

# Comparison on Development of Ossification Centres of Radius and Ulna in Male and Female Dogs by Radiographically

Nay Zin Myo\*<sup>1</sup>, Saw Po Po<sup>2</sup>, Hnin Yi Soe<sup>1</sup>, Hlaing Hlaing Myint<sup>2</sup>,  
Khin Thida Khaing<sup>1</sup>

<sup>1</sup>Department of Anatomy, University of Veterinary Science, Yezin, Nay Pyi Taw, Myanmar

<sup>2</sup>Department of Medicine, University of Veterinary Science, Yezin, Nay Pyi Taw, Myanmar

---

**Abstract:** The present study was conducted for six months to observe the radiographic anatomy on the appearance of ossification centres of radius and ulna of eight local dogs (four male and four female). Puppies were placed under the same condition. Each puppy was radiographed eight times on the right forelimb at Day 15, 30, 45, 60, 90, 120, 150 and 180 of age. Craniocaudal and lateral views were taken to observe the appearance of ossification centres of radius and ulna. Centres of distal epiphysis of radius were appeared at 15 days of age in both male and female groups. Centres of proximal radial epiphysis were appeared at 30 days of age in both groups. Centres of distal ulnar epiphysis were appeared at 45 days of age in both groups. Centres of proximal ulnar epiphysis were appeared clearly at 90 days of age in both groups. In both male and female groups, both centres of proximal and distal epiphyses of the radius were well-developed at 120 days of age. At 150 days of age, the mid diaphyses of the ulna were thinner than those of the radius in both groups. All epiphyses of the ulna were completely developed at that age in all dogs. Both proximal and distal epiphyses of the radius were completely developed at 180 days of age in all dogs.

**Keywords:** epiphyses, male and female dogs, ossification centres, radiographs, radius, ulna.

---

## I. INTRODUCTION

Development of skeletal system of dog starts before birth and continues during postnatal life up to three years (Smith, 1964). The radius is the main weight-supporting bone of the forearm and the ulna is the longest bone in the body of dog (Miller *et al.*, 1964). Development of the long bone can be determined by observing the first appearance of ossification centres (Charjan *et al.*, 2014). According to Patton and Kaufman (1995), the time of appearance of ossification centres was varied based on animal species and even within species. In addition, Patel *et al.* (2009) stated that in human, ossification centers at the elbow appeared earlier in females than in males but the normal range in age for the time of appearance of these centers was quite wide for both sexes.

For the observation of ossification centres of the bones, radiological imaging is an effective method to demonstrate the time of appearance and positions of ossification centres which are very important in order to decide whether there is normal or abnormal development of the bone (Anderson, 2004; Todhunter *et al.*, 1997).

Some reports discussed the development of limbs and joints of the dog (Smith, 1960; Miller *et al.*, 1964). However, there was very limited study on the radiographic observations of the forelimb of local dogs in Myanmar. Therefore, the objective of this study was to observe the time of appearance of ossification centres of radius and ulna of male and female local dogs by using radiograph.

## II. METHODOLOGY

### *Experimental animals*

Fifteen-day old, eight local dogs were used for the present study. Dogs were divided into two groups, one group consisted of four male dogs and another contained four female dogs. All dogs were weaned around 45 days of their age. Puppies were kept individually in the cage and placed under the same environmental condition. All animals were fed the same diet twice a day and provided free access of fresh water. General health was monitored by observing their physical characters weekly.

### *Radiographic examination*

The radiography was carried out on 50 milliamperere (mA), 90 kilovoltage (kV) x-ray machine (Yueshen, Guangzhou, China) installed at the Veterinary Teaching Hospital, University of Veterinary Science, Yezin, Nay Pyi Taw. Puppies were radiographed with exposure factors 45-55kV, 50mA and time of exposure was 0.2 to 0.5 second. The radiography was done at a fixed tube-film distance of 100 centimetres (Armbrust, 2009). Each puppy was radiographed eight times on the right forelimb at Day 15, 30, 45, 60, 90, 120, 150 and 180 of age. All puppies were radiographed at 15 days interval until 60 days of age and later at 1 month interval until 180 days of age. Craniocaudal and lateral views were taken to observe development of bones. Films were developed manually. The first appearance of ossification centres of radius and ulna on radiographs were observed based on age and sex. The appearance of radio opaque area at the appropriate anatomical locations on radiographs for the first time was considered as the appearance of ossification center (Hare, 1959).

## III. RESULTS

There was no orthopedic disorder in both male and female dogs. All dogs were in good health and ate well during the entire experimental period. Physical examinations that were performed weekly showed that all dogs were within normal range. Any infectious diseases were not observed in all dogs.

In this experiment, diaphyses of radius and ulna were well-developed at 15 days of age in both male and female groups. Centre of distal epiphysis of the radius were appeared at that age in both groups but it was barely visible in male group at the lateral view. They were small ovoid in shape. In both male and female groups, metaphyses of radius and ulna were wider than midshafts of their diaphyses (Figure 1).

At 30 days of age, centres of distal epiphysis of the radius were gradually developed and became oval shaped in both groups. Centres of proximal epiphysis of the radius were firstly visible at that age in both groups. They were small disk in appearance (Figure 2 and 3).

At 45 days of age, centres of proximal epiphysis of the radius took the shape of a disk over the proximal end of the diaphysis in both male and female groups. Ossification centres of distal ulnar epiphyses were appeared at that age in both groups. They were rounded in appearance. These centres were more distinct in male than in female (Figure 4).

At 60 days of age, centres of distal ulnar epiphysis became larger in size and turned as rectangular in shape in both male and female groups. Centres of proximal ulnar epiphysis were not appeared until that age in both groups (Figure 5).

At 90 days of age, centres of proximal ulnar epiphysis were visible clearly in both male and female dogs. The centre of the proximal ulnar epiphysis was nearly triangular in male and oval shaped in female. At that age, the distal radial epiphysis was rectangular in shape. The diaphyseal surface of distal radial epiphysis was slightly concave to fit with the distal end of diaphysis. The centre of the distal ulnar epiphysis was cone-shaped. Its diaphyseal surface was hollowed out to receive distal end of diaphysis (Figure 6 and 7).

