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Radiographic Monitoring of Secondary Ossification Centers of Radius and Ulna Bones in Dogs

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Abstract

Monitoring the Secondary ossification centers and growth plates is necessary in order to decide whether there is abnormal development of these structures. It also to provide a base line in which the development of radius and ulna bones can be compared as there is paucity of information on the development of secondary ossification centers and growth plates of Nigerian local dogs as inferences are often drawn from foreign breeds of dogs. The present study was conducted for 16 weeks to monitor the appearance of secondary ossification centers and growth plates of radius and ulna bones of 16 dogs (8 males and 8 females). Each puppy was radiographed 11 times on the right forelimb at week 1-9, 12 and 16 weeks of age. A descriptive study was conducted and radiographic images were reviewed which revealed that no secondary ossification center and growth plate was present at week 1. Therefore Nigerian Local dogs had no secondary ossification centers and growth plate of the radius and ulna bones at birth, they all develop post natal.

Key words: Radiography; ossification centers; epiphysis; radius; ulna and dogs.

1. Introduction

In monitoring the radiographs of these bones, it is important to know the usual time of appearance and development of secondary ossification centers and their growth plates in order to decide whether there is abnormal formation, or delayed in the time of appearance of these structures. Some reports have been documented on the development of limbs and joints of the dog [1, 2, 3, 4]. However, limited studies have been documented on the radiographic observations of the radius and ulna bones of Nigerian local dogs.

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Thus, the objective of this study was to monitor the time of appearance of secondary ossification centers of radius and ulna bones of Nigerian local dogs using radiography. The time of appearance of ossification center for dogs between 25 to 35kg was reported to be variable for anconeal process, prenatal for proximal epiphysis and distal epiphysis of the radius, 3-4 months for proximal and distal epiphysis of the ulna [5]. Reference [6] reported that the time of appearance of Secondary ossification centers is different based on animal species and within species. However this variation in the time of appearance and development of secondary ossification centers documented for different breed of dogs makes it a necessity to document its developmental patterns in Nigerian Local dogs.

Secondary Ossification Centers appears after the development of primary ossification center and is usually found at the expanded end of long bones. It is initially made of cartilage but during development it is converted to bone. The appearance of the radiopaque area at the epiphyseal region on radiographs for the first time is considered as the appearance of secondary ossification center [4]. Secondary ossification centers begin to form at each end of long bones calcifying tissues to bonelike mass. In the long bones, secondary ossification centers appear at different times and their pattern of development is by endochondral ossification [7]. The endochondral ossification area of long bones is referred to as growth plates [8], which appears as a radiolucent space on a radiograph in young bones [9]. Growth plates are specialized cartilage extending longitudinally between the epiphysis and metaphysis of immature long bones. At maturity, the growth plate fuses with the metaphysis to become a single bone [10].

2. Methodology

Experimental animals

A total of sixteen (8 males, 8 females) (G-power statistical soft were) apparently healthy Nigerian local puppies, weighing an average of 0.3kg (week 1) and 7.2kg (week 16), obtained from three different liters were used for the present study. They were physically examined to ascertain their health status. The puppies were dewormed and vaccinated against rabies, parvovirus enteritis, hepatitis, leptospirosis, and canine distemper. They were maintained on daily ration of jollof rice, gari with soup and beans. Drinking water was provided *ad libitum*.

Radiographic examination

Each puppy was radiographed 11 times on the right forelimb at 1, 2, 3, 4, 5, 6, 7, 8, 9, 12 and 16 weeks of age. The radiograph was taken at weekly interval for 9 weeks in order to monitor the appearance of secondary ossification centers and thereafter the development of the secondary ossification centers and their growth plates at 4 weeks interval (twice). Each puppy was radiographed using the radiographic film cassette (Dr Goos Suprema® Germany, size 35x43cm and 24x30cm) and an X-ray film (AGFA DT2B India and FUJI Japan Tokyo, size 35x43cm and 24x30cm) with exposure factors of 50-55kV and 10-12 mAs at a film-focal distance of 100 cm [11] using Power mobile x-ray machine (LX-8 MOB) installed at Veterinary radiology unit of Usmanu Danfodiyo University Sokoto.

