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RADIOGRAPHIC STUDIES ON THE DEVELOPMENT OF SOME SECONDARY OSSIFICATION CENTRES IN CAMELS (*Camelus dromedarius*)

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ABSTRACT

The present study was carried out on 2 newly born female camel calves and 6 adult female camels at ages 2.5, 4.5, and 5.5 years. Radiography was performed on the elbow, stifle and hock joints at ages one day, 15 day, then every month up to 6 months, then every two months up to one year, then at 1.5, 2.5, 4.5 and 5.5 years age. All radiographs were arranged in sequence and the times of appearance and fusion of humeral medial epicondyle, olecranon tuberosity, tibial tuberosity, and calcanean tuberosity were noted. The length and width of each tuberosity were also measured. The time of appearance of all tuberosities occurs at birth while the time of fusion occurs at 1.5 years for humeral medial epicondyle, at 4.5 years for olecranon tuberosity, and at 5.5 years for calcanean and tibial tuberosities.

Key words: Camels, radiography, secondary ossification centres

A typical long bone develops from three primary centres of ossification; a diaphysis and two epiphyses. Many long bones have secondary centres of ossification from which processes and apophyses develop (Denny, 1975; Owens, 1982 and Morgan, 1999). Apophyses have the same structure as epiphyses and fuse with the shaft in the same manner by a physis or growth plate as do epiphysis and diaphysis. Some of these secondary ossification centres are the greater humeral tubercle, medial humeral epicondyle, olecranon process of the ulna, trochanteric major of the femur, cranial tibial tuberosity, and tuber calcis (Dietz and Wiesner, 1984; Auer and Stick, 1999 and Morgan, 1999).

A large groups of muscles are attached to these apophyses and violent skeletal muscle contraction may lead to avulsion fractures specially in immature animals in which the physis has not yet been ossified (Brown and Norrie, 1978; Monin, 1978; Brinker *et al*, 1983; Marretta and Schrader, 1983; Stashak, 1987; Lipowitz *et al*, 1993; Thrall, 1996; Tyagi and Singh, 1996; and White and Moore, 1998).

Radiographically, the bony components of the apophysis appear rounded in shape. Later, they change in shape and size, then fuse with the main bone and only a very fine sclerotic line remains. For every apophysis there is a normal time of anatomic closure which varies within breeds and may vary so much among species.

Radiographic studies on some secondary ossification centres in camels are clinically important areas that are frequently examined. Accurate interpretation and objective evaluation of these radiographs especially in immature animals require detailed knowledge of normal radiographic anatomy for the specific age of young camel being examined. Typical variations in ossification rate and pattern must also be recognised. Although numerous references are available that contains information on normal radiographic appearance and fusion times of secondary ossification centres in equines and canines (Brown and MacCallum, 1975; Llewellyn, 1976; Marretta and Schrader, 1983; Ticer, 1984; Morgan, 1999; and Denny and Butterworth, 2000). No reports on the development of these centres are available in camels.

The purpose of the present study is to describe the normal radiographic development of some secondary ossification centres in camels and

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describe the normal radiographic development of some secondary ossification centres in camel and to determine the time of appearance and time of fusion of these centres to the main bone.

Materials and Methods

The present study was carried out on 2 newly born female camel calves and 6 adult female camels at ages 2.5, 4.5 and 5.5 years (2 camels in each age). Age of adult camels was determined according to Misk *et al* (1998).

Radiography for newly-born camels was performed at day 1 and 15 then every month up to 6 months, then every two months up to one year, and at 18 months of age. Radiography for adult camels was performed at 2.5, 4.5 and 5.5 years. Animals were tranquilised and lateral radiography was performed for elbow, stifle and hock joints of both limbs. Exposure factors were 15-20 mAs and 55-60 KV at a FFD of 90-110 cm. Standard speed film and intensifying screens were used. Measurements on radiographs were taken by using a ruler and a divider.

All radiographs were arranged in serial sequence from day 1 up to 5.5 years old and subjected to the following studies: 1) Determination of the time of appearance and the time of fusion of the humeral medial epicondyle, the olecranon tuberosity, the tibial tuberosity, and the calcanean tuberosity, 2) The length and the width of the medial epicondyle and the tibial tuberosity, 3) The length at the base and the height of the olecranon tuberosity and the calcanean tuberosity. 4) Description of the process of normal radiographic development of these secondary ossification centres.