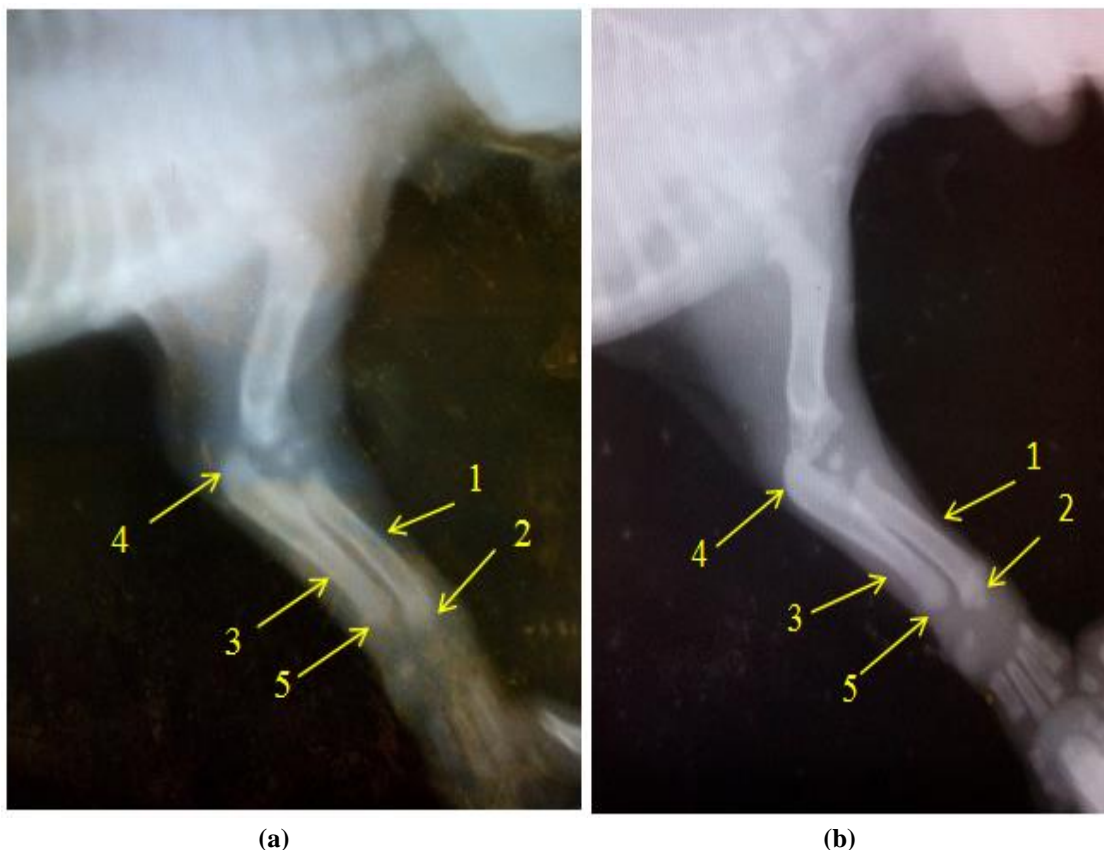
In both male and female groups, both centres of proximal and distal epiphyses of the radius were well-developed at 120 days of age. Distal ends of the radius and ulna were located at the same level in the lateral view but in the cranio-caudal view, distal ends of the ulnar styloid process were a little above than those of the radial epiphyses. The radius and ulna of the male dogs were approximately the same diametre at the level of the mid diaphysis. Nevertheless, mid diaphyses of the

ulna of female dogs were a little thinner than those of the radius at that age. The medial aspects of the distal radial epiphyses were extended distally to articulate with the radial carpal bones (Figure 8, 9 and 10).

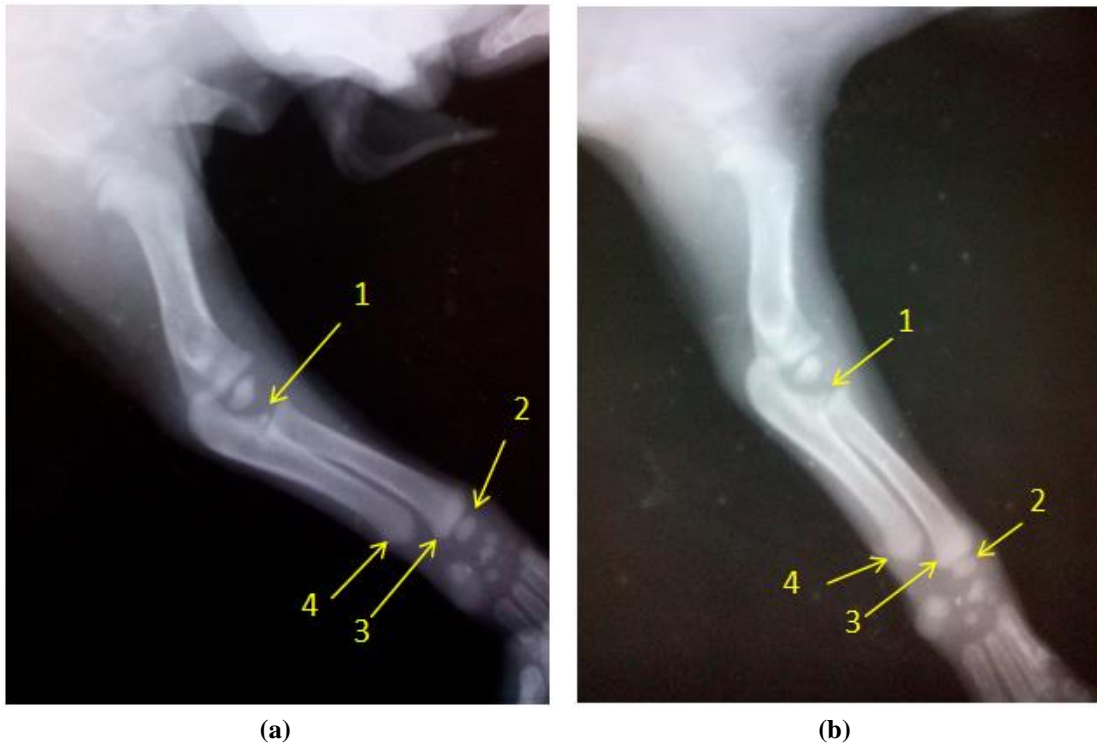
The proximal ulnar epiphysis was started to fuse with the diaphysis at 150 days of age in male groups. However, fusion of the proximal ulnar epiphysis with the diaphysis was not started at that age in female group. In both male and female groups, distal epiphyses of the radius were narrow in the middle and wide in both sides at 150 days of age. Mid diaphyses of the ulna were thinner than those of the radius. The distal tip of the ulnar styloid process was bowed medially to articulate with the ulnar carpal bone. During this time all epiphyses of the ulna were completely developed in all dogs. The growth plates were seen as radiolucent lines (dark lines) between epiphyses and diaphyses of the bones (Figure 11, 12 and 13).

