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Determination of the Closure Time of Growth Plates of Tibia-Fibula in Colored Mohair Goat's Kids by Radiography

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ABSTRACT

In the present study, closure times of growth plates of tibia-fibula in mohair coloured goat kids were aimed to determine by radiography. For this purpose, a total of 20 mohair coloured goat kids (10 male, 10 female) were used. Body weights of the kids, sacrum height determined and tibia-fibula radiographies were taken monthly for 17 months. The first signs of the closure in the growth plates were the opaque areas developed in the middle radiolucent growth line up to across region through epiphysis. Full closure times were changed between 2 to 5 months in male and female goats. Full closure in the proximal plates occurred 14 month in females and 15 month in males. On the other hand, full closure in the distal plates occurred 16 month in females and 17 month in males. Therefore, distal growth plates closure of the tibia-fibula occurred latter compared proximal plates.

Key words: Closure time, goat, growth plate, radiography, tibia-fibula

INTRODUCTION

Specialized tissues extending longitudinally between the epiphysis and diaphysis of immature long bones, working in harmony with each other and providing longitudinal bone growth are called growth plates (Brighton, 1978).

Growth plates are endochondral ossification regions of long bones. These plates, which are existed until the postnatal growth is finished, ossify after the postnatal growth process. Growth plates are also called as physis, metaphyseal growth plate, epiphyseal plate, epiphyseal cartilage and epiphyseal disk (Herron, 1993; Aytekin, 1993; Aslanbey, 2002; Whittick, 1990; Artan, 1988; Carrig, 1983).

Closure times of the growth plates of long bones are different from each other. This difference is caused by the animal's breed, species and bones. Early ossification of epiphyseal cartilage induces the arrest of longitudinal bone growth. After the closure, only the transverse bone growth occurs (Aytekin, 1993; Smith and Allcock, 1960; Chapman, 1965; Yilmaz, 1999).

There is a parallelism between the development and maturation of the genital system and skeletal system. Early sexual development decreases the epiphyseal activity, thus speeds up the maturation of the skeleton. This situation differs between males and females (Whittick, 1990; Oberbauer, 1985; Tuzlaci and Alver, 1985; Jungueira *et al.*, 1992). Oberbauer (1985) reported that the closure of the distal epiphyseal plate of 3rd metacarpal bone occurs on the twentieth and fifteenth month in the rams and the sheep, respectively.

The distal end of tibia of the sheep and goats is divided into two joint pits through a sagittal crista. In addition, it also has a joint face for malleolus. Corpus of the fibula that is located lateral to the tibia is as completely missing in ruminants. Its proximal end is found as a small protrusion that is stuck to or even fused with the lateral condyle of tibia. The distal end is a small and special form of bone that is called as malleolus (Dursun, 1998).

The aim of this study was to determine closure times of growth plates of tibia-fibula in mohair coloured goat kids by radiography.

MATERIALS AND METHODS

For radiographic shots, 100 kV, 60 mAs power x-ray device (Shimadzu Corp., Kyoto, Japan) was used. This study has used goats from Yuzuncu Yil University, Faculty of Veterinary Medicine, Research and Practice Farm.

The four-week goats, which have been determined to be healthy by clinical examination, were divided into two groups according to the gender (10 male, 10 female). Before shootings, mohairs of the region of the relevant bones were sheared and physical examination was performed for orthopedic disorders.

The first radiographic image of tibia and fibula was taken when the kids were 4 weeks. The shootings were performed in Anteroposterior (AP) and Mediolateral (ML) positions. Film to focus distance was set as 100 cm. When the growth plates at both ends appeared radiolucently, kids were decided to be eligible for the study. The shootings were repeated every month until the plates were closed. X-ray doses of 47 and 56 kV-15 mAs were given in the first and last shoots, respectively. X-ray films were bathed manually. Closure of the tibia-fibula growth plates of the goats in the study occurred in different months and shooting was not performed in goats that were considered to have a closed growth plate.

Sacrum heights and body weights of the animals were recorded after taking x-rays in each month. Measurements were performed on films taken in the AP position, because of the superposition on films taken in the ML position. Because of the anatomic integrity of the tibia and fibula, the measurements were based on the length of the tibia. Values were recorded in cm (Fig. 1).



Fig. 1: The method used in determining the length of tibia-fibula

RESULTS

The clinical examination performed in each month revealed no disorder of the tibia and fibula of goats. High rate of increase in body weight, sacrum height and tibia length was found in both genders within the first 8 months. It was determined that the increase in the sacrum height and tibia length was slowed within the second 8 months, but the increase in body weight was further accelerated after the 8 and 9th months in females and males, respectively (Table 1).

Radiographic findings: The shooting in AP position was preferred for the evaluation and measurement of radiographic findings. Measurements could not be performed with images taken in M/L position, because the terminal point of the upper end of tibia could not be identified on the films due to the superposition of femoral condyles and intercondylar eminences. In addition, the distal tibial-fibular growth plate was found to be superposed by malleolus. For these reasons, ML images were excluded from the evaluation of length measurements.

