Normal tissue and joint anatomy
US and correlative gross anatomy and histology

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National Institute of Rheumatology and Physiotherapy

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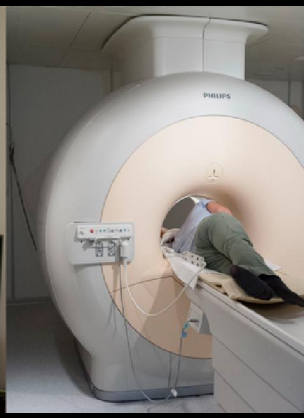
National Institute of Rheumatology and Physiotherapy, Budapest



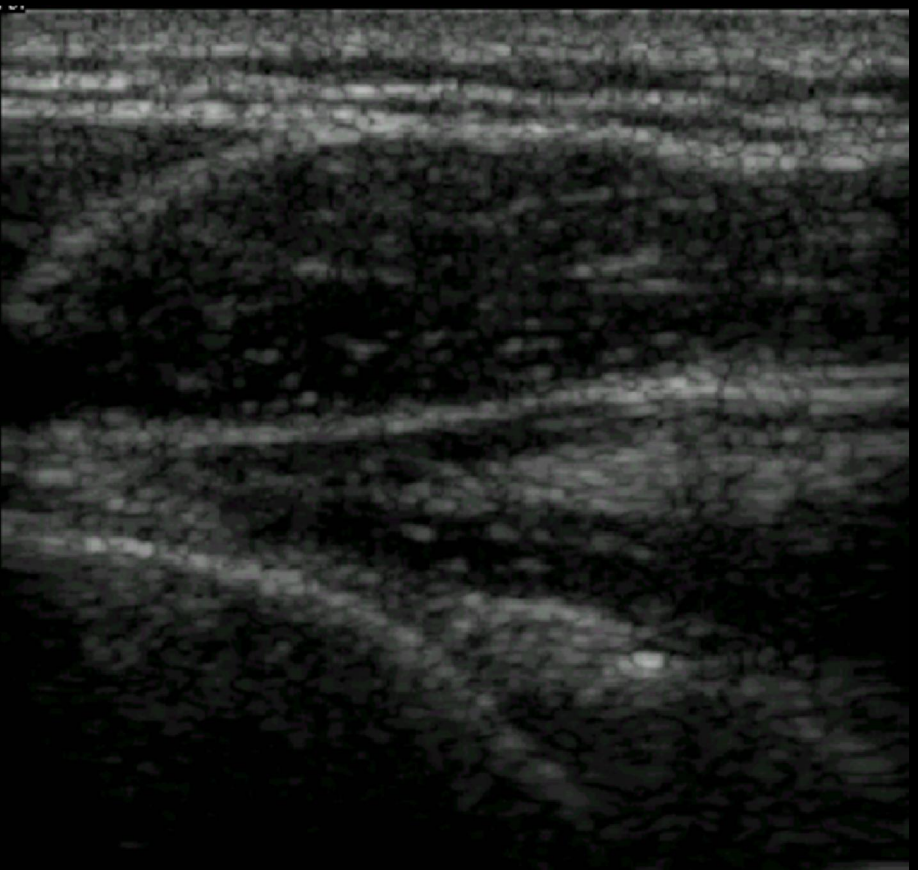
Attila AC 434- 453

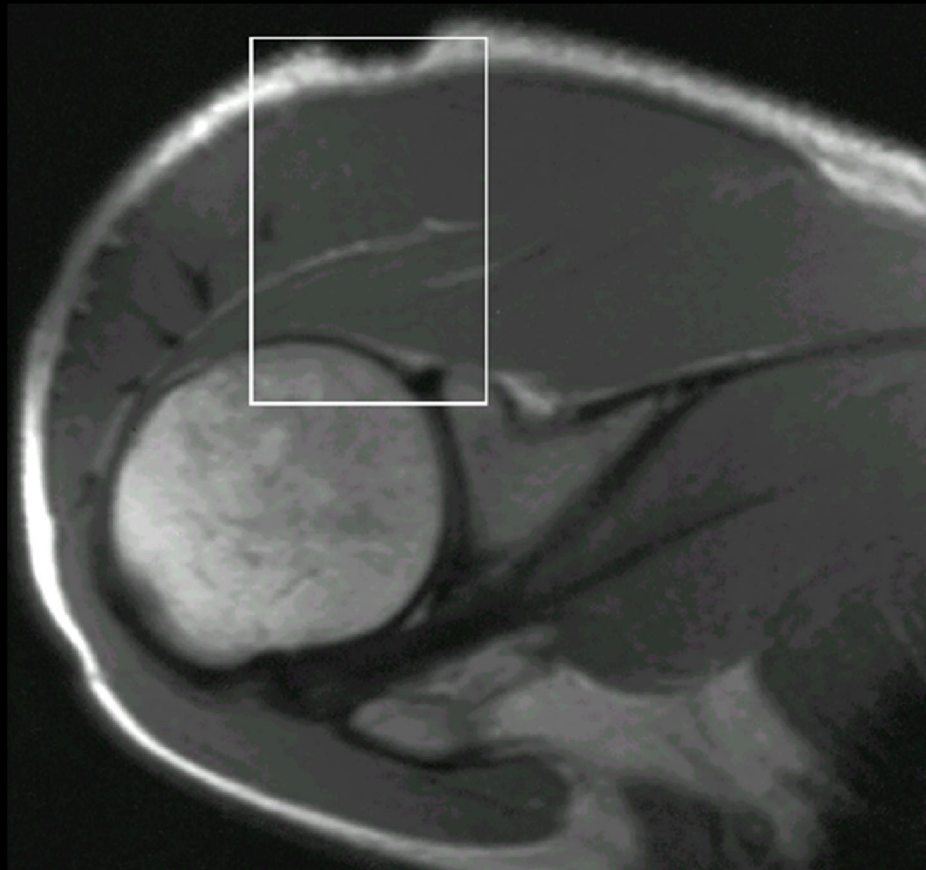
Ancient theatre
AC 2nd Century (Trajan),
Philipopolis

Attila-ChroniconPictum by Anonymus (P. Magister) - Chronicon Pictum, facsimile edition stored at the University of Maryland library.. Licensed under Közkincs via Wikimédia Commons - https://commons.wikimedia.org/wiki/File:Attila-ChroniconPictum.jpg#/media/File:Attila-ChroniconPictum.jpg

Joint structure

US-MR correlation





Understanding morphological and functional anatomy is essential for MSUS

MCPs

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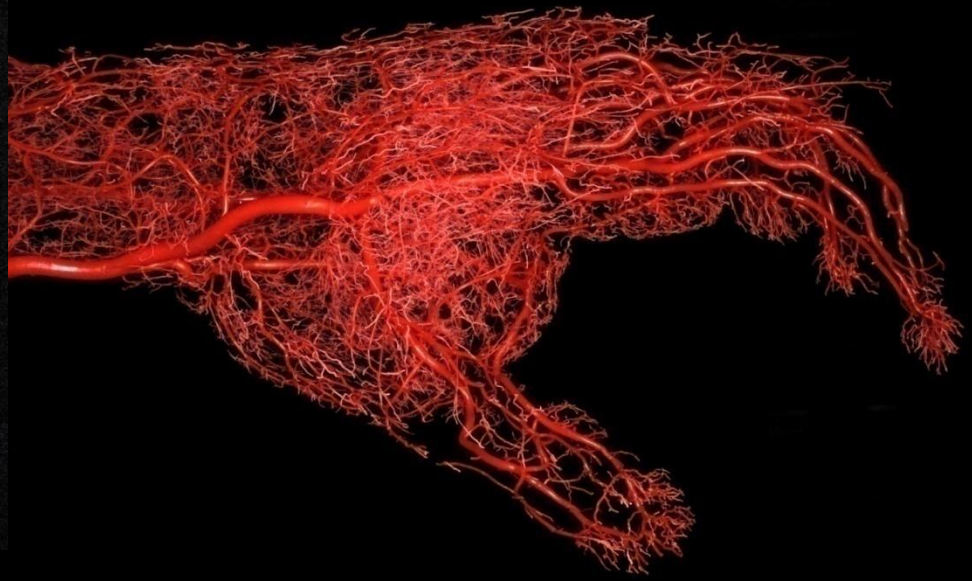
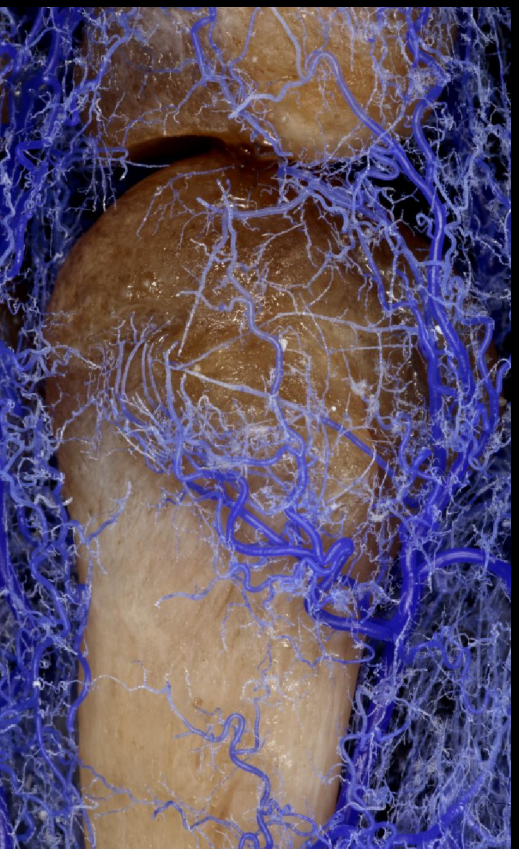


Hand’s vascular tree

Smaller and smaller anatomical details are more relevant for us



DIP

MCP

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Vessels penetrate into capsule and intraarticular space

