

## Computed Tomography and Cross Sectional Anatomy of the Metatarsus and Digits of the Small Ruminants

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### Abstract

The present study didn't aim to compare between sheep and goat, but its goal was to establish an atlas of both CT and cross sectional anatomy of the metatarsus and digits in the native breed of each of sheep and goat in Egypt, to outstand a basis for diagnosis of their diseases. One cm contiguous transverse CT images and cross sectional anatomy were obtained and photographed. Clinically relevant anatomic structures were identified and labeled at each level in the corresponding images (CT and anatomic slices). In both species, the medullary cavity of the fused third and fourth metatarsal bones was divided internally by a vertical bony septum at the proximal and distal extremities. On the dorsal aspect of the fused third and fourth metatarsal bones and proximal and middle phalanges, in both species, the digital extensor tendons were differentiated in the cross sectional anatomy, only when the fascia dorsalis pedis was dissected. These tendons appeared in the CT images but the outline of each tendon was undifferentiated. In both species, on the palmar aspect of the fused third and fourth metatarsal bones and proximal and middle phalanges, the superficial and deep digital flexor tendons were differentiated in the cross sectional anatomy, only when the fascia plantaris was dissected. These tendons appeared in the CT images but the outline of each tendon was undifferentiated. CT images of the current study are presented as a reference for normal anatomy and clinical imaging studies of the sheep and goat metacarpus and digits.

### Introduction

A great role is provided to the domestic small ruminants (sheep and goat) in solving meat problem, owing to their high productivity. No one can deny the importance of the limbs body support and weight bearing as well as in the grazing behavior of the small ruminants. Awareness with the normal structure of the metatarsus and digits is necessary to be able to recognize changes in the diseased animal.

Classical anatomic atlases cannot provide the spectrum of views and the details required in modern diagnostic and surgical techniques (8). CT is able to discriminate physical density differences as small as 0.5 %, whereas in conventional radiography, 10% physical density difference is needed for visual detection, moreover CT eliminated the problem of the

organ shadow projection one upon another in the conventional radiography (2).

Computed tomography (CT) was not initially used in veterinary medicine because of its limited accessibility and high costs. However accessibility has improved, which has increased the need of the use of this technique in animals (13).

The knowledge of normal anatomy of the sheep and goat metatarsus and digits on CT images is necessary to provide accurate interpretation of these images and to describe abnormalities that may be present. The aim of this study was to provide an atlas of normal CT and cross-sectional anatomy of the sheep and goat metatarsus and digits.

### **Materials and Methods**

The present work was carried out on the metatarsus and digits of ten healthy asymptomatic adult native small ruminants (five sheep and five goats) of 2-5 years old, 3 males and 2 females of each species. The specimens were obtained from Benha slaughter house immediately after slaughter, by disarticulating the tarsometatarsal joints, cooled and imaged within 12 hours to minimize post-mortem changes. The specimens underwent consecutive CT scan, with slice thickening of 1 cm, using TOSHIBA 600 HQ (third-generation equip TCT). CT scan was carried out at Ahmed Farid radiology center- Benha.

After CT images were obtained, the sheep and goat metatarsus and digits were frozen at -20° then sectioned using an electric band saw, with the slabs cut transversely to correspond with the CT images. All sections were cleaned, photographed and kept for the future studies.

Important anatomic structures were recognized and labeled in two corresponding photographs of gross cross-sections and CT scans of the sheep and goat metatarsus and digits. These photographs were shown in a proximal to distal progression from the level of 1 cm below the carpus to 2 cm distal to the coffin joint.

The nomenclature used in this work was adopted by the illustrated *Nomina Anatomica Veterinaria* (16) and the *Nomina Anatomica Veterinaria* (12). Some structures present in the anatomical sections could not be seen on the corresponding CT images and vice versa.

## Results

The results of the present study were performed on 14 CT images and 14 gross cross-sections of the sheep and goat metatarsus and digits. CT provided good discrimination between bone and soft tissue and slight to moderate discrimination between the adjacent soft tissues according to their physical density difference.

### Metatarsus:

The metatarsus represented the part of the hind limb, lying between the tarsus and digits. Its skeleton was formed by the fused third and fourth metatarsal bones in both species.

The proximal extremity (base) of the fused third and fourth metatarsal bones showed internally a vertical bony septum (1/2). The latter extended for 1-2 cm distal to the carpal articular surface, partially dividing the medullary cavity in both species.

The distal extremity (head) of the fused third and fourth metatarsal bones, in both species, showed internally a vertical bony septum (4/2). The latter extended proximally for 1-2 cm, partially dividing the medullary cavity.

In both species, on the dorsal aspect of the fused third and fourth metatarsal bones, the tendon of *M. extensor digitorum longus* (2/5, 3/5 & 4/7) and the tendon of *M. extensor digitorum lateralis* (2/7, 3/6 & 4/8) as well as *M. extensor digitorum brevis* (2/6), were differentiated in the cross sectional anatomy only when the intervening *Fascia dorsalis pedis* was dissected to demonstrate these tendons. These structures (extensor tendons) appeared in CT images as narrow transverse strap on the dorsal aspect of the fused third and fourth metatarsal bones, but the outline of each tendon was undifferentiated (2/8 & 3/7).

On the plantar aspect of the fused third and fourth metatarsal bones, in both species, the interosseous muscle (2/2, 3/2, 4/9 & 5/6) appeared more distinctly in the cross sectional anatomy than in CT images. The deep digital flexor tendon (1/5, 2/3, 3/3, 4/6 & 5/7) and the superficial digital flexor tendon (1/6, 2/4, 3/4, 4/5 & 5/8) were differentiated in the cross sectional anatomy only when the intervening *Fascia plantaris* was dissected to demonstrate these tendons. These structures (flexor tendons) appeared in CT images together as a roughly rounded mass on the plantar aspect of the interosseous muscle and the fused third and fourth

metatarsal bones, but the outline of each tendon was undifferentiated (2/9 & 3/8).