Results

The age at which ossification centres appear and the age that these centres fuse to the main bone are illustrated in table 1.

The length and the width of the medial humeral epicondyle and the tibial tuberosity and the length at the base and the height of the olecranon tuberosity and the calcanean tuberosity are illustrated in table 2.

The body component of the ossification centre of the medial epicondyle of the humerus appears as spindle-shape structure caudal to the medial humeral condyle in one day old camel. The centre keeps its shape but increases in length and width until the animal becomes 12 months of age. Fusion starts at 6 months of age and the process appears completely fused with the main bone except few millimetres at both ends at 12 months of age. Complete fusion occurs and the line of fusion can not be detected radiographically in 1.5 years old camel (Figs 1-6 and Diagrams 1).

Table 1. The age of appearance and age of fusion of some ossification centres in camels.

Secondary ossification centre	Age of appearance Buffaloes	Age of fusion Camels
Humeral medial epicondyle	At birth	1.5 years
Olecranon tuberosity	At birth	4.5 years
Tibial tuberosity	At birth	With epiphysis, 6 months, With diaphysis, 5.5 years
Calcanean tuberosity	At birth	5.5 years

The ossification centre of the olecranon tuberosity appears at birth as a half circle structure capping the proximal extremity of the ulna from the caudal aspect and quickly changes into a triangular structure. At early ages, the line of fusion is seen straight or slightly concave then becomes serrated. At 4 months of age, fusion starts at the middle of the contact line which extends proximally. At one year old camel, complete fusion is seen except at the distal one third. Fusion is complete at 4.5 years old animal and a fine

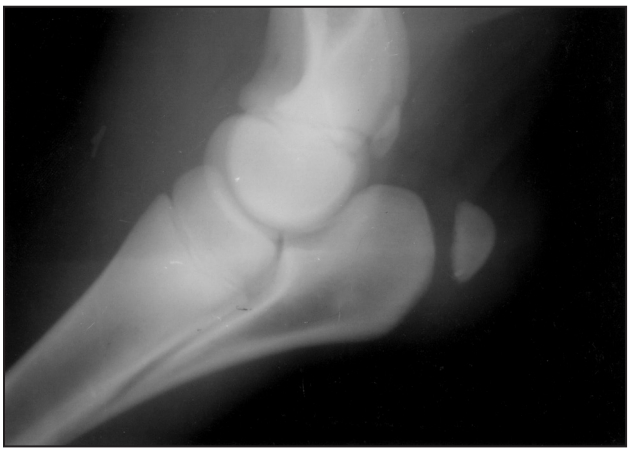

Fig 1. Lateral radiographs of the elbow joint showing the humeral medial epicondyle and olecranon tuberosity in a one-day-old-camel.

Table 2. Some measurements (average in cm) concerning the studied ossification centres in camels.

Secondary O.C.	Humeral medial epicondyle		Olecranon tuberosity		Tibial tuberosity		Calcanean tuberosity	
Age	**Length**	**Width**	**Base**	**Height**	**Length**	**Width**	**Base**	**Height**
1 day	1.9	0.6	3.1	1.2	3.1	1.2	2.8	1.2
15 day	2.1	0.7	3.5	1.4	3.4	1.7	3.0	1.5
1 month	2.5	0.7	3.7	1.6	3.7	1.8	3.2	1.6
2 months	2.6	0.7	4.2	1.6	3.9	2.0	3.7	1.7
3 months	3.5	0.7	4.4	1.8	4.1	2.1	3.8	1.7
4 months	4.2	0.9	4.9	2.1	4.3	2.1	3.9	1.8
5 months	5.2	1.3	5.1	2.1	4.6	2.2	3.9	2.0
6 months	5.2	1.4	5.4	2.4	4.7	2.2	4.0	2.0
8 months	5.2	1.8	6.1	2.4	4.9	2.5	4.1	2.0
10 months	NR	NR	NR	NR	5.3	2.5	4.1	2.0
1 year	6.0	2.5	6.5	2.9	5.3	2.5	4.2	2.0
1.5 years	fused	fused	6.8	3.0	5.3	2.5	4.2	2.0
2.5 years	fused	fused	6.8	3.0	6.0	2.6	4.6	2.1
4.5 years	fused	fused	fused	fused	7.0	2.7	5.0	2.1
5.5 years	fused	fused	fused	fused	fused	fused	fused	fused

O.C. = Ossification centre, Base = length at the base, NR = Not recorded

sclerotic line is seen at the seat of fusion at 5.5 years-old camel (Figs 1-6 and Diagram 2).

