

**MORPHOLOGICAL STUDIES ON THE  
SESAMOIDEAN LIGAMENTS OF THE MANUS  
AND PES IN DONKEY**  
(With 1 Table and 11 Figures)

By

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دراسات مورفولوجية على الأربطة السمسمانية للقدم الأمامية والخلفية  
في الحمير

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أجريت هذه الدراسة على عدد إثني عشر حميرا بالغاً وذلك لإستيضاح الخصائص التشريحية للأربطة السمسمانية في كل من القدم الأمامية والخلفية في الحمير. كما تم أخذ عدد من القياسات لهذه الأربطة. كذلك تم أخذ عينات للفحص الميكروسكوبي من الرباط السمساني العلوي. يتميز الرباط السمساني العلوي في القدم الأمامية بعرضه القليل في المنتصف مقارنة بنهايتيه العلوية والسفلية على أن نفس الرباط في القدم الخلفية يتميز بأنه حبل الشكل علوياً وعريض سفلياً. كما أن هذا الرباط وفرعه الباسط لهذا الرباط فإنه ذا عرض قليل في الوسط مقارنة بالقدم الخلفية. أما بالنسبة للفرع الباسط عند الثلث الأوسط والسفلي للسلامية العليا في القدم الأمامية والخلفية بالتتابع. هذا وقد أوضحت الدراسة أن شقي الرباط السمساني العلوي وفرعه الباسطين يمكن جسهما من خلال الجلد. أما نسيجياً فقد بينت الدراسة وجود حزم من العضلات الهيكلية في نسيج الرباط السمساني العلوي وكانت هذه العضلات تمثل نسبة عالية في الجزء العلوي منه والتي تتناقص تدريجياً كلما إتجهنا إلى أسفل. أما فيما يتعلق بالرباط السمساني السفلي والذي ينقسم إلى ثلاث أجزاء، مستقيم ومائل وتصابلي فإن الجزء المستقيم منه ينتهي في الغضروف المكمل للسلامية الوسطى إضافة إلى وتر العضلة القابضة السطحية. هذا وتم ملاحظة أن الجزء المائل من هذا الرباط ينقسم هو الآخر إلى ثلاث أجزاء.

## SUMMARY

The present investigation was performed on 12 donkeys to study the morphological features of the sesamoidean ligaments of the manus and pes. Certain measurements of these were taken. The proximal sesamoidean ligament of the manus is narrower at its middle than at both ends, while that of the pes is rounded proximally and flattened distally. It terminates mainly in the proximal sesamoid bones and the palmar/plantar ligament. It is related dorsally to the pouch of the fetlock joint. The extensor branches join the extensor tendon at the middle and distal third of the proximal phalanx in the manus and pes respectively. Light microscopically, the proximal sesamoidean ligament displays the presence of skeletal muscle bundles in the form of one or two longitudinal bands, that fade out distally. The volume percentage of these skeletal muscle bundles demonstrates decreasing values distalwards, from 7.35 % to 1.24 in the manus and from 8.06% to 2.54% in the pes. The straight sesamoidean ligament attaches distally to the complementary cartilage of the middle phalanx and to the superficial flexor tendon. It is related dorsally to the pouch of the pastern joint. The oblique sesamoidean ligament consists of three parts filling the space between the central two ligaments of the palmar/plantar ligaments of the pastern joint. The morphometrical study reveals that the proximal sesamoidean ligament and its extensor branches of the manus are shorter and thinner than those of the pes. Contrarily the straight and oblique sesamoidean ligaments are longer and thicker in the manus than in the pes. The two limbs of the proximal sesamoidean ligament and its extensor branches are palpable through the skin which is of great importance as landmark to deal clinically with that part of the limbs of the donkey.

*Key words: Sesamoidean ligaments of manus and pes in donkey.*

## INTRODUCTION

It is well known that donkeys are working animals which belong to the equine species. Although the sesamoidean ligaments are extensively studied in many domestic species such as horse (Skerritt and McLelland, 1984), cattle (Dyce *et al.*, 1996), buffalo (Ibrahim, 1970) and camel (Smuts & Bezuidenhout, 1987 and Ereisha, 1982), information

about these ligaments in the donkey are meagre. The aim of this study is to throw light on the sesamoidean ligaments of the manus and pes in the donkey regarding their position, relations, proximal and distal attachments as well as some morphometrical aspects. In addition, light microscopy of the proximal sesamoidean ligament is considered.