At week 1, each puppy was placed on the right lateral recumbency on the x-ray table for radiography without

sedation due to their tender nature till they were 4 weeks, when the puppies were sedated (in order to immobilize the animal for radiography) using Xylazine hydrochloride (0.2mg/kg) (VMD Arendonk, Belgium®) and Atropine (0.04mg/kg) intramuscularly (I.M) [12]. Medio-lateral views were taken to observe development of bones and the films were processed manually using the method documented by [13]. The time of appearance and development of secondary ossification centers of radius and ulna bones, presence or absence of a separate center of ossification for the anconeal and coronoid processes and the time of appearance and development of proximal and distal growth plates of radius and ulna bones were monitored till 16 weeks. The radiographs were reviewed by a team of professionals consisting of a radiologist, surgeons, and an anatomist who planned, organized and interpreted the radiographs using an X-ray film illuminator (Techmel and Techmel Texas U.S.A).

3. Results

At 1 week of age, the medial and lateral coronoid processes were present as a direct extension from the ulna bone but all the proximal and distal secondary ossification centers and growth plates were absent in both male and female dogs (Figure 1 week1). At 2 weeks of age, the medial coronoid process touched the radius at this stage and the secondary ossification center of the distal radius appeared in 12 dogs but absent in 4 (2 males and 2 females) as a small radiopaque area which completely appeared at 3 weeks. The growth plate of the distal radius appeared after the appearance of the secondary ossification centers (Figure 1 week 2). At 3 weeks of age, the secondary ossification center of the distal radial epiphysis of the other 4 dogs appeared and became prominent in all the dogs. The structure observed in week 3 continued developing in week 4 and the secondary ossification center of the distal radius and its growth plate were the only ones developed at this time.

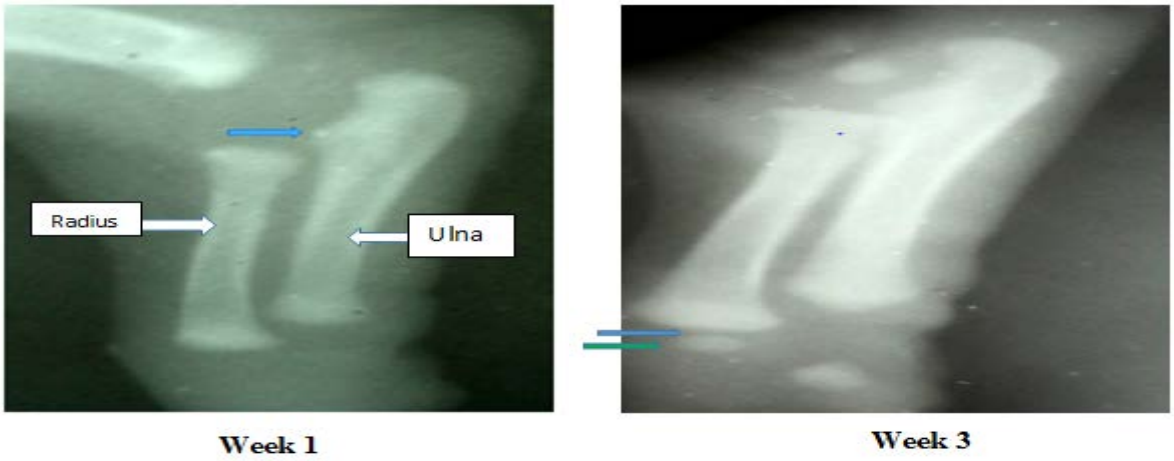

Figure 1: The development of coronoid process at week 1 and week 3 indicating the appearance of secondary ossification center of the distal ulna in all the dogs. The radiolucent space (blue arrow) is the growth plate.