© Benis S, Patonay L, Balint P

MCP

Dorsal part of metacarpal head

Vessels entry into MCP's head

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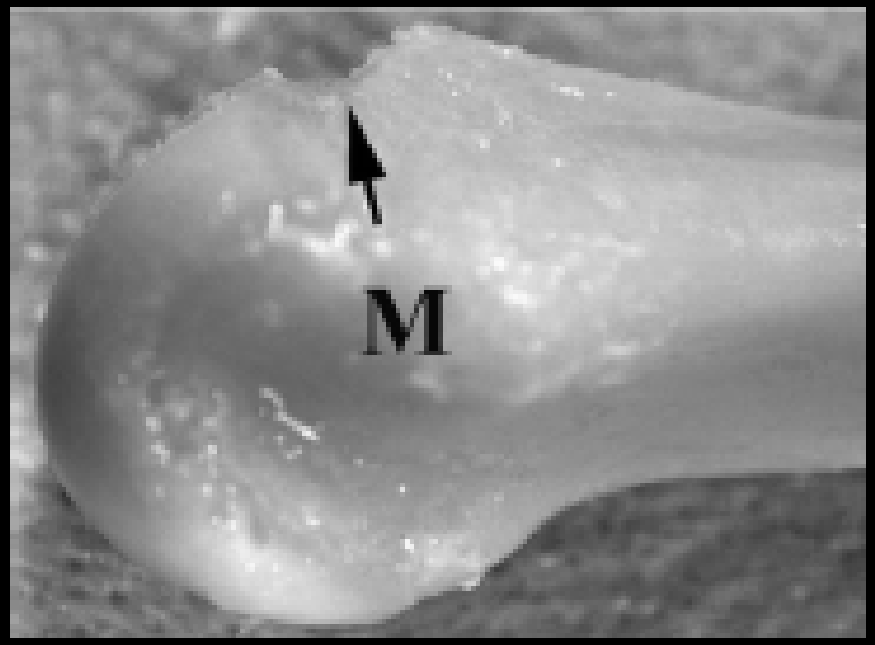
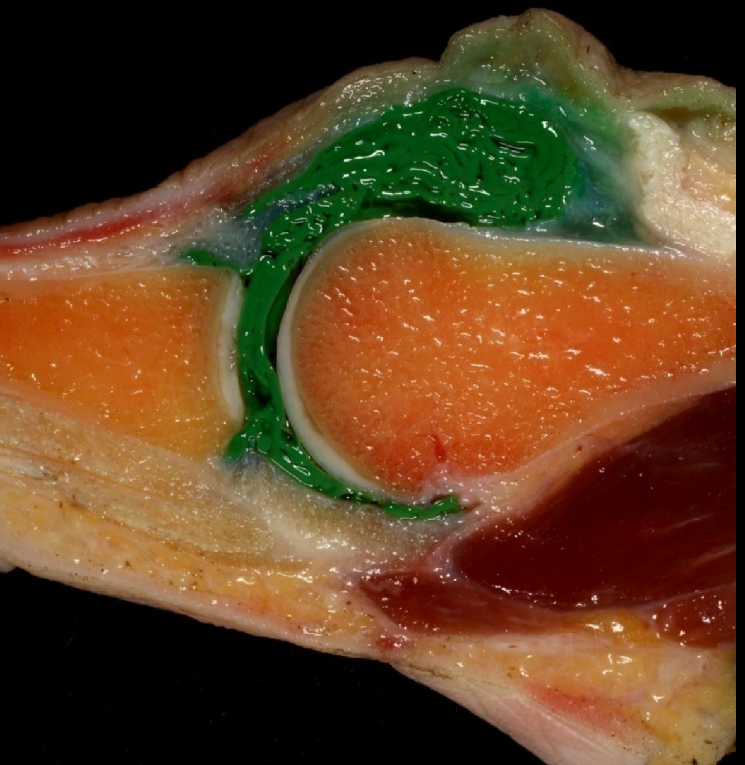
Dorsal depression of metacarpal head
Or anatomical neck

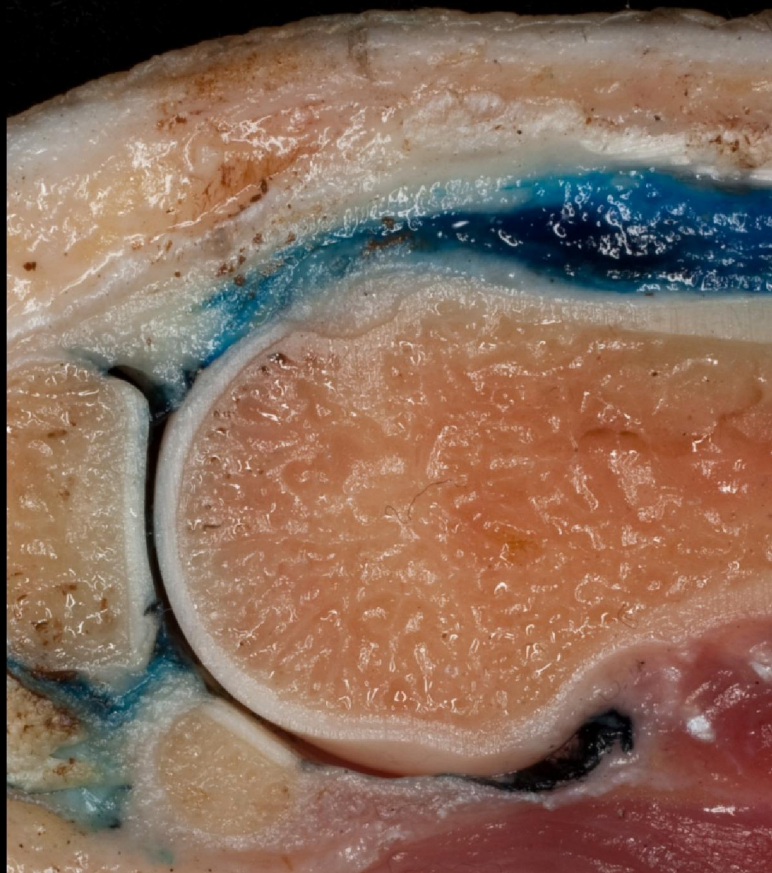


Boutry N et al. Metacarpophalangeal joints at US in asymptomatic volunteers and cadaveric specimens. Radiology, 2004;232:716-24.

MCP recesses

© Baksa G, Keglevich L, Patonay L, Balint P



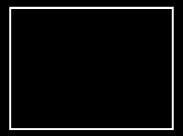


Limitation of US

Normal synovium

ACR slide

TERMINOLOGY - PATTERN RECOGNITION



Anechoic

Absolute term

eg. fluid or
hyaline cartilage

Hypoechoic

Relative term

loose connective tissue
or cells (eg. adipose cells)

Isoechoic

Convention

liver

Hyperechoic

Relative term

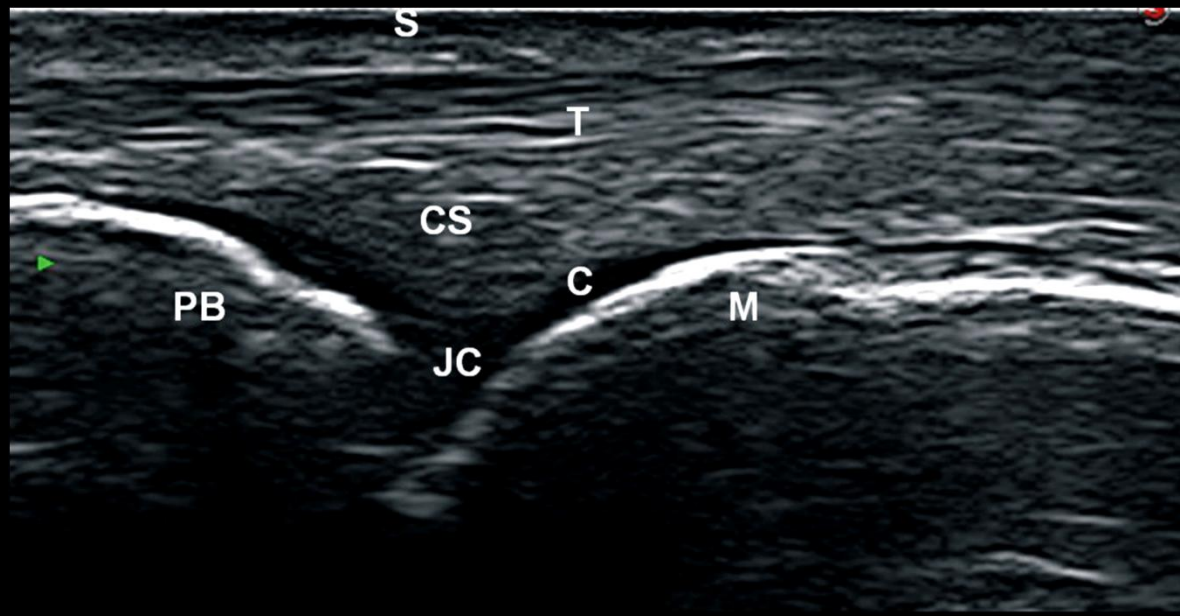
eg. collagen fibers

Echoic

Absolute term

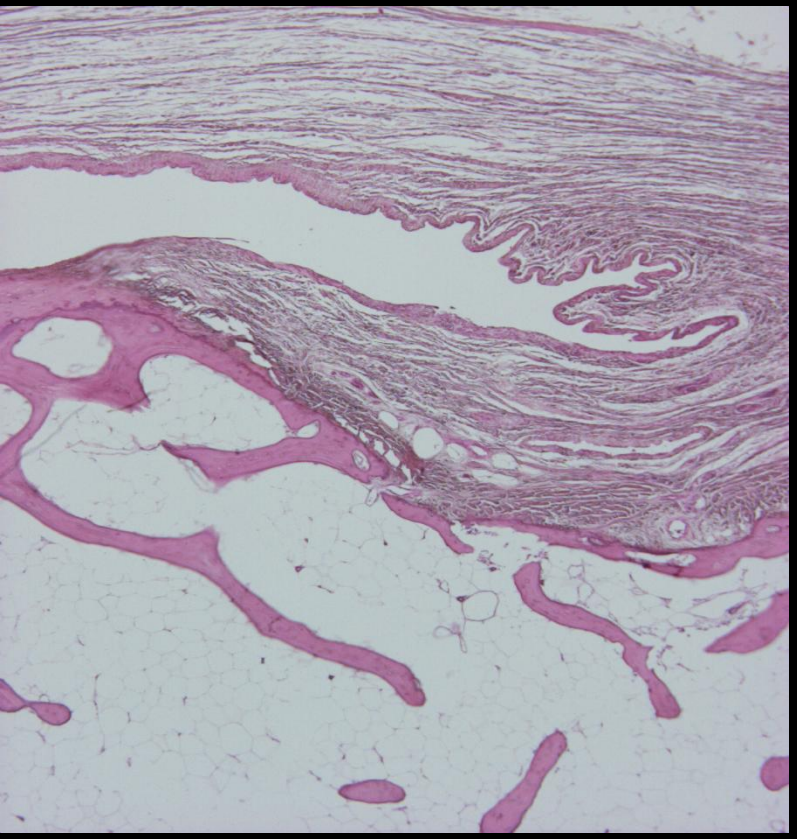
eg. bone

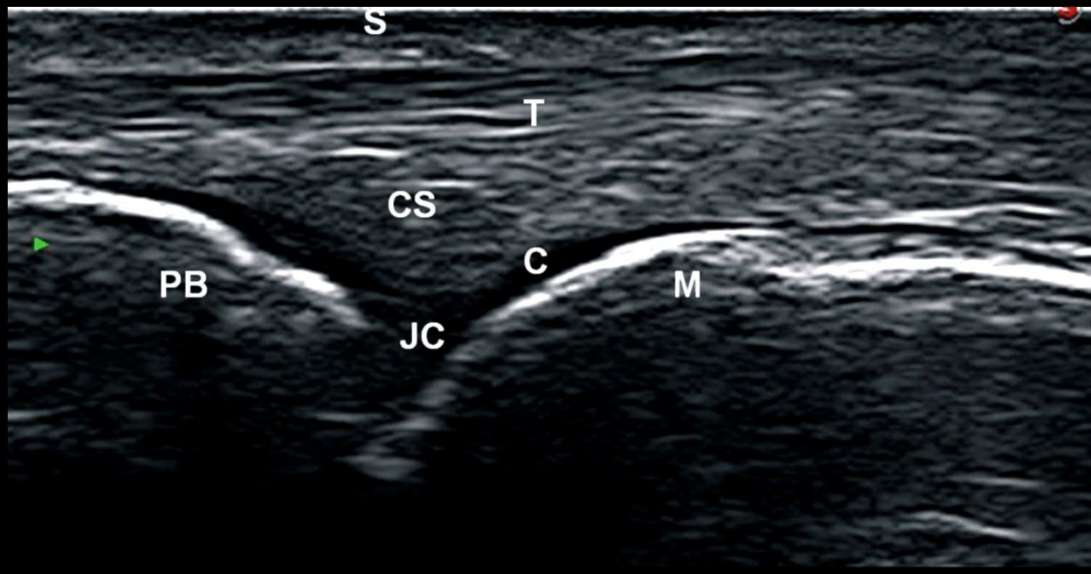
PB: phalangeal base
M: metacarpal head
C: hyaline cartilage
T: extensor tendon
S: skin
CS: dorsal triangle
JC: joint space
arrow: synovial membrane



Mandl P, Benis S, Patonay L, Balint PV. The normal joint . in eds. Maria Antonietta D'Agostino, Richard Wakefield Essential Applications of Ultrasound in Rheumatology. Elsevier .