### **MATERIAL and METHODS**

The present work was done on 12 adult and apparently healthy donkeys from both sexes. The animals were anaesthetized by chloroform and bled through the common carotid artery. For gross anatomical study, the manus and pes regions were taken and examined grossly in fresh state. Some measurements such as length, width and thickness of the sesamoidean ligaments were measured.

For light microscopy, samples from the proximal sesamoidean ligament were taken from three different levels; the proximal end, middle and directly before bifurcation. The samples were fixed in neutral buffer formalin solution, post-washed in running water and dehydrated in ascending grades of ethanol, cleared in methyl benzoate and embedded in paraffin wax. 5  $\mu$ m thick sections were taken and stained with H & E and Grossman's trichrome (Grossman, 1937), then examined and photographed using light microscope. The volume percentage of the skeletal muscle bundles in the whole cross sectional area of the proximal sesamoidean ligament was determined using an image analysis system (Leica Q500).

### **RESULTS**

#### ***Lig. sesamoideum proximale:***

The proximal sesamoidean ligament or the middle interosseous muscle lies in the palmar aspect of the large metacarpal bone occupying the entire width of the metacarpal groove (Fig. 1). It attaches proximally to the palmar aspect of the distal row of the carpal and that of the proximal extremity as well as the adjacent area of the body of the large metacarpal bone. This ligament is related palmarly to the inferior check ligament and the deep digital flexor tendon.

About 27.5 mm above the proximal sesamoid bones and nearly at the distal fourth of the metacarpus, the proximal sesamoidean ligament

bifurcates into medial and lateral limbs (Fig. 1). Distal to the bifurcation, the limbs can be palpated through the skin. Each limb passes distally and outwards to attach to the abaxial surface of the corresponding sesamoid bone and to the palmar ligament. The two limbs are related dorsally to the palmar pouch of the fetlock joint and palmarly to the digital tendon sheath. In addition, each limb gives off an extensor branch which extends obliquely distodorsally lateral to the collateral sesamoidean ligament crossing the fetlock joint and the respective border of the proximal phalanx to gain its dorsal surface. It then joins the common digital extensor tendon at the middle of the proximal phalanx (Fig. 2). Clinically, this extensor branch is palpable due to its subcutaneous location.

Concerning the proximal sesamoidean ligament of the pes, it is similar to that of the manus with some differences (Fig. 1). It arises from the plantar aspect of the fused first and second as well as the fourth tarsal bones in addition to the metatarsal attachment. It bifurcates about 32.3 mm above the sesamoid bones nearly at the distal fifth of the metatarsus. The extensor branch joins the long extensor tendon at the distal third of the proximal phalanx.

Morphometrically (Table 1 and Fig. 11), the proximal sesamoidean ligament of the manus is shorter, wider and thinner than that of the pes. This ligament in the manus is narrow in the middle (13.2mm) and increases in width proximally and distalwards. In the pes, the width of the ligament in the proximal and middle thirds is nearly equal, but widens distalwards. The thickness of the ligament of the manus is nearly the same along its length, while it decreases distalwards in the pes. The extensor branch in the manus is shorter, wider and thinner than that in the pes. In both manus and pes, it is narrow in the middle and wide at both ends. The thickness of the extensor branch decreases distalwards.

Light microscopically (Figs. 7-10), the proximal sesamoidean ligament consists mainly of longitudinal bundles of collagenous bundles together with one or two longitudinal bands of skeletal muscle bundles. These skeletal muscle bundles concentrate in the proximal part of the ligament and demonstrate decreasing volume percentages distalwards, from 7.35 % to 1.24 in the manus and from 8.06% to 2.54% in the pes.

***Lig. Palmare or plantare:***

The palmar or plantar ligament is a thick fibrocartilaginous structure. It fills the space between the proximal sesamoid bones (Figs.

1, 3-6). With the articular surfaces of the previous bones the ligament forms the palmar /plantar boundary of the fetlock joint. The ligament covers the palmar/plantar aspect of the sesamoid bones forming a concave smooth surface which lodges the flexor tendons. The ligament also shares in the dorsal boundary of the digital tendon sheath. Laterally, the ligament connects with the proximal and collateral sesamoidean ligaments.