Both proximal and distal epiphyses of the radius were completely developed at 180 days of age in all dogs. Proximal ulnar epiphyses were fused with their diaphysis but fusion was not completed at that age in both groups. Mid diaphyses of the ulna were much thinner than those of the radius at 180 days of age. Both proximal and distal epiphyses of the radius and ulna were remained separately from their diaphyses by cartilaginous plates which were seen on radiographs as dark lines (Figure 14 and 15).

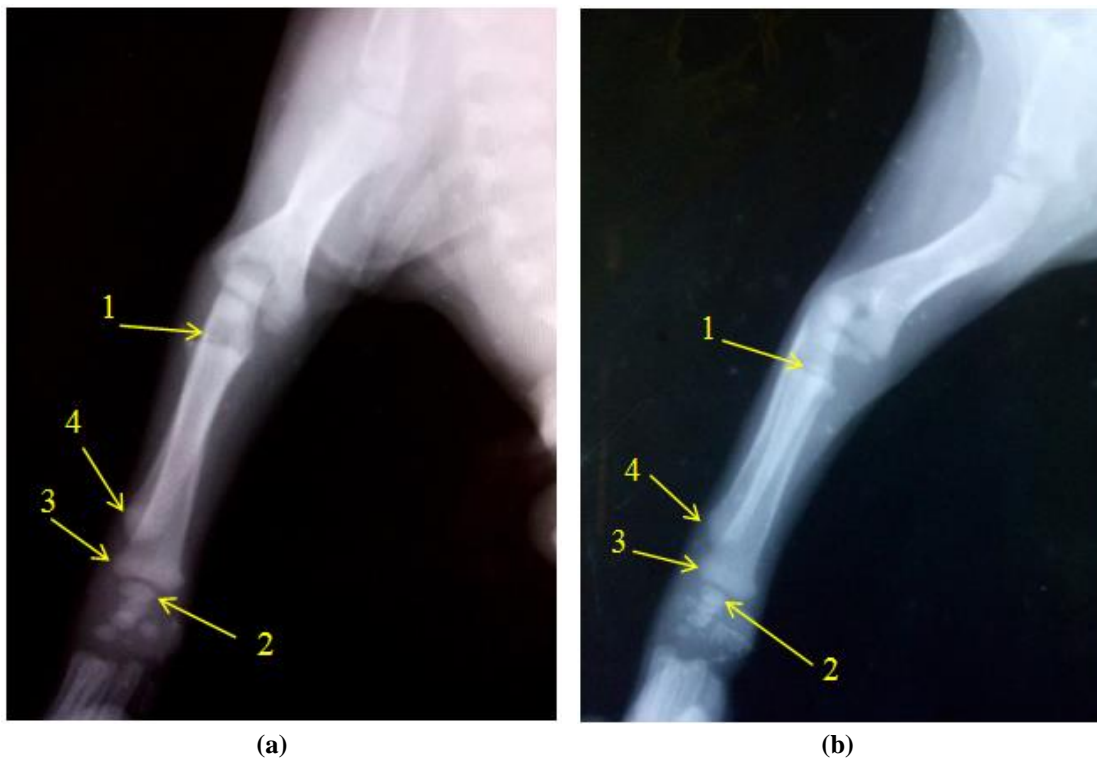
According to the present study, it could be summarized that, in both male and female groups, the centre of distal epiphysis of the radius was appeared at 15 days of age. The centre of the proximal radial epiphysis was appeared at 30 days of age. The centre of the distal ulnar epiphysis was appeared at 45 days of age. The centre of proximal ulnar epiphysis was appeared clearly at the age of 90 days (Table I).



**Figure 1 Radiographs of the lateral view of right forelimb in 15-day old local dogs: male (a) and female (b) showing diaphysis of the radius (1), distal radial epiphysis (2), diaphysis of the ulna (3), proximal metaphysis of the ulna (4) and distal metaphysis of the ulna (5).**



**Figure 2 Radiographs of the lateral view of right forelimb in 30-day old local dogs: male (a) and female (b) showing proximal radial epiphysis (1), distal radial epiphysis (2), distal radial metaphysis (3) and distal ulnar metaphysis (4)**



**Figure 3 Radiographs of the craniocaudal view of right forelimb in 30-day old local dogs: male (a) and female (b) showing proximal radial epiphysis (1), distal radial epiphysis (2), distal radial metaphysis (3) and distal ulnar metaphysis (4)**

