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ANATOMICAL STUDY OF BONE OF CAMEL FOOT

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ABSTRACT

The intent of this study were to explain the gross anatomical study of the bones of the camel feet (Forelimb and Hindlimb) from under the carpal and tarsal joints by using traditional techniques for gross anatomical preparation of bones (using 6 pairs of forelimb and hindlimb). The camel is characterized by two contrary adaptive factors, firstly, its camel leg must be long and skinny for protective from hot desert environment, and secondly, the leg must be strong enough to a bear the heavy weight of the camel body and to prevent sinking in the sands of the desert. The camel leg have these two factors (elongation & slimness) and at the same time the strength stemming from of several structural adaptations such as the abundance of fatty-elastic (digital cushions) inside the foot, the length of the metacarpal and metatarsal and the horizontal positioning of phalanges. The results showed that the large metacarpal and metatarsal bones are characterized by the fusion of 3rd and 4th metacarpal and metatarsal bones on the entire length of the bone except at the distal end which happens a divergence of bone from each other larger than the rest of the animals to distribute the weight of the camel on a larger area, metatarsal bone resemble the metacarpal with the exception of the metatarsal being smaller and has more cylindrical body, the bones of the phalanges are longest when compared to other animals, the proximal phalanx of camel was characterized by its elongation when compared with ruminants, the length of the middle phalanx reach to almost half the length of the proximal phalanx while the distal phalanx was considered the smallest of the three phalanges and has the wedge shape, the number of sesamoid bones in the camels were different from other animals in the absence of the distal sesamoid bone in order to allow free movement of the foot.

INTRODUCTION

The camel is an even-toed ungulate within the genus Camelus, bearing distinctive fatty deposits known as humps on its back. Camelids, in comparison to other domestic and farm animals, were little scientifically studied. However, recently scientific working groups increasingly begun to recognize and intensely be aware of the importance of this species. The camel is a very hard animal and is well adapted anatomically and physiologically to harsh climatic desert conditions (1).

The family Camelidae is divided into two genera, the old world camels (genus Camelus) and the new world camels (genus Lama) (2). Two domesticated species of old world camels exist, the dromedary or one humped camel (Camelus dromedarius), known as Arabic camel, that has its distribution in the hot deserts of Africa and Asia and the Bactrian or two-humped camel (Camelus bactrianus) that can be found in the cold deserts and dry steppes of Asia (2 & 3).

The camel plays an important socio-economic role in the life of the pastoral people, browse scanty vegetation and produce where other livestock species cannot survive. The camel has been used for milk and meat production as well as for draught and riding purposes (4).

Recently, camel races and beauty shows the economic value of the dromedary camels which are held regularly in the Gulf region where camels may be worth a fortune which is especially the case for the winning camels. Lameness in racing camels is also considered to be a major welfare and economic problem encountered by camel owners at the present time and therefore imaging this regions can be a challenge. The camel has a different pattern of lameness as compared to bovine and equines. This may be due to its peculiar anatomy, biomechanics, geoclimatic adaptation and use (5, 6, 7 & 8), The aims of this study were to explain the gross anatomical study of the normal bones of the forelimb and hindlimb of one-humped camel (below the carpal and tarsal joints to the foot pad).

MATERIALS AND METHODS

Collection of specimens : The present study was carried out on the metacarpus (Mc.), metatarsus of both forelimb and hindlimb of symptomatically healthy camel (the age range from 3-7 years old) from both sexes. The specimens were obtained from Al-Diwaniya slaughter house immediately after slaughtering by disarticulating the carpometacarpal and tarsometatarsal joint. The specimens were cooled (by using cool box with ice after the specimens covered by nylon bag) and transported to the laboratory then dissected and imaged within 6-8 hours to minimize post-mortem changes.

The Anatomical Study Of The Bones (Metacarpus, Metatarsus and Digits) : The study of camel digits (Mc., Mt. and digits) were done by taking six pairs (6 forelimbs and 6 hindlimb) and preparing by ordinary way (boiling and bleaching). Firstly the skin, tendons, ligaments, the sole and digital cushions were removed from the bones of foot then the bones were boiled in suitable pot and cooked at a simmer for 2-3 hours to remove the residual tissue and afterwards these bony segment were cleaned again under tap water using brusher and small scrapers then the bones put in bleaching water solution (for 5-6 hour) to remove any remaining non-bone material and whiten. Then the bones were allowed for complete sun drying for 7-10 hours (9 &10).

