and hip joint in healthy Labrador retriever and German shepherd breeds of dog

Sandeep Singh and Rohit Kumar

Abstract
The study was conducted with the objective to compare the radiographic morphometry of proximal femur and hip joint on client owned healthy Labrador Retriever (N=12) and German Shepherd (N=12) breeds of dog presented to referral veterinary polyclinic (RVP) & Division of Surgery, IVRI, Izatnagar (U.P.) India. All the dogs were screened for canine hip dysplasia with inclusion criteria of having norberg angle over 105° and no pathological changes in femoral head and neck and acetabulum. Those with the evidence of fracture, arthritis, sequel of old sepsis, skeletal dysplasia, were excluded. Radiographs of each animal was taken in standard hip extended position under anaesthesia.
In the present study German Shepherd group revealed lower Canal Flare Index (CFI) values and a more stovepipe femoral geometry as compared to Labrador Retriever. However, weight wise no significant variations were found in all acetabular and proximal femoral radiographic measurements between Labrador Retriever and German Shepherd group. In an overall and sex-wise comparison Labrador group showed a high degree of steepness of cranial acetabular edge (high acetabular index angle).

Keywords: Radiographic morphometry, proximal femur, hip joint, Labrador retriever, German shepherd

1. Introduction

There are many diseases associated with abnormal morphology of coxofemoral joint. Many of them can be diagnosed by measuring the variations of coxofemoral joint morphology. Femoroacetabular impingement (FAI), dysplastic hip and osteoarthritis are associated with abnormalities in the depth, orientation, and diameter of acetabulum (Zeng *et al*., 2012) [21]. Radiography and computerized tomography scan (CT) are the common methods used to assess the hip joint morphology (Zacharia and Fawa, 2021) [20].

A Center Edge Angle (CEA) value of ≥40° is a reasonably good predictor of pincer FAI (Kutty *et al*., 2012) [22]. The CEA is an important landmark in the development of osteoarthritis in humans and has been used to classify humans as either dysplastic or normal (Ajadi *et al*., 2018) [1].

It is reported that normal coxofemoral joints have well formed femoral heads that fit closely into the acetabula; that is, the diameters of the acetabular cavities are only slightly larger than the femoral heads. This relationship was confirmed by the ratio of the acetabulum width (AW) to the femoral head diameter (FHD), 1·14, and by the correlations between the FHD and the width and depth of the acetabulum, indicating the morphometric interaction between these two bones (Ocal *et al*., 2004) [15].

Surgical correction of serious hip problems frequently requires total hip replacement. Therefore, a detailed knowledge of the morphology of the dog's proximal femur is required for the development of an ideal hip joint prosthesis that closely mimic the hip joint architecture, thus playing an important role in achieving favourable functional outcomes (Al Aiyan *et al*., 2019) [2].

A minimal subluxation is to be reported when 50% of the FHD is within the acetabulum. For this reason, radiographic parameters like the NA, linear measurements such as different distraction indices and the percentage coverage (PC) of the femoral head have been used to assess the degree of lateral displacement of the femoral head from the acetabulum. The dorsal and ventral centre-edge angles (CEA) indicate the extent of acetabular coverage of the femoral head dorsally and ventrally in dogs (Ocal *et al*., 2004) [15].

A positive correlation between CEA and NA revealed a close relationship between the degree of subluxation of the femoral head and the acetabular coverage (Meomartino *et al*., 2002) [11].

CFI is a tool used in evaluating femur morphology during preoperative planning process. It can be converted as the femoral canal enlargement index, it aids in the choosing of the stem of femoral in planning for THR in both veterinary medicine and human (Gomide *et al.,* 2021) [7]. Noble and colleagues first defined the concept of a CFI to acknowledge the proximal canal design of the femur of human using plain radiography (Sevil-Kilimci and Kara, 2020) [19]. Rashmir-Raven and colleagues used CFI for first time in veterinary orthopedics. Canines CFI values are established and classified into three categories: normal shape, stovipipe shape, and champagne-flute shape (Andrade *et al*., 2021) [3].