At week 5, the secondary ossification center of the proximal radial epiphysis developed in all the dogs and the growth plate was present as well. At this age the growth plate and secondary ossification centers of the radial bone were all present in all the dogs (Figure 2 week 5). At week 6, the secondary ossification center of the distal ulna and its growth plate developed in all the dogs (Figure 2 week 6). At week 7 all the secondary ossification

centers already present kept developing as the dog grew older.

Figure 2: The appearance of proximal secondary ossification center of the radius in week 5 and week 6 showing the appearance of distal secondary ossification center and growth plate of the distal ulna.

At week 8 of age, the secondary ossification center of the proximal epiphysis of the ulna and its growth plate appeared in all the dogs. All the secondary ossification centers of the radius and ulna bones and their growth plates were present at this stage in all the dogs (Figure 3 week 8) (Table 1). At week 9. the secondary ossification centers kept developing in all the dogs as the animals grew older. At week 12, the anconeal process appeared as a direct extension of the ulna bone not having a separate ossification center (Figure3 week 12) it is at this age that all the ossification center took their proper anatomical shape.

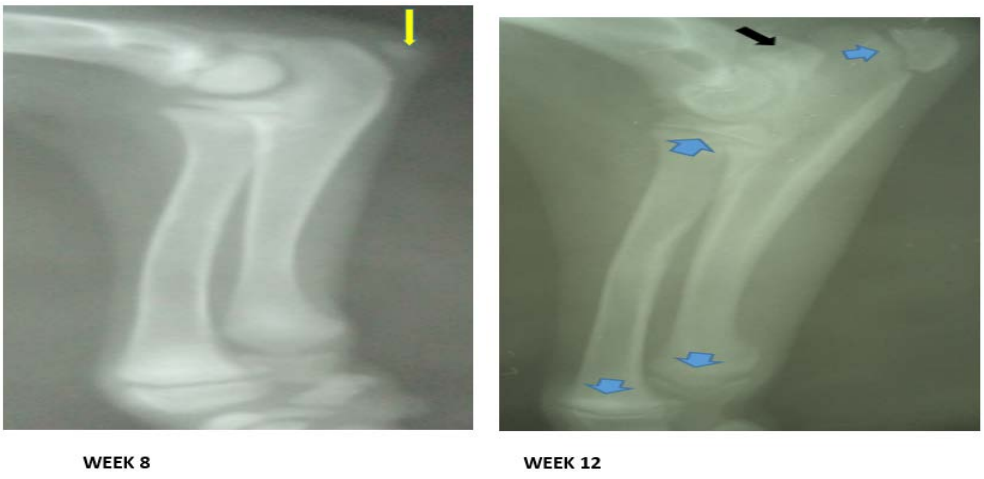

Figure 3: The appearance of the secondary ossification center of the proximal ulna (olecranon) at week 8 and week 12 showing the appearance the anconeal process with the black arrow and all the secondary ossification centers took their normal shapes (blue arrows).

At 16 weeks of age, all the secondary ossification centers developed to a point where their growth plate became a tiny line in all the dogs. At the appearance of each secondary ossification centers, the growth plate appeared

(Table 2) and had its largest thickness at this age but the thickness kept reducing as the animal grew older until it became thin in week 16.

Figure 4: Showing the third stage of development where all the secondary ossification centers and their tiny growth plate.

Table 1: Showing the, radiographic appearance of the Secondary Ossification Centers of radius and ulna bones.

Bone	Ossification Centers	Age of appearance of secondary ossification center (week)
Ulna	Medial coronoid process	1
	Lateral coronoid process	1
	Distal epiphysis	6
	Olecranon	8
	Anconeal process	9
Radius	Distal epiphysis	2-3
	Proximal epiphysis	5

Table 2: Showing the time of appearance of growth plates

Bone	growth plates (GP)	age of appearance of GP (weeks)
Ulna	Distal epiphysis	6
	Olecranon	8
Radius	Distal epiphysis	2-3
	Proximal epiphysis	5

4. Discussion

The absence of secondary ossification center observed in this study in week one was similar to the work reported by [14] who reported that at birth, the secondary ossification center to be radiographically visible at 2 weeks of age but this result differs from the work documented by [15] who reported the proximal and distal radial epiphysis to be prenatal and the proximal and distal ulnar epiphysis to appear 3-4 months post natal.

