Computed Tomography and Cross Sectional Anatomy of the Metacarpus and Digits of the Small Ruminants

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Abstract

The purpose of this study was not to compare between sheep and goat, but to provide an atlas of synchronized normal computed tomography and cross sectional anatomy of the metacarpus and digits in the native breed of sheep and goat in Egypt, to outstand a basis for diagnosis of their diseases by the aid of CT. 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 metacarpal 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 metacarpal 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 manus 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 metacarpal bones and proximal and middle phalanges, the superficial and deep digital flexor tendons were differentiated in the cross sectional anatomy, only when the fascia palmaris 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

The domestic small ruminants (sheep and goats) are very important meat producing animals, characterized by moderate gestation period (5 months) and considerable litter size (1-3). Thus, a great role is provided to sheep and goat in solving meat problem. No one can deny the importance of the limbs in body support and weight bearing as well as in the grazing behavior of the small ruminants.

Diseases of the metacarpus and digits are not rare, which necessitates awareness with its normal structure 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) currently plays a prominent role in the diagnosis and evaluation of many human diseases. It 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 expertise in the use of this technique in animals (13).

Since CT have become more available to veterinarians, the knowledge of the normal conventional anatomy and radiographic anatomy could no longer serve as a basis for recognizing structural abnormalities in diseased animals (2).

The present work was carried out, not to compare between sheep and goat, but to provide an atlas of synchronized normal computed tomography and cross sectional anatomy of the metacarpus and digits of these important animals, to outstand a basis for diagnosis of their diseases by the aid of CT.

Materials and Methods

The present work was carried out on the metacarpus 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 carpometacarpal 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 metacarpus and digits were frozen at -20° then sectioned transversely using an electric band saw, to correspond with the CT images. All sections were cleaned, photographed and kept for the future studies.

Important anatomic structures were detected and labeled in two corresponding photographs of gross cross-sections and CT scans. These sections 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. Labeling was in accordance with the illustrated Nomina Anatomica Veterinaria (16) and the Nomina Anatomica Veterinaria (12).

Results

The results of the present study were performed on 12 CT images and 14 gross cross-sections of the sheep and goat metacarpus 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.

Metacarpus:

The metacarpus represented the part of the fore limb, lying between the carpus and digits. Its skeleton was formed in both species, by the fused third and fourth metacarpal bones.

The proximal extremity (base) of the fused third and fourth metacarpal 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 metacarpal 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 metacarpal bones, the tendon of M. extensor digitorum lateralis (1/6, 2/5, 3/6, 4/8 &5/10), the tendons of the lateral belly of M. extensor digitorum communis (1/7, 2/6, 3/7, 4/9& 5/11) and the tendon of the medial belly of the latter muscle (1/8, 2/7, 3/8, 4/10 & 5/12) were differentiated in the cross sectional anatomy only when the intervening Fascia dorsalis manus 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 metacarpal bones, but the outline of each tendon was undifferentiated (4/12).

On the palmar aspect of the fused third and fourth metacarpal bones, in both species, the interosseous muscle (1/5, 2/2, 3/3, 4/5&5/6)

appeared more distinctly in the cross sectional anatomy than in CT. The deep digital flexor tendon (1/10, 2/3, 3/4, 4/6& 5/7) and the superficial digital flexor tendon (1/9, 2/4, 3/5, 4/7& 5/8) were differentiated in the cross sectional anatomy only when the intervening Fascia palmaris was dissected to demonstrate these tendons. These structures (flexor tendons) appeared in CT images together as a roughly rounded mass on the palmar aspect of the interosseous muscle and the fused third and fourth metacarpal bones, but the outline of each tendon was undifferentiated (4/11).

The *Manica flexori* (5/9 &6/11) 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 metacarpophalangeal (fetlock) joint , in both species.

Articulatio metacarpophalangea manus:

Two metacarpophalangeal (fetlock) joints were present in each fore limb, in both species, one for each digit. The articular cavity (6/5) was a potential cavity so it didnot appear in the CT images, while in the cross sectional anatomy, it appeared linear, except it was widened artificially (Fig.6).The axial and abaxial proximal sesamoid bones of each metacarpophalangeal joint were connected by a palmar ligament (6/6).The two axial proximal sesamoid bones were connected together by the inter digital intersesamoideum ligament (6/7). 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 metacarpal bones by a collateral sesamoideum ligament (6/8).

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 (12/9) connected the 3rd and 4th digits proximal to the interdigital space.

The tendon of M. extensor digitorum lateralis (8/8) on the dorsum of the proximal and middle phalanges of the 4th digit, and the tendon of the medial belly of M. extensor digitorum communis (8/10) on the dorsum of the proximal and middle phalanges of the third digit, as well as the

bifurcated tendon of the lateral belly of M. extensor digitorum communis(8/9) were differentiated in the cross sectional anatomy only when the intervening Fascia dorsalis manus was dissected to demonstrate these tendons in both species. 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 in both species (7/8, 8/11).

On the palmar aspect of the digits in both species, the cross sectional anatomy differentiated the tendon of the deep digital flexor tendon (8/6, 9/7, 10/7&11/5) and superficial digital flexor tendon (8/5, 9/6& 10/6), only when the fascia plantaris was dissected to demonstrate these tendons. These structures appeared in the CT images as a rounded gray mass, while their outlines were undifferentiated (7/9, 8/12).