The body component of the ossification centre of the tibial tuberosity appears at birth as a vertical oval structure just cranial to the proximal tibial epiphysis and diaphysis. The centre keeps its shape but increases gradually in length and width until the process of fusion starts. The middle third of the tibial tuberosity fuses with the diaphysis at 4 months of age. The proximal third fuses with the proximal tibial epiphysis at 6 months. The distal third of the tibial tuberosity remains unfused for a long time until complete fusion occurs at 5.5 years (Figs 7-12 and Diagram 3).

The ossification centre of the calcanean tuberosity appears at birth as a half circle structure capping the proximal extremity of the fibular tarsal bone. The process gradually increases in size but keeps its shape without change until complete fusion occurs. Fusion with the main bone starts

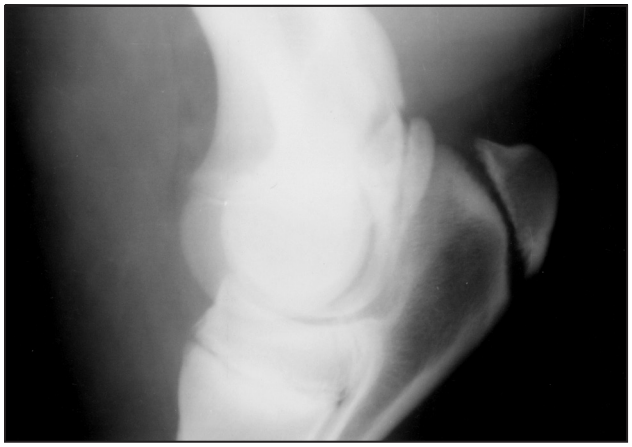

Fig 2. Lateral radiographs of the elbow joint showing the humeral medial epicondyle and olecranon tuberosity in a 3-months-old-camel.

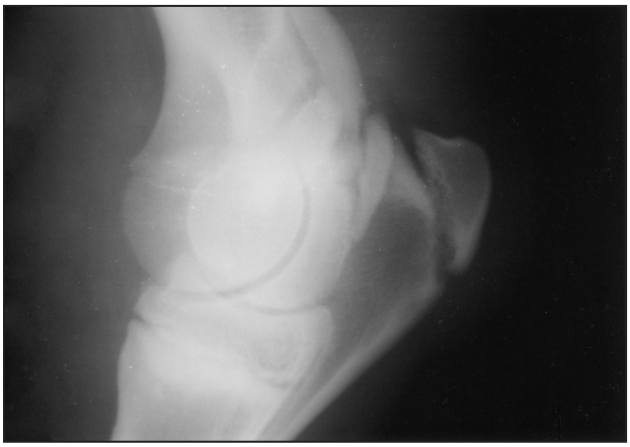

Fig 3. Lateral radiographs of the elbow joint showing the humeral medial epicondyle and olecranon tuberosity in a 4-months-old-camel.