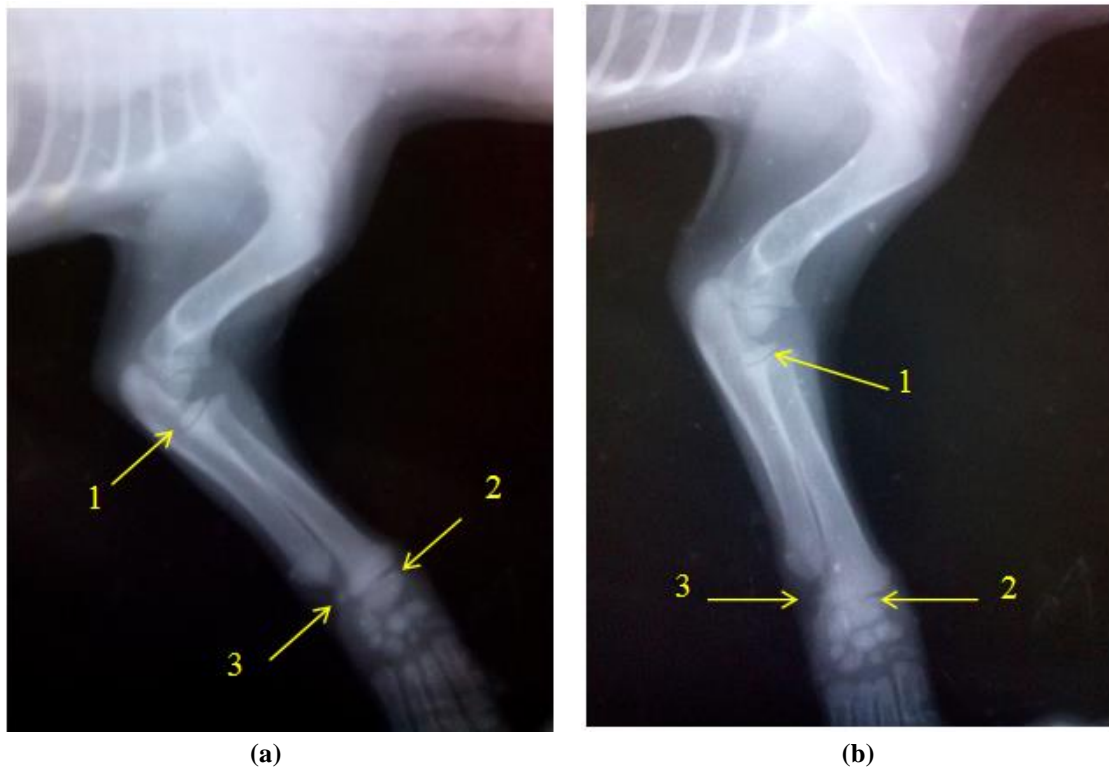
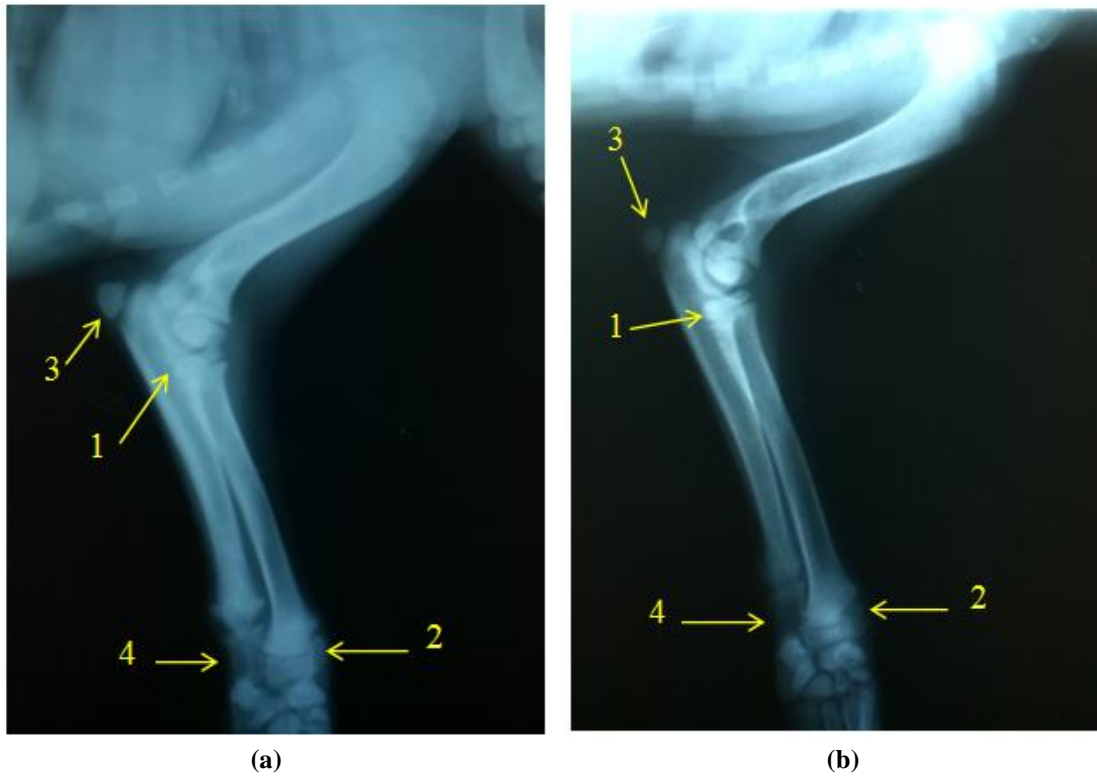