In both species, the superficial digital flexor tendon (8/5 & 9/6) gained a position deeper to that of the deep digital flexor tendon (8/6 &9/7), just distal to the fetlock joint, and prior to its insertion in the base of the middle phalanx.

In both species, the proximal interdigital (pastern joint) (10/5) was formed by articulation of the head of the proximal phalanx and the base of the middle phalanx. The distal interphalangeal (coffin) joint (12/8) 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 (12/8) was a potential cavity so it appeared linear in the cross sectional anatomy, but didn't appear in the CT images.

The *Sinus interdigitalis (10/8)* of the sheep was located at the level of the distal interphalangeal joint, between the bases of the proximal phalanges of the 3rd and 4th digits (Fig.10).

Discussion

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

CT images of the sheep and goat metacarpus 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 metacarpal 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 adajacent 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 metacarpus 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 metacarpus 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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Figures and Legend

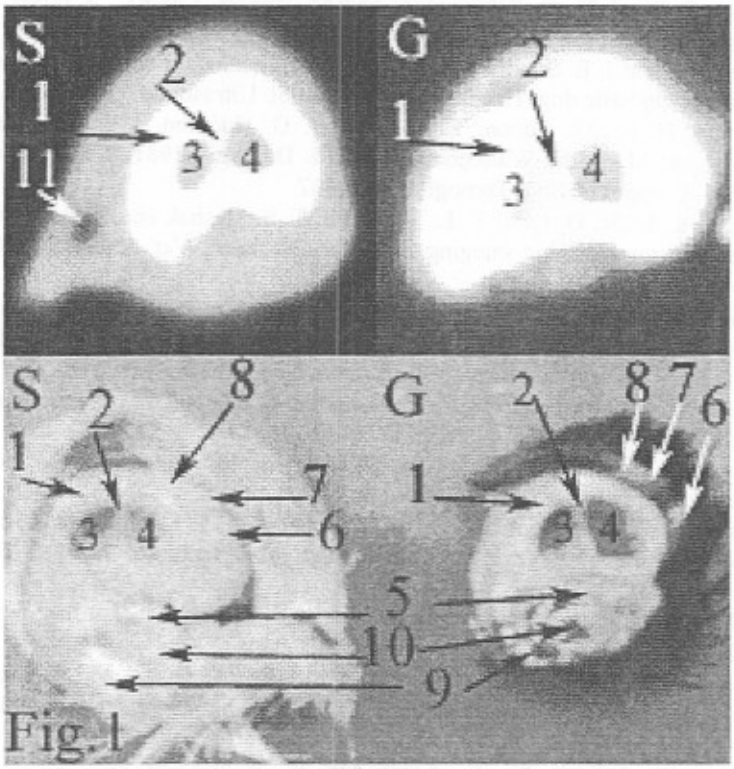

Fig. 1: Distal view of CT(up) and cross section (down) of the left metacarpus in the sheep (S) and goat (G) at the level of the base of the large metacarpal bone, 2 cm distal to the carpal articular surface (dorsal is up and lateral is to the right of the viewer). 1-Os metacarpale III et IV, 2- Septum between fused third and fourth metacarpal bones, 3-Cavum medullare ossis metacarpale III, 4- Cavum medullare ossis metacarpale IV, 5-M. interosseous 6-Tendo musculus extensor digitorum lateralis, 7-Tendo ventri lateralis musculus extensor digitorum communis. 8-Tendo ventri medialis musculus extensor digitorum communis. 9-Tendo musculus flexor digitorum superficialis, 10-Tendo musculus flexor digitorum profundus, 11- V. metacarpea palmaris II.