RESULT AND DISCUSSION

1-Metacarpal Bone (Mc.): The present study revealed that the metacarpus in camel consisted of the fusion of the Mc. III & IV, the fusion extended along the Mc. bone except in the distal end where they diverge to form separate articulation with digits (Fig. 1), this came in agreement with (11) in that the Mc. bone in bovine consist of the large metacarpal bone (fusion of Mc. III and IV) and lateral small metacarpal bone. In equine the only fully developed and carrying the digit is the 3rd metacarpal bone and the other two are 2nd and 4th metacarpal bones which are called small or splint metacarpal bones (12 & 13). This fusion in metacarpal bones form strong bone that enough to resist the forces involved in standing and moving immediately after birth (14)

The proximal end has medio-palmar facet of the Mc. III is form articulation with the 2nd carpal bone (distal row), the other two facets connected with 3rd carpal bone and the articular surface of the Mc. IV its articulate with 4th carpal bone (Fig. 2). While in the horse the greater part of the proximal extremity is supported to the 3rd carpal bone and other articulating surface adapted to the other distal row carpal bones, in ruminant the proximal extremity appears slightly concave for articulation with distal row of carpal bones (13 & 15)

The present study revealed that the Metacarpal tuberosity was present dorsally and proximally on Mc. III and there is a small tuberosity distally along the same surface, while in ruminant has on the medial aspect dorsal and palmar tuberosity, in equine on the medial side of dorsal surface of the Mc. III there is metacarpal tuberosity in which the extensor carpi radialis is inserted in it. (11, 12, 13 & 16)

The distal articular extremity of Mc. in camel a compared with ruminant was more separated from the articular surface of Mc. III and IV and each articular surface prepared to articulate with proximal phalanx (PI) and proximal sesamoid bone (Fig. 1). While equine was different from camel and ruminant in that the distal extremity is composed of two condyles separated by a sagittal ridge to articular with one digit and proximal sesamoid bones. Also our result revealed that the two thirds of palmar surface of the Mc. bone was a concave in shape This result corresponds with the (6) and there is also a rough surface in this area for the attachment of ligaments and this differs from in bovine in which the palmar surface is flat and has a fainter groove (palmar longitudinal sulcus) not found in camel while in equine the palmar surface is convex from side to side. (11, 13, 15 & 16).

The present study showed that the dorsal surface showed a faint line or a shallow groove which indicates the fusion line between Mc. III and IV., this differ in equine which represented by smooth and convex from side to side and nearly straight in its length (17), while in bovine the dorsal surface was recognize by a vertical groove (dorsal longitudinal sulcus). (12).

2-Metatarsal Bone: The present study revealed that the metatarsus in camel consisted of the fusion of Mt. III and IV as in Mc (Fig. 3) are fused except distally to form the articulation surface for digits III and IV. Approximately its length was equivalent to Mc. bone but different from it in that the shaft was more slender and the distal extremity and its articular surface were smaller and the lateral border of shaft was slightly concave on the proximal half, the plantar border was convex and rough, the plantar surface was concave and flanked on each side by a rough border. The tuberosity of the dorsal aspect of Mt. bone was raised and elongated and at the same level on the lateral aspect of Mt. 4th there was oval and rough area. The proximal articular surface was recognized plantarly by a pointed process (Fig. 4), it articulate with 4th tarsal bone and the dorsal longitudinal sulcus is faintly appearance.

3-Digital Bones: The present study showed that there were two digits present in camel each of them consisted of three phalanges (proximal, middle and distal) and two proximal sesamoid bones, there were no distal sesamoid bones in camel, the phalanges and sesamoid bones of the forelimb were similar to that in the hindlimb but slightly smaller so the anatomical description to be limited on the forelimb.