Radiographic evaluation revealed no deformation of the bone structure in both genders during seven months of radiolucent appearance epiphyseal plates of the tibia (Fig. 2).

The occurrence of radiopaque area forming a bridge between the epiphysis and metaphysis in the central part of the growth plates was considered to be the first sign of the closure. This was detected in the proximal plate of the tibia in females and males after 8 and 9th months, respectively (Table 2).

Disappearance of the radiolucent appearance of growth plate and the occurrence of radiopaque appearance throughout the growth plate were accepted as a complete closure. This was detected in proximal plaques in females in the 11th month of the study. Closure of proximal plaque was completed in all the females in the 14th month (Fig. 3), (Table 2).

Table 1: Colored mohairs goat kid's mean body weight and height at the sacrum and minimum and maximum values of the tibia length

Age (months)	Male (n = 10)			Female (n = 10)		
	Sacrum height (cm)	Body weight (kg)	Tibia length (min.-max.) (cm)	Sacrum height (cm)	Body weight (kg)	Tibia length (min.-max.) (cm)
1	32.5	9.2	11.9-13.9	34.0	9.7	11.1-12.8
2	43.5	16.8	13.2-14.7	42.1	16.0	12.4-14.1
3	47.0	21.4	14.1-15.2	45.5	20.0	13.2-15.2
4	51.2	23.6	15.1-16.2	50.0	23.0	14.8-15.9
5	52.1	25.0	15.9-16.7	53.0	25.5	15.4-16.5
6	56.0	27.0	16.4-17.1	54.8	27.0	16.0-17.2
7	57.0	31.0	16.7-17.3	57.0	30.0	16.6-17.5
8	58.5	36.4	17.3-17.8	59.0	35.5	17.2-17.8
9	60.0	41.0	17.6-18.1	59.5	40.0	17.6-18.2
10	62.5	45.1	17.8-18.5	60.0	44.1	17.7-18.5
11	61.0	47.5	18.0-18.9	60.2	45.7	17.9-18.8
12	64.1	49.0	18.4-19.1	60.9	46.0	18.1-19.2
13	65.5	50.5	18.8-19.5	61.5	47.5	18.2-19.4
14	66.0	52.0	19.1-19.8	62.0	48.5	18.4-19.6
15	67.0	54.5	19.2-20.1	62.4	49.0	18.6-19.7
16	67.0	55.0	19.3-20.2	62.8	50.0	18.6-19.7
17	67.0	55.3	19.5-20.5	-	-	-

Table 2: Analysis of proximal and distal plates (tibia) growth time in male and female kids of colored mohair goats

Months	Male				Female			
	PGP		DGP		PGP		DGP	
	St (n)	Co (n)	St (n)	Co (n)	St (n)	Co (n)	St (n)	Co (n)
8	-	-	-	-	2	-	-	-
9	3	-	-	-	5	-	-	-
10	4	-	-	-	3	-	2	-
11	3	-	3	-	-	5	4	-
12	-	3	4	-	-	2	4	-
13	-	3	3	-	-	2	-	2
14	-	3	-	2	-	1	-	3
15	-	1	-	3	-	-	-	2
16	-	-	-	4	-	-	-	3
17	-	-	-	1	-	-	-	-

N: Number of animals, PGP: Proximal growth plate, DGP: Distal growth plate, St: Starting, Co: Completion

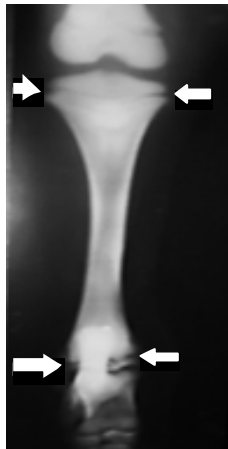


Fig. 2: Proximal and distal growth plates are open (arrows) male, 1 month old



Fig. 3: The proximal plate is completely closed (upper arrow), the process continues to the distal plate (lower arrow), female, 12 months old



Fig. 4: The proximal plate is in completely closed state (white arrow), male, 13 months old



Fig. 5: The proximal and distal plate is completely closed (arrows), male, 16 months old

The first closure of the proximal growth plate of male kids was detected in the 12th month of the study. The closure of all proximal plaques was found to be ended in the 15th month (Fig. 4).

Table 3: The mean length of tibia (cm) in goat kids of 1st, 8 and 16th months

	n	1st month	8th month	16th month
Male	10	12.7	17.6	19.7
Female	10	12.2	17.4	19.1

The development of the distal plaque was ended in all the female kids and in all except one of male kids in the 16th month of the study (Fig. 5). The latest closure took place in the seventeenth month and the study was terminated (Table 2). In conclusion, the distal tibial growth plates were closed later than the proximal tibial growth plates. The months of the beginning and the completion of the closure of tibial growth plates and the number of animals are presented in Table 2.