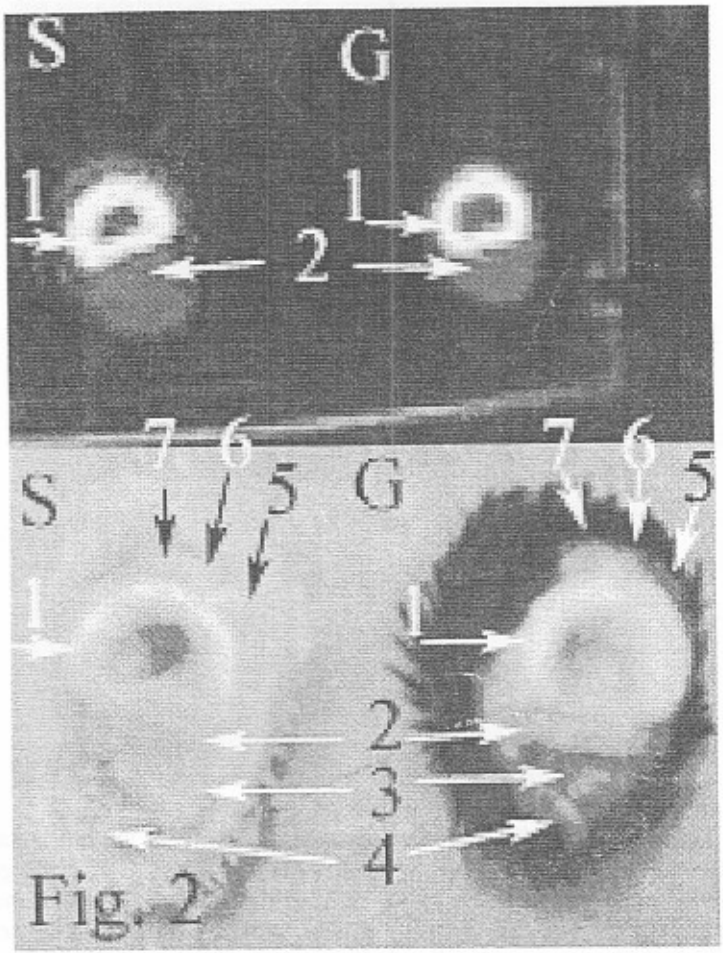

Fig.2 : Distal view of CT(up) and cross section (down) of the left metacarpus in the sheep (S) and goat (G) at the level of the proximal half of the shaft of the large metacarpal bone (dorsal is up and lateral is to the right of the viewer). 1- Facies medialis ossis metacarpale III et IV, 2- M. interosseous, 3-Tendo musculus flexor digitorum profundus, 4-Tendo musculus flexor digitorum superficialis, 5-Tendo musculus extensor digitorum lateralis, 6-Tendo ventri lateralis musculus extensor digitorum communis, 7-Tendo ventri medialis musculus extensor digitorum communis.

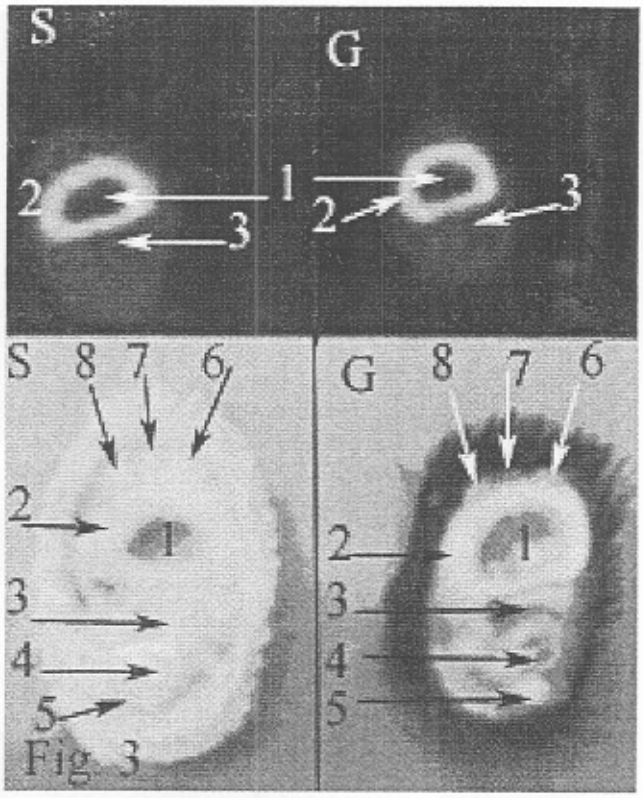

Fig. 3 : Distal view of CT(up) and cross section (down) of the left metacarpus in the sheep (S) and goat (G) at the level of the distal half of the shaft of the large metacarpal bone (dorsal is up and lateral is to the right of the viewer).1- Cavum medullare ossis metacarpale III et IV, 2- Facies medialis ossis metacarpale III et IV, 3- M. interosseous, 4-Tendo musculus flexor digitorum profundus, 5-Tendo musculus flexor digitorum superficialis, 6-Tendo musculus extensor digitorum lateralis, 7-Tendo ventri lateralis musculus extensor digitorum communis. 8- Tendo ventri medialis musculus extensor digitorum communis.