3-1-Proximal Phalanx (PI): The current study declared that the camel has a relatively long PI (Fig. 5), with a length of about five times that of the diameter and this differs from the ruminant that the relative length is shorter, with a length around four times that of the diameter (18). The proximal end (the base) was slightly convex dorsally and flattened palmarly. The fovea articularis on the base of the PI is roughly circular in outline and slightly concave along a transverse axis and dorso-palmarly in their direction. The articular surface of the base increase in height palmarly and ends by two facets separated by an intermediated sagittal notch. These facets articulate with sesamoid bones. On axial aspect of the base there is a transverse ridge for ligamentous attachment.

The present study showed that the distal articular surface was a saddle in shape and strongly convex and extended up onto the dorsal surface (Fig. 5), this extension not found in ruminant, so this extension in distal articular surface consider a modification for allowing greater degree of extension of the PII on the PI in association with a digitigrades foot posture. In contrast the restriction of the articular surface in ruminant would serve to limit mobility between the PI and PII may be in association with a more derived unguligrade foot posture. (19).

There was on the tip of the proximal articulation of the PI and on the palmar facet a groove which relatively wider, shallower and smoother than in ruminant (19) while in ruminant this groove and the articular surface is longer antero- posteriorly presumably in association with the complete metapodial keels this differs from camel for allowing more interlocking the joint (20).

3-2-Middle Phalanx (PII): The present study showed that the PII was nearly half as long as the PI (Fig. 5). The base (proximal end) is more or less oval (nearly circular in outline) in diameter and the articular surface of it was slightly concave and is longer in the medio-lateral direction than in the antero-posterior direction with little surface grooving this result corresponding with (3) and due to this articulation the surface shape in the camel probably represent greater mobility between PI and PII. While in ruminant the articular surface of proximal end of PII is more square in shape and deeper (21). Also on this surface dorsally and abaxialy there was a transverse ridge (extensor process). The body of PII is convex dorsally and flattened palmarly.

The distal end of PII has a depression for ligaments on each side (axialy and abaxialy), the articular surface is convex and slightly extension on the anterior (dorsal) surface and differ than in ruminant (20) which the greater extension of the PII on the PIII with an unguligrade foot posture that is more stable (Fig. 5).

3-3-Distal Phalanx (PIII): The present study showed that the PIII was very small in comparison with other phalanges, its wedge-shape (Fig. 5) with a very shallow relatively flat articular surface. The parietal (dorsal) surface is rough and raised proximally and slightly convex area, distally to it there was a transverse ridge unguicular crest, the axial foramen is found behind the crest. The margo dorsalis divides the dorsal surface into a axial and abaxial and the last larger than the axial, while the solar (palmar or plantar) surface is smooth and represented by facies flexoria (Fig. 6). This result corresponds with (5 & 13).

The differences between camel and ruminant which also reflect the foot posture in that the ruminant has long and deep PIII which encased within a hoof and the deep relief on the articular surface reflects greater restriction of interphalangeal mobility with an unguligrade foot posture (5 & 13).

4-Sesamoid Bones : There is no distal sesamoid bones in camel.

4-1-Proximal Sesamoid Bone: The present study showed that both of the proximal sesamoid (Fig. 5) bone had an elongated articular surface on its anterior aspect which articulate with palmar and plantar facet of the trochlea of the distal end of the metacarpal and metatarsal, on the axial surface there was also articular surface which articulate with intermediate ridge of the trochlea of the metacarpal this articulation is continued with the dorsal aspect of sesamoid bone. Distally has small a proximally flattened surface on the dorsal part for articulation with the base of PI. While in horses the proximal sesamoid bone has three sided pyramids, dorsally articulate with distal end of metacarpal and the flexor tendons ride over it. Palmarly also with a branch of interosseous muscle, the equine differs from camel in which the proximal sesamoid bone doesn't articulate with PI (11).

The current study revealed many anatomical structural peculiarities in camel feet, revealed that the PII and PIII was located entirely in the foot in horizontal position. This result was in agreement with (5, 18 & 22). Also the distal part of the PI lies in the camel foot in an obliquely and cranioventrally position.

The camel walks only on the pads of the two last phalanges instead of on the sole of the foot and is therefore regarded as hoof less digitigrades. The digital bones of the dromedary camel are particularly important component of its locomotor anatomy because they dual functions, including shock absorption and bear the weight of the body mass (23).