At week 2, the distal radius appeared in 12 dogs (6 males and 6 females) as a very small radiopaque spot which

was absent in 4 dogs (2 males and 2 females) but eventually appeared in 3 weeks and at this week, the secondary ossification centers and growth plate became more obvious in all the dogs so therefore the time of appearance can be said to be between 2-3 weeks which is in line with the work reported by [4] who reported 2 weeks 1 day for local dogs in Myanmar and also the report of [3] who described the center of distal radial epiphysis to appear at 2 weeks, 3 days of age in Pomeranian but contrary to the time of appearance in non-descript dogs which was documented to be greater than 3 weeks [3]. No new structure developed at 4 weeks in this study. The variations observed in the time of appearance in these studies could have been due to genetic variations within the same breed caused by the nature of their breeding.

At 5 weeks of age, the secondary ossification center of the proximal radial epiphysis appeared in all the dogs which was similar to the time reported by [3] who reported that the center of proximal radial epiphysis appeared at 5 weeks of age in Pomeranian dogs but contrary to the work reported by [4] who reported an earlier time of 4 weeks for local dogs of Myanmar. This could be due to breed variation.

At 6 weeks of age, the secondary ossification center of the distal ulnar epiphysis appeared which is in line with the work documented by [3] who reported that the center of distal ulnar epiphysis appeared at the age of 6 weeks in Non-descript dogs and German shepherd but at later age in Pomeranian dogs which appeared after 7 weeks. It was established that the time of appearance of the center of distal ulnar epiphysis in Nigerian local dogs was virtually similar with that in non-descript dogs and German shepherd but slightly earlier than that in Pomeranian dogs. These differences might be due to genetic variations, nutrition or management system. No new structures were observed in week 7. At 8 weeks of age, the proximal epiphysis (olecranon) appeared in all dogs which is in line with the time reported by [15] who described that the center of proximal ulnar epiphysis (olecranon) becomes radiographically visible at 8 weeks of age in Keeshound dogs and 8.1 weeks for non-descript dogs [3]. In addition to that, [3] revealed that the secondary ossification center of the proximal ulnar epiphysis appeared slightly earlier in German shepherd at the age of 7.8weeks and much later in local dogs of Myanmar at the age of 8.6 weeks [4]. This difference in the time of appearance might be due to nutritional and genetic variation. In 9 weeks of age, centers of proximal ulnar epiphysis were clearly visible and kept developing in all the dogs. At 12 weeks of age, the anconeal process (AP) appeared as a direct extension of the proximal ulna from the base to the tip in all the dogs which is similar to the appearance reported by [16] for Bernese Mountain, Rottweiler, Mastiff, St. Bernard and Newfoundland breeds of dogs but contrary to the appearance reported by [17] who reported that the AP developed from a separate ossification center for German Shepherd and Greyhound dogs. This could be due to breed genetic variations. The time of appearance of AP in this research was 12 weeks which is similar to the time documented by [18] and [19] who reported the appearance of the AP to be 12 to 14 weeks. The largest thickness of the growth plate was observed at their time of appearance which kept reducing as the animal was maturing to a tiny line as observed at the end of this research (16 weeks) and the time of appearance of the secondary ossification center was the same as the time of appearance of the growth plate.

5. Conclusion

At birth, all the secondary ossification centers of radius and ulna bones were absent in Nigerian local dogs they

all appeared postnatal. The ossification centers of the coronoid process and anconeal process in this breed of dogs developed as a direct extension of the ulna bone.

6. Limitations

The inability to use 3D imaging techniques like computed tomography (CT) and magnetic resonance imaging (MRI) to monitor the appearance of secondary ossification centers and their growth plates. This is because such technology was not available in the institution of the research.

7. Recommendations

Further researches should be conducted to monitor the appearance of secondary ossification centers on other long bones in Nigerian local dogs.

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