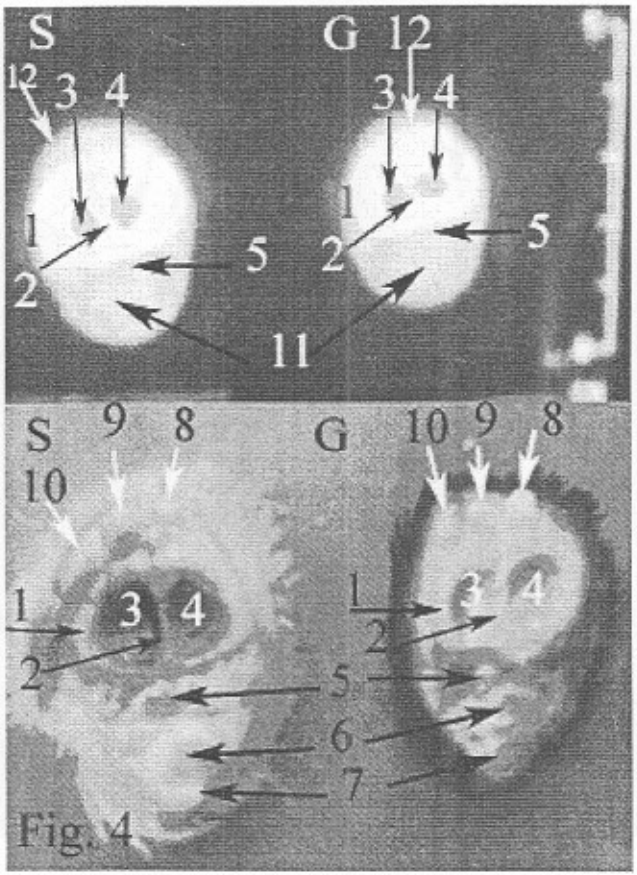

Fig. 4: Distal view of CT(up) and cross section (down) of the left metacarpus in the sheep (S) and goat (G) at the level of the head (distal extremity) of the large metacarpal bone, 2 cm above the distal articular surface (dorsal is up and lateral is to the right of the viewer). 1- Facies medialis ossis metacarpale III et IV, 2- Septum between fused third and fourth metacarpal bones, 3-Cavum medullare ossis metacarpale III, 4- Cavum medullare ossis metacarpale IV, 5- M. interosseous, 6- Tendo musculus flexor digitorum profundus, 7-Tendo musculus flexor digitorum superficialis, 8- Tendo musculus extensor digitorum lateralis, 9- Tendo ventri lateralis musculus extensor digitorum communis, 10-Tendo ventri medialis musculus extensor digitorum communis, 11- Flexor tendons (not outlined), 12- Extensor tendons (not outlined).

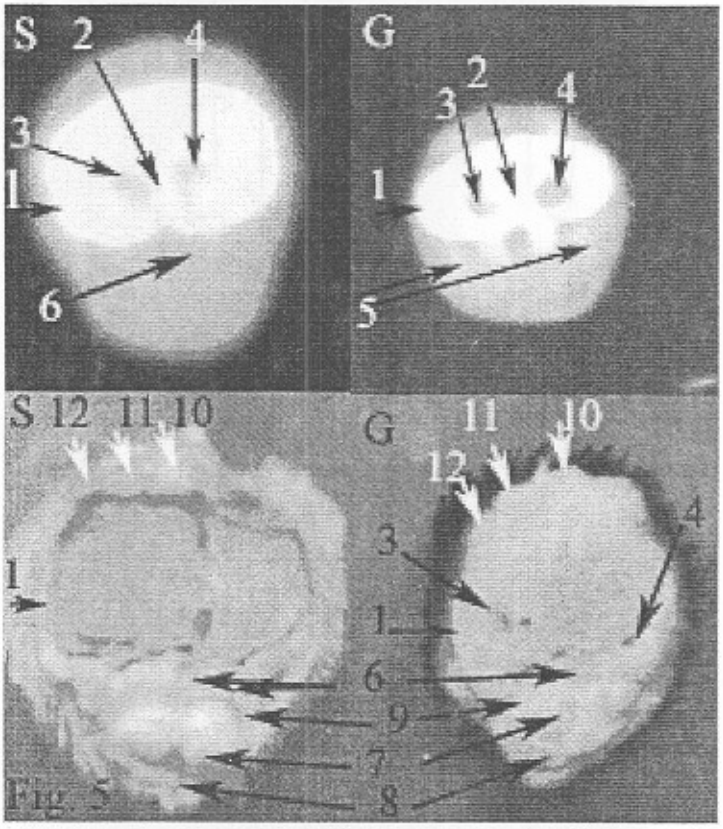

Fig. 5: Distal view of CT(up) and cross section (down) of the left metacarpus in the sheep (S) and goat (G) at the level of the head (distal extremity) of the large metacarpal bone, 1 cm above the distal articular surface (dorsal is up and lateral is to the right of the viewer). 1- Caput ossis metacarpale III et IV, 2- Septum between fused third and fourth metacarpal bones, 3-Cavum medullare ossis metacarpale III, 4- Cavum medullare ossis metacarpale IV, 5-Ossa sesamoidea proximalia, 6- M. interosseous (branched into 5 branches), 7-Tendo musculus flexor digitorum profundus (divided), 8-Tendo musculus flexor digitorum superficialis, 9- Manica flexoria, 10-Tendo musculus extensor digitorum lateralis, 11- Tendo ventri lateralis musculus extensor digitorum communis, 12- Tendo ventri medialis musculus extensor digitorum communis.