There is no comprehensive radiological morphometric analysis to find out the radiographic morphology of proximal femur and hip joint of the Indian dog breeds. Our objective is to compare the radiographic morphometry of proximal femur and hip joint in healthy Labrador Retriever and German Shepherd breeds of dog.

2. Materials and Methods

The study was conducted in 24 dogs randomly divided into two groups i.e. Labrador Retriever and German Shepherd (GSD) with 12 animals in each group. However, in case of body weight additional animals were added to satisfy the requirement of statistical test.

All the acetabular (acetabular width (AW), acetabular depth index (ADI), norberg angle (NA), Percent Coverage (PC), Center-edge angle (CEA), Acetabular index angle (AIA), Acetabular offset (AO) and femoral parameters (Femoral head diameter (FHD), Femoral neck length (FNL), Trochanteric width (TW), Neck-shaft angle (NSA), Femoral length (FL), Isthmus position index, canal flare index (CFI) were measured in the hip extended ventrodorsal (VD) position (fig. 1) under xylazine HCL (1 mg/kg dose rate, intravenously) and ketamine HCL (2 mg/kg dose rate, intravenously) anaesthesia following premedication with subcutaneous administration of atropine sulphate at 0.04 mg/kg dose rate.

2.1 Evaluation of different radiographic morphometric parameters

2.1.1 Measurement of acetabular parameters

All the acetabular parameters were evaluated in the hip extended VD pelvis view as follow:

2.1.1.1 Acetabular Width (AW): Acetabular width was measured from the cranial to the caudal rim of the acetabulum (Kanthavichit *et al*., 2021) [8].

2.1.1.2 Acetabular Depth Index (ADI): Acetabular depth index was measured as a ratio of the biggest right-angle distance between a straight line, tangent to the craniolateral effective acetabular rim and caudal acetabular edge, and the internal boundary of the acetabular circle to the acetabular diameter (Martins *et al.,* 2012) [10].

2.1.1.3 Acetabular Andex Angle (AIA): Acetabular index angle was measured as an angle formed between a line connecting acetabular edge’s lateral and medial extents and a horizontal line perpendicular to the corresponding axis of ilium (Mostafa *et al*., 2022) [13].

2.1.1.4 Percent Coverage (PC): Percent coverage was measured by software by dividing the area of the femoral head covered by the acetabulum by the total area of the femoral head and multiplying by 100.

2.1.1.5 Acetabular Offset (AO): Acetabular offset was measured as distance between center of the femoral head and inner wall of quadrlateral plate/true floor (Bhaskar *et al*., 2017) [5].

2.1.1.6 Norberg Angle (NA): Norberg angle was measured as the angle formed between a horizontal line connecting the centers of the right and left femoral heads and a line connecting each center to the cranial margin of the corresponding acetabulum (Schachner and Lopez, 2015) [17].

2.1.1.7 Center Edge Angle (CEA): Center-edge angle was measured between two straight lines originating from the center of the femoral head, a line tangential to the lateral acetabular rim and a second line parallel to the longitudinal axis of the body of the corresponding ilium (Mostafa *et al*., 2022) [13].

2.1.2 Measurement of femoral parameters

All the femoral parameters were evaluated in the hip extended VD pelvis view as follow:

2.1.2.1 Femoral Head Diameter (FHD): Femoral head diameter was measured as the diameter of a complete circle drawn around the femoral head (Mokrovic *et al*., 2021) [12].

2.1.2.2 Femoral Neck Length (FNL): Femoral neck length was measured as a distance between the femoral head center and the intersection point of the femoral shaft axis and femora neck axis (Baharuddin *et al*., 2014) [4].

2.1.2.3 Trochanteric Width (TW): Trochanteric width was measured as the distance between just above the trochanter minor and the most lateral point of the trochanter major (Sarierler *et al*., 2017) [16].