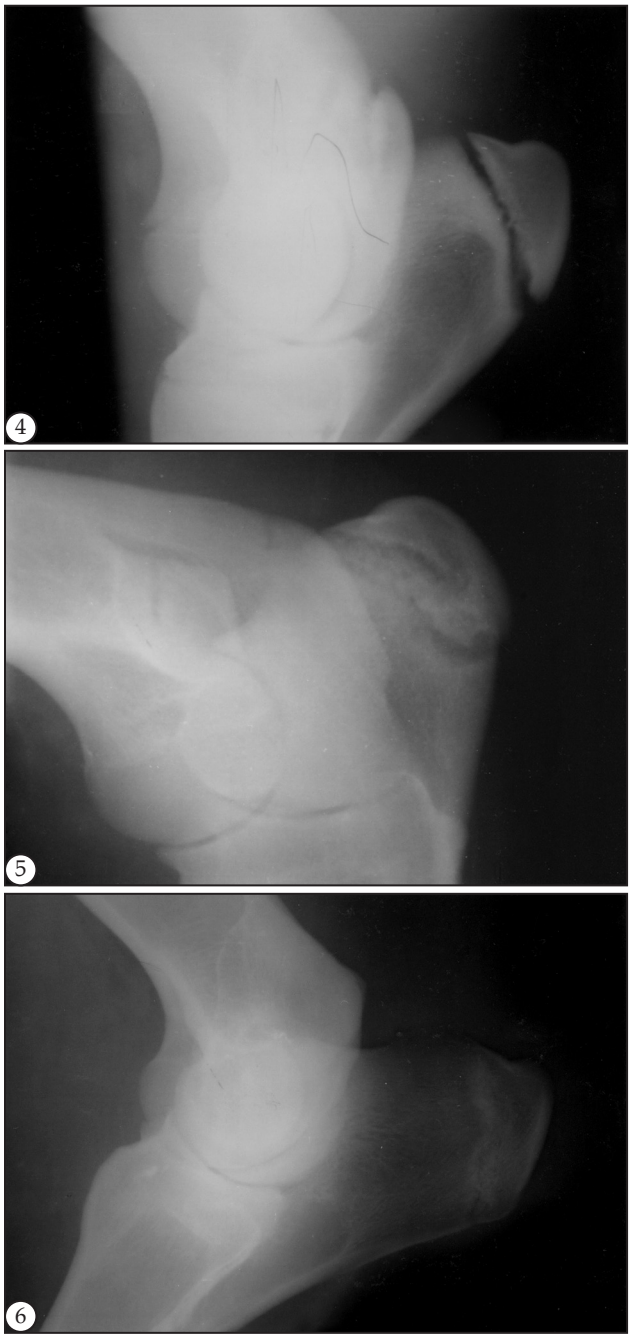

Fig 4-6. Lateral radiographs of the elbow joint showing the humeral medial epicondyle and olecranon tuberosity in a six-months-old-camel (fig 4), one-year-old-camel (fig 5) and 5.5-years-old-camel (fig 6).

early at the middle in 2 months old animal. The line of fusion appears as a serrated double line with slight lipping at the proximal and distal ends of the process. At 10 months of age, the process appears completely fused with main bone except at its distal fourth, which has a prominent lipping directed distally. Complete fusion is seen at 5.5 years (Figs 13-18 and Diagram 4).

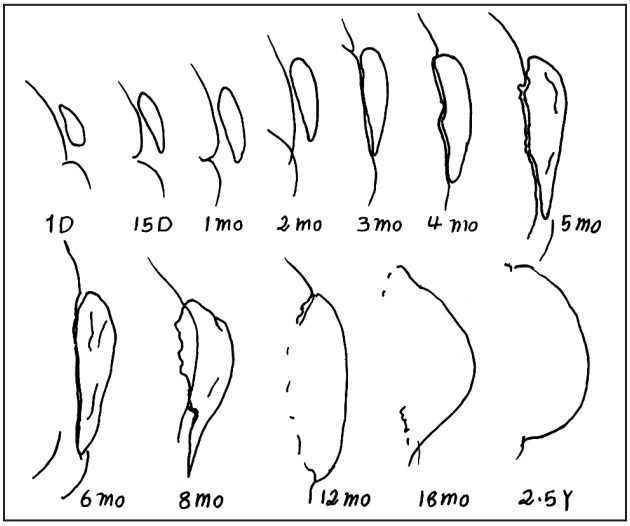

Diagram 1. Showing a copy of the radiographs of the humeral medial epicondyle development at different ages in camel (Reduced to 71% of normal radiographic size).