Dorsal depression, synovial recess





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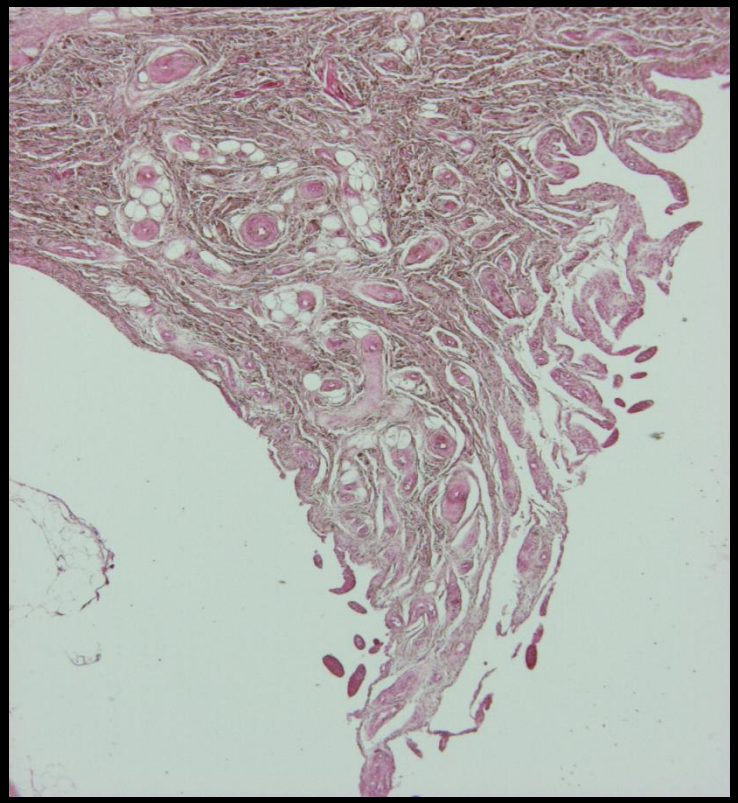
Dorsal triangle



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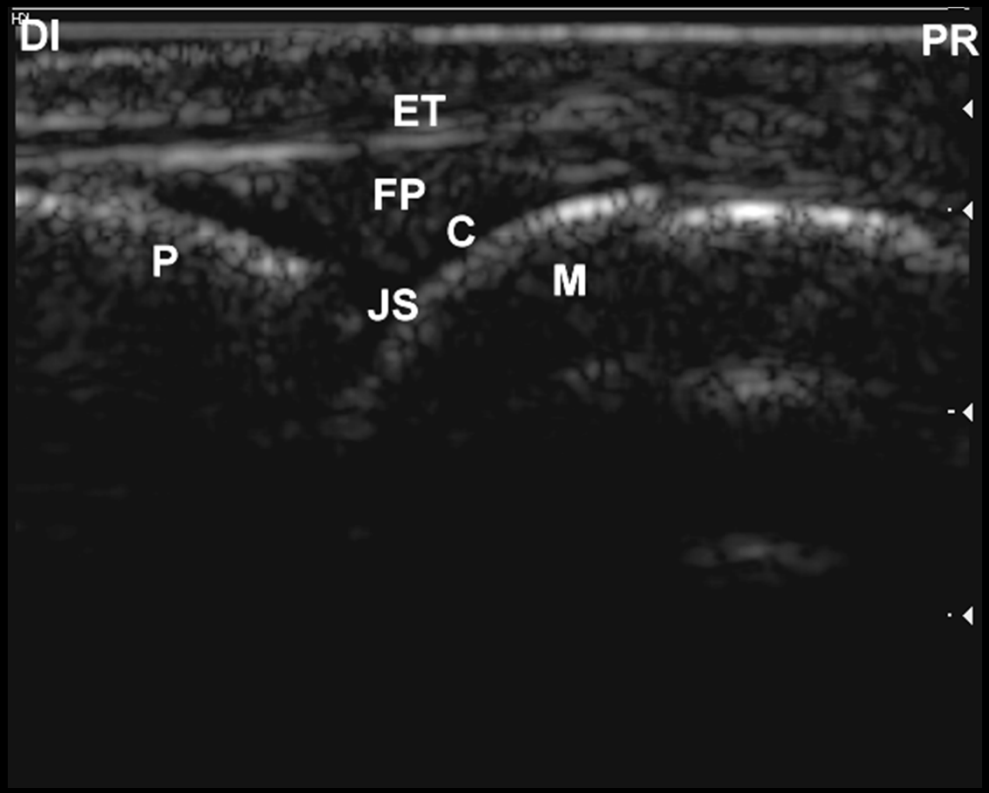
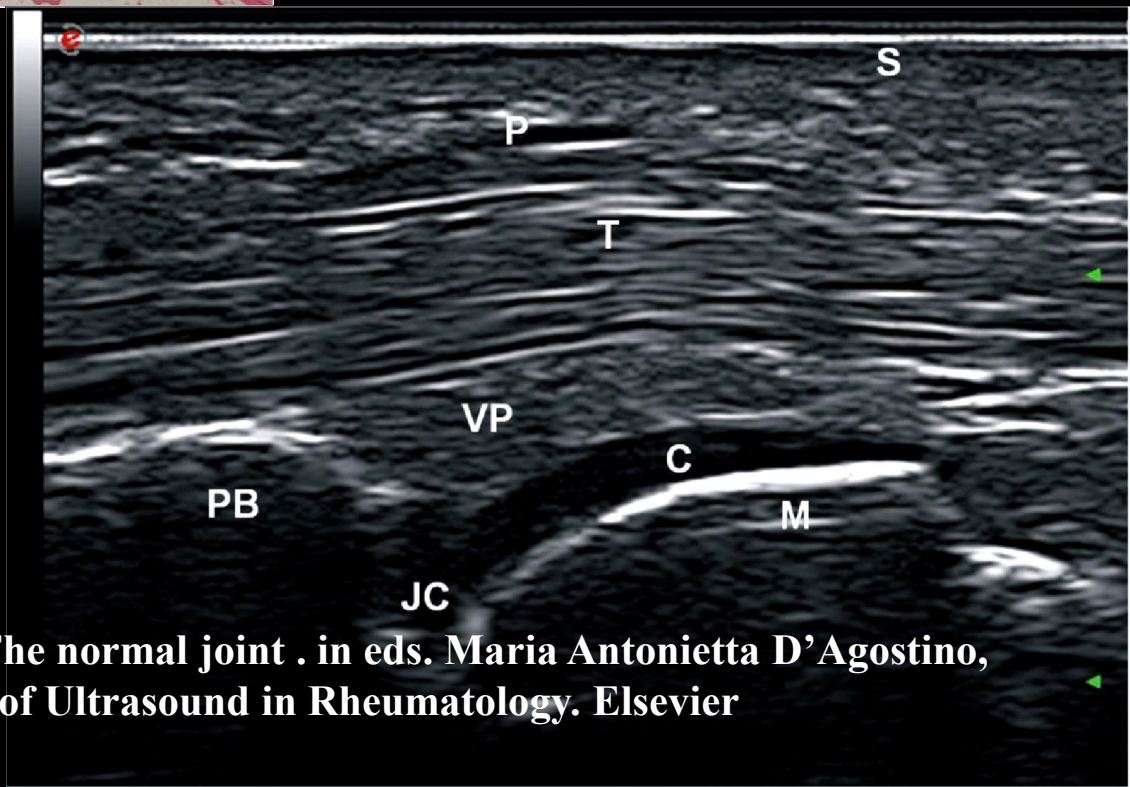


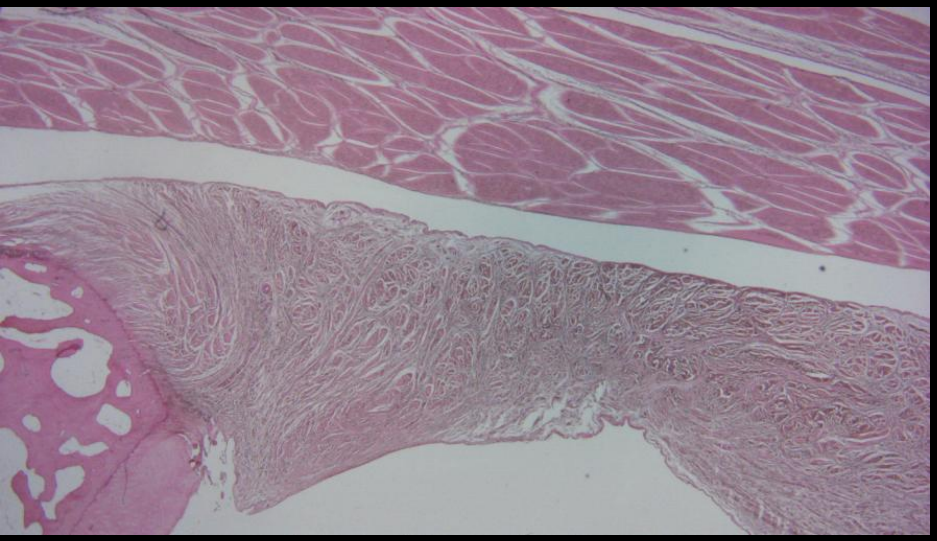
DI: distal, PI: proximal, ET: extensor tendon, FP: dorsal trinagle C= hyaline cartilage, JS: radiological, I.P : phalanx, M: metacarpal head

PB: phalanx
M: metacarpal head
C: hyaline cartilage
T: flexor tendons
P: pulley
S: skin
VP: volar plate
JC: radiolgical joint space
Nyíl: synovial membrane