The phalanges of the camel are longer than those of other artiodactyls species. This inter-species anatomical variation in the length of phalangeal bones were thought to be one of the adaptive features to be related to the capacity for shock absorption during locomotion, longer and larger bones have a greater capacity than shorter and slender bones to absorb shock (impact energy). The ability to absorb mechanical shock seems to help the camel to adapt to arid desert environment by reducing the energy expenditure (mechanical requirements) of its locomotor mode (19, 23, 24, 25, & 26).

Consequently and due to the burden of an increasing body size and the effect of gravity the camel had evolved other locomotor adaptations such as limb elongation and joint posture to increase its weight-bearing ability and to increase walking ability for a long period of time and distance in response to the above factors. (23, 24 & 27).

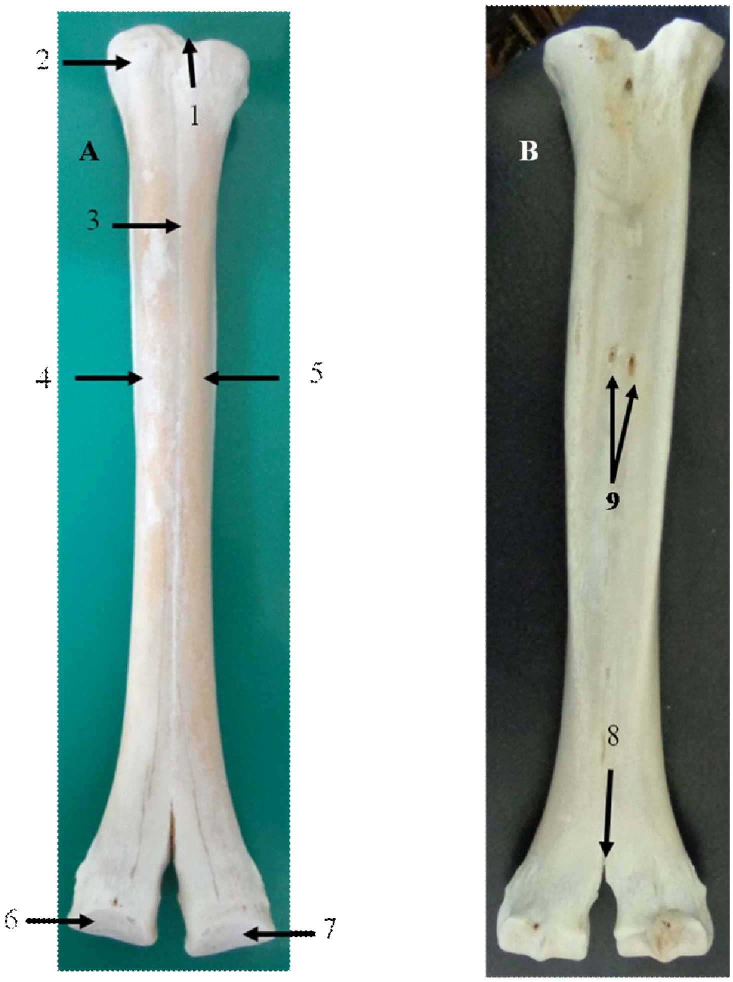

Figure (1) (A) Dorsal and (B) Palmar views of the Left Metacarpal Bone, 1-Articular surface, 2-Tuberosity of the 3rd Mc., 3-Dorsal longitudinal sulcus, 4-Metacarpal bone (III), 5- Metacarpal bone (IV), 6-Distal articular surface of 3rd Mc., 7- Distal articular surface of 4th Mc. 8-intertrochlear incisure. 9-Nutrient foramen.