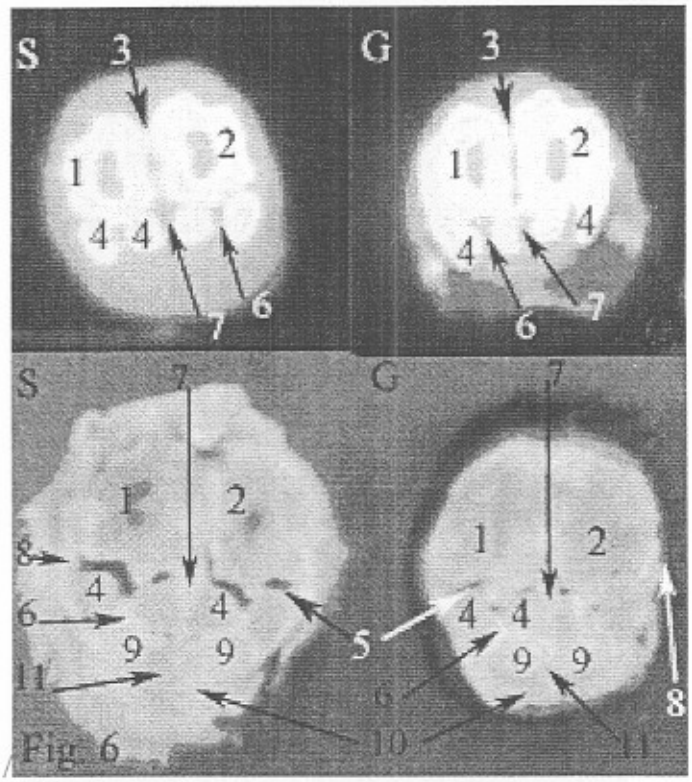

Fig. 6: Distal view of CT(up) and cross section (down) of the left metacarpus in the sheep (S) and goat (G) at the level of the metacarpophalangeal (Fet lock) joint (dorsal is up and lateral is to the right of the viewer).1- Caput ossis metacarpale III, 2- Caput ossis metacarpale IV, 3- Incisura intertrochlearis,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

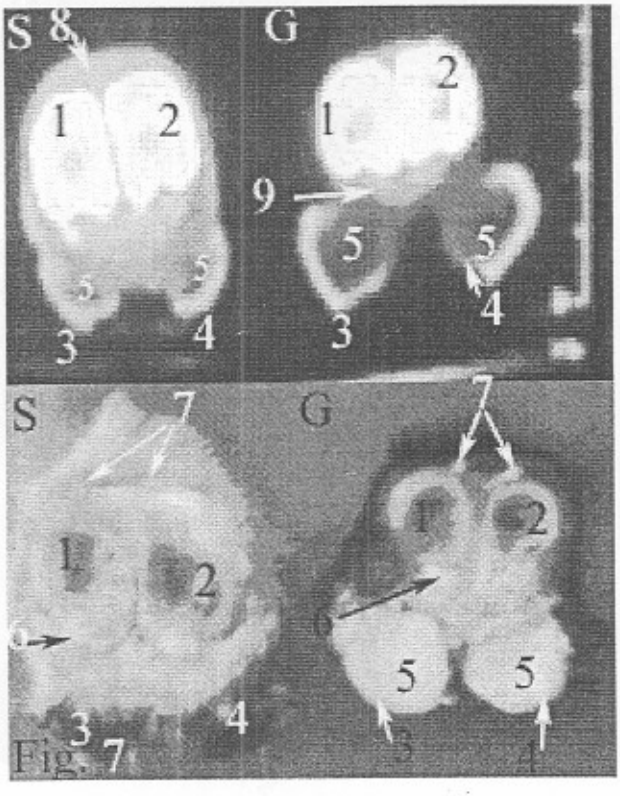

Fig. 7: Distal view of CT(up) and cross section (down) of the left fore digits in the sheep (S) and goat (G) at the level of the base of the proximal phalanx (dorsal is up and lateral is to the right of the viewer).1- Basis phalangis proximalis digiti III, -2- Basis phalangis proximalis digiti IV, 3 -Digitus II, 4-Digitus V, 5- Tela subcutanea tori, 6- Tendo musculus flexor digitorum profundus, 7-Tendo ventri lateralis musculus extensor digitorum communis (bifurcated), 8-Extensor tendons (not outlined), 9- Flexor tendons (not outlined).

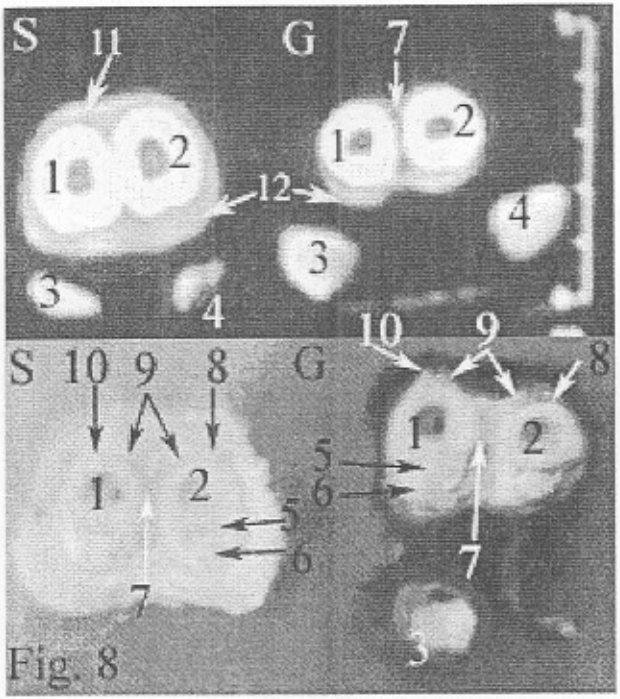

Fig. 8: Distal view of CT(up) and cross section (down) of the left fore digits in the sheep (S) and goat (G) at the level of the middle of the body (shaft) of the proximal phalanx (dorsal is up and lateral is to the right of the viewer).1- Corpus phalangis proximalis digiti III, -2- Corpus phalangis 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, 8-Tendo musculus extensor digitorum lateralis, 9- Tendo ventri lateralis musculus extensor digitorum communis, 10-Tendo ventri medialis musculus extensor digitorum communis, 11-Extensor tendons (not outlined), 12- Flexor tendons (not outlined).

