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ORIGINAL ARTICLE

Determination of Radiographic Closure Time of Appendicular Skeleton Growth Plates in the Marghoz Goat

Rasoul Rahimzadeh*

Department of Clinical Science, Faculty of Veterinary Medicine, Sanandaj Branch, Islamic Azad University, Sanandaj, Iran.

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Abstract

Objective - The aims of this study were to determine the approximate radiographic closure time of the growth plates of the fore and hind limbs of Marghoz goat as a small breed of goat is distributed over the western and North-West of Iran near to the Turkey and Iraqi borders and to compare these closure times with those previously published.

Design- Experimental study.

Animals- 20 healthy Marghoz goats.

Procedures- In order to study the fore and hind limbs, The 20 goats, which have been determined to be healthy by clinical examination, were divided into two groups (10 males, 10 females). They were selected from 10 days after their birth until the growth plates of anterior, posterior and back bones were closed. For the purpose of this study, the growth plates were classified as fully open and fully closed, in order of advancing fusion of the growth plate.

Results- The earliest closure time of the proximal growth plate of male was detected in the 12th month of the study. The closure time of all growth plates in the forelimbs in females was fond to be ended in the 13th month and in males in the 16th month were closed; closure time of growth plates for hind limbs in females was in the 15th month and in male was in the 18th month. The latest closure took place in the 26 month and the study was terminated.

Conclusion and clinical relevance- Radiological imaging is an effective method in demonstrating ossification centers and determining the age of epiphyseal closure.

* Correspondence to: Rasoul Rahimzadeh, Department of Clinical Science, Faculty of Veterinary Medicine, Sanandaj Branch, Islamic Azad University, Sanandaj, Iran.
E-mail: drtwor@gmail.com

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1. Introduction

Sheep and goats form the most important group of ruminants in Iran mainly in rural areas. They comprise more than 57% of the available animal units in the country.[1] Most of the sheep and goat keepers who are mainly small farmers regard this enterprise as a complementary enterprise to plants culture or horticulture. On average, every sheep and goat keeper has 38 and 25 heads of the animals, respectively.[2] Iranian goats are not grouped well according to their products importance. More than 20 breed of goats have been recognized in Iran, but the two typical breeds are Marghoz and Raeni goats, producing attractive and expensive mohair and Kashmir fiber. Sheep and goat systems in Iran are changing rapidly in response to various drivers. This small goat breed is distributed across the western and north-west of Iran near the Turkey and Iraqi borders. They produce quite fine mohair with different colors such as white, golden, brown, gray and even black. The average mohair production is approximately 0.6 kg per year. This fiber type is expensive and mainly exported. Marghoz goats are fertile animals with twin kidding over 30%. It is believed that Angora goats are originated from this breed of goat. Angora goats appear in one color, which is white to silver, but Marghoz goats produce mohair in different natural colors, being among the unique characteristics of this type of goat.[3] Radiography as the primary diagnostic imaging to evaluate musculoskeletal disorders can provide the morphologic characterization of bone, leading to formation of a definitive or differential diagnosis according to Kraft[4] and Latorre et al.[5]

The age of closure of the epiphysis has been reported to vary according to the animal's breed and species.[6,7] In addition, the physiology of growth plate and the time of closure of growth plate are complex and vary among bones as studied by Kilborn et al.[8] At puberty, the bone growth and the plate growth stop at this time, while the appositional bone growth still works and progresses, leading to changes in the shape of the bone.[9] Longitudinal bone growth is the product of discrete, but linked operations are carried out through chondrocytes division and differentiation. The mechanics of this process occur in all growth plates. Germinal chondrocytes pass through a series of regulated gates, enter the cell cycle, divide, and leave the cell cycle.[9]

The present study aimed to determine the approximate radiographic closure time of the growth plates of the fore and hind limbs of Marghoz goat and to compare these closure times to those previously published.

The radiographs were also examined to document evidence of developmental orthopedic diseases such as osteochondrosis and osteochondral bone cysts in the neighboring joints in order to further describe the growth pattern of Marghoz goats. The information would provide practical guidance to owners and veterinarians; for example when the skeleton is mature enough to commence formal ridden training, and would be potentially interesting to those scientists investigating the pathogenesis of osteochondrosis. The closure time of the fore and hind limbs in male and female goats were evaluated, and it would be used as a reference in determining the metabolic diseases and other joints and bones disorders.