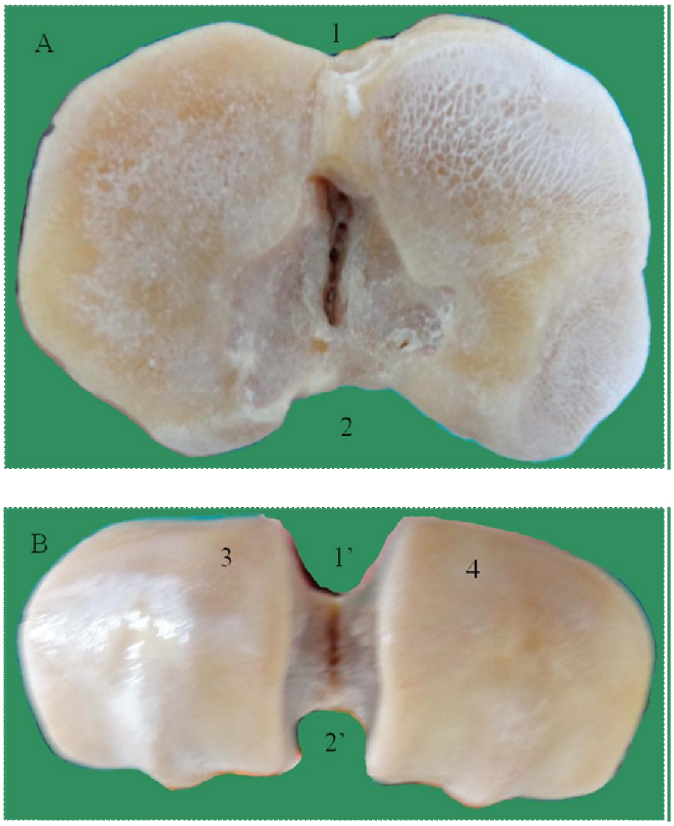

Figure (2) (A) Proximal and (B) Distal articular surfaces of the left metacarpal bone,
1 and 1'- Dorsal aspect, 2 and 2'- Palmar aspect, 3-Medial trochlea, 4-Lateral trochlea.

Figure (3) (A) Dorsal and (B) Plantar views of the Left Metatarsal Bone, 1-Tarsal articular face, 2- Dorsal longitudinal sulcus, 3- intertrochlear incisures, 4- Distal articular surface of 3rd Mt., 5- Distal articular surface of 4th Mt., 6- Proximal Mt. canal, 7-Nutrient foramen.

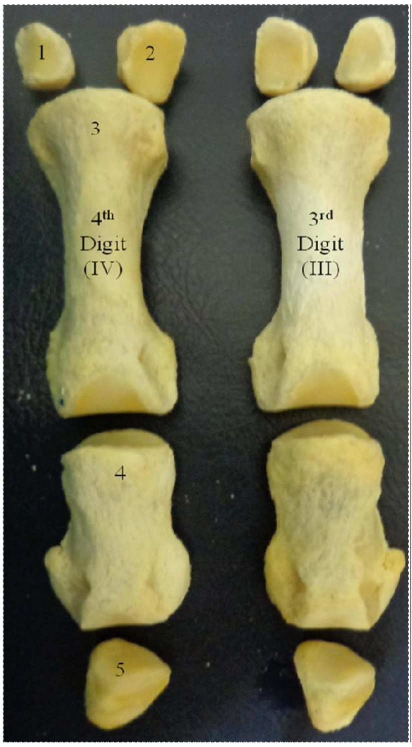

Figure (5) Digital bones of the right forelimb, dorsal view, 1- Abaxial proximal sesamoid bones, 2- Axial proximal sesamoid bones, 3- Proximal Phalanx (PI), 4-Middle Phalanx (PII), 5-Distal Phalanx (PIII).

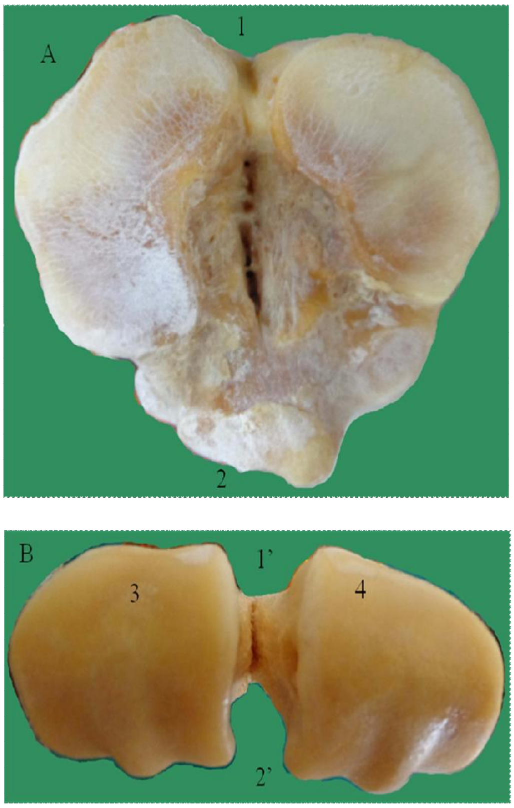

Figure (4) (A) Proximal and (B) Distal articular surfaces of the left metatarsal bone, 1 and 1'- Dorsal aspect, 2 and 2'- Palmar aspect, 3-Medial trochlea, 4-Lateral trochlea.