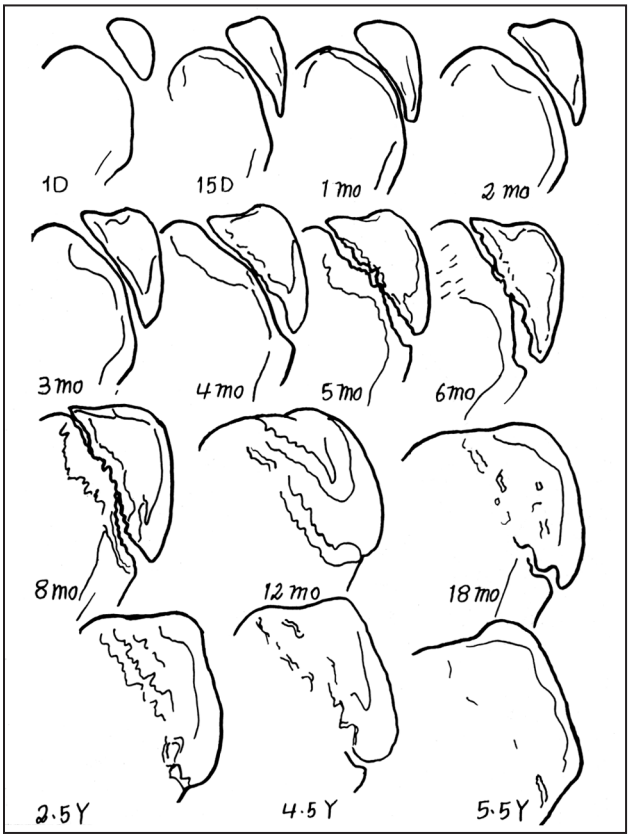

Diagram 2. Showing a copy of the radiographs of the olecranon tuberosity development at different ages in camel (Reduced to 71% of normal radiographic size).

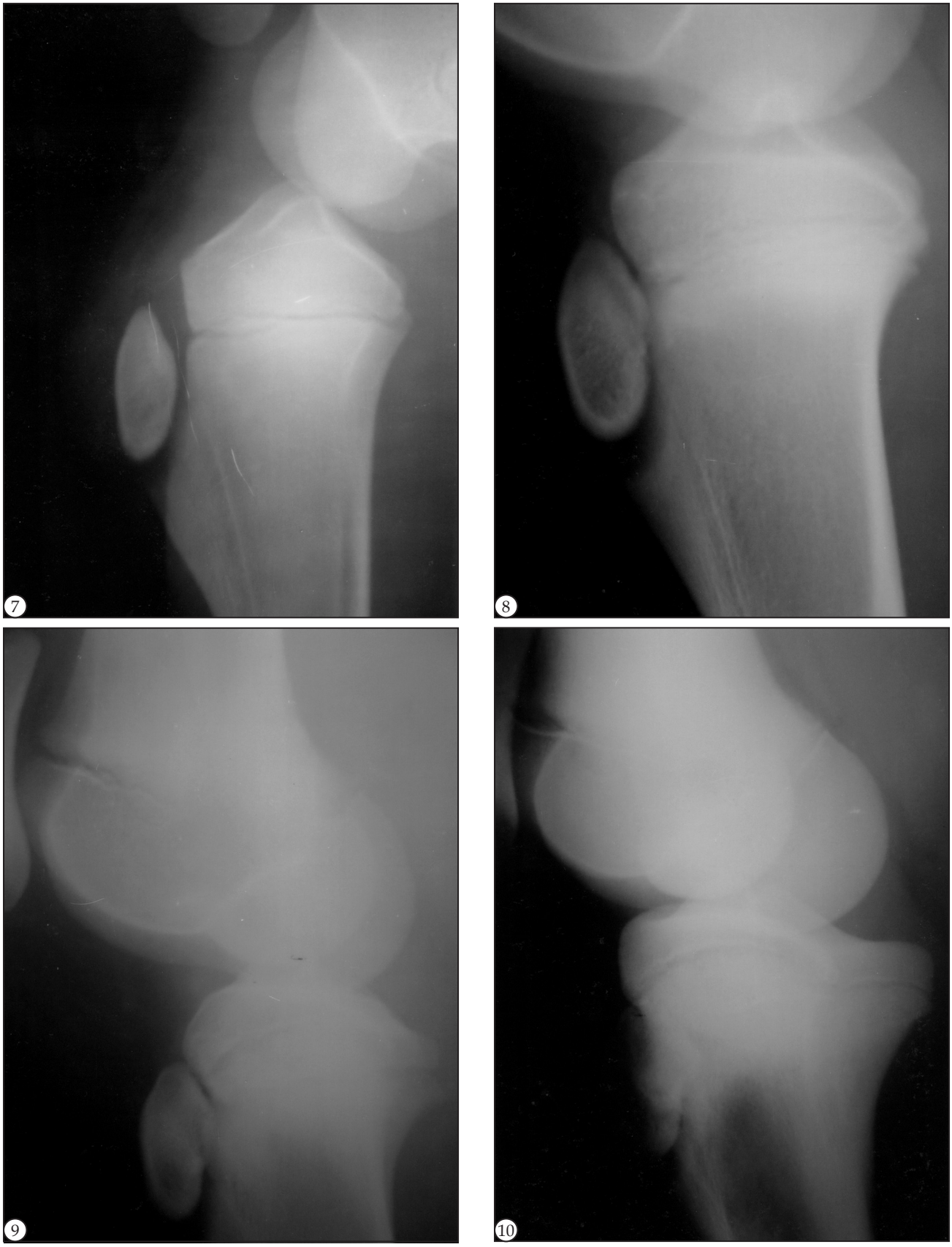

Fig 7-10. Lateral radiographs of the stifle joint showing the tibial tuberosity in one-day-old-camel (fig 7), one-month-old-camel (fig 8), five-months-old-camel (fig 9), eight-months-old-camel (fig 10).