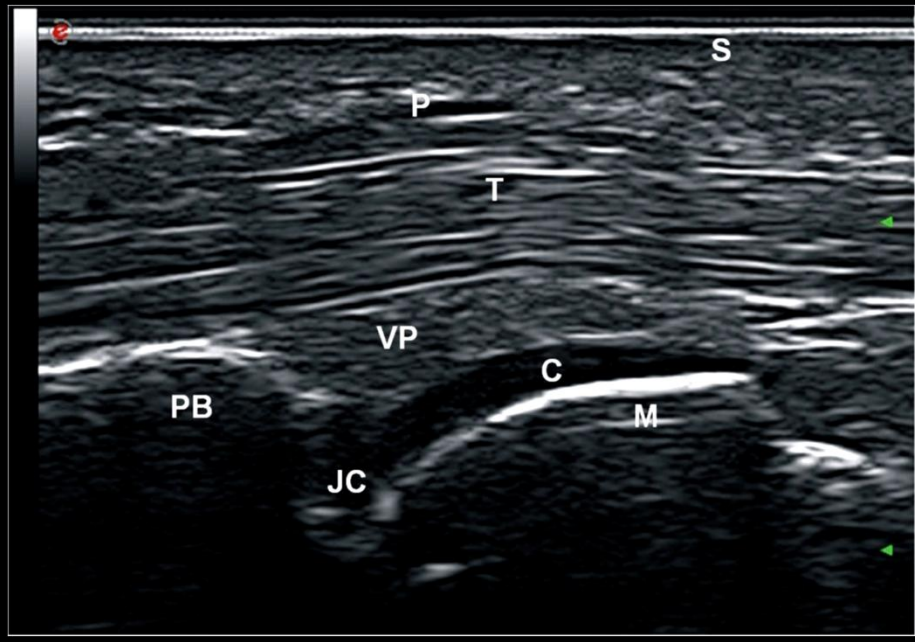


Mandl P, Benis S, Patonay L, Balint PV. The normal joint . in eds. Maria Antonietta D'Agostino, Richard Wakefield Essential Applications of Ultrasound in Rheumatology. Elsevier

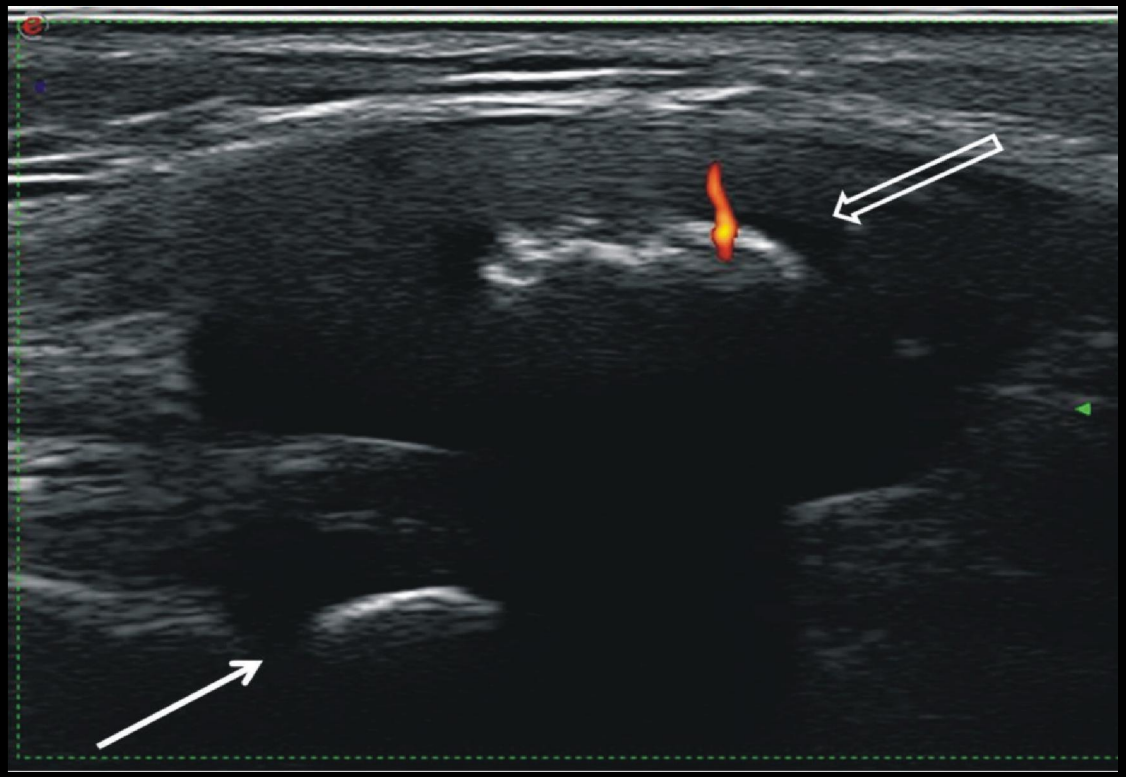
Volar or palmar plate



@ Benis Szabolcs, Patonay Lajos



Ultrasound image of the epiphyseal plate of the distal femur and the ossification center of the patella of a 3-year-old child.

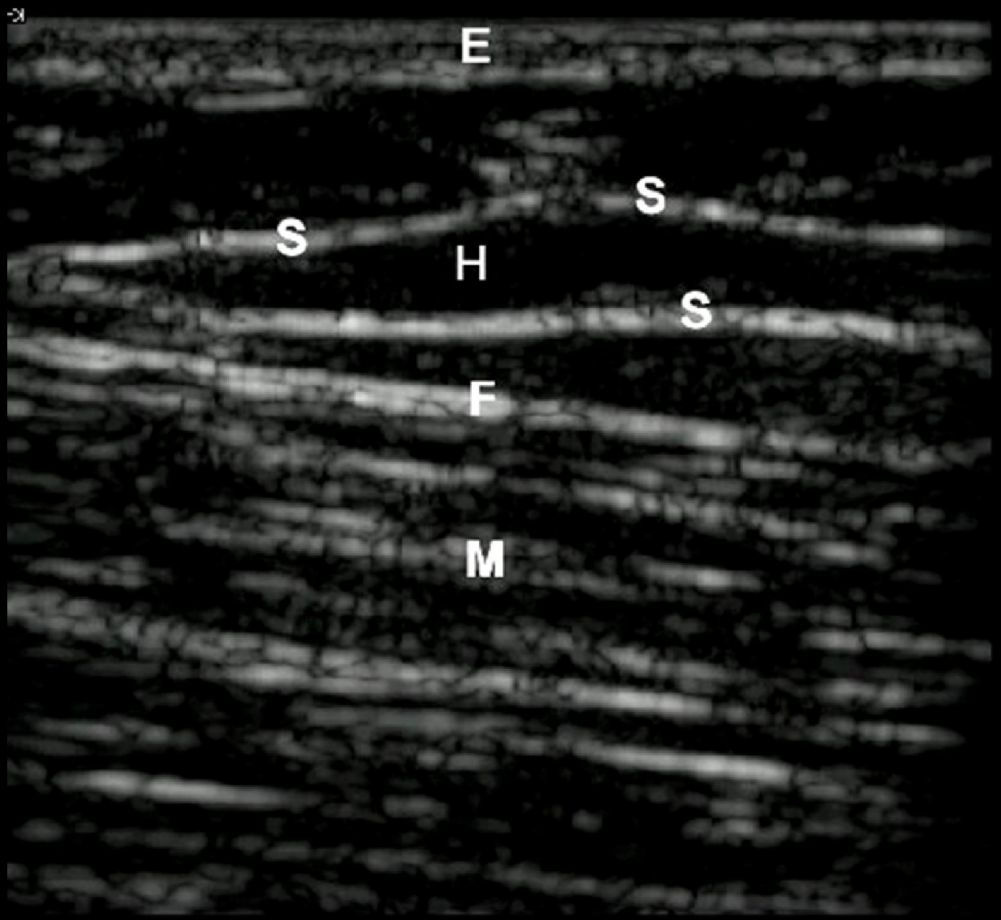


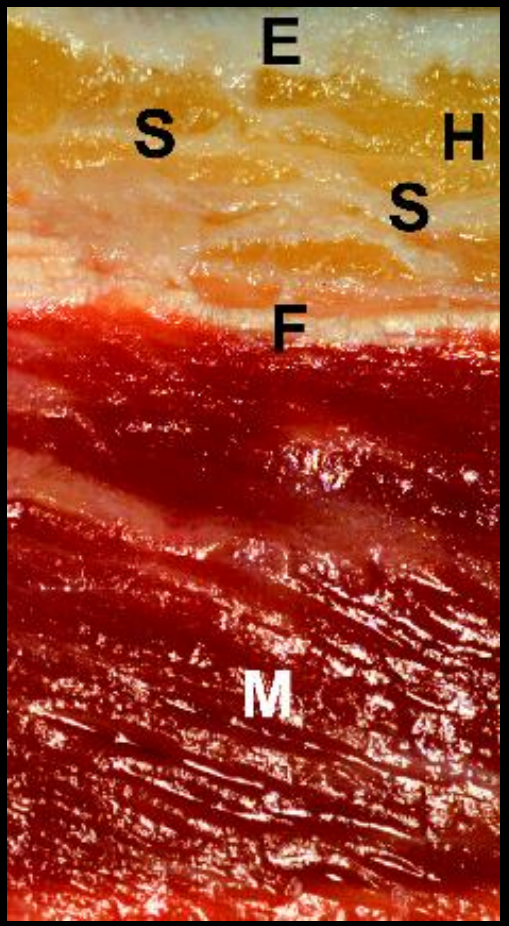
Mandl P[1], Benis S[2], Patonay L[2], Balint PV[1]. The normal joint in eds. Maria Antonietta D'Agostino, Richard Wakefield Essential Applications of Ultrasound in Rheumatology, Elsevier