The palmar/plantar ligament extends above the level of the proximal sesamoid bones by 12.7mm in the manus and 11.4mm in the pes. This ligament is wider at the middle than at both ends. Moreover its distal end is wider than the proximal end. In the manus, the ligament is longer but narrower than in the pes (Table 1).

***Ligg. Sesamoidea collateralia:***

The collateral sesamoidean ligaments are relatively short and somewhat wide bands (Fig. 2). Each ligament attaches to the abaxial surface of the respective sesamoid bone and the palmar/plantar ligament. It passes dorsally for about 5mm where it gives a weak dorsodistally directed branch which terminates in an eminence on the side of the base of the proximal phalanx. The parent ligament runs proximodorsally to end in an elevation on the side of the distal extremity of the large metacarpal/metatarsal bone above the area of the attachment of the collateral ligament of the fetlock joint with which it is closely connected. The collateral sesamoidean ligaments are crossed laterally by the extensor branch of the proximal sesamoidean ligament.

***Ligg. Sesamoidea brevia:***

The short sesamoidean ligaments are the shortest of the sesamoidean ligaments. Each ligament extends dorsally and somewhat outwards from the abaxial part of the base of the proximal sesamoid bone to attach in a rough area on the sides of the palmar/plantar aspect of the base of the proximal phalanx just axial to its buttress. This ligament is attached to the joint capsule of the fetlock joint. It is related to the cruciate sesamoidean ligament axially and the collateral sesamoidean ligament abaxially.

***Ligg. Sesamoidea distalia:***

They are three ligaments which are straight, oblique and cruciate ligaments.

**Lig sesamoideum rectum:**

The straight sesamoidean ligament is an elongated flat ligament arising from the palmar/plantar aspect of the base of the proximal sesamoid bones and the distal end of the palmar/plantar ligament. It extends distally between the oblique sesamoidean ligament dorsally and the flexor tendons palmarly/plantarly to terminate in the proximal margin of the complementary cartilage of the middle phalanx (Figs. 1-6). About 12 mm before its termination, the straight sesamoidean ligament descends between the two branches of the superficial digital flexor tendon with which it is attached. Also about 6 mm before its end the ligament is related dorsally to the palmar/plantar pouch of the pastern joint.

The straight sesamoidean ligament (Fig. 11) of the manus (59.4 mm) is longer than that of the pes (56.9 mm). Within the same limb, the width decreases distalwards. The measurements indicate also that the ligament of the manus is wider and thicker than that of the pes (Table 1).

**Table 1: Dimensions (mm) of some sesamoidean ligaments in donkey.**

The ligament	Manus			Pes		
	Length	Width	Thickness	Length	Width	Thickness
Prox. Ses. Lig.	160.2±10.5			217.4±15.5		
At prox. End		17.2±1.2	5.3±0.5		9.9±0.8	9.4±0.7
At middle		13.2±1.1	5.9±0.4		8.8±0.7	7.1±0.5
At bifurcation		18.2±1.6	5.7±0.3		17.6±1.5	6.4±0.4
Extensor branch	51.9±4.6			57.4±4.9		
At prox. End		6.5±0.5	1.8±0.1		5.8±0.5	1.9±0.1
At middle		4.9±0.3	1.2±0.1		4.9±0.4	1.3±0.1
At dist. end		6.1±0.5	0.7±0.06		5.5±0.5	0.8±0.02
Straight ses. lig.	59.4±5.4			56.9±5.2		
At prox. End		16.6±1.5	2.1±0.2		15.8±1.1	2.0±0.2
At middle		10.9±1.1	2.7±0.2		10.2±1.1	2.6±0.2
At dist. end		6.4±0.5	2.4±0.2		5.2±0.4	2.1±0.1
Oblique ses. lig.	37.4±3.1			30.5±2.8		
At prox. End		27.0±1.9	3.0±0.2		26.4±2.1	2.9±0.1
At middle		15.6±1.4	2.5±0.2		15.5±1.3	2.2±0.2
At dist. end		8.9±0.9	1.9±0.1		8.7±0.7	1.3±0.1
Palmar (plantar) lig.	39.3±2.9			33.6±2.8		
At prox. End		14.9±1.2			16.3±1.3	
At middle		21.7±1.9			24.6±1.9	
At dist. end		19.6±1.1			21.3±1.8	