2.1.2.4 Neck-Shaft Angle (NSA): Neck-shaft angle was measured as the angle formed by the intersection of the neck axis line and the femoral shaft anatomical axis line (Mokrovic *et al*., 2021) [12].

2.1.2.5 Femoral Length (FL): Femoral length was measured proximally from the femoral neck midpoint to the intercondylar fossa distally (Fonseca *et al*., 2017) [6].

2.1.2.6 Isthmus Position Index (IPI): The isthmus position index was measured as the ratio of femoral isthmus distance to the FL (Sevil-Kilimci and Kara, 2017) [19].

2.1.2.7 Canal Flare Index (CFI): Canal Flare Index was calculated as the ratio between the endosteal width at the medial aspect of the lesser trochanter and at the isthmus (Sevil-Kilimci *et al*., 2020) [18].

3. Results and Discussion

Weight wise categorization of the animals of Labrador Retriever and GSD groups revealed a non-significant (p>0.05) variation in the values of all acetabular and femoral parameters (Table 2 & 3). An overall and sex-wise comparison of acetabular parameters showed a significantly ($p<0.05$) higher values of acetabular index angle in Labrador Retriever group as compared to GSD dogs (Table 1).

A significant ($p<0.05$) positive correlation of body weight was noted with AW, AIA and AO in overall animals of GSD group and only female animals of Labrador Retriever group and with AW and NA in female animals of both groups. In contrast, body weight showed a significant ($p<0.05$) negative correlation with PC in overall animals of GSD group. AW showed a significant ($p<0.05$) positive correlation with age in female animals of Labrador group and with AO in the animals of GSD group. PC showed a significant negative correlation with age in male animals of Labrador Retriever group. However, showed a significant ($p<0.05$) positive correlation with linear CEA and a negative correlation with AIA and AO.

The observations of the present study inferred that radiographic attribute of acetabular and femoral parameters differed non-significantly ($p>0.05$) in the adult animals of Labrador retriever and GSD of different weight groups. However, a significant ($p<0.05$) positive correlation of body weight was noted with AW, AIA, AO in overall animals of GSD group and only female animals of Labrador Retriever group and with AW in female animals of Labrador and GSD group. In contrast, body weight showed a significant ($p<0.05$) negative correlation with PC in overall animals of GSD group. Similarily, Kanthavichit *et al*., (2021) [8] had reported a strong positive correlation of body weight with radiographic AW. Ocal *et al*., (2004) [15] reported the width of the acetabulum was about twice its depth and a little larger than the diameter of the femoral head. However, Kanthavichit *et al*., (2021) [8] had also observed the AWs obtained by radiography, 2D-CT, and 3D-CT, and AD, were significantly greater in Shih Tzu than in Maltese. Shih Tzu had larger acetabulum depth and width than those of Maltese. Therefore, differences among races and breeds influence acetabular parameters.

In the present study AW showed a non-significant correlation with age in all the animals except a significant positive correlation in female animals of Labrador Retriever. Similarily, Kanthavichit *et al*., (2021) [8] reported no significant correlations between age and acetabular parameters in Shih Tzu and Maltese. However, Ocal *et al*., (2004) [15] reported significant correlations between the diameter of the femoral head and the width and depth of the acetabulum, between the distances of the dorsal and ventral rims of the acetabulum and between the width and depth of the acetabulum.

The AIA quantifies steepness of cranial acetabular edge (sourcil slope) (Nahla *et al*., 2021) [14]. The results of present study showed a significant higher value of AIA in Labrador group as compared to German shepherd in overall and sexwise comparison of acetabular parameters.