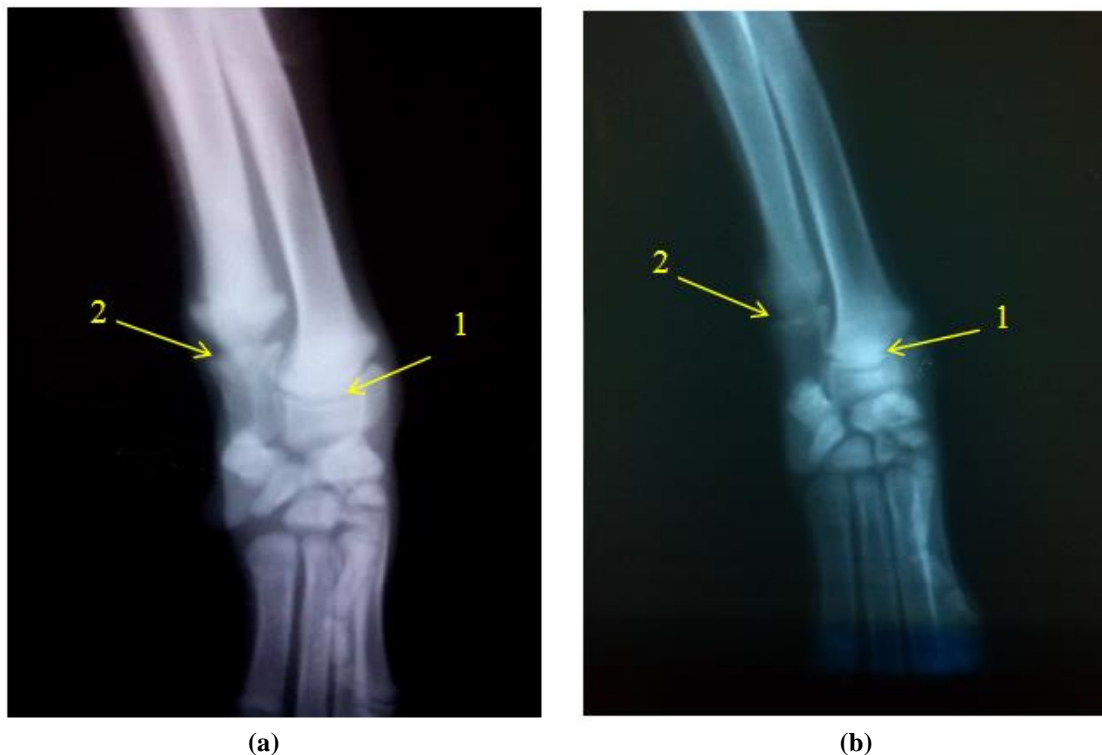
Figure 4 Radiographs of the lateral view of right forelimb in 45-day old local dogs: male (a) and female (b) showing proximal radial epiphysis (1), distal radial epiphysis (2) and distal ulnar epiphysis (3).



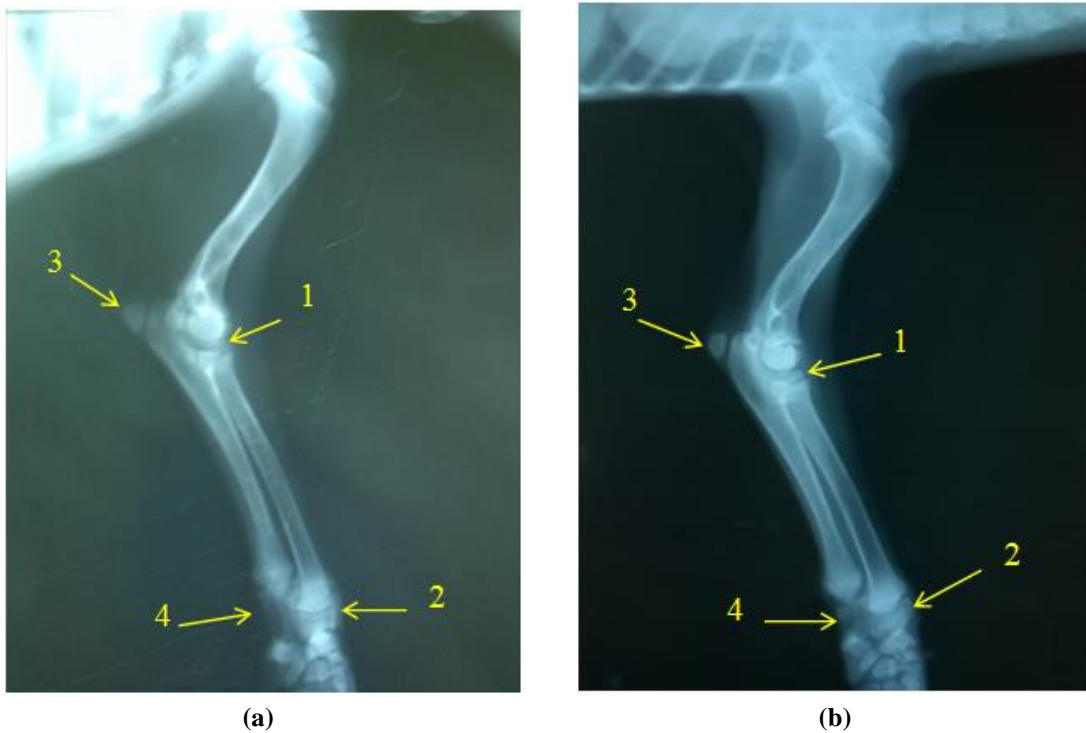
Figure 5 Radiographs of the lateral view of right forelimb in 60-day old local dogs: male (a) and female (b) showing proximal radial epiphysis (1), distal radial epiphysis (2) and distal ulnar epiphysis (3).