***Lig. Sesamoideum obliquum:***

The oblique sesamoidean ligament is a triangular ligament occupying the triangular area on the palmar/plantar surface of the proximal phalanx. It consists of three parts; one thin axial and two thick abaxial parts which are separated proximally and united distally towards their termination (Figs. 5&6). The axial part arises from the axial parts of the bases of the proximal sesamoid bones, its fibres are straight and related palmarly to the straight sesamoidean ligament. Each abaxial part arises from the abaxial part of the base of the respective sesamoid bone, their fibres are oblique converging to meet the axial part distally. Nearly 7 mm before its distal end the ligament connects with the central pair of the palmar/plantar ligament of the pastern joint.

Morphometrically, the oblique sesamoidean ligament (Fig. 11) of the manus is longer (37.4 mm) than that of the pes (30.5 mm). Moreover the width and thickness at the three different levels of the ligament in the manus are higher than in the pes (Table 1).

***Ligg. Sesamoidea cruciata:***

The cruciate sesamoidean ligaments are short ligaments that are undercovered by the oblique sesamoidean ligament. Each ligament arises from the axial part of the base of the proximal sesamoid medial to the area of attachment of the short sesamoidean ligament. Each extends to the contralateral aspect of the base of the proximal phalanx crossing each other to attach on a depression on the palmar/plantar aspect of the proximal phalanx.

## DISCUSSION

In the examined donkeys as well as in cattle, buffalo, camel and horse (Ereisha, 1982; Nickel *et al.*, 1986 and Ereisha, 1989), there is only one middle interosseous muscle that is named also as suspensory or proximal sesamoidean ligament. The latter ligament, in the manus of the donkey, attaches proximally to the palmar aspect of the distal row of the carpal bones and that of the proximal extremity as well as the adjacent area of the large metacarpal bone. Similar results were mentioned by Sisson (1975) in the horse. Contrarily and in the latter animal, this ligament was recorded to arise from the proximal end of the large metacarpus (Delahunta and Habel, 1986) or from the radiate ligament of the carpus, but also in part from the proximal part of the Mc III (Nickel

*et al.*, 1986). Shively (1984) mentioned that in domestic mammals, the interossei originate near the proximal end of the metacarpal bones.

In the pes, the proximal sesamoidean ligament of the donkey arises from the plantar aspect of the distal row of the tarsal bones, except the third, as well as that of the proximal extremity and adjacent area of the body of the large metatarsal bone. In the same connection, Frandson (1986) did not exclude the third tarsal bone from the connection in the horse.

The proximal sesamoidean ligament of the donkey bifurcates at the distal fourth of the metacarpus in the manus and at the distal fifth of the metatarsus in the pes. This agrees with the statement of Sisson (1975), but disagrees with that of Nickel *et al.* (1986) that it bifurcates at the distal third of the metacarpus. In addition, the two limbs of the proximal sesamoidean ligament in the present study could be palpated through the skin. The area of its bifurcation is of clinical importance, because it is one of the most common sites of sprain as stated by Skerritt and Mclelland (1984).

The present investigation reveals that the extensor branch of the proximal sesamoidean ligament joins the extensor tendon at the middle of the proximal phalanx in the manus and at its distal third in the pes. In horse and according to Smallwood (1992) and Dyce *et al.* (1996), this branch joins the extensor tendon at lower level (at or just below the pastern joint). Additionally, Smallwood (1992) explained that the extensor branches are easily palpable in the alive horses, and by lifting up the opposite limb, they could be seen under more added tension as more weight is transferred to the supporting limb.

In the horse, Sisson (1975) reported that the proximal sesamoidean ligament is in the form of wide thick band mentioning no regional differences. In the donkey and morphometrically, the present study elucidates that the shape of the proximal sesamoidean ligament is formulated according to the shape of the metacarpal/metatarsal groove. In the manus, the ligament is narrower in the middle than at both ends, but in the pes it widens distalwards. On the other hand, in the manus, the ligament is thin with nearly similar thickness along its length, while in the pes its thickness decreases distalwards. The proximal sesamoidean ligament and its extensor branch are shorter and thinner in the manus than in the pes. Contrarily the straight and oblique distal sesamoidean ligaments are longer and thicker in the manus than in the pes.