The *Manica flexori* (5/9 & 6/7) was a tubular sleeve (sheath) formed by the superficial digital flexor tendon and the interosseous muscle around the bifurcated deep digital flexor tendon in the vicinity of the metatarsophalangeal (fetlock) joint, in both species.

#### Articulatio metacarpophalangea pedis:

Two metatarsophalangeal (fetlock) joints were present in each hind limb, in both species, one for each digit. The axial and abaxial proximal sesamoid bones of each metatarsophalangeal joint were connected by a plantar ligament (6/9). The two axial proximal sesamoid bones were connected together by the interdigital intersesamoideum ligament (6/10). Each abaxial proximal sesamoid bone was attached to the corresponding (medial or lateral) aspect of the head (distal extremity) of the fused third and fourth metatarsal bones by a collateral sesamoideum ligament (6/11).

#### Digits:

In both species, the proximal phalanges of the third and fourth digits were connected together along their interdigital surfaces by the proximal interdigital ligament (8/7). The distal interdigital ligament (11/6) connected the 3<sup>rd</sup> and 4<sup>th</sup> digits proximal to the interdigital space.

In both species, the tendon of *M. extensor digitorum lateralis* (9/8) on the dorsal aspect of the 4<sup>th</sup> digit, and the bifurcated tendon of the *M. extensor digitorum longus* (9/7) on the dorsal aspect of both the 3<sup>rd</sup> and 4<sup>th</sup> digits were differentiated in the cross sectional anatomy only when the intervening Fascia dorsalis pedis was dissected to demonstrate these tendons. These structures appeared in the CT images as a narrow transverse strap on the dorsum of the proximal and middle phalanges, but the outline of each tendon was undifferentiated (10/8).

In both species, on the palmar aspect of the digits, The cross sectional anatomy differentiated the tendon of the deep digital flexor tendon (8/6, 9/6, 10/7 & 11/4) and superficial digital flexor tendon (8/5, 9/5 & 10/6), only when the fascia palantaris was dissected to demonstrate

these tendons. These structures appeared in the CT images as a rounded gray mass, while their outlines were undifferentiated (10/9).

Just distal to the fetlock joint and prior to and at its insertion in the base of the middle phalanx, the flexor digitorum superficialis tendon gained a position deeper to that of the flexor digitorum profundus in both species (Figs. 9, 10&11).

The distal interphalangeal (coffin) joint (12/6) was formed by articulation of the head of the middle phalanx, the distal sesamoid (navicular) bone (12/5) and the distal phalanx. The articular cavity (12/6) was a potential cavity so it appeared linear in the cross sectional anatomy, but didn't appear in the CT images.

### Discussion

Knowledge of normal cross sectional anatomy of the sheep and goat metatarsus and digits is essential to the evaluation of CT scans.

CT images of the sheep and goat metatarsus and digits provides acceptable details of the anatomical structures and correlated well with corresponding gross specimens.

In accordance with (6, 7, 10, 3, 14, 5, 9, 4, 18, 19, 1, 11 and 15) CT provides good discrimination between bone and soft tissue architectures.

The present work revealed that both the proximal and distal extremities of the fused third and fourth metatarsal bones presented internally a vertical bony septum, which extended for 1-2 cm, partially dividing the medullary cavity, similarly, (17) in the ruminants, stated that the medullary cavity is divided into two parts by a vertical septum, which is usually incomplete in the adult.

The adjacent extensor tendons appeared in CT images as transverse narrow strap, and the adjacent flexor tendons appeared in CT as roughly rounded mass, but the outline of each tendon was undifferentiated. This may be due to a physical density difference less than 0.5%. In this respect (2) mentioned that CT is able to discriminate physical density differences as small as 0.5%.

The undifferentiating of the outlines of the adjacent tendons in CT images is equivalent to cross sectional anatomy without dissection of the intervening fascia, where the outlines didn't appear in the latter also. Hence, cross sectional anatomy is superior to CT only when the intervening fascia is dissected. Thus CT can be considered as a good tool for diagnosing diseases of the metatarsus and digits of the sheep and goat.

The present study should serve as an initial reference aid in CT imaging diagnosis of the sheep and goat metatarsus and digits disorders. More benefits could be harvested from CT imaging when a future study is focused on certain part or joint, especially when the inter- slicing space is few millimeters.

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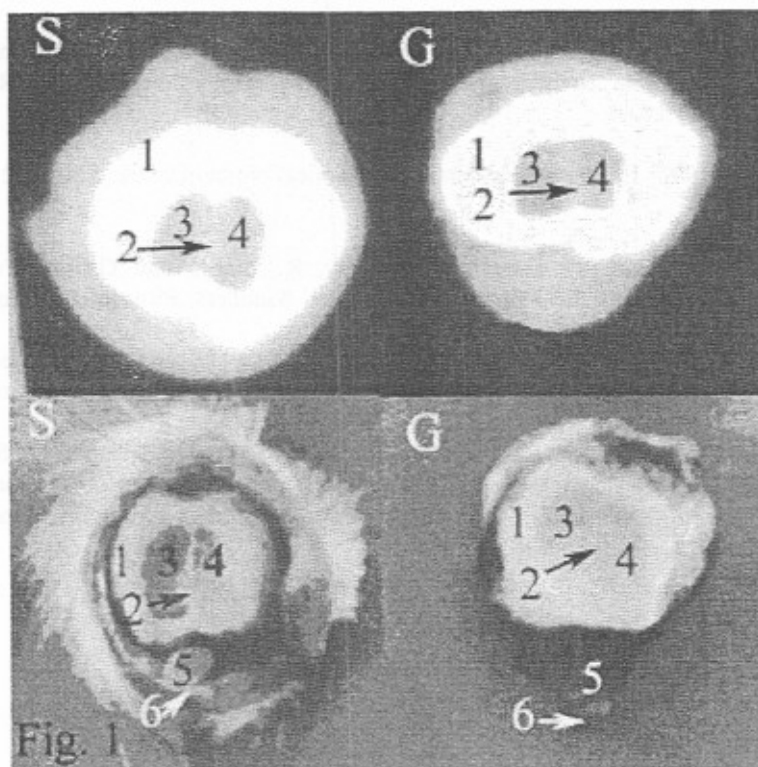