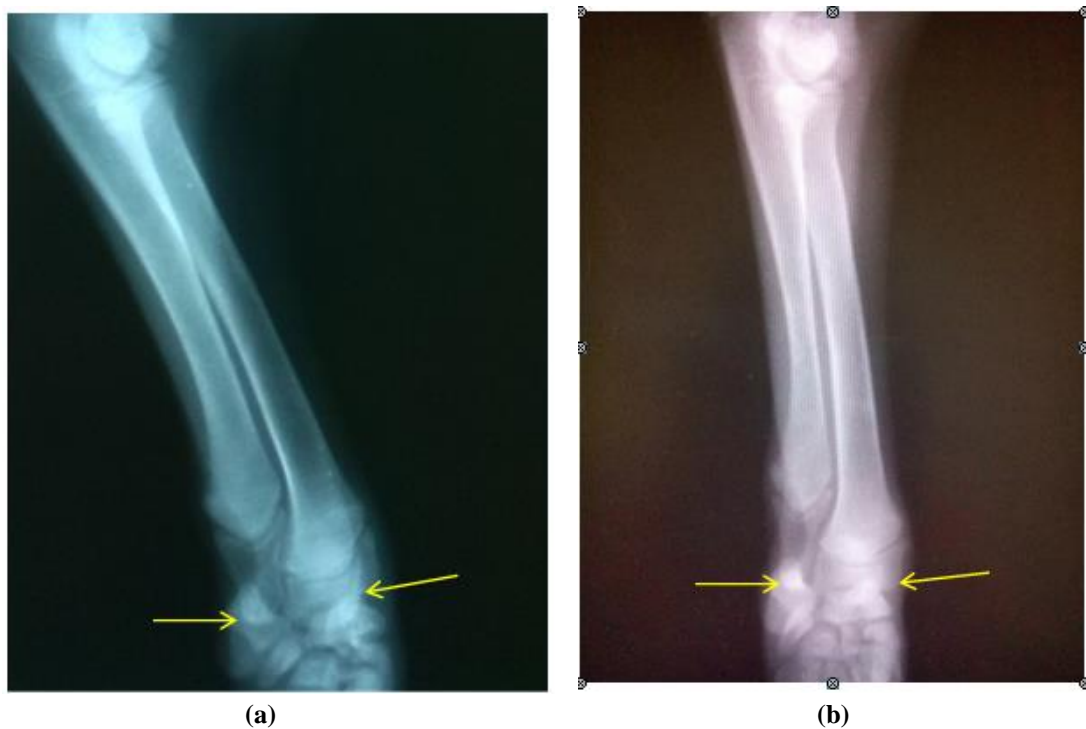
**Figure 6 Radiographs of the lateral view of right forelimb in 90-day old local dogs: male (a) and female (b) showing proximal radial epiphysis (1), distal radial epiphysis (2), proximal ulnar epiphysis or olecranon (3) and distal ulnar epiphysis (4).**



**Figure 7 Radiographs of the lateral view of right forelimb in 90-day old local dogs: male (a) and female (b). The diaphyseal surface of the distal radial epiphysis was slightly concave to fit with the distal end of diaphysis (1) and the diaphyseal surface of the distal ulnar epiphysis was hollowed out to receive the distal end of the diaphysis (2)**



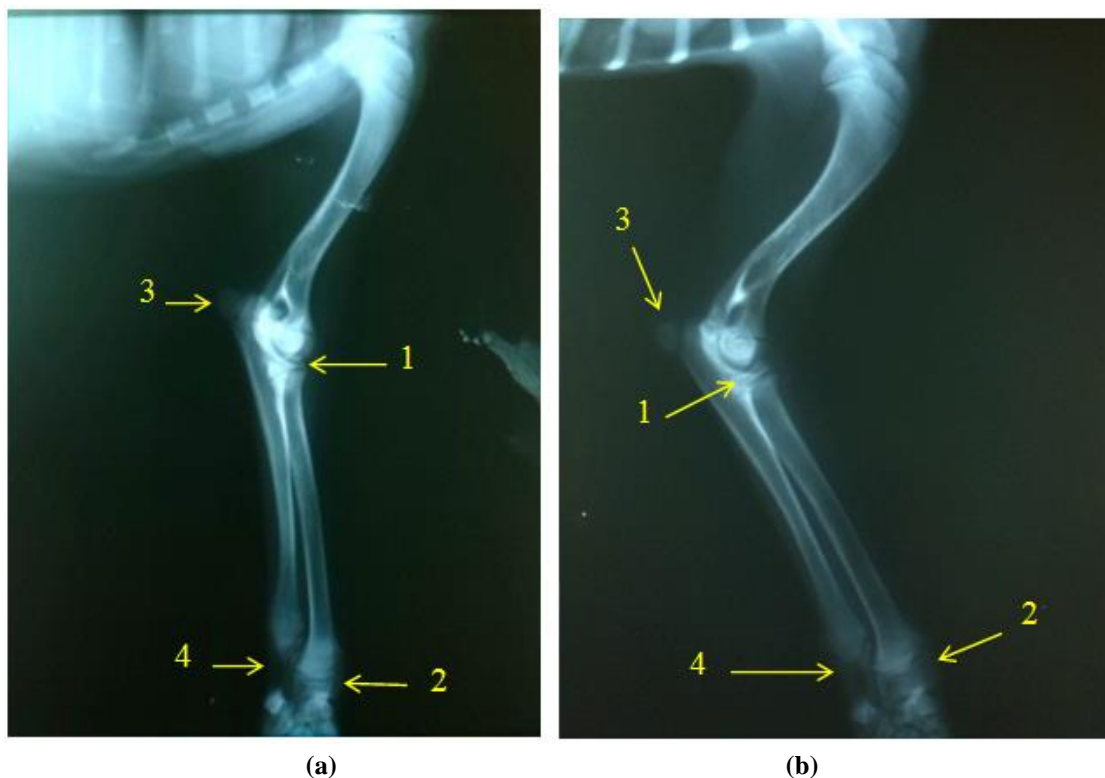
**Figure 8 Radiographs of the lateral view of right forelimb in 120-day old local dogs: male (a) and female (b) showing proximal radial epiphysis (1), distal radial epiphysis (2), proximal ulnar epiphysis or olecranon (3) and distal ulnar epiphysis (4).**



**Figure 9 Radiographs of the lateral view of right forelimb in 120-day old local dogs: male (a) and female (b). The distal ends of the radius and ulna were located at the same level (arrow). The radius and ulna of male dogs were the same diameter at the level of the mid diaphysis and the mid diaphysis of the ulna of female dogs was a little thinner than that of the radius.**



**Figure 10** Radiographs of the craniocaudal view of right forelimb in 120-day old local dogs; male (a) and female (b). The distal end of the ulna was a little above than that of the distal radial epiphysis. The medial aspect of the distal radial epiphysis extended distally to articulate with the radial carpal bone (arrow).