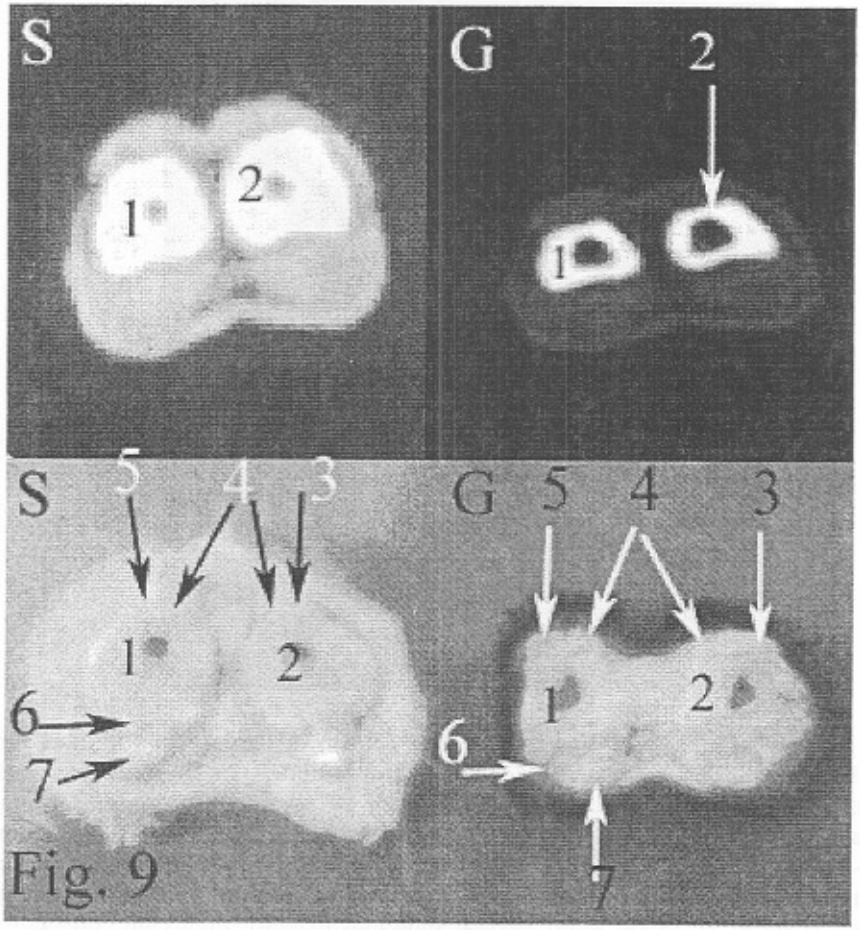

Fig. 9

Fig. 9: Distal view of CT(up) and cross section (down) of the left fore 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-Tendo musculus extensor digitorum lateralis, 4-Tendo ventri lateralis musculus extensor digitorum communis (bifurcated) 5-Tendo ventri medialis musculus extensor digitorum communis, 6-Tendo musculus flexor digitorum superficialis, 7-Tendo musculus flexor digitorum profundus.

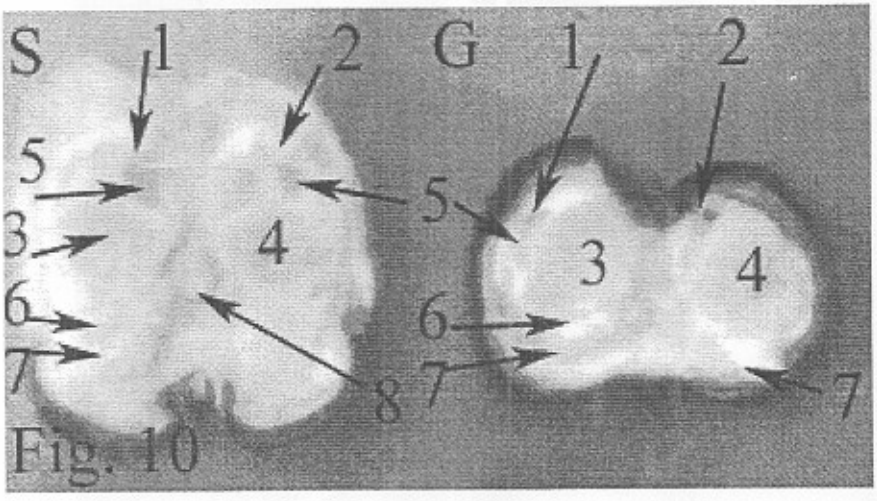

Fig 10 : Distal view of cross section of the left fore digits in the sheep (S) and goat (G) at the level of the proximal interphalangeal (pastern) joint (dorsal is up and lateral is to the right of the viewer). 1-Caput phalangis proximalis digiti III, -2- Caput phalangis proximalis digiti IV, 3- Basis phalangis mediae digiti III, 4- Basis phalangis mediae digiti IV, 5- Articulatio interphalangea proximalis manus(Cavum articulare), 6-Tendo musculus flexor digitorum superficialis, 7-Tendo musculus flexor digitorum profundus, 8- Sinus interdigitalis.