Fig. 1: Distal view of CT(up) and cross section (down) of the left metatarsus in the sheep (S) and goat (G) at the level of the base of the large metatarsal bone, 1cm distal to the tarsal articular surface (dorsal is up and lateral is to the right of the viewer). 1-Os metatarsale III et IV, 2- Septum between fused third and fourth metatarsal bones, 3- Cavum medullare ossis metatarsale III, 4- Cavum medullare ossis metatarsale IV, 5- Tendo musculus flexor digitorum profundus, 6-Tendo musculus flexor digitorum superficialis.



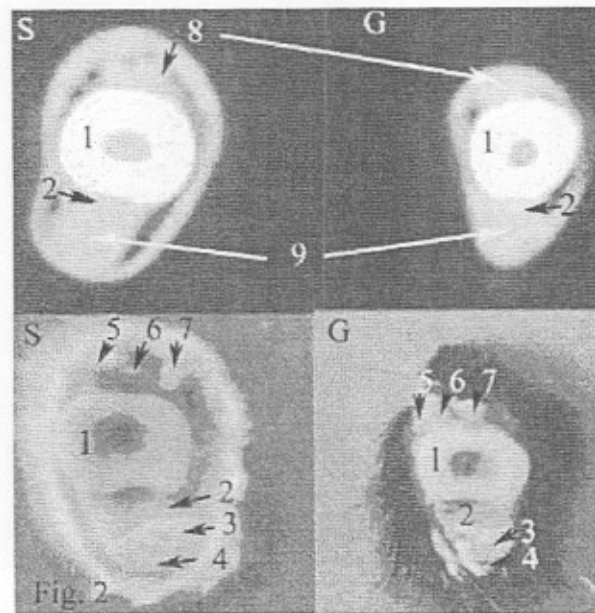


Fig. 2: Distal view of CT(up) and cross section (down) of the left metatarsus in the sheep (S) and goat (G) at the level of the proximal half of the shaft of the large metatarsal bone (dorsal is up and lateral is to the right of the viewer). 1- Os metatarsale III et IV, 2- M. interosseus, 3- Tendo musculus flexor digitorum profundus, 4-Tendo musculus flexor digitorum superficialis, 5-Tendo musculus extensor digitorum longus. 6- M. extensor digitorum brevis, 7-Tendo musculus extensor digitorum lateralis. 8- Extensor tendons (un differentiated), 9- Flexor tendons (un differentiated).

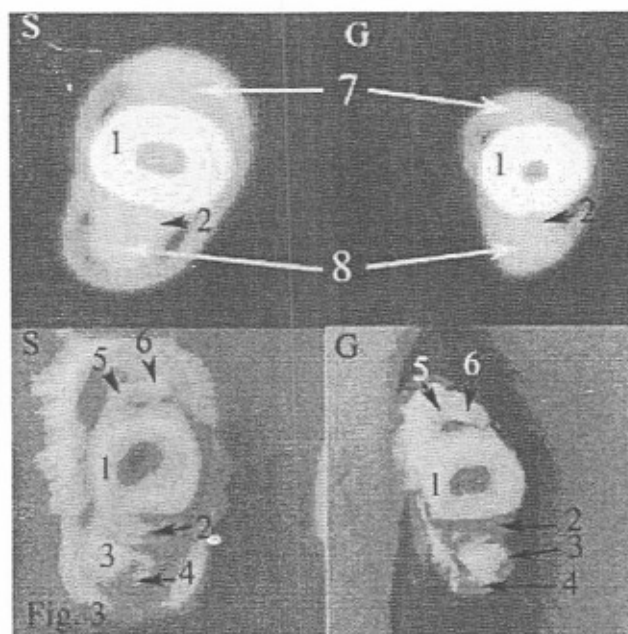


Fig. 3: Distal view of CT(up) and cross section (down) of the left metatarsus in the sheep (S) and goat (G) at the level of the distal half of the shaft of the large metatarsal bone (dorsal is up and lateral is to the right of the viewer). 1- Os metatarsale III et IV, 2- M. interosseus, 3- Tendo musculus flexor digitorum profundus, 4- Tendo musculus flexor digitorum superficialis, 5-Tendo musculus extensor digitorum longus, 6-Tendo musculus extensor digitorum lateralis, 7- Extensor tendons (un differentiated), 8- Flexor tendons (un differentiated) .