Table 1: Sex wise Mean ± SD values of right and left acetabular parameters in Labrador Retriever and German Shepherd breeds of dog

Acetabular parameters	Groups	Right Hip		Left Hip	
		Male	Female	Male	Female
Acetabular Width (mm)	LAB	26.30±0.75	24.29±1.04	26.16±1.17	24.27±1.27
	GSD	26.96±2.50	26.53±3.10	26.58±2.28	26.21±2.65
Acetabular Depth Index	LAB	0.46±0.07	0.35±0.08	0.48±0.07	0.36±0.11
	GSD	0.44±0.07	0.44±0.09	0.48±0.09	0.48±0.07
Norberg Angle (degree)	LAB	105.31±0.23	105.63±0.65	105.36±0.27	105.71±0.44
	GSD	105.43±0.28	105.49±0.26	105.32±0.36	105.44±0.40
Percent Coverage (percent)	LAB	48.67±11.27	39.00±9.29	48.67±9.33	41.17±10.73
	GSD	46.00±8.07	42.17±10.70	51.50±10.93	49.50±10.29
Center Edge Angle (degree)	LAB	20.26±9.21	10.47±11.58	18.04±8.78	16.00±9.87
	GSD	16.07±11.87	18.76±12.34	19.47±12.29	20.95±8.74
Acetabular Index Angle (degree)	LAB	19.19±4.56^{aA}	20.31±7.81^{aA}	20.09±5.84^{aA}	24.70±10.29^{aA}
	GSD	8.45±6.33^{bB}	6.97±2.68^{bB}	10.22±8.24^{bB}	6.23±2.89^{bB}
Acetabular Offset (mm)	LAB	20.07±1.89	21.43±1.79	18.47±2.04	20.13±2.95
	GSD	19.81±2.09	20.57±5.55	19.25±3.16	17.78±3.06

*Values with different small letter superscripts differ significantly ($p<0.05$) in a row

* Values with different capital letter superscripts differ significantly ($p<0.05$) in a column for a particular parameter.

Table 2: Body Weight wise Mean ± SD values of combined right and left acetabular parameters in Labrador Retriever and German Shepherd breeds of dog.

Acetabular parameters	Groups		Right and left Hip
Acetabular Width (mm)	LAB	<25 (n=4)	24.30±1.01
		25-35 (n=5)	24.89±1.03
		>35 (n=4)	26.54±0.83
	GSD	<25 (n=6)	25.19±1.82
		25-35 (n=5)	28.00±2.71
		>35 (n=4)	28.96±1.13
Acetabular Depth Index	LAB	<25 (n=4)	0.44±0.09
		25-35 (n=5)	0.34±0.06
		>35 (n=4)	0.49±0.09
	GSD	<25 (n=6)	0.48±0.06
		25-35 (n=5)	0.44±0.05
		>35 (n=4)	0.46±0.05
Norberg Angle (degree)	LAB	<25 (n=4)	105.40±0.25
		25-35 (n=5)	105.62±0.39

		>35 (n=4)	105.38±0.22
	GSD	<25 (n=6)	105.34±0.15
		25-35 (n=5)	105.44±0.21
		>35 (n=4)	105.76±0.24
Percent Coverage (percent)	LAB	<25 (n=4)	44.63±14.29
		25-35 (n=5)	29.90±10.26
		>35 (n=4)	50.25±12.70
	GSD	<25 (n=6)	50.25±7.48
		25-35 (n=5)	45.50±6.71
		>35 (n=4)	49.88±7.80
Center Edge Angle (degree)	LAB	<25 (n=4)	21.18±13.58
		25-35 (n=5)	18.34±6.12
		>35 (n=4)	21.03±10.30
	GSD	<25 (n=6)	20.25±9.06
		25-35 (n=5)	19.47±10.00
		>35 (n=4)	21.23±9.79
Acetabular Index Angle (degree)	LAB	<25 (n=4)	14.48±9.21
		25-35 (n=5)	22.81±8.39
		>35 (n=4)	21.46±5.19
	GSD	<25 (n=6)	6.41±2.38
		25-35 (n=5)	9.13±8.00
		>35 (n=4)	7.97±2.61
Acetabular Offset (mm)	LAB	<25 (n=4)	18.51±2.28
		25-35 (n=5)	21.22±1.20
		>35 (n=4)	19.53±2.22
	GSD	<25 (n=6)	17.84±2.00
		25-35 (n=5)	20.57±3.88
		>35 (n=4)	20.58±2.23