As a result of the evaluation, the process of closure of proximal and distal plaques after the start of the first symptoms related to the closure of the epiphyseal plates were determined to vary between 2 and 5 months in both genders (Table 2).

The rate of the lengthening of the bones was found to be higher in the first 8 months (mean deference 4.9 and 5.2 cm male and female, respectively) than the following 8-month period in both genders (mean deference 2.1 and 1.7 cm male and female, respectively) (Table 3).

DISCUSSION

Specialized tissues extending longitudinally between the epiphysis and diaphysis of long bones, consisting of three different anatomical components, working in harmony with each other and providing longitudinal bone growth are called growth plates (Brighton, 1978).

In the study, the difference between the tibial lengths measured in two consecutive months was attributed to the bone growth as a result of activation of the growth plates.

Radiological imaging is an effective method in demonstrating ossification centers and determining the age of epiphyseal closure (Asimus *et al.*, 1995; Gencelep *et al.*, 2002; Todhunter *et al.*, 1997; Conzemius *et al.*, 1994; Smith *et al.*, 1991). In this study, ease of monitoring of the growth plate development phases and the estimation of approximate age of the animal was owing to the radiographic examination.

Gencelep *et al.* (2002) have reported that the process of closure of the growth plate of the radius and ulna of Morkaraman lambs starts with the formation of a radiopaque bridge between epiphysis and metaphysis in the middle part of the growth plate. In the study, the occurrence of radiopaque appearance in the middle parts of the radiolucent lines of proximal and distal growth plates was considered to be the beginning of the process of closure the growth plates.

Complete closure of growth plates can be identified by the displacement of a radiopaque track with the radiolucent line in the epiphyseal-metaphyseal line (Asimus *et al.*, 1995; Todhunter *et al.*, 1997; Conzemius *et al.*, 1994). In addition, in goats, radiopaque line reaching from one end to the other end of the growth plate has been considered to indicate the completion of the closure and thus the termination of the bone lengthening arising from the relevant region.

Closure time of the growth plates has been reported to vary according to the animal's breed, species, gender and bones (Chapman, 1965; Gencelep *et al.*, 2002; Smith *et al.*, 1991). The gender was considered to be a determinant of the maturation of the tibia and fibula because of the earlier termination of the complete closure in both bones in female kids compared to male kids used in this study. In addition, lower sacrum heights of females than that of males were attributed to the early closure of the growth plates of tibia and fibula. Similar results have been reported in the sheep (Oberbauer, 1985; Gencelep *et al.*, 2002).

Gencelep *et al.* (2002) in their study on the radius and ulna of Morkaraman lambs, have reported that proximal epiphyseal plate was closed earlier than the distal epiphyseal plate in both genders. In the present study, proximal epiphyseal plate was also observed to be closed earlier than the distal epiphyseal plate in both genders.

Radiological follow-up of structure of the epiphyseal plate in each animal species in all the stages of the growth period has been reported to be an advantage (Carrig, 1983; Asimus *et al.*, 1995; Todhunter *et al.*, 1997; Conzemius *et al.*, 1994; Smith *et al.*, 1991; Maccallum *et al.*, 1978). Deformations of the calves and poultry growth plates have been reported (Ribeiro *et al.*, 2004; Subapriya *et al.*, 2007; De Carvalho *et al.*, 2010). Literature reviews revealed no publication dealing with the goat species for determining the duration of closure of tibial and fibular epiphyseal growth plates. In this study, follow-up of the growth plates of colored mohair goats was performed.

It has been reported that, following the ossification of epiphyseal plate and the fusion of the epiphysis and diaphysis, a very thin and white line called as epiphyseal cicatrix exists for a while in this region (Tuzlaci and Alver, 1985; Paker, 1993; Jungueira *et al.*, 1992). In the present study, horizontal radiopaque epiphyseal cicatrice was seen in each case after the completion of closure of epiphyseal plates.

It has been reported that the line of ossification centers can be considered as the interval between fracture fragments in the interpretation of skeletal radiographs (Maccallum *et al.*, 1978). Based on this information, knowing the closing times of plaques is becoming increasingly important. As closing times are different for each animal, the reference closing times should be pre-determined. One of the aims of this study is to establish reference values.

It has been reported that, a piece of cartilage can remain in the periphery of the epiphyseal cartilage after the end of longitudinal growth. This has been reported to inhibit the complete fusion of the ossification center with the main bone Smith *et al.* (1991) and Maccallum *et al.* (1978). In the present study, such formations were found in the peripheral parts of the growth plate. We believe that, it is necessary to shoot in AP position for the evaluation of any lesion of the tibia, because of superposition of the tibia and femur in radiographs taken in ML position.

With this study, the time prior to the start of the process of closure of plates, the process of closure and estimated age of the animal during the periods of the completion of closure can also be determined.

It was concluded that this study, which was conducted to determine the closure times of tibial and fibular epiphyseal plates of colored mohair goats, will contribute the studies that will be conducted to determine the development standards of mohair goats.

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