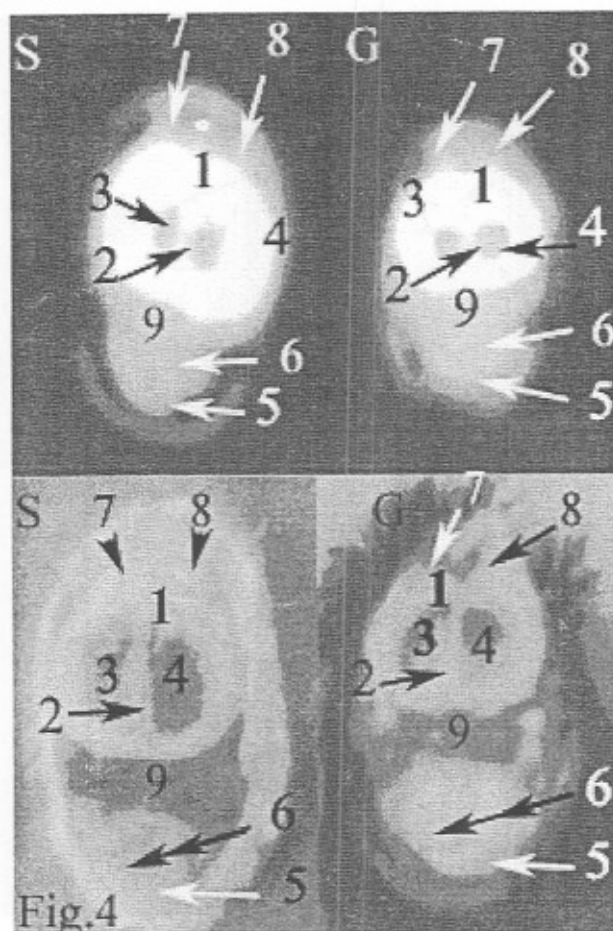


Fig. 4: Distal view of CT(up) and cross section (down) of the left metatarsus in the sheep (S) and goat (G) at the level of the head (distal extremity) of the large metatarsal bone, 2 cm above the distal articular surface (dorsal is up and lateral is to the right of the viewer). 1-Os metatarsale III et IV, 2- Septum between fused third and fourth metatarsal bones, 3-Cavum medullare ossis metatarsale III, 4- Cavum medullare ossis metatarsale IV , 5- Tendo musculus flexor digitorum superficialis, 6-Tendo musculus flexor digitorum profundus (divided), 7- Tendo musculus extensor digitorum longus, 8- Tendo musculus extensor digitorum lateralis, 9- M. interosseus.

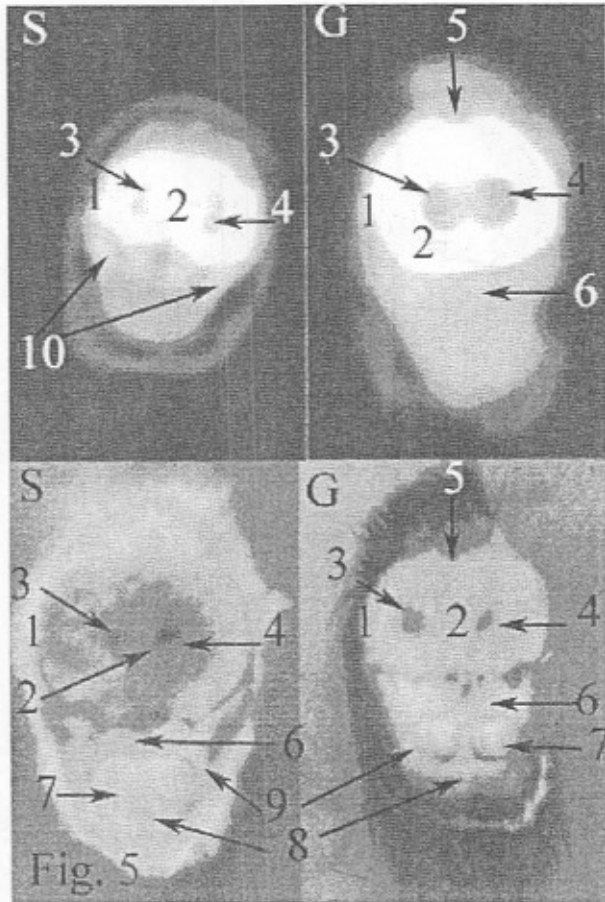


Fig. 5: Distal view of CT(up) and cross section (down) of the left metatarsus in the sheep (S) and goat (G) at the level of the head (distal extremity) of the large metatarsal bone, 1 cm above the distal articular surface (dorsal is up and lateral is to the right of the viewer). 1-Facies medialis ossis metatarsale III et IV, 2- Septum between fused third and fourth metatarsal bones, 3- Cavum medullare ossis metatarsale III, 4- Cavum medullare ossis metatarsale IV, 5- Sulcus longitudinalis dorsalis, 6- M. interosseous, 7- Tendo musculus flexor digitorum profundus (divided), 8-Tendo musculus flexor digitorum superficialis, 9-Manica flexoria, 10- Ossa sesamoidea proximalia.