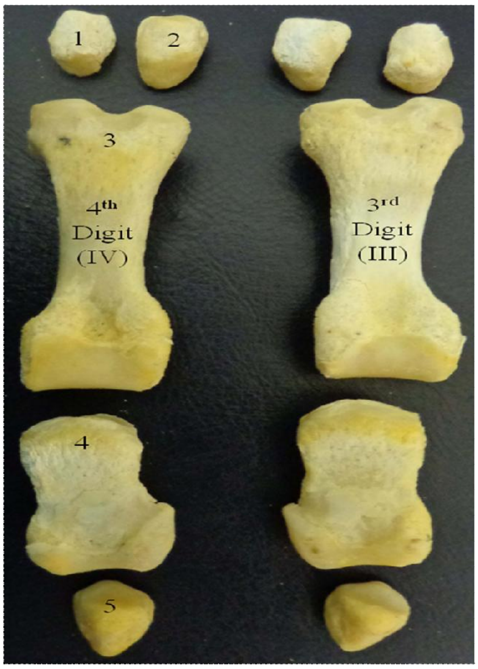

Figure (6) Digital bones of the right forelimb, palmar view, 1- Abaxial proximal sesamoid bones, 2- Axial proximal sesamoid bones, 3- Proximal Phalanx (PI), 4-Middle Phalanx (PII), 5-Distal Phalanx (PIII).

دراســة تــشــريــحــيــة لــعــظــام في قــدم الــجــمــال

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الــخــلاصــة

أجريت هذه الدراسة على الجمال وحيدة السنام لدراسة التشريح العياني لعظام الأطراف الأمامية و الخلفية للمنطقة من تحت مفصل الرسغ إلى الخف و بواقع ستة أزوج من الأقدام الأمامية و الخلفية. يقع الجمل تحت تأثير عاملين تكيفين متعاكسين أولهما أن ساق الجمل يجب أن تكون طويلة و نحيفة لتبعد الجمل عن حر البيئة الصحراوية و ثانيهما أن ساق الجمل يجب ان تكون قوية بما فيها الكفاية لتحمل جسم الجمل الثقيل و لتمنع انغرازه في رمال الصحراء ، لهذين العاملين فأن ساق الجمل جمعت هاتين الصفتين الطول و النحافة و بنفس الوقت القوة من خلال أظهار عدة تكيفات تركيبية مثل غزارة الشحوم داخل الخف و التجهيز الدموي العالي من خلال وجود تفرعات شريانية عديدة، طول عظام المشط و الموضع الأفقي لعظام السلاميات.

أظهرت نتائج تشريح العظام بأن العظم المشطي الكبير يتميز باندماج العظميين المشطين الثالث و الرابع على طول العظم ما عدا الجهة القاصية التي يحدث بها انفراج العظميين عن بعضهما بشكل اكبر مقارنة بباقي الحيوانات لغرض توزيع وزن الجمل على مساحة اكبر و يتشابه عظم مشط القائمة الخلفية مع الأمامية باستثناء كونه اصغر حجما و يكون جسمه أكثر اسطوانياً، تكون عظام السلاميات في الجمل أطول مقارنة بباقي الحيوانات، تتميز عظام السلاميات بكون أن السلامية الدانية في الجمل أطول مقارنةً بالمجترات و يصل طول السلامية الوسطى تقريباً إلى نصف طول السلامية الدانية أما السلامية القاصية فتكون اصغر السلاميات الثلاث و يكون شكلها وتدي، يختلف عدد العظام السمسمانية في الجمال عن الحيوانات الاخرى وذلك لعدم وجود العظام السمسمانية القاصية كي تتيح حرية أكثر لحركة القدم.

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