The present study proves the presence of some skeletal muscle bundles amongst the proximal sesamoidean ligament in both manus and pes. These bundles, which represent a rather significant values proximally (7-8%), fade out distally to constitute minimal percentages distally (1-2%). In general, the skeletal muscle bundles constitute a lower value in the manus than in the pes. In this respect, Nickel *et al* (1986) reported that isolated skeletal muscle fibres are found only in the foal, these are transformed very largely into strong tendinous bands (Sisson, 1975). On the other hand Dyce *et al.* (1996) mentioned that the interosseous muscle in the horse is predominantly tendinous and there seem a little evidence for the common belief that the muscle fibres are gradually replaced by tendinous tissue as the animal becomes older and heavier.

In the investigated donkeys, the palmar/plantar ligament, which is called intersesamoidean ligament (Lesbre, 1903; Morcos, 1955; Ibrahim, 1970 and Frandson, 1986) is a thick fibrocartilagenous structure filling the space between the two proximal sesamoid bones and extends above them by 12.7 mm in the manus and 11.4 mm in the pes. A similar finding has been reported in the horse by Shively (1984). The present study also reveals that this ligament forms a concave smooth surface lodging the flexor tendons. This surface has a protective function (Nickel *et al.*, 1986) providing a bearing surface for flexor tendons (Shively, 1984). The proximal extension of the palmar ligament supports the flexor tendons when the sesamoids themselves slip below the condyle in maximal overextension of the fetlock joint (Dyce *et al.*, 1996).

The present work agrees with the findings of Sisson (1975) and Skerritt and Mclelland (1984) in horse that the straight sesamoidean ligament arises from the bases of the proximal sesamoid bones and the palmar/plantar ligament. While Shively (1984), Delahunta and Habel (1986) and Nickel *et al.* (1986) stated that this ligament originates in horse only from the proximal sesamoid bones. Moreover, about 12mm before its termination, the straight sesamoidean ligament of the donkey descends between the two terminal branches of the superficial digital flexor tendon with which it is attached in addition to its attachment to the complementary cartilage of the middle phalanx; a result which has not been reported in the horse by the aforementioned authors. This attachment may play a role in limiting the overextension of the pastern joint together with its palmar/plantar ligament.

In the present study, the oblique sesamoidean ligament consists of a thin axial part and two thick abaxial parts, a finding that is more or less similar to the statement of Sisson (1975). On the other hand, Skerritt and Mclelland (1984); Delahunta and Habel (1986) and Nickel et al (1986) described two oblique sesamoidean ligaments in the horse laying on either side of the straight sesamoidean ligament and are partially covered with it. Functionally and according to Skerritt and Mclelland (1984), the distal sesamoidean ligament assists the proximal sesamoidean ligament in supporting the fetlock joint. In particular the oblique sesamoidean ligament assists the superficial flexor tendon in preventing the pastern joint from buckling forwards when the foot hits the ground.

The oblique sesamoidcan ligament of the horse was reported to terminate in the rough triangular area on the palmar/plantar aspect of the proximal phalanx (Sisson, 1975 and Dyce *et al.*1996) or in the rough ridges bordering this triangular area (Shively, 1984; Delahunta and Habel, 1986 and Nickel et al, 1986). While in the donkey, this ligament terminates in both the rough triangular area and the ridges bordering it on the palmar/plantar aspect of the proximal phalanx.

### LEGENDS

**Fig. 1:** A photograph showing the sesamoidean ligaments in both manus (right) and pes (left). PS (proximal sesamoidcan ligament), PL (palmar ligament), DS (distal sesamoidean ligament). Note that the proximal sesamoidean ligament (PS) of the manus is shorter, wider and bifurcates at a lower level than that of the pes.

**Fig. 2:** A photograph showing side view of the sesamoidean ligaments in the manus. PS (proximal sesamoidean ligament), EB (extensor branch), DS (distal sesamoidcan ligament), ET (extensor tendon).