2. Materials and Methods

All procedures involving the experimental use of animals were approved by the Animal Ethics Committee, a branch of the Research Council at Islamic Azad University, Iran, and administered by the National Animal Ethics Advisory Committee. For radiographic shots, 47 and 65 kV, 3 mAs power x-ray device (Siemens®, Nanodor II., Germany) were provided in the first and last exposure. To study the fore and hind limbs, the 20 goats diagnosed healthy by clinical examination were divided into two groups according to their gender (10 males, 10 females), and they were fed in same condition. They were from the ruminant farm of Agricultural and Natural Research Center of Kurdistan Province, Kurdistan, Iran. The exposure was performed in craniocaudal (Cr-Cd) and mediolateral (ML) positions. Film to focus distance was set as 100 cm. The exposure was repeated every 10 days until the plates were closed.

For the purpose of this study, the growth plates were classified as fully open, closing and fully closed, in order of advancing fusion of the growth plate. A growth plate was classified as fully open when a distinctly radiolucent line could be observed spanning the whole extent of the growth plate region. A growth plate was classified as closing when a radiolucent line was present in the growth plate area, but increased bone opacity intermittently.[10,11] A growth plate was classified as fully closed with total absence of the radiolucent line in the region of the previous growth plate in the two radiographic projections. When a difference existed in the appearance of the growth plates on separate views of the same area, the growth plate was classified according to the view showing the lowest degree of fusion. Other subjective features of the growth plates such as width were noted. Time of closure for each growth plate was defined as the age range from the youngest horse

observed with a fully closed growth plate to the age after which all further examined goats had a fully closed growth plate.[12,13]

3 Results

The clinical examination performed in each month revealed no disorder in the goats. 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. Fully open = distinct radiolucent line spanning the entire extent of the physis; fully closed = no radiolucency in the region of the physis. The radiographic closure time was defined as the age range from the youngest horse observed with a fully closed physis to the age after which all other horses had a fully closed physis.

The results shown in the following tables compare the closure time of special anatomical growth plates in two genders of Marghoz goats.

All growth plates of fore limb were fully open in the 10th month of the study in females (Figure 1) and in the 12th month of the study in males. The first closure of the proximal growth plate of male was detected in the 12th month of the study. The closure of all proximal growth plate was found to be ended in the 15th month.

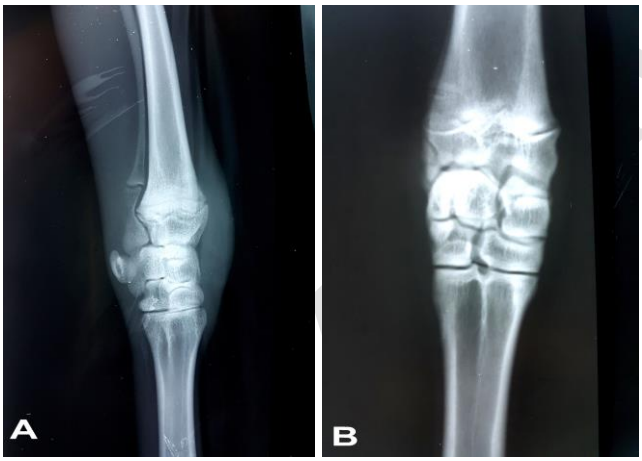

Figure 1. Examples of fully open growth plates. Lateral (A) and ventrodorsal (B) views of the distal radius and ulna of a 10-month-old goat.

The development of the distal growth plate was ended in all the female and in all except one of the males in the 16th month of the study. The latest closure occurred in the 26th month, and the study was ended (Table 2).

As a result of the evaluation, the process of closure of proximal and distal growth plate after starting the first symptoms related to the closure of the epiphyseal plates were determined to vary between 7.5 and 18 months in both genders (Tables 1, 2).

Table 1. Closure time of the fore limb growth plates (month).