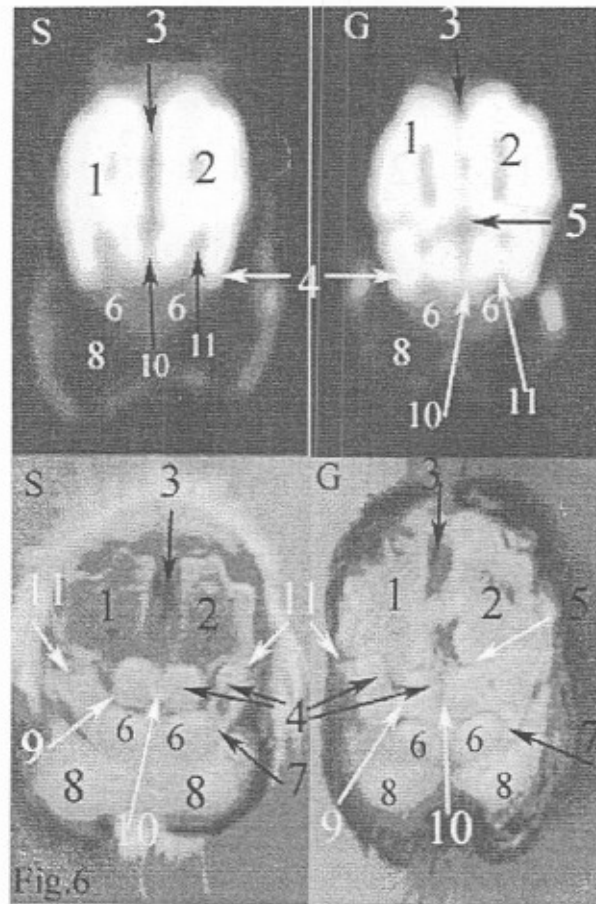


Fig. 6: Distal view of CT(up) and cross section (down) of the left metatarsus in the sheep (S) and goat (G) at the level of the metatarsophalangeal (Fet lock) joint (dorsal is up and lateral is to the right of the viewer).1- Caput ossis metatarsale III, 2- Caput ossis metatarsale IV, 3- Incisura intertrochlearis, 4-Ossa sesamoidea proximalia, 5- Articulatio metatarsophalangea (Cavum articulare), 6-Tendo musculus flexor digitorum profundus (divided), 7- Manica flexoria , 8- Tela subcutanea tori (Pulvinus digitalis), 9- Ligg. Plantaria, 10- Lig. Intersesamoideum interdigitale, 11- Ligg. Sesamoidea collateralia.

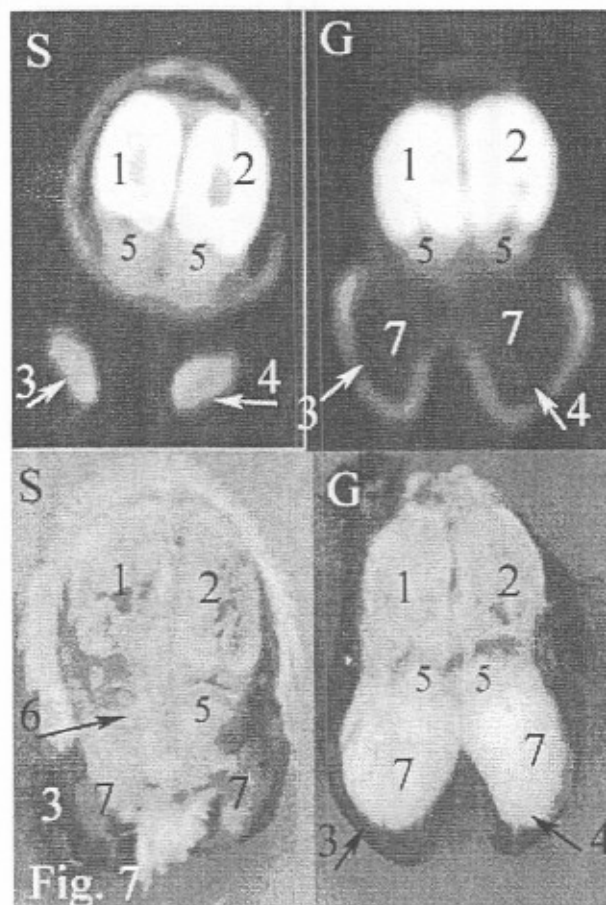


Fig. 7: Distal view of CT(up) and cross section (down) of the left hind digits in the sheep (S) and goat (G) at the level of the base of the proximal phalanx (dorsal is up and lateral is to the right of the viewer).1- Basis phalangis proximalis digiti III, -2- Basis phalangis proximalis digiti IV, 3 -Digitus II, 4-Digitus V, 5- Tendo musculus flexor digitorum profundus, 6-Manica flexoria, 7-Tela subcutanea tori.

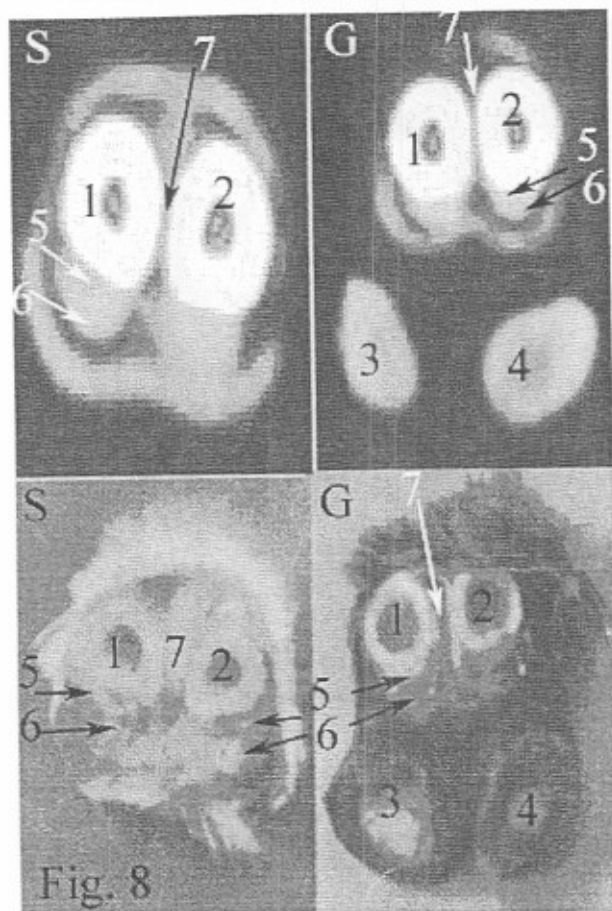


Fig. 8: Distal view of CT(up) and cross section (down) of the left hind digits in the sheep (S) and goat (G) at the level of the proximal half of the body (shaft) of the proximal phalanx (dorsal is up and lateral is to the right of the viewer). 1- Corpus phalangis proximalis digiti III, -2- Corpus phalangis proximalis digiti IV, 3 -Digitus II, 4-Digitus V, 5 -Tendo musculus flexor digitorum superficialis, 6 -Tendo musculus flexor digitorum profundus,7- Lig. Interdigitale proximale.