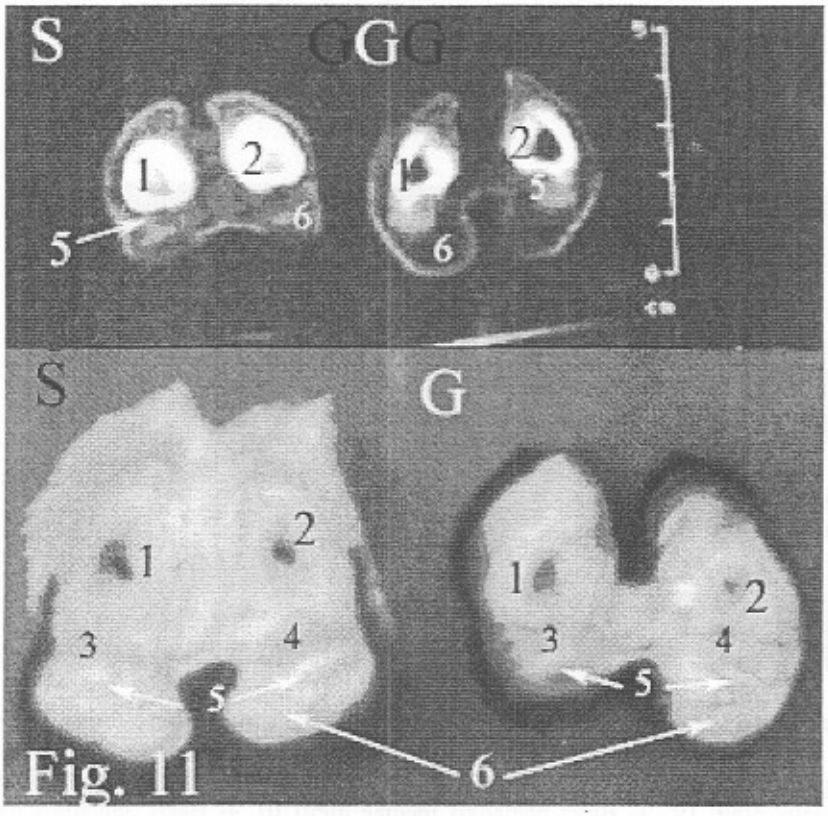

Fig. 11: Distal view of CT (up) and cross section (down) of the left fore digits in the sheep (S) and goat (G) at the level of the head of the middle phalanx (dorsal is up and lateral is to the right of the viewer). 1-Caput phalangis mediae digiti III, 2- Caput phalangis mediae digiti IV, 3- Tuberculum flexorium Phalangis distale digiti III, 4- Tuberculum flexorium Phalangis distale digiti IV, 5 -Tendo musculus flexor digitorum profundus, 6-Tela subcutanea tori (Pulvinus digitalis or digital cushion).

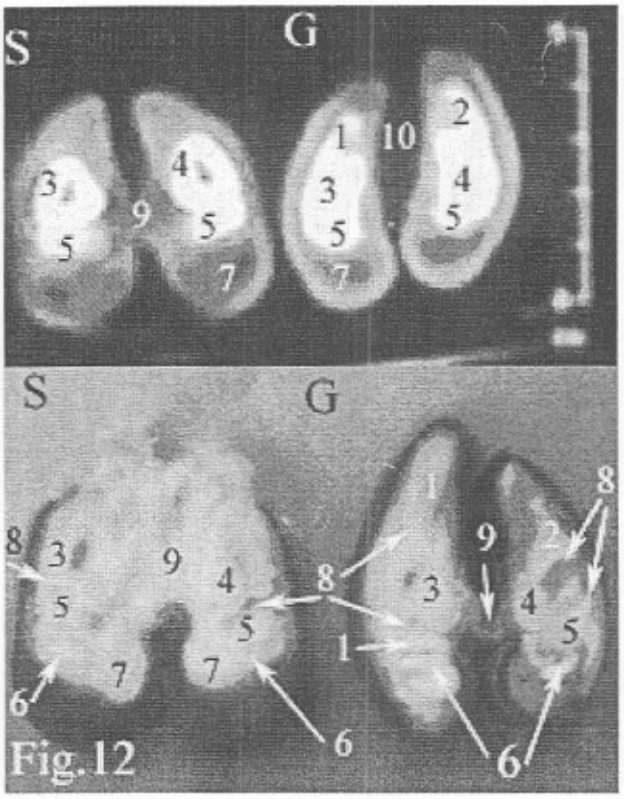

Fig. 12 : Distal view of CT(up) and cross section (down) of the left fore digits in the sheep (S) and goat (G) at the level of the distal interphalangeal (Coffin) joint (dorsal is up and lateral is to the right of the viewer). 1- Phalanx distale digiti III, 2- Phalanx distale digiti IV, 3 -Caput phalangis mediae digiti III, 4- Caput phalangis mediae digiti IV, 5- Os sesamoideum distale, 6-Tendo musculus flexor digitorum profundus, 7- Tela subcutanea tori (Pulvinus digitalis or digital cushion), 8- Articulatio interphalangeae distalis manus (Cavum articulare), 9- Ligg. interdigitalia distalia, 10- Spatium interdigitale.