	Female		Male	
Anatomical Site Growth plate	Fully open	Fully closed	Fully open	Fully closed
Shoulder				
Supraglenoid tubercle	10	13.2	12.6	15.1
Humerus				
Distal Epiphysis	7.5	13.3	12	15.7
Proximal Epiphysis	8.7	13.8	13.8	17.1
Lateral condyle	9.8	13.2	12	16.9
Medial condyle	13	13.6	13.4	17
Radius				
Distal Epiphysis	10.8	14.1	13.6	17
Proximal Epiphysis	9.1	13.7	12.9	16.6
Ulna				
Olecranon tuberosity	11.2	15.1	14	18
Distal Epiphysis	10.6	15.5	13.5	17.3
Proximal Epiphysis	10.8	15.2	13.1	17.2
Metacarpus				
Distal Epiphysis	9	14.2	11	17.1
First phalanx				
Proximal Epiphysis	8	12.4	9.6	13.1
Distal Epiphysis	10.1	15.2	11.4	16.3
Second phalanx				
Proximal Epiphysis	8.5	12.6	9.7	14.2
Distal Epiphysis	9.2	14.3	11	16.5
Third phalanx				
Proximal Epiphysis	9	12.2	11.1	14.8
Distal Epiphysis	10.3	14.2	12.2	15.7

4. Discussion

Closure times of the growth plates of long bones are different from each other. Closure time of the growth plates has been reported to vary according to the animal's breed, species, gender and bones.[14] In general, the differences at the closure times of the growth plates appear to be minimal between breeds despite the considerable variation in adult sizes.[15] A complex array of factors, both genetic and epigenetic, is involved in the mechanisms by which growth plate cellular activity during endochondral ossification results in bone elongation.[16] While mechanisms regulating the differentiation cascade of

growth plate chondrocytes can be studied by the reductionist and transgenic approaches of molecular biology, stereological approaches to understanding the kinetics of chondrocytic performance parameters in growth plates growing at different rates have been valuable to analyze how the chondrocytic differentiation cascade is quantitatively converted into incremental bone elongation through time.[17]

Table 2. Closure time of the hind limb growth plates (month) in both genders.

	Female		Male	
Anatomical Site Growth plate	Fully open	Fully closed	Fully open	Fully closed
Pelvis				
Ilium growth plate	14	17	18.4	21.3
Pelvic Symphysis	19.1	22.3	23.1	26
Femur				
Distal Epiphysis	9.2	14.8	12.3	17.3
Proximal Epiphysis	8.7	13.6	12.5	17.1
Lateral condyle	9.5	14.1	11.8	16.8
Medial condyle	10.2	14	12.1	16.7
Tibia				
Distal Epiphysis	9	14.3	11.7	16.8
Proximal Epiphysis	9.6	14.5	11.5	16.7
Fibula				
Distal Epiphysis	10.6	14.4	12.5	17
Proximal Epiphysis	10	14.8	12.4	17.7
Vertebral bones				
Thoracic	11.4	15.2	12.2	17
Cervical	11.5	14.7	14	18
Lumbar	11.5	15.1	14.1	17.8
Metatarsus				
Distal Epiphysis	10	15	13.1	18.2
First phalanx				
Proximal Epiphysis	9.2	13.2	13.2	17
Distal Epiphysis	11.4	15.4	14.6	18.4
Second phalanx				
Proximal Epiphysis	10.2	14.2	12.2	16.5
Distal Epiphysis	11.1	17.6	12.4	18.1
Third phalanx				
Proximal Epiphysis	10.3	14.3	11.7	16.6
Distal Epiphysis	13	17.1	14	18.2