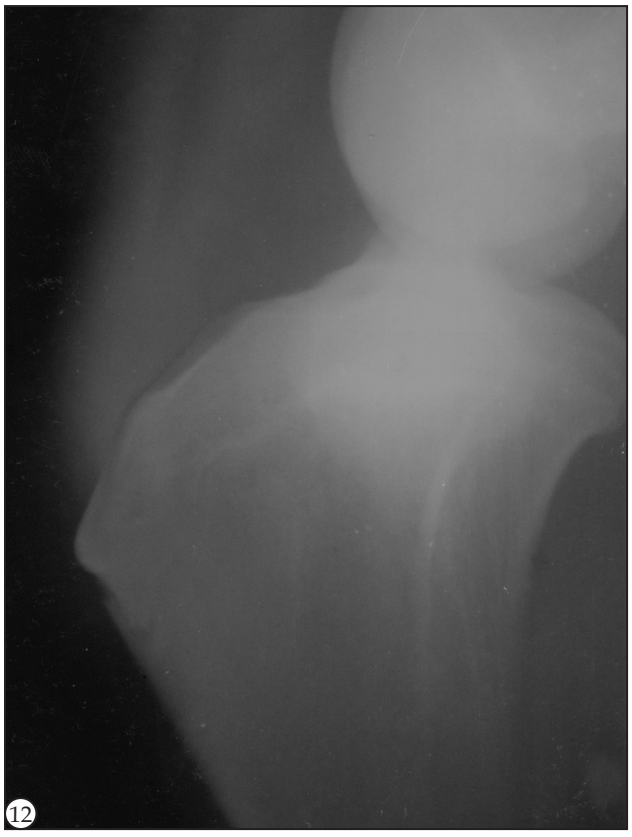

Fig 11-12. Lateral radiographs of the stifle joint showing the tibial tuberosity in a 1.5 year-old-camel (fig 11) and 5.5 year-old-camel (fig 12).

Fig 13-14. Lateral radiographs of the hock joint showing the calcanean tuberosity in a one-day-old-camel (fig 13), 2-months-old-camel (fig 14).