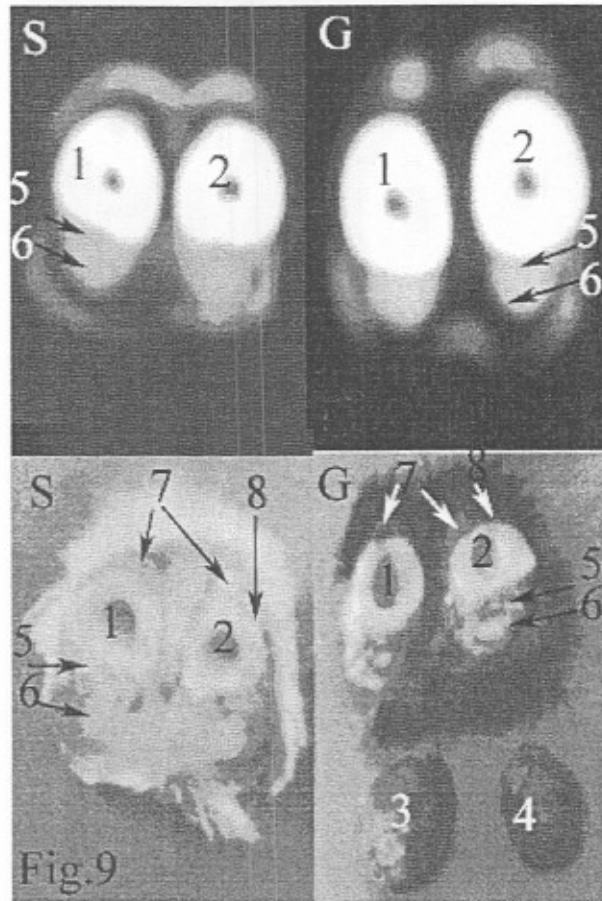


Fig. 9: Distal view of CT(up) and cross section (down) of the left hind digits in the sheep (S) and goat (G) at the level of the distal half of the body (shaft) of the proximal phalanx (dorsal is up and lateral is to the right of the viewer).1- Corpus phalangis proximalis digiti III, 2- Corpus phalangis proximalis digiti IV, 3 -Digitus II, 4-Digitus V, 5-Tendo musculus flexor digitorum superficialis, 6-Tendo musculus flexor digitorum profundus, 7-Tendo musculus extensor digitorum longus, 8-Tendo musculus extensor digitorum lateralis.



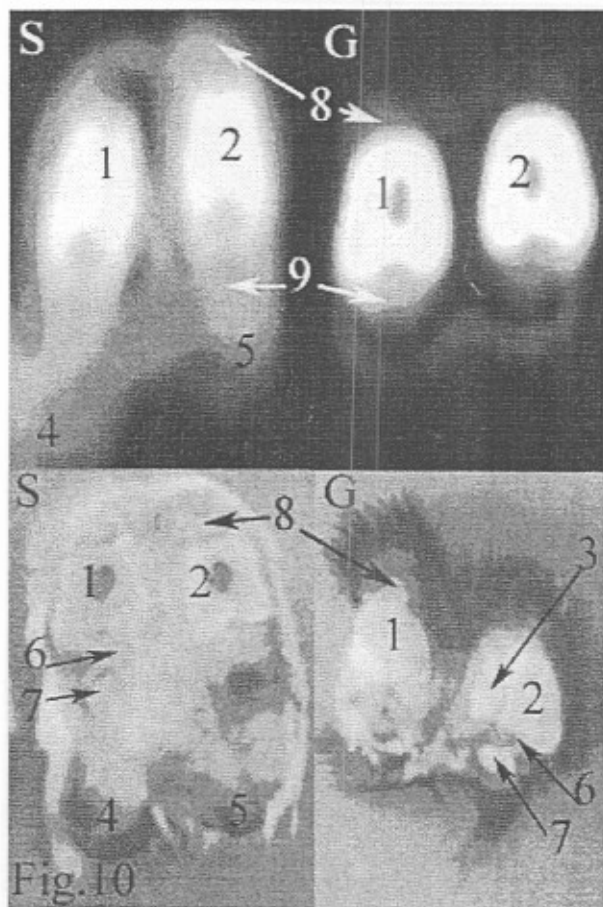


Fig. 10: Distal view of CT(up) and cross section (down) of the left hind digits in the sheep (S) and goat (G) at the level of the head (distal extremity) of the proximal phalanx (dorsal is up and lateral is to the right of the viewer). 1- Caput phalangis proximalis digiti III, -2- Caput phalangis proximalis digiti IV, 3- Basis phalangis mediae digiti IV, 4-Digitus II, 5-Digitus V, 6 -Tendo musculus flexor digitorum superficialis, 7 -Tendo musculus flexor digitorum profundus, 8- Extensor tendons (un differentiated), 9- Flexor tendons (un differentiated) .