Normal ultrasound tissue anatomy

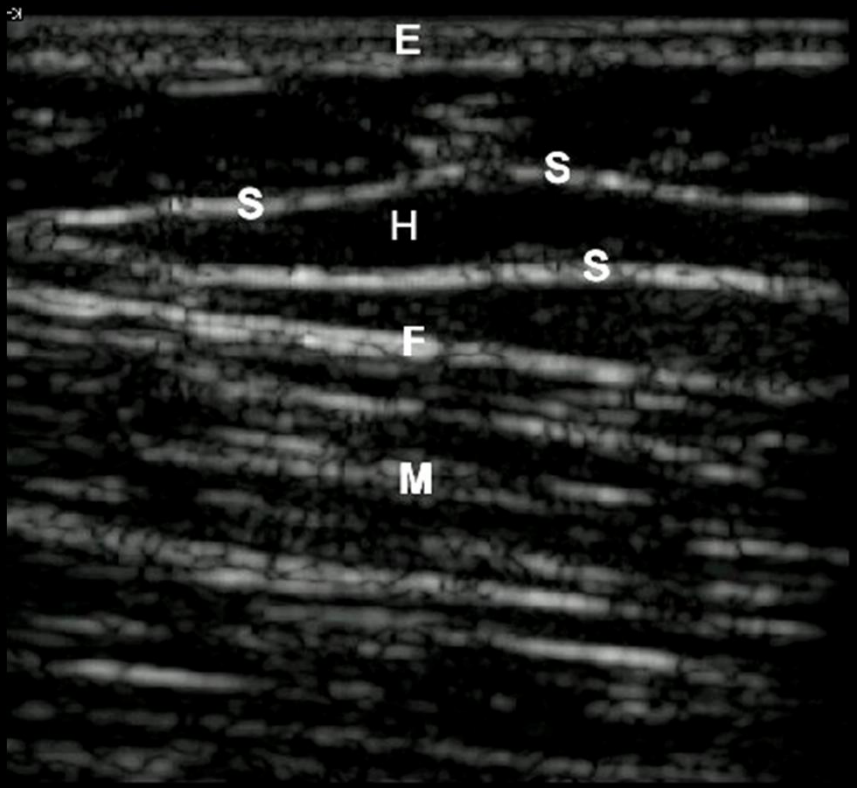
Skin, subcutaneous tissue

1. Epidermis, dermis 1.5-4mm thick single hyperechoic line.
2. No blood flow detected in the epidermis and dermis



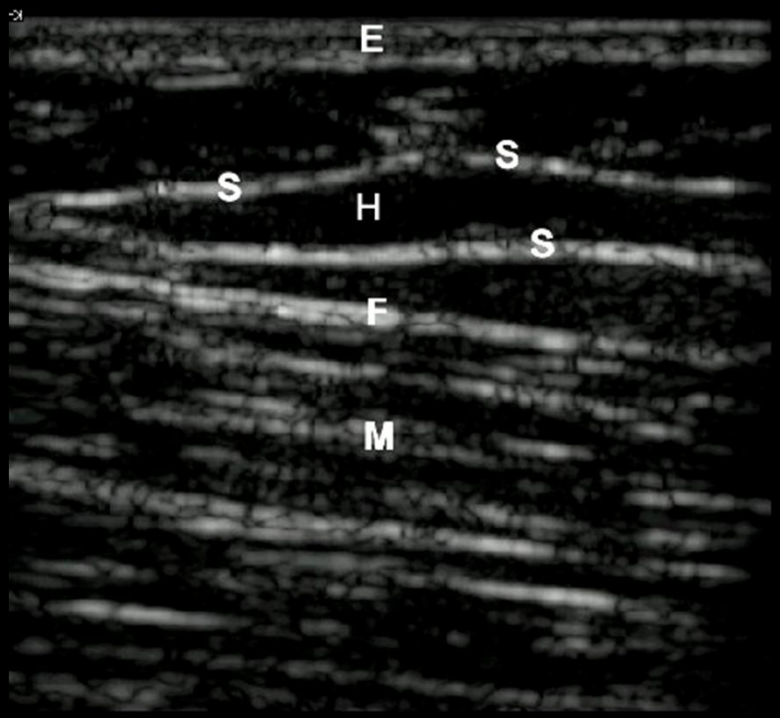


3. Subcutaneous tissue hypodermis hypoechoic layer with hyperechoic strands. The hypoechoic area corresponds to subcutaneous fat and loose connective tissue. Curvilinear hyperechoic strands corresponds to fibrous septa.

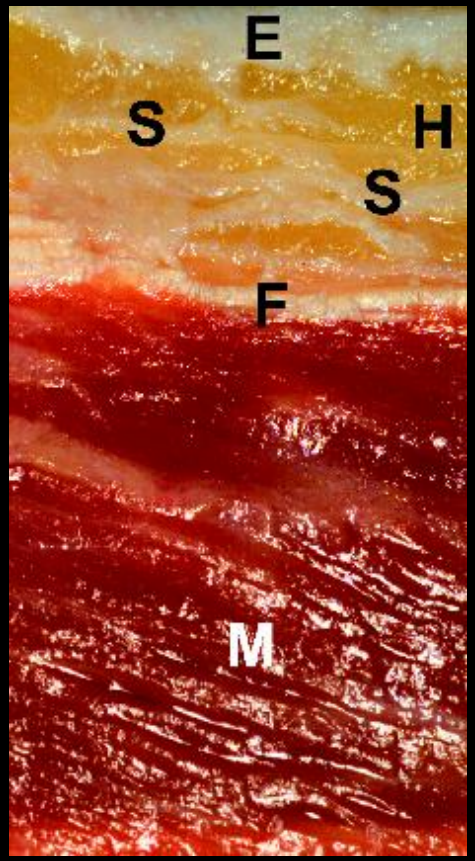


4. Superficial veins can be detected in the subcutaneous tissue.

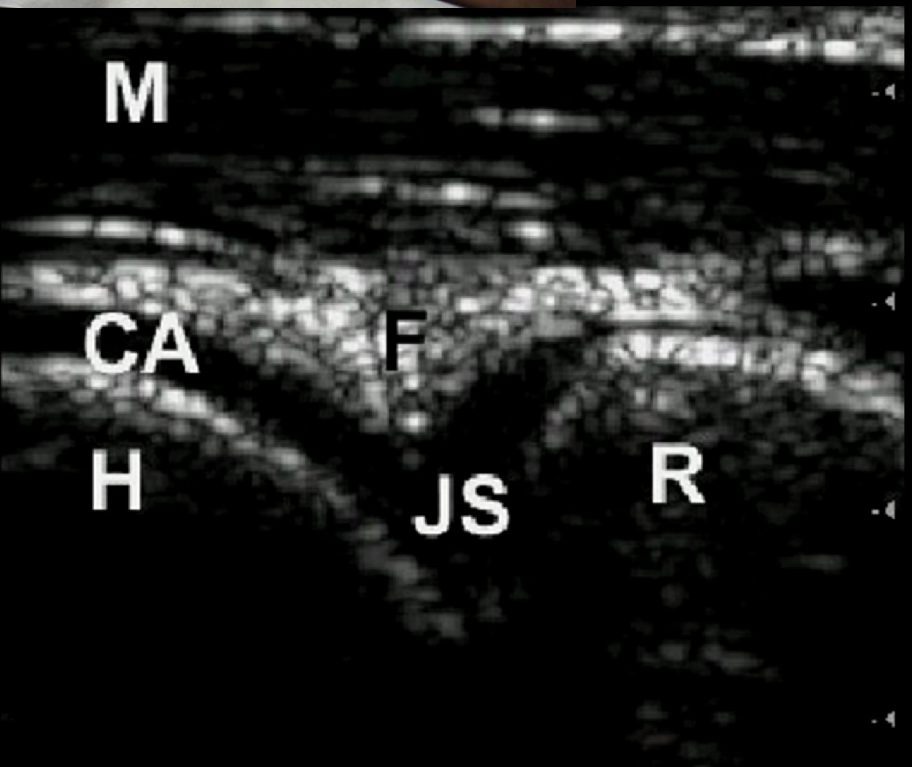
5. No focal hypo-,hyperechoic or anechoic area in the the skin or in the subcutaneous tissue.