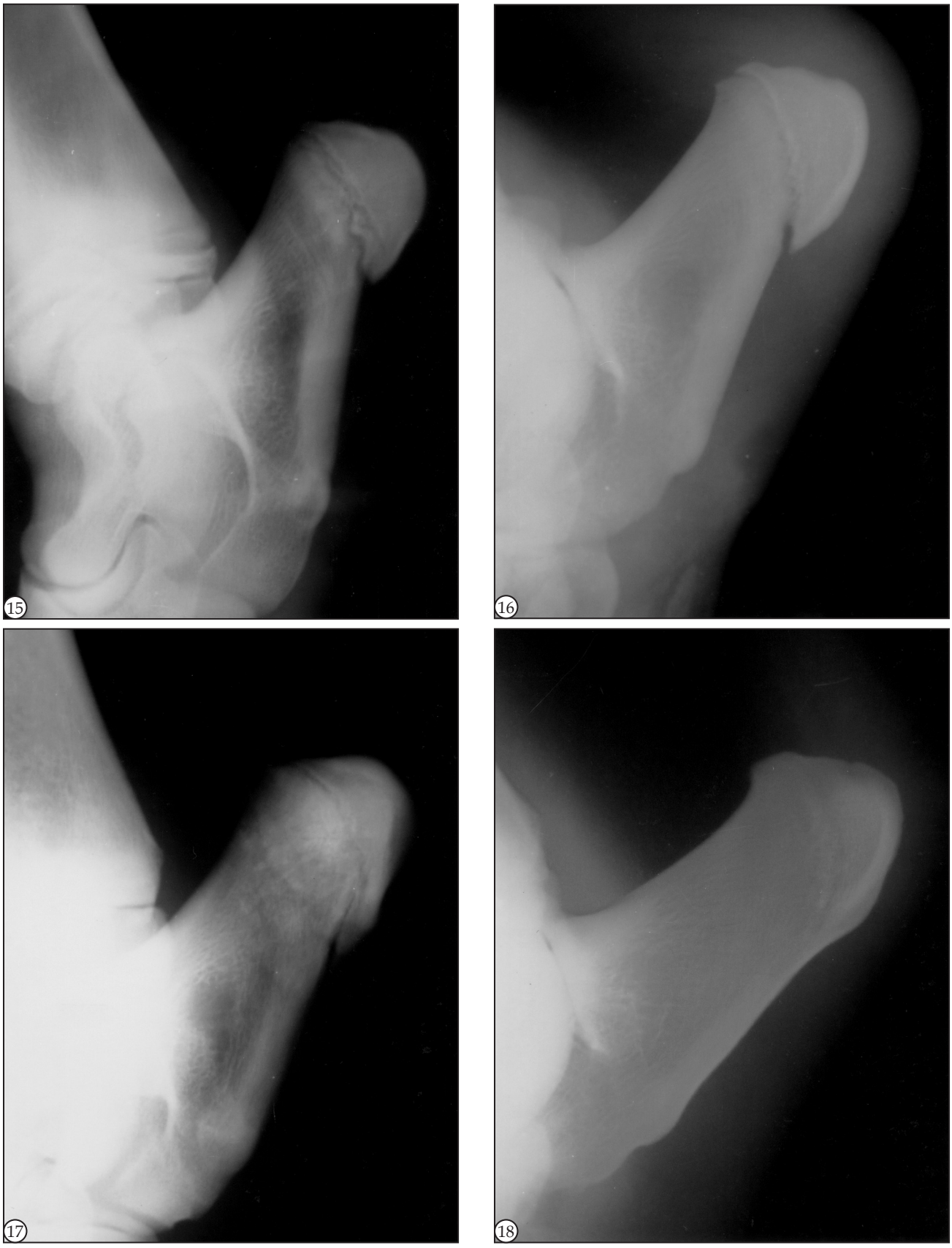

Fig 15-18. Lateral radiographs of the hock joint showing the calcanean tuberosity in a 4-months-old-camel (fig 15), 10-months-old-camel (fig 16), 4.5-years-old-camel (fig 17) and 5.5-years-old-camel (fig 18).

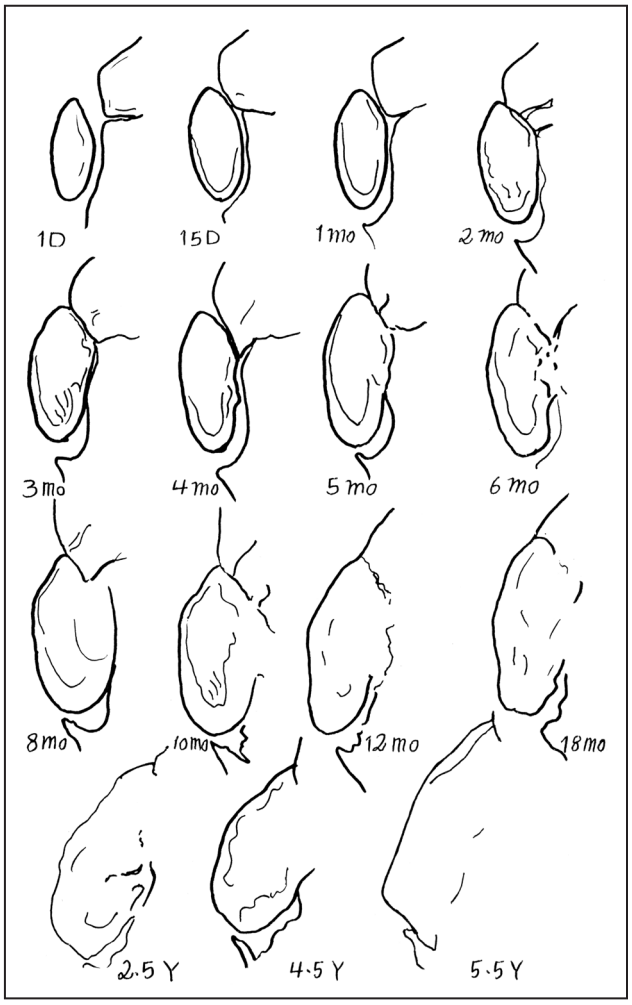

Diagram 3. Showing a copy of the radiographs of the tibial tuberosity development at different ages in camel (Reduced to 71% of normal radiographic size).