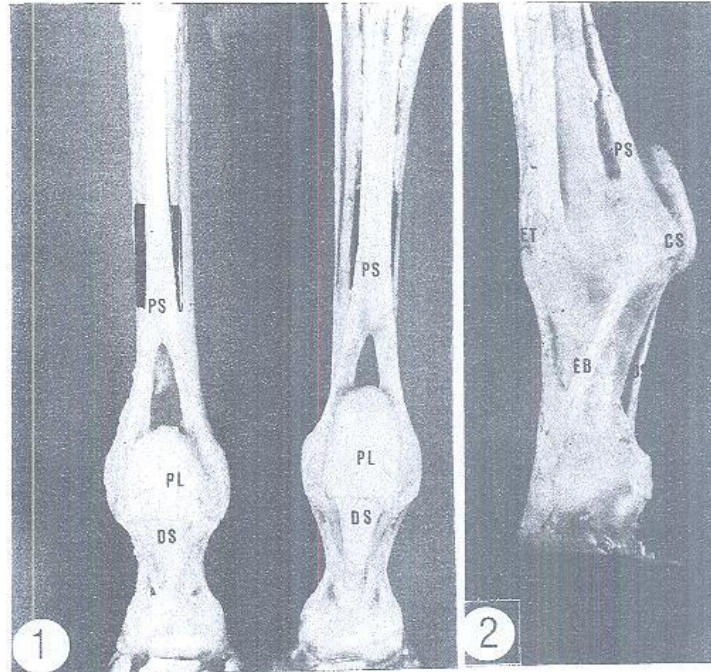
**Figs. 3 & 4:** Photographs showing a higher magnification of the palmar/plantar view of the sesamoidean ligaments of the manus (Fig. 3) and pes (Fig. 4). PS (proximal sesamoidean ligament), PL (palmar ligament), SDS (straight distal sesamoidean ligament) ODS (oblique distal sesamoidean ligament). Note the palmar ligaments of the pastern joint (arrows).

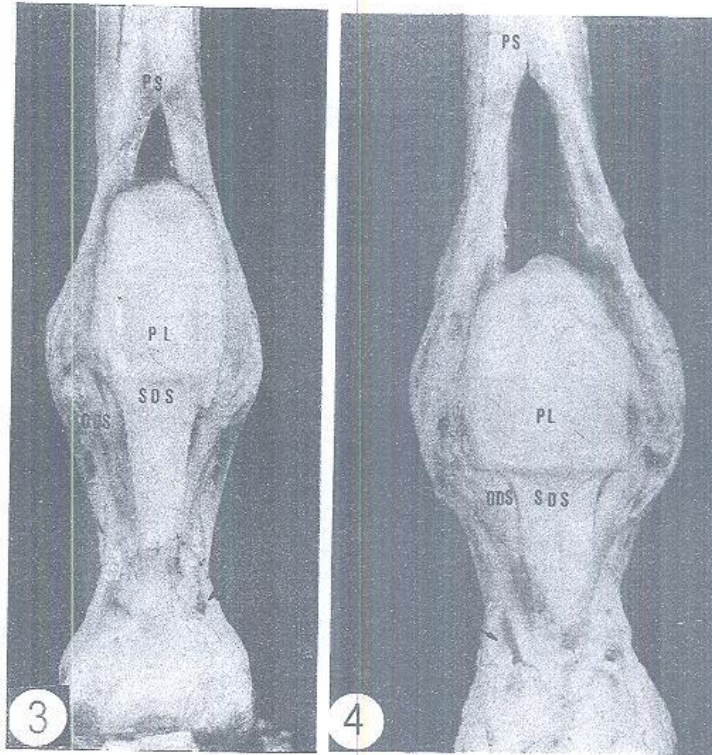
- Figs. 5 & 6:** Photographs showing the oblique sesamoidean ligament of the manus (Fig. 5) and pes (Fig. 6) after removal of the straight distal sesamoidean ligament. Note that the oblique ligament is formed of three parts: one axial part (C) and two thick abaxial parts (P).
- Figs. 7-10:** Trichrome stained paraffin sections from the proximal sesamoidean ligament (middle interosseous muscle) in the manus: proximal part (Fig. 7) and distal part (Fig. 8) as well as in the pes: proximal part (Fig. 9) and distal part (Fig. 10). Note that the skeletal muscles stained red while the collagenous bundles stained green.