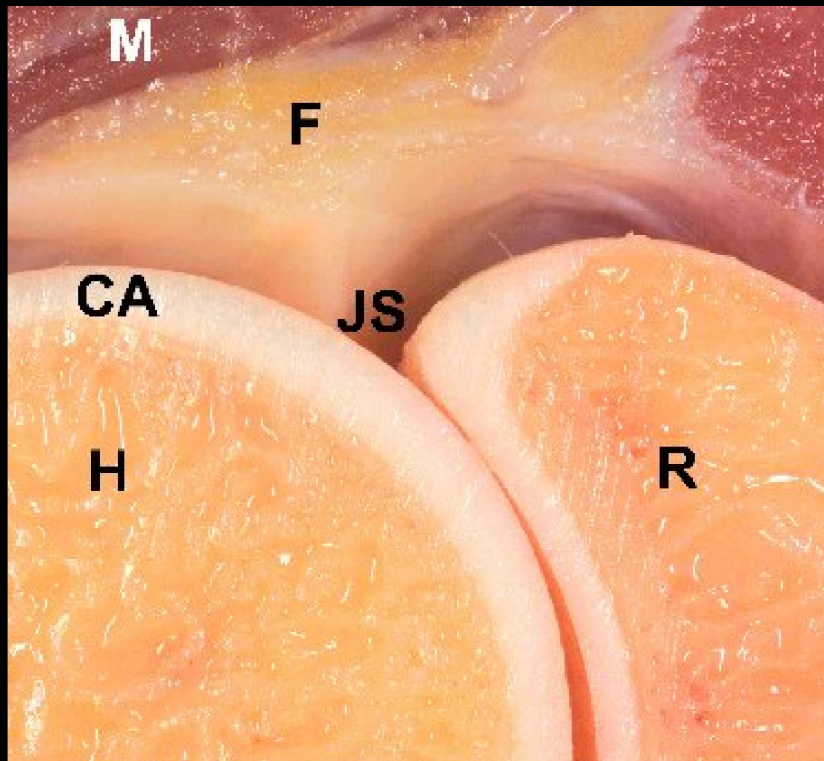


6. No focal or diffuse thickening or thinning of subcutaneous tissue compared with the other side.



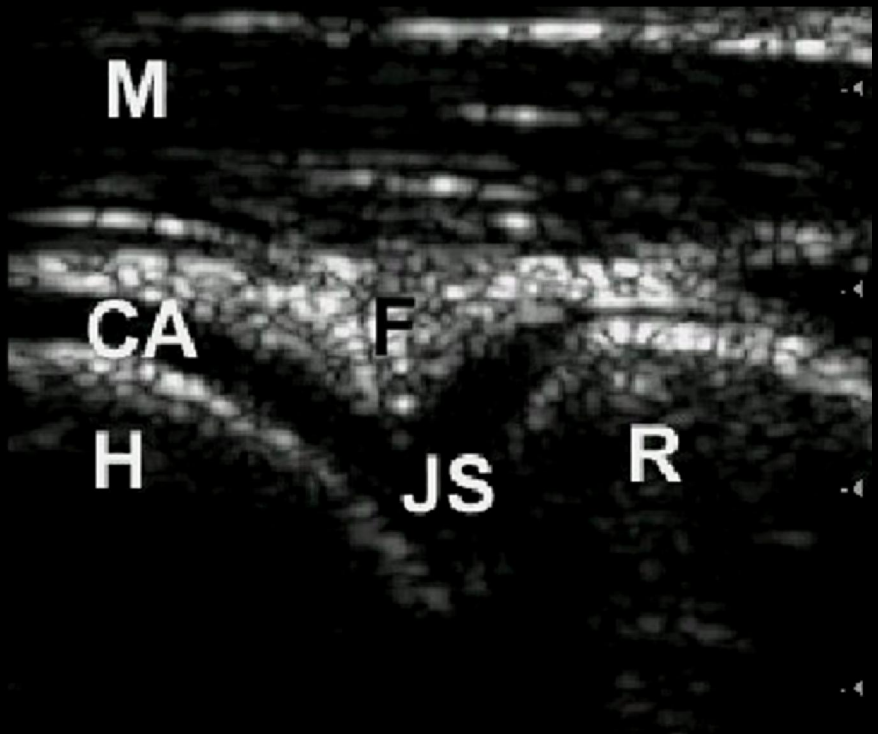
Fat pad

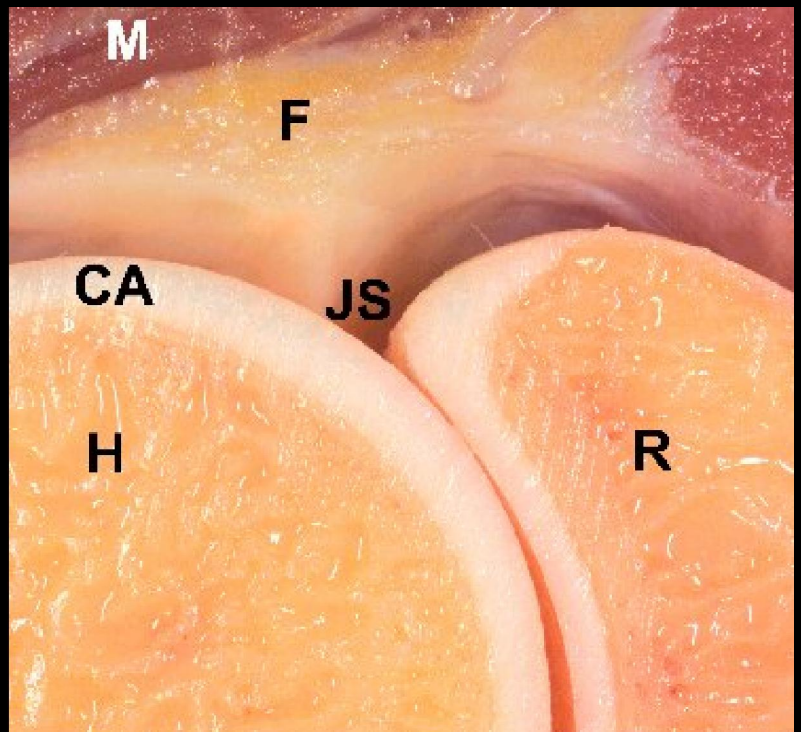




1. Fat pads can be visualised e.g. anterior elbow fat pad, Hoffa fat pad (knee), Kager fat pad (ankle).

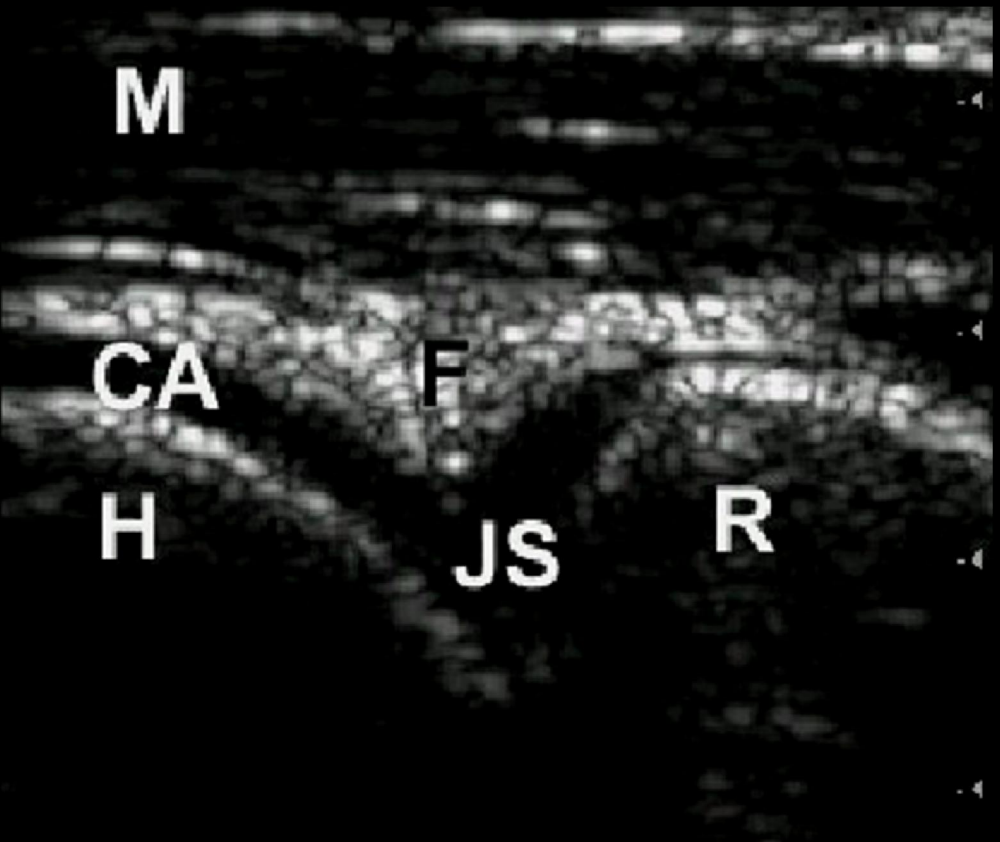
2. Some fat pads are hyperechoic, some are hypoechoic and some are inhomogenously hypo-and hyperechoic.

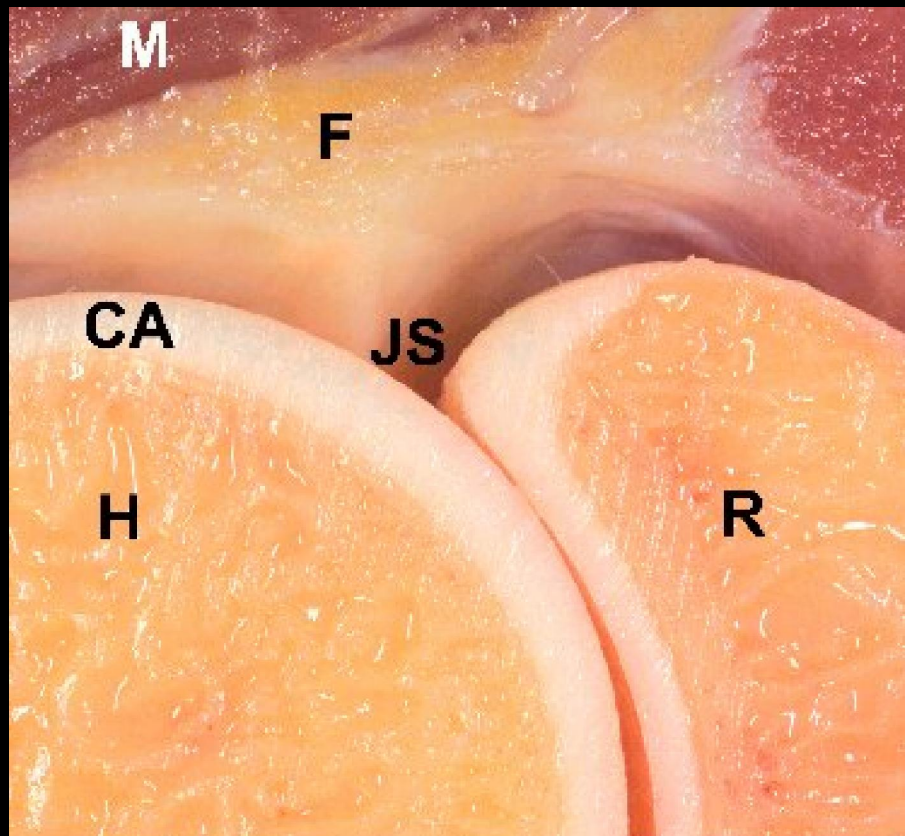




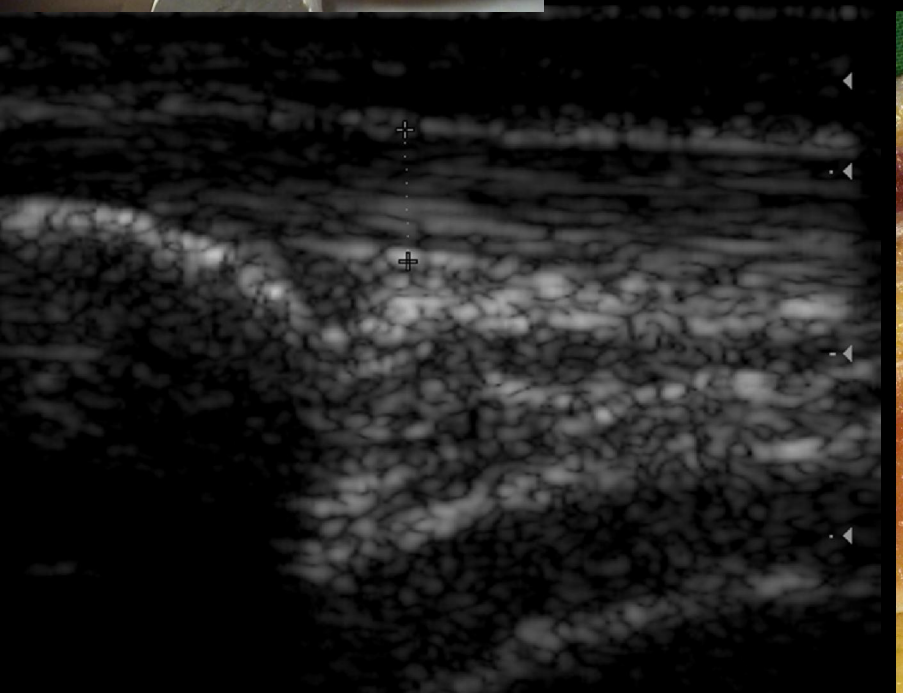
3. Rarely blood flow detected in the fat pads.

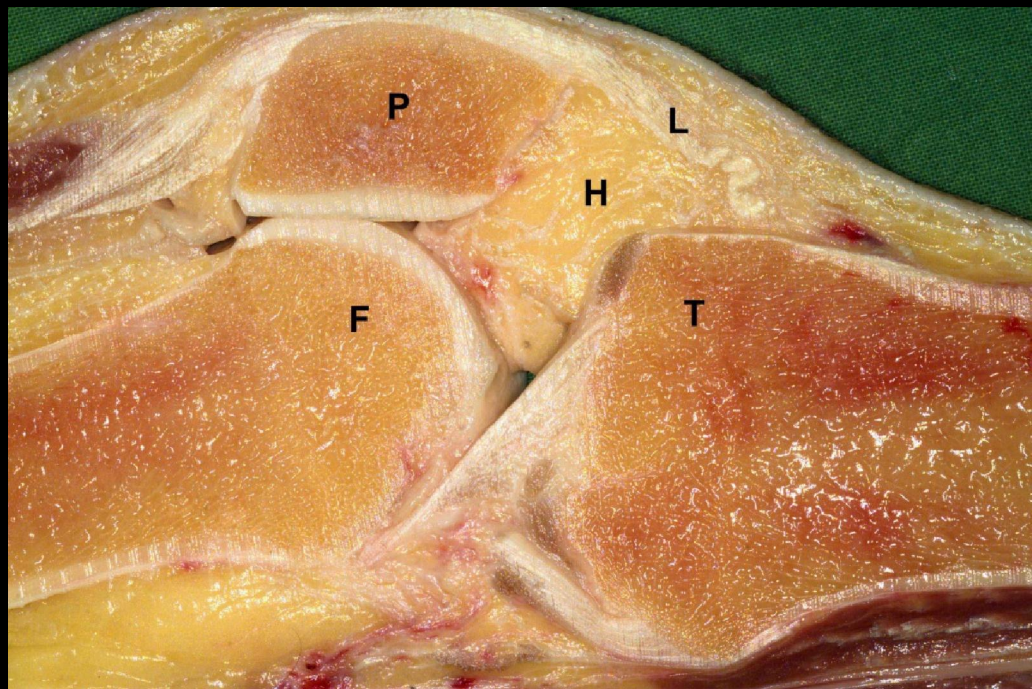
4. No focal anechoic or hypo- or hyperechoic area detected in fat pads.