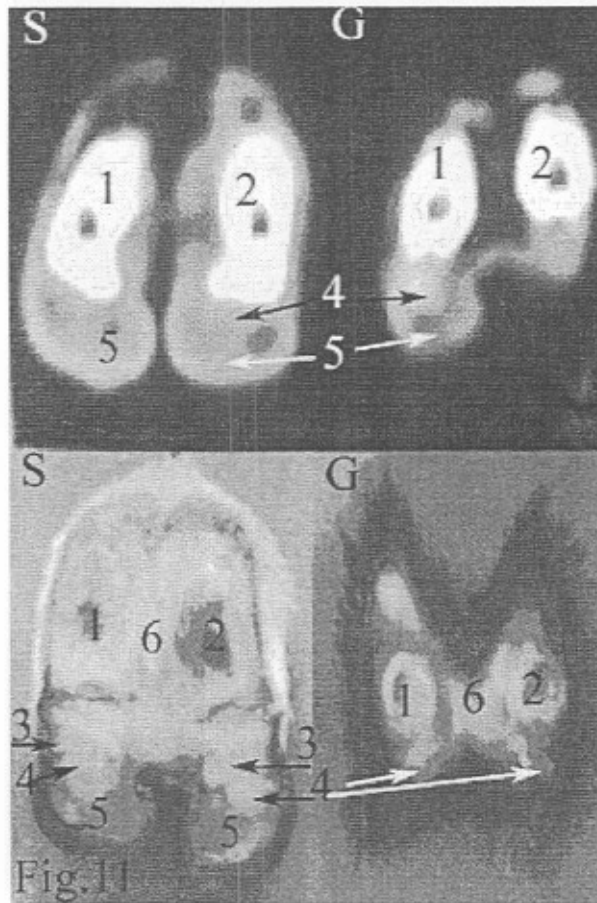


Fig.11: Distal view of CT(up) and cross section (down) of the left hind digits in the sheep (S) and goat (G) at the level of the body (shaft) of the middle phalanx (dorsal is up and lateral is to the right of the viewer). 1-Corpus phalangis mediae digiti III, -2- Corpus phalangis mediae digiti IV, 3- Tuberculum flexorium Phalangis distale digiti III , 4-Tendo musculus flexor digitorum profundus , 5- Tela subcutanea tori (Pulvinus digitalis or digital cushion).

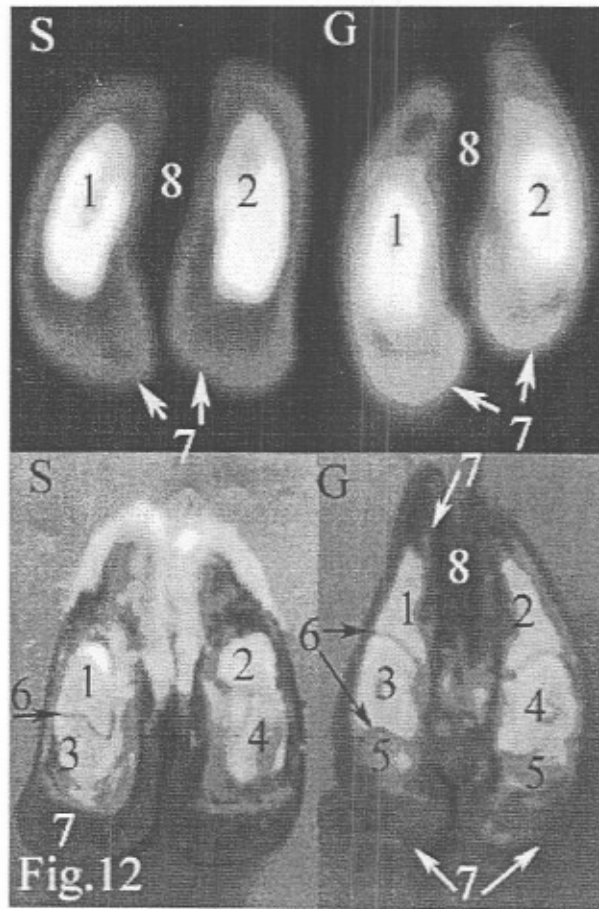


Fig. 12: Distal view of CT(up) and cross section (down) of the left hind digits in the sheep (S) and goat (G) at the level of the distal interphalangeal (Coffin) joint (dorsal is up and lateral is to the right of the viewer). 1 -Phalanx distale digiti III, 2-Phalanx distale digiti IV, 3-Caput phalangis mediae digiti III, 4-Caput phalangis mediae digiti IV, 5- Os sesamoideum distale, 6-Articulatio interphalangeae distalis pedis (Cavum articulare), 7-Capsula unguli, 8- Spatium interdigitale .

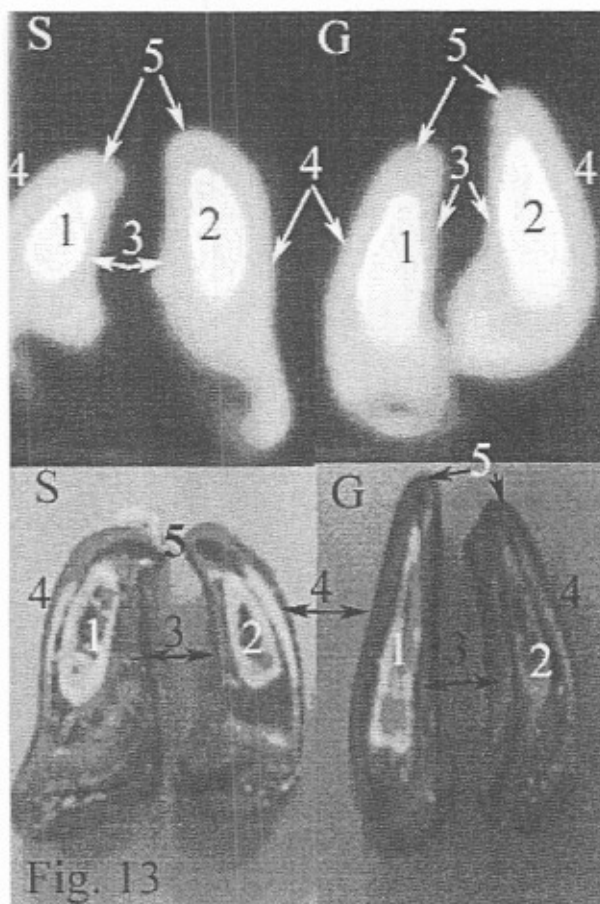


Fig. 13: Distal view of CT(up) and cross section (down) of the left hind digits in the sheep (S) and goat (G) at a level of 1 cm below the distal interphalangeal (Coffin) joint (dorsal is up and lateral is to the right of the viewer). 1- Phalanx distale digiti III, 2- Phalanx distale digiti IV, 3-Pars axialis paries corneus, 4- Pars abaxialis paries corneus, 5-Margo dorsalis.