Table 3: Body Weight wise Mean ± SD values of combined right and left femoral parameters in Labrador Retriever and German Shepherd breeds of dog

Femoral parameters	Groups		Right and Left Hip
Femoral Head Diameter (mm)	LAB	<25 (n=4)	20.72±1.85
		25-35 (n=5)	19.02±1.57
		>35 (n=4)	22.87±3.39
	GSD	<25 (n=6)	22.06±1.65
		25-35 (n=5)	25.19±3.10
		>35 (n=4)	21.05±0.72
Femoral Neck Length (mm)	LAB	<25 (n=4)	18.58±1.16
		25-35 (n=5)	21.66±1.53
		>35 (n=4)	22.68±1.54
	GSD	<25 (n=6)	20.45±2.28
		25-35 (n=5)	21.88±2.86
		>35 (n=4)	24.26±3.34
Trochanteric Width (mm)	LAB	<25 (n=4)	33.82±1.11
		25-35 (n=5)	33.89±2.08
		>35 (n=4)	38.04±1.35
	GSD	<25 (n=6)	36.94±2.09
		25-35 (n=5)	40.13±3.46
		>35 (n=4)	40.84±1.25
Neck-Shaft Angle (degree)	LAB	<25 (n=4)	139.06±2.44
		25-35 (n=5)	142.90±2.63
		>35 (n=4)	144.05±3.09
	GSD	<25 (n=6)	139.44±3.36
		25-35 (n=5)	137.88±1.34
		>35 (n=4)	141.50±1.96
Femoral Length (mm)	LAB	<25 (n=4)	179.07±6.92
		25-35 (n=5)	177.27±6.83
		>35 (n=4)	189.89±8.81
	GSD	<25 (n=6)	197.59±10.80
		25-35 (n=5)	211.26±13.15
		>35 (n=4)	221.77±8.32
Isthmus Position Index	LAB	<25 (n=4)	0.37±0.03
		25-35 (n=5)	0.38±0.01
		>35 (n=4)	0.41±0.01
	GSD	<25 (n=6)	0.40±0.02
		25-35 (n=5)	0.38±0.03
		>35 (n=4)	0.37±0.01

Canal Flare Index	LAB	<25 (n=4)	2.05±0.12
		25-35 (n=5)	2.05±0.32
		>35 (n=4)	2.00±0.26
	GSD	<25 (n=6)	1.88±0.23
		25-35 (n=5)	1.88±0.09
		>35 (n=4)	1.93±0.26

4. Conclusion
- Weight wise no significant variations were found in all acetabular and proximal femoral radiographic measurements between Labrador Retriever and German Shepherd groups.
- In an overall and sex-wise comparison Labrador group showed a high degree of steepness of cranial acetabular edge (high acetabular index angle) that would help in orientation of acetabular up with different inclination .
- German Shepherd group revealed lower Canal Flare Index (CFI) values and a more stovepipe femoral geometry as compared to Labrador Retriever suitable for selection of cemented implant under Indian conditions.