The radiographic determination of growth plate closure is a result of subjective evaluation, and correct interpretation depends on many factors. To reveal the radiolucent cartilage at the growth plate, the x-ray beam must be directly and perpendicularly aimed at the growth plate; otherwise overlapping bone tissue can be misinterpreted as evidence of fusion of the growth plate. Since the growth plates in many sites are not flat discs, but undulate to a variable degree, often in two or more directions, the problem of overlapping often exists in good-quality radiographs.[18] Furthermore, the physeal cartilage becomes narrower with increasing age,[19] making it more difficult to discern between fully open and partially fused growth plates. Therefore, to minimize interpretation difficulties, two views (craniocaudal and lateralmedial) of each region were used. In some cases, it was still difficult to distinguish between "late" closing and fully closed. This is a possible explanation to the outliers in the present study. Other authors have also found what seems to be single outliers in their material.[18] Radiological imaging is an effective method in demonstrating ossification centers and determining the age of epiphyseal closure.[20-22] In this study, ease of monitoring of the growth plate development phases and estimation of the approximate age of the animal were owing to the radiographic examination. Genccelep et al.[9] reported that the process of closure of the growth plate of the radius and ulna of Morkaraman lambs started with 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. Vosough *et al.*[23] reported the process of the closure of the growth plate in Raeini goats. They were selected 10 days after their birth until the closure of the growth plates of forelimbs and hindlimbs. Most of the growth plates in the forelimbs in females in the 13th month and in males in the 16th month were closed; closure time of growth plates for hind limbs in females was in the 16th month and 14th month, respectively.[23] Radiological follow-up of the structure of the epiphyseal plate in each animal species in all the stages of the growth period has been reported to be an advantage.[24-26] Through 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. The complete closure of the epiphyseal plates of the humerus in this study occurred at the age of 13 months in Marghoz goats, respectively, while the closure of the epiphyseal plates of the humerus of female Korean native goat was found after 12 months as studied by Choi et al.[27] The complete epiphyseal closure of the tibia in this study appeared at age of 16 months in Marghoz goats, respectively. The age of the epiphyseal closure of the tibia

in our study differs from the result obtained by Das et al. reporting that the closure time of the epiphyseal plates of the tibia occurred after 28 months in black Bengal and Ganjam goats.[28] The radiographic images can used as significant tools to determine age in sheep and goat in farms.

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Conflict of interests

None.

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چکیده

تعیین رادیوگرافی زمان بسته شدن صفحات رشد اندام‌های ضمیمه‌ای در بز مرغز

رسول رحیم‌زاده

گروه علوم درمانگاهی، دانشکده دامپزشکی، واحد سنندج، دانشگاه آزاد اسلامی، سنندج، ایران.

هدف- هدف از این مطالعه تعیین زمان بسته شدن رادیوگرافیک صفحات رشد اندام‌های حرکتی قدامی و خلفی در بز مرغز به‌عنوان یکی از نژادهای کوچک و مهم بز ایرانی که در غرب، شمال غربی ایران و در نزدیکی مرز عراق مستقر هستند و مقایسه آن با مطالعات قبلی بوده است.

طرح مطالعه- آزمایش تجربی.

حیوانات- ۲۰ رأس بز سالم مرغز.

روش کار- به‌منظور مطالعه اندام‌های حرکتی قدامی و خلفی ۲۰ رأس بز مرغز توسط که معاینه بالینی سالم تعیین شده بودند به دو گروه (۱۰ رأس بز ماده و ۱۰ رأس بز نر) تقسیم شدند. از سن ۱۰ روزگی و به فاصله هر ۱۰ روز تا زمان بسته شدن صفحات رشد استخوان‌های ضمیمه‌ای مورد مطالعه قرار گرفتند. برای دستیابی به هدف مطالعه صفحات رشد به دو مرحله کاملاً باز و کاملاً بسته تقسیم شدند.

نتایج- اولین زمان بسته شدن صفحات رشد بالایی در هر دو اندام در ۱۲ ماهگی شناسایی شد، بیشتر صفحات رشد اندام قدامی در جنس ماده در ۱۳ ماهگی و در جنس نر در ۱۶ ماهگی بسته می‌شود، زمان بسته شدن صفحات رشد اندام خلفی در جنس ماده در ۱۵ ماهگی و در جنس نر در ۱۸ ماهگی بود و آخرین صفحه رشد در ۱۶ ماهگی بسته شد.

نتیجه‌گیری و کاربرد بالینی- تصاویر رادیولوژی به‌عنوان یک روش مؤثر برای نشان دادن مراکز استخوان‌سازی و تعیین زمان بسته شدن صفحات رشد می‌باشند.

واژه‌های کلیدی - رادیوگرافی، صفحات رشد، زمان بسته شدن، بز مزغز، اسکلت ضمیمه‌ای