**Figure 11** Radiographs of the lateral view of right forelimb in 150-day old local dogs: male (a) and female (b) showing proximal radial epiphysis (1), distal radial epiphysis (2), proximal ulnar epiphysis or olecranon (3) and distal ulnar epiphysis (4).

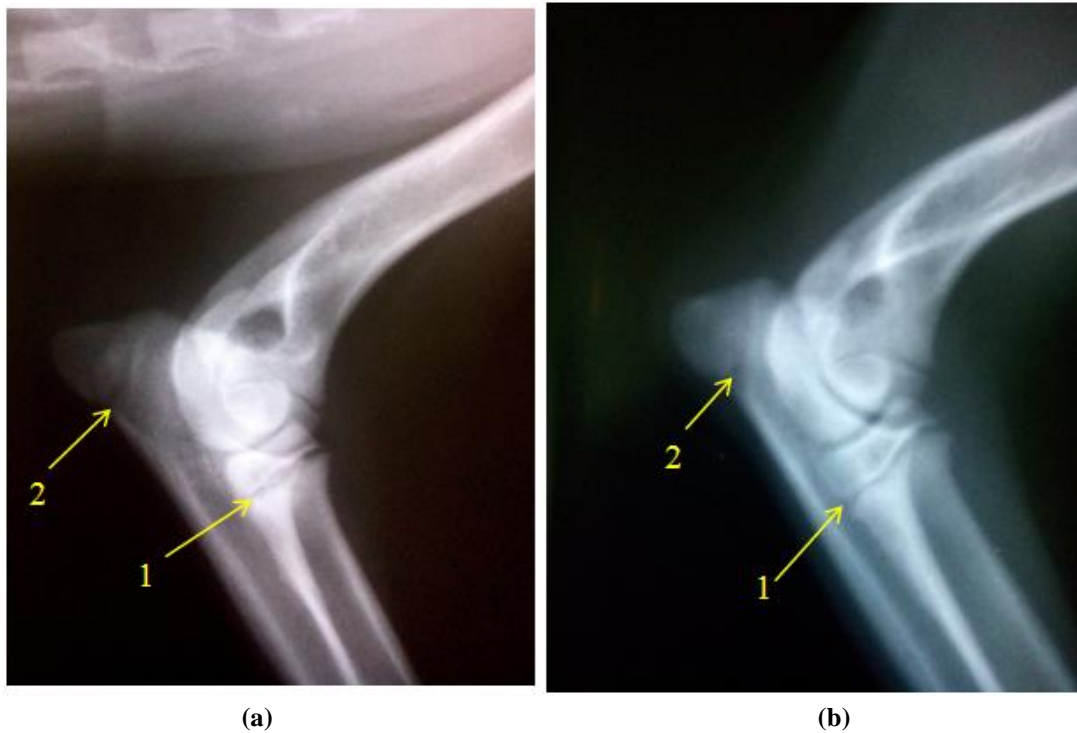




**Figure 12 Radiographs of the lateral view of right forelimb in 150-day old local dogs: male (a) and female (b). The distal radial epiphysis was narrow in its middle and wide in both sides (arrow). The mid diaphysis of the ulna was thinner than that of the radius.**



**Figure 13 Radiographs of the craniocaudal view of right forelimb in 150-day old local dogs: male (a) and female (b). The distal tip of the ulnar styloid process was bowed medially to articulate with the ulnar carpal bone (arrow).**



**Figure 14 Radiographs of the lateral view of right forelimb in 180-day old local dogs: male (a) and female (b). The proximal epiphyses of the radius (1) and ulna (2) were remained separated from their diaphyses by epiphyseal plates which were seen on the radiographs as dark lines.**



**Figure 15 Radiographs of the lateral view of right forelimb in 180-day old local dogs: male (a) and female (b). The mid diaphysis of the ulna was much thinner than those of the radius. The distal epiphyses of the radius and ulna were remained separated from their diaphyses by cartilaginous plates (arrows).**

**Table I Summary of the appearance of the secondary ossification centres in radius and ulna of local dog at different days of age**

Bone	Name of ossification centres	Age of dog (days)								
		15	30	45	60	90	120	150	180	
Radius	Proximal epiphysis	-	+	+	+	+	+	+	+	+
	Distal epiphysis	+	+	+	+	+	+	+	+	+
Ulna	Proximal epiphysis (olecranon)	-	-	-	-	+	+	+	+	+
	Distal epiphysis	-	-	+	+	+	+	+	+	+

+ represents the presence of the appearance of ossification centre

- represents the absence of the appearance of ossification centre

#### IV. DISCUSSION

Physical examinations revealed that all dogs were in good health. No orthopedic disorder was observed during the entire experimental period. This showed that bones were developed normally in all dogs.

It was observed that radius in both groups developed from three main centres of ossification, one each for the diaphysis, proximal epiphysis and distal epiphysis. Ulna in both groups developed from three principal centres of ossification, one in the middle of the diaphysis, one in each of two epiphyses (proximal and distal). These findings were strongly agreed with findings of Parcher and Williams (1970) and Charjan *et al.* (2014). Therefore, the present study showed that ossification centres of radius and ulna were developed according to normal ossification pattern.

In this study, the centre of distal radial epiphysis was found noticeably at 15 days of age in both group. It was barely visible at that time in male group at lateral view. Charjan *et al.* (2014) described that the centre of distal radial epiphysis was appeared at  $17.5 \pm 2.50$  days of age in Pomeranian. This statement was almost similar with the present finding. However, this centre was appeared at  $22.5 \pm 3.36$  days of age in German Shepherd and  $25 \pm 3.17$  days of age in non-descript dogs (Charjan *et al.*, 2014). According to the above statement, the time of appearance of the centre for the distal radial epiphysis in local dogs was a little earlier than that of the German Shepherd and non-descript dogs. This difference might be due to breed or other factors such as nutrition and management.