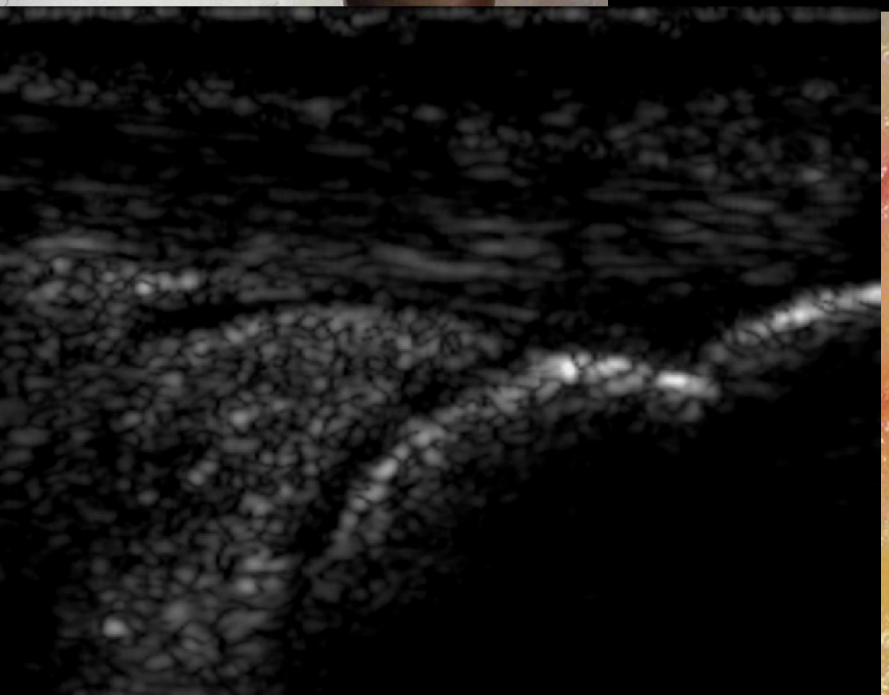


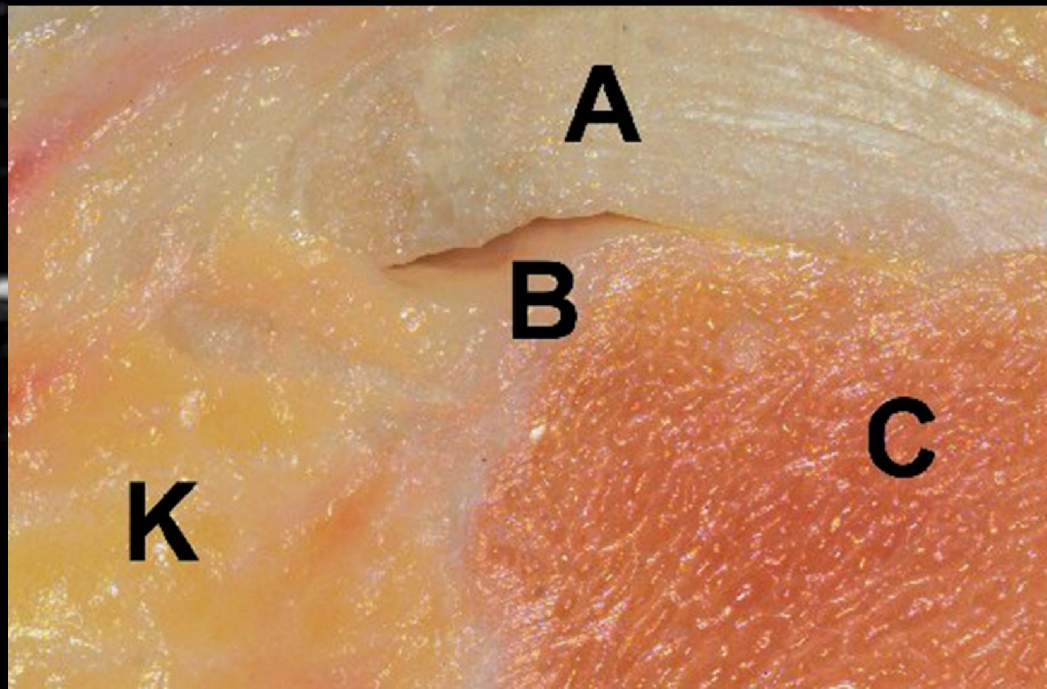
Hoffa fat pad



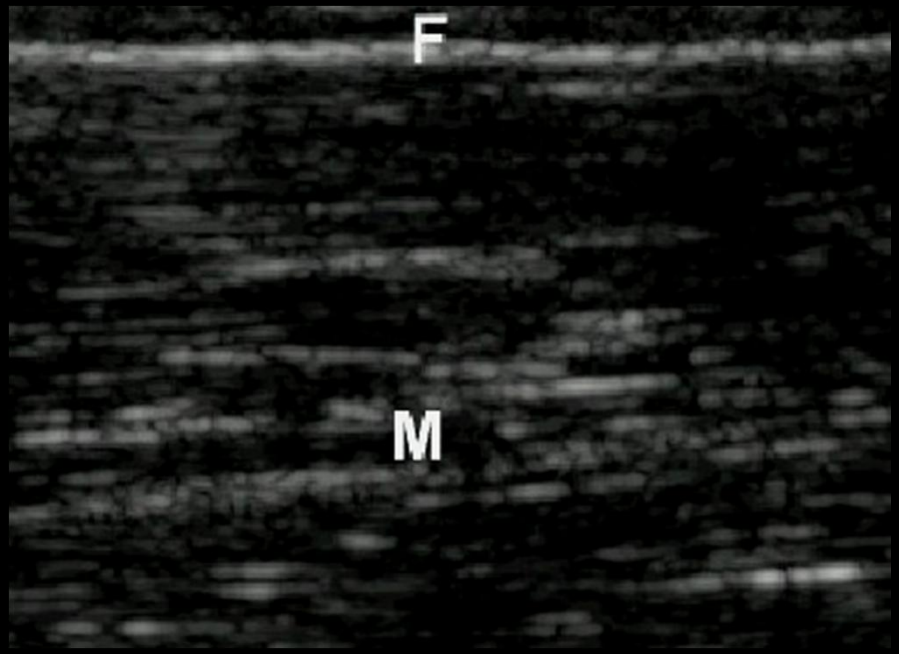


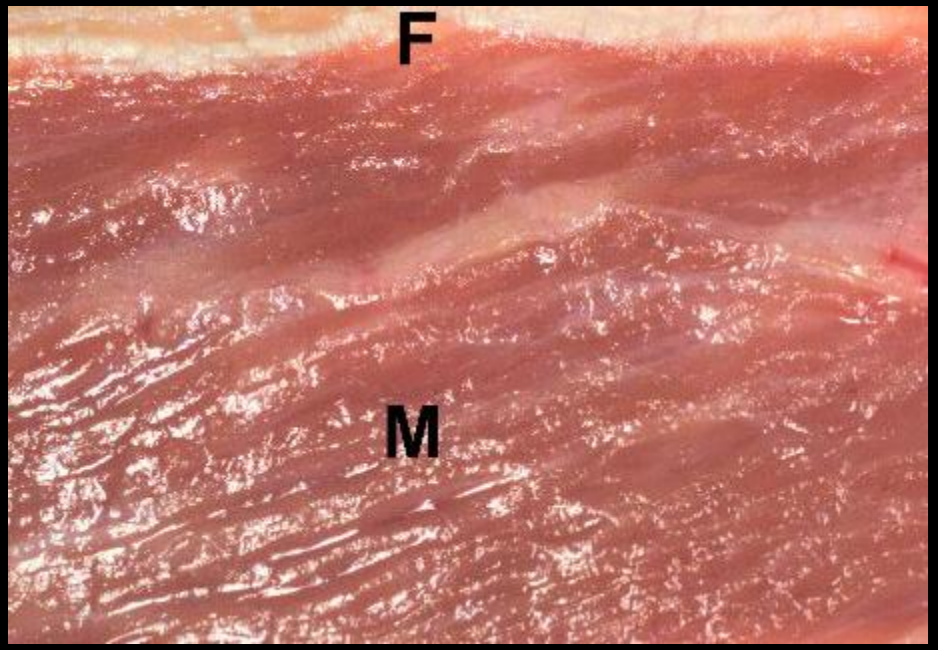
Kager fat pad



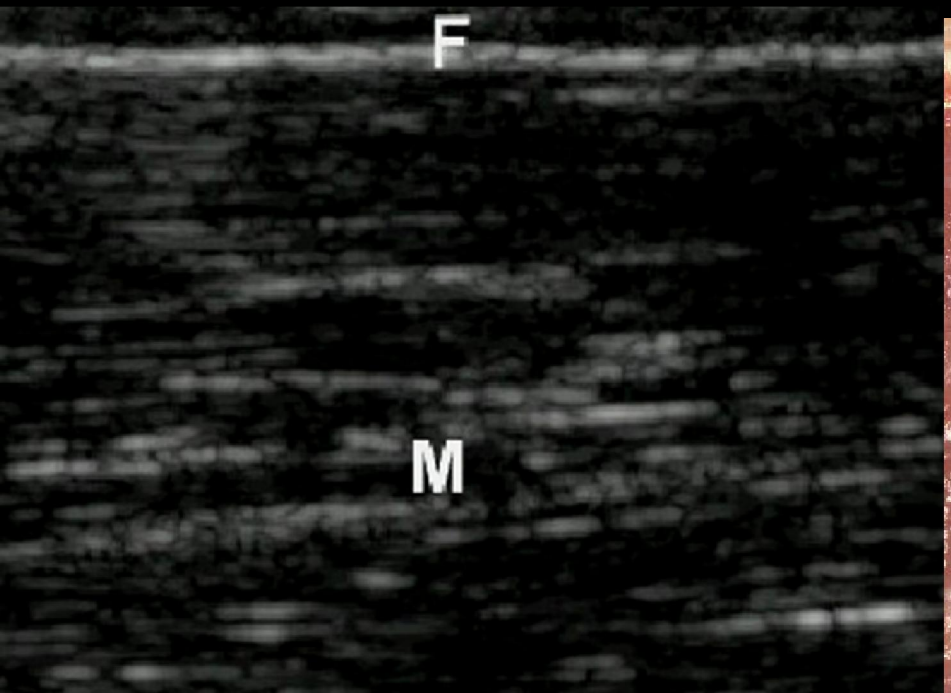


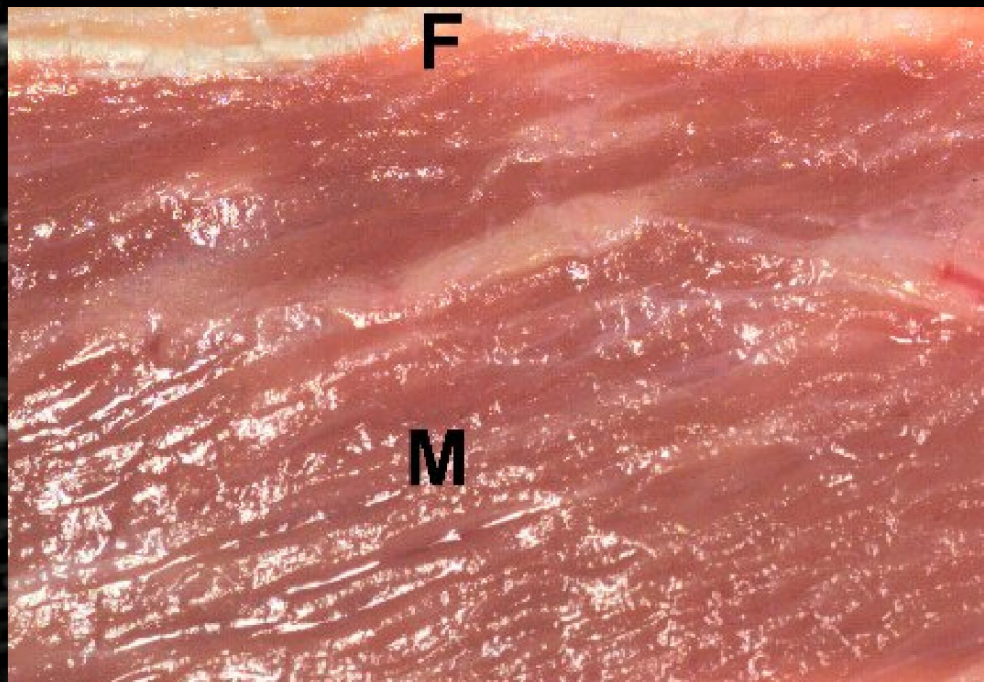
Muscle (longitudinal)



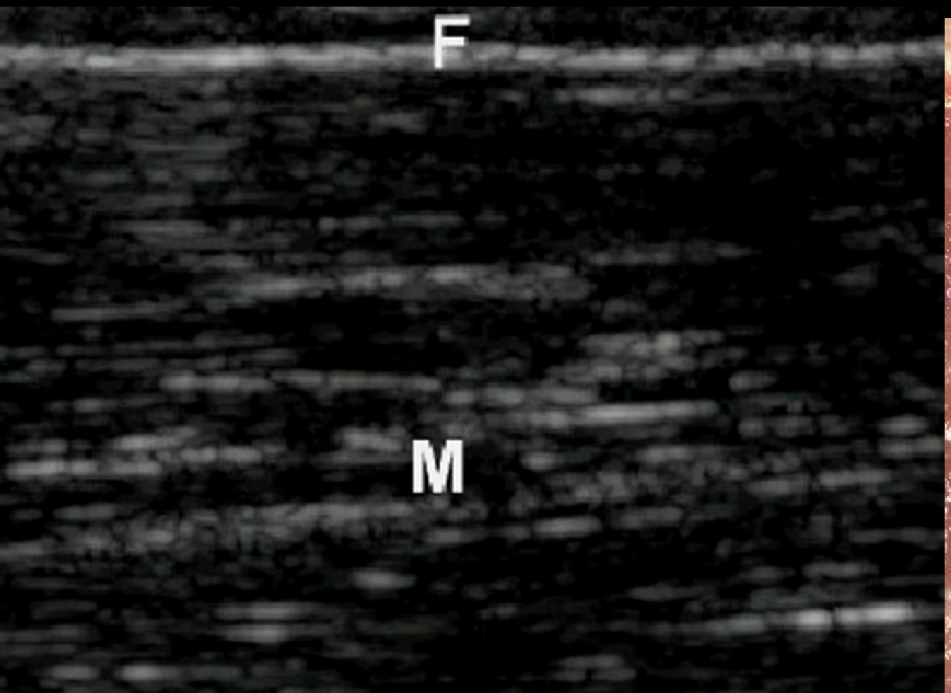


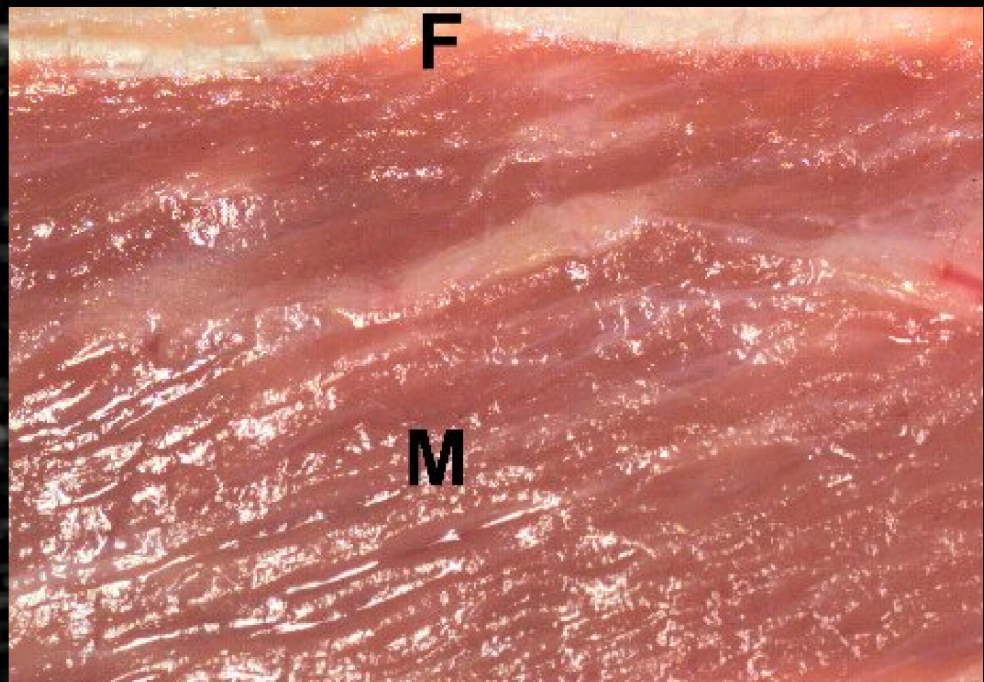