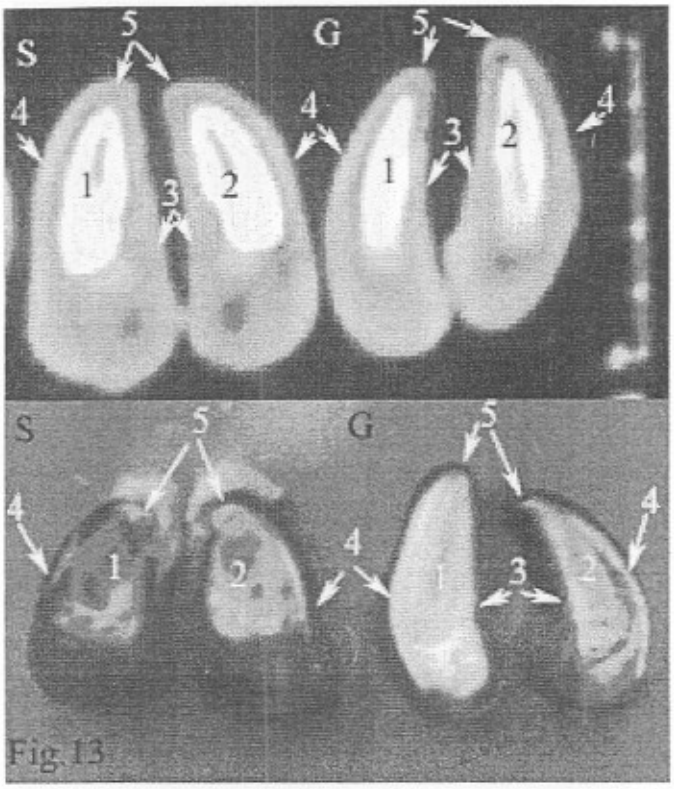

Fig. 13: Distal view of CT(up) and cross section (down) of the left fore digits in the sheep (S) and goat (G) at a level of 1 cm below the distal interphalangeal (Coffin) joint (dorsal is up and lateral is to the right of the viewer) 1- Phalanx distale digiti III, 2- Phalanx distale digiti IV, 3-Pars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

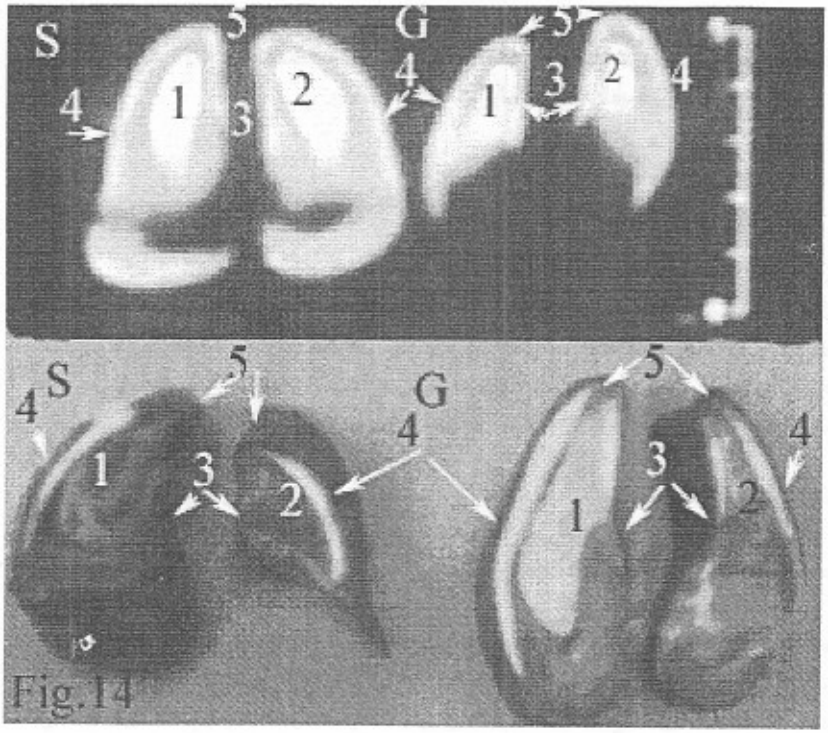

Fig. 14: Distal view of CT(up) and cross section (down) of the left fore digits in the sheep (S) and goat (G) at a level of 2 cm below the distal interphalangeal (Coffin) joint (dorsal is up and lateral is to the right of the viewer)1 -Phalanx distale digiti III, 2 - Phalanx distale digiti IV, 3-Pars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

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

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ليس الغرض من هذه الدراسة هو المقارنة بين الأغنام والماعز، ولكنها تهدف إلى المساهمة في عمل أطلس مزدوج من الأشعة المقطعية المحسوبة و التشريح القطاعي المستعرض لمشط وأصابع اليد السليمة إكلينيكيا في السلالة المحلية لكل من الأغنام والماعز في مصر، من أجل وضع أساس لتشخيص أمراضهما باستخدام الأشعة المقطعية المحسوبة.

أجريت هذه الدراسة على خمسة اغنام وخمسة ماعز بالغة، حيث تم اخذ مشط واصابع اليد، 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 كهربي، ثم تم تصويرها. كما تم التعرف ووضع البيانات على التراكيب التشريحية الهامة إكلينيكيا في كل من المستويات المتناظرة من الأشعة المقطعية المحسوبة والتشريح القطاعي المستعرض.

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