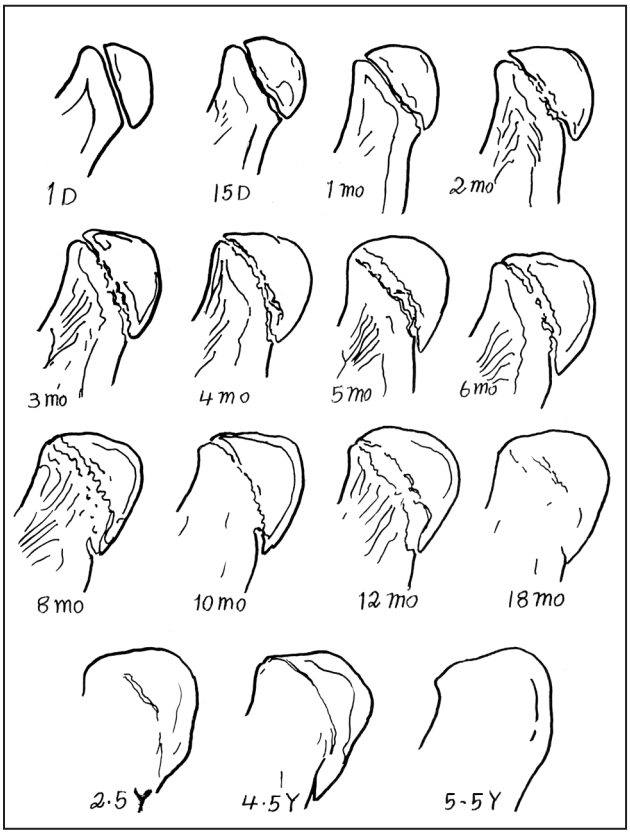

Diagram 4. Showing a copy of the radiographs of the calcanean tuberosity development at different ages in camel (Reduced to 71% of normal radiographic size).

Discussion

Diagnosis and treatment of bone fracture in camels have been receiving more attention now a days than previously mainly due to the steep rise in the cost of racing camels. Avulsion fractures are associated with excessive traction or pulling by a muscle, ligament or tendon at the point of origin or insertion. They are usually peri-articular or intra-articular or involve traction epiphysis or apophysis (Salter and Harris, 1963; Llewellyn, 1976; Thrall, 1996; and Tyagi and Singh, 1996).

Presence of a radiolucent line at the seat of fusion of secondary ossification centre to the main bone during the first few years of life raise a question; whether this line is the normal growth plate (physis) of un-united apophysis or is it an avulsion fracture. Many of the so called pathological changes of the tibial tuberosity that appear on radiographs are considered to be normal in young horses (Stashak, 1987).

Knowledge about the time of apophyseal closure is important in order to recognise any delay or premature closure (Brown and MacCallum, 1975; Dietz and Wiesner, 1984; and Ticer, 1984). If the physeal plates are still visible in radiographs of a camel, a film of the contra-lateral limb should be made for comparison. Our results indicated that complete fusion of the humeral medial epicondyle occurred at 1.5 years, while complete fusion of the olecranon tuberosity and calcanean tuberosity occurred at 4.5 and 5.5 years, respectively. Fusion of the tibial tuberosity occurred in two stages with a wide range of time between them. The proximal third of the tibial tuberosity fused with the proximal tibial epiphysis within 6 months, while the distal two thirds fused with the tibial diaphysis at 5.5 years.

In horses, the olecranon tuberosity remains unfused until 27-42 months and the tibial tuberosity joins the proximal epiphysis during

second year, and union is not complete until sometimes between 36 and 42 months. Avulsion fracture of the tibial tuberosity is seen in horses up to 3 years of age (Stashak, 1987). Separation occurs by the pull of quadriceps femoris muscles on the patella and patellar ligaments.

Avulsion fracture of the olecranon tuberosity is most commonly seen in young horses of 12 months of age but they have been reported in horses up to 36 months of age (Monin, 1978; Colahan and Meagher, 1979; Donecker *et al*, 1984; White and Moore, 1998; and Auer and Stick, 1999). The avulsion occurs during contraction of the *triceps brachii* muscle when the foal jumps to its feet.

Avulsion fracture of the calcanean tuberosity is reported with other types of fibular tarsal bone fractures in horses (Jones, 1976 and Jakovijevic *et al*, 1982). Distraction occurs due to contraction of the tendon Achille's.

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