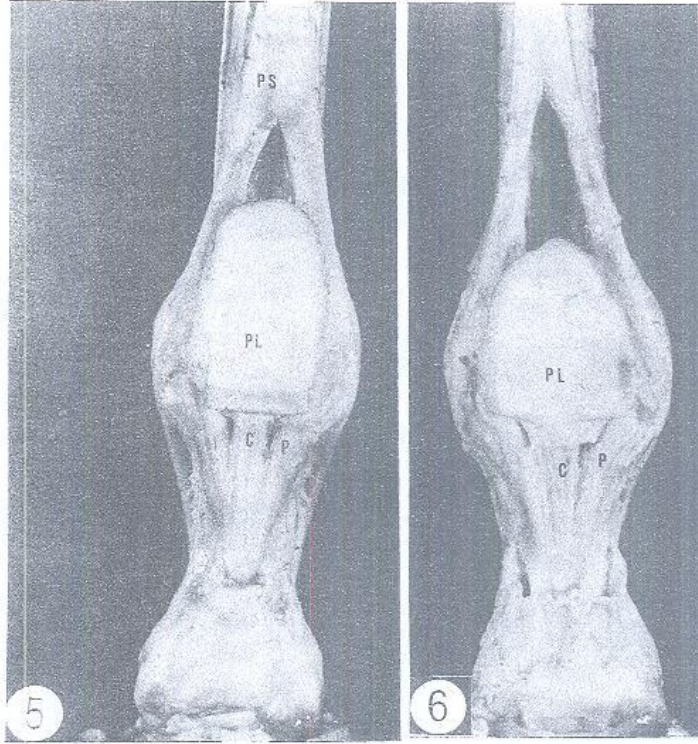
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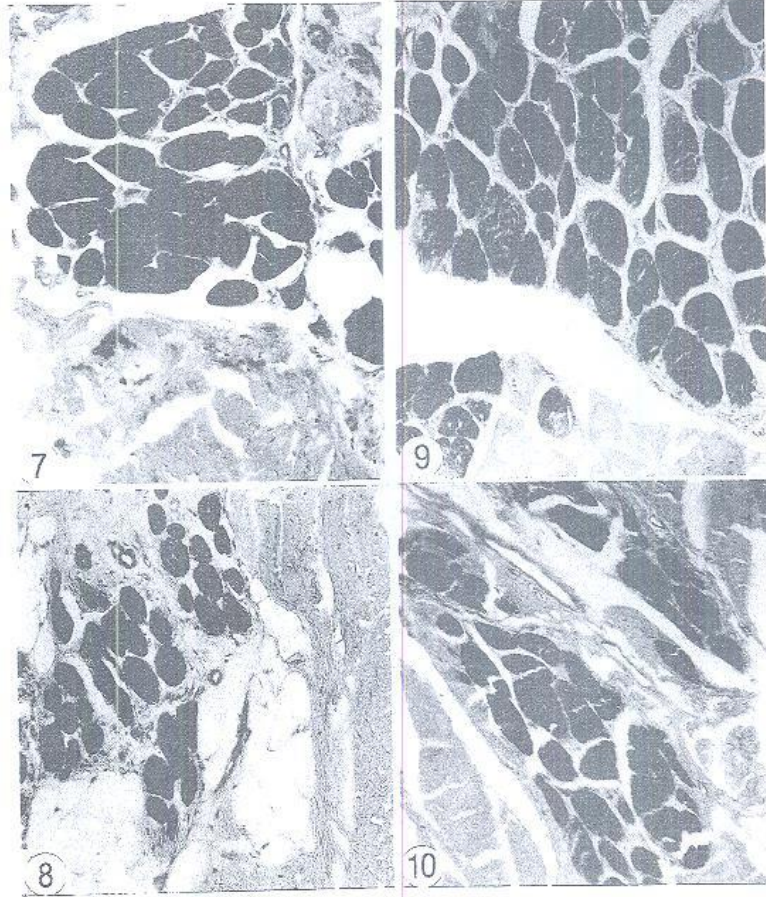




Figure 11: A histogram showing the lengths (in mm) of the proximal sesamoidean ligament (PSI), its extensor branch (EB), straight sesamoidean (SL) and oblique sesamoidean ligament (OL)