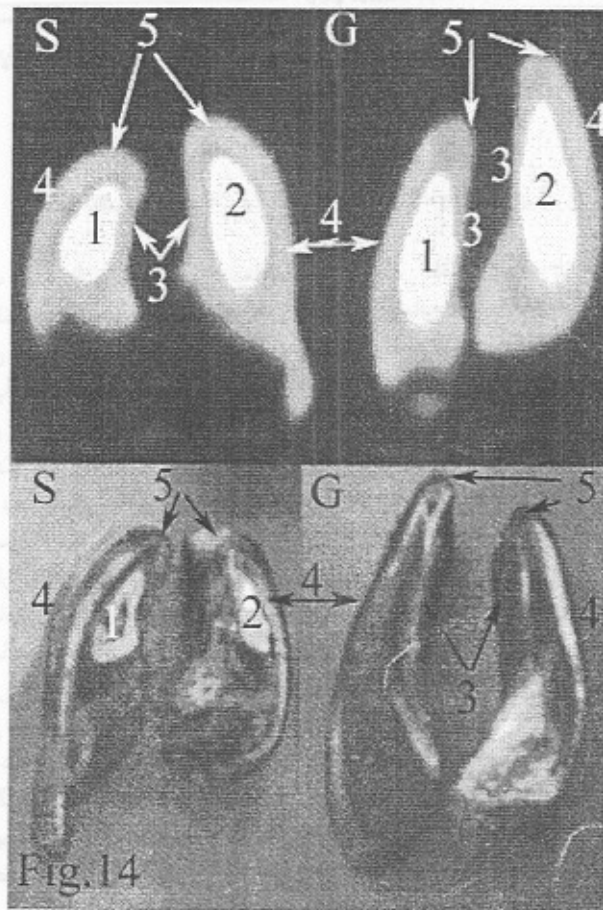


Fig. 14: Distal view of CT(up) and cross section (down) of the left hind digits in the sheep (S) and goat (G) at a level of 2 cm below the distal interphalangeal (Coffin) joint (dorsal is up and lateral is to the right of the viewer). 1 -Phalanx distale digiti III, 2 - Phalanx distale digiti IV, 3-Pars axialis paries corneus, 4- Pars abaxialis paries corneus, 5-Margo dorsalis.

الأشعة المقطعية المحسوبة والتشريح القطاعي المستعرض لمشط  
وأصابع القدم في المجترات الصغيرة

حاتم بهجات

قسم التشريح والأجنة- كلية الطب البيطري- جامعة بنها. ج. م. ع.

تهدف هذه الدراسة إلى المساهمة في عمل أطلس مزدوج من الأشعة المقطعية المحسوبة و التشريح القطاعي المستعرض لمشط وأصابع القدم السليمة إكلينيكيًا في السلالة المحلية لكل من الأغنام والماعز في مصر، من أجل وضع أساس لتشخيص أمراضهما باستخدام الأشعة المقطعية المحسوبة، لمساعدة أخصائيي الأشعة و الأطباء البيطريين، من أجل مواكبة سبل التشخيص الحديثة.

أجريت هذه الدراسة على خمسة اغنام وخمسة ماعز بالغة سليمة، حيث تم اخذ مشط واصابع القدم، بعد الذبح مباشرة، وتصويرها في قطاعات مستعرضة متتالية كل 1 سم ، بالأشعة المقطعية المحسوبة. بعد ذلك تم تجميد العينات، ثم عمل قطاعات مستعرضة متتالية كل 1 سم باستخدام منشار كهربائي، ثم تم تصويرها. كما تم التعرف ووضع البيانات على التراكيب التشريحية الهامة إكلينيكيًا في كل من المستويات المتناظرة من الأشعة المقطعية المحسوبة والتشريح القطاعي المستعرض.

أظهرت النتائج في كل من الأغنام والماعز أن التجويف النخاعي لعظمي مشط القدم الثالث والرابع الملتحمين قد انقسم داخليا بحاجز عظمي رأسي، عند النهايتين الدانية والقاصية. في كل من الأغنام والماعز، ظهرت الأوتار بأسطة الأصابع على الجهة الظهرية لعظمي مشط القدم الثالث والرابع الملتحمين في التشريح القطاعي المستعرض جلية واضحة فقط عند تشريح لفافة القدم الظهرية ، كما ظهرت أيضا في صور الأشعة المقطعية المحسوبة على هيئة شريط ضيق مستعرض، بينما لم تظهر حدود كل وتر على حده. في التشريح القطاعي المستعرض، في كل من الأغنام والماعز، ظهرت الأوتار قابضة الأصابع واضحة جلية على الجهة الأمامية لعظمي مشط اليد الثالث والرابع الملتحمين فقط عند تشريح لفافة الأمامية، كما ظهرت أيضا في صور الأشعة المقطعية المحسوبة على هيئة كتلة شبه مستديرة، بينما لم تظهر حدود كل وتر على حده.