5. Acknowledgement
Authors are highly thankful to the Director of the Institute for providing necessary facility.

6. References
1. Ajadi RA, Sanni JL, Sobayo EL. Evaluation of radiographic coxofemoral measurements in Boerboel dogs. Folia. Vet. 2018;62(4):66-73.
2. Aiyan AA, Richardson K, Manchi G, Plendl J, Brunnberg L. Measurement of the femoral neck angle in medium and large dog breeds using computed tomography. Acta. Vet. Hung. 2019;67(1):22-33.
3. Andrade CR, Minto BW, Dreibi RM, Diogo LMI, Rocha TASS, Kawamoto FYK, *et al*. Comparison of radiographic and tomographic evaluations for measurement of the Canal Flare Index in dogs. Arq. Bras. Med. Vet. Zootec. 2021;73:571-582
4. Baharuddin MY, Salleh SH, Zulkifly AH, Lee MH, Mohd Noor A. Morphological study of the newly designed cementless femoral stem. Biomed Res. Int, 2014, 11
5. Bhaskar D, Rajpura A, Board T. Current concepts in acetabular positioning in total hip arthroplasty. Indian. J. Orthop. 2017;51(4):386-396.
6. Fonseca RL, Lobo AR, Santana MIS. Measurements of femoral angles, femur length and hip width in cat radiographs. Arq. Bras. Med. Vet. Zootec. 2017;69:1513-1520
7. Gomide PRS, Souza LRVD, Andrade CRD, Dreibi RM, Santarosa BP, Minto BW. Canal flare index evaluation for different dog breeds. Ciência Rural. 2021;51(3):4
8. Kanthavichit K, Klaengkaew A, Thanaboonnipat C, Darawiroj D, Soontornvipart K, Choisunirachon N. Comparison of radiographic and computed tomographic acetabular index in small-breed dogs: a preliminary study using Maltese and Shih Tzu. J. Vet. Sci. 2021;22(4):4.
9. Reyes AT, Agbisit KMB, Darca LG, Marquez RC, Quilinguin JB. Morphometry and length-length relationship of Jagora spp. collected from the river and stream of Aurora Province, Philippines. Int. J. Biol. Sci. 2020;2(1):18-21.
   DOI: 10.33545/26649926.2020.v2.i1a.18
10. Martins J, Ferreira AJ, Ginja MM. Morphometric assessment of the hip joint in the Estrela Mountain Dog breed. Vet. Comp. Ortho. Trauma. 2012;25(03):202-210.
11. Meomartino L, Fatone G, Potena A, Brunetti A. Morphometric assessment of the canine hip joint using the dorsal acetabular rim view and the centre-edge angle. J. Small. Anim. Pract. 2002;43(1):2-6.
12. Mokrovic H, Komen S, Gulan L, Gulan G. Radiographic analysis of the proximal femoral anatomy in the Croatian population. Int. Ortho. 2021;45(4):923-929
13. Mostafa AA, Nahla MA, Ali KM, Berry CR. Modified FCI (Federation Cynologique Internationale) Scoring of the coxofemoral joint in Labrador Retrievers without and with hip dysplasia. Front. Vet. Sci. 2022;9:278
14. Nahla MA, Mostafa AA, Ali K. Radiographic assessment of normal coxofemoral joints of Labrador Retrievers. J. Vet. Med. 2021;67(1):183-191.
15. Ocal MK, Kara ME, Turan E. Computed tomographic measurements of the hip morphology of 10 healthy German shepherd dogs. Vet. Rec. 2004;155(13):392-395
16. Sarierler M, Tatli ZB, Akin I, Yaygingul R, Derincegoz OÖ. Radiographic examination of hip joint geometry in healthy Sivas Kangal dogs. J. Vet. Anim. Sci. 2017;41(1):85-92.
17. Schachner ER, Lopez MJ. Diagnosis, prevention, and management of canine hip dysplasia. J. Vet. Med. 2015;6:181.
18. Sevil-Kilimci F, Kara ME. The geometry of the proximal femoral medullary canal in German Shepherd and Kangal dogs. J.Vet Med. 2017;43(1):52-60
19. Sevil-Kilimci F, Kara, M.E. 2020. Canal flare index in the canine femur is influenced by the measurement method. Vet. Comp. Orthop. Traumatol. 2017;33(03):198-204
20. Zacharia B, Fawas KM. A comparative radiographic morphometric analysis to assess the normal radiological morphology of the adult hip in Indian population. J. Clin Orthop Trauma. 2021;15:117-124.
21. Zeng Y, Wang Y, Zhu Z, Tang T, Dai K, Qiu S. Differences in acetabular morphology related to side and sex in a Chinese population. J. Anat. 2012;220(3):256-262.
22. Kutty S, Schneider P, Faris P, Kiefer G, Frizzell B, Park R, *et al*. Reliability and predictability of the centre-edge angle in the assessment of pincer femoroacetabular impingement. Inter. Orthop. 2012;36(3):505-510.