At 30 days of age, centres of proximal radial epiphysis were appeared in both male and female groups. The present finding was similar with findings of Parcher and Williams (1970) and Charjan *et al.* (2014). According to Charjan *et al.* (2014), this centre was appeared at that age in German Shepherd and non-descript dogs. Parcher and Williams (1970) also described that this centre was appeared at four weeks of age in Beagle dogs. The centre of proximal radial epiphysis was appeared at  $35 \pm 3.17$  days of age in Pomeranian dogs (Charjan *et al.*, 2014). It was observed that the appearance of this centre was earlier in local dogs than in Pomeranian dogs.

In the current study, centres of distal ulnar epiphysis were appeared at the age of 45 days in both male and female dogs. This finding was in agreement with the finding of Morillo (2007), who noted that the centre of distal ulnar epiphysis was firstly visible at six weeks of age in Keeshound dogs. Charjan *et al.* (2014) also reported that the centre of distal ulnar epiphysis was appeared at the age of  $42.5 \pm 2.50$  days in German Shepherd and non-descript and  $55 \pm 3.17$  days of age in Pomeranian dogs. It was found that the time of appearance of the centre of distal ulnar epiphysis in local dogs was almost similar with that in German Shepherd and non-descript dogs and a little earlier than that in Pomeranian dogs. These differences might be due to genetic, nutritional and environmental factors.

In this study, centres of proximal ulnar epiphysis were not appeared until the age of 60 days in both male and female dogs. The present finding was in contrast with findings of Morillo (2007) and Charjan *et al.* (2014). Morillo (2007) described that the center of proximal ulnar epiphysis (olecranon process) became visible radiographically at two months of age in Keeshound dogs. In addition, Charjan *et al.* (2014) mentioned that the center of proximal ulnar epiphysis was appeared at the age of  $55 \pm 3.17$  days and  $57.5 \pm 2.50$  days in German Shepherd and non-descript dogs, respectively. At 90 days of age, centres of proximal ulnar epiphysis were clearly visible in both male and female dogs. It was observed that ossification centres of proximal ulnar epiphysis in local dogs were appeared quite late in comparison with German

Shepherd and Keeshound dogs that were studied by Morillo (2007) and Charjan *et al.* (2014). This difference might be due to genetic, nutritional and environmental factors.

In the present study, the time of appearance of ossification centres of radius and ulna were not different between male and female groups. However, in contrast with Patel *et al.* (2009), who described that ossification centers of the elbow joints in human were appeared earlier in females than in males but the normal range in age for the times of appearance of these centers was quite wide for both sexes. Patton and Kaufman (1995) stated that the time of appearance of ossification centre varied between species and even within species. In this study, there was a difference in the time of appearance of ossification centres of local dogs in comparison with Keeshounds, German Shepherd, Pomeranian and non-descript dogs those were studied by Morillo (2007) and Charjan *et al.* (2014). It was assumed that this might be due to the differences among breeds of dog as described by Patton and Kaufman (1995).

## V. CONCLUSION

From this study, it can be concluded that all principal ossification centres of radius and ulna of local dogs were gradually developed with increasing age. The time of appearance of ossification centres of radius and ulna were not different between male and female.

## REFERENCES

- [1] KL. Anderson, "Small animal musculoskeletal radiology", [www.citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.484.9761&rep=rep1&type=pdf](http://www.citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.484.9761&rep=rep1&type=pdf). Accessed on 15 December 2015. 2004.
- [2] L. Armbrust, "Radiology developing technique charts" [www.cliniciansbrief.com/sites/default/files/sites/cliniciansbrief.com/files/Radiology Developing TechniqueCharts.pdf](http://www.cliniciansbrief.com/sites/default/files/sites/cliniciansbrief.com/files/Radiology%20Developing%20TechniqueCharts.pdf). Accessed on 20 August 2015. 2009.
- [3] RY. Charjan, S. Sathapathy, SB. Banubakode and SK. Joshi, "Radiographic anatomical studies on the fusion of ossification centres in the developing radius, ulna, carpals, metacarpals and phalanges of right forelimb in different breeds of dog (*Canis familiaris*)", *Ind. J. Vet. Ana.* Vol. 26, pp. 76-78, 2014.
- [4] WC. Hare, "Radiographic anatomy of the canine pectoral limb. Part II. Developing limb", *J. Am. Vet. Med. Assoc.* 135: 305-310, 1959.
- [5] MI. Miller, GC Christensen, and HE. Evans, "The skeletal system," In: *Anatomy of the Dog*. 2<sup>nd</sup> ed. (Ed. Dusseau J), Saunders, Philadelphia, 1964.
- [6] MA. Morillo, "Age Determination in young Keeshound puppies using a simple radiographic study of the radius, ulna and carpus", *Multiciencias*, Vol. 7, pp. 249- 255, 2007.
- [7] B. Patel, M. Reed, and S. Patel, "Gender-specific pattern differences of the ossification centers in the pediatric elbow", *Pedia. Radio.*, Vol. 39, pp. 226-231, 2009.
- [8] JT. Patton, and MH. Kaufman, "The timing of ossification of the limb bones, and growth rates of various long bones of the fore and hind limbs of the prenatal and early postnatal laboratory mouse", *J. Anat.* Vol. 186, pp. 175-185, 1995.
- [9] RN. Smith, "Radiological observations on the limbs of young greyhounds", *J. Small Anim. Pract.* Vol. 1, pp. 84-90, 1960.
- [10] RN. Smith, "The pelvis of the young dog", *Vet. Rec.* Vol. 76, pp. 975-979, 1964.
- [11] RJ. Todhunter, TA. Zachos, RO. Gilbert, HN. Erb, AJ. Williams, N. Burton-Wurster, and G. Lust, "Onset of epiphyseal mineralization and growth plate closure in radiographically normal and dysplastic Labrador retrievers", *J. Am. Vet. Med. Assoc.* Vol. 210, pp. 1458-1462, 1997.