1. Epimysium, fibroadipose septa, perimysium are hyperechoic. Epimysium covers the entire muscle. Fibrous intersections are also hyperechoic.
2. Muscles bundles are hypoechoic





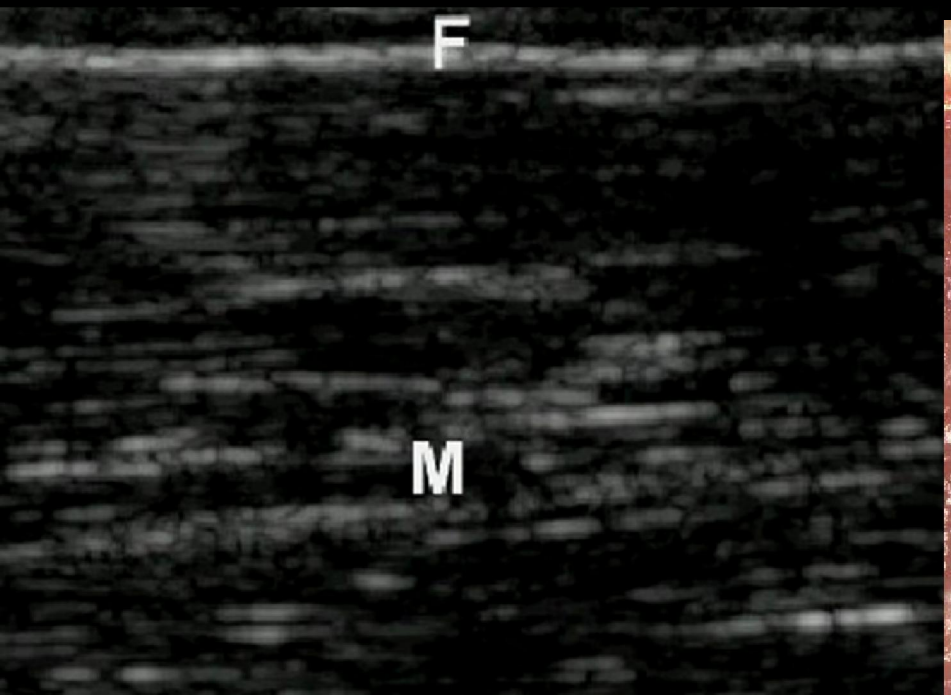
3. The ultrasound pattern mimicking the anatomical structure of muscle eg. unipennate, bipennate, circumpennate.

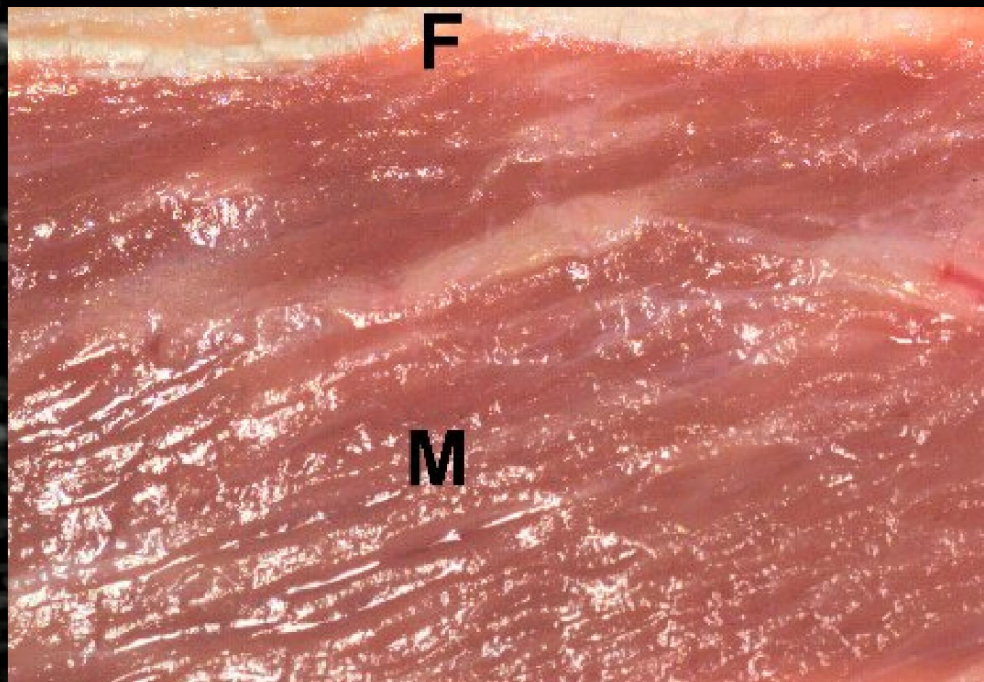




4. Some vessels could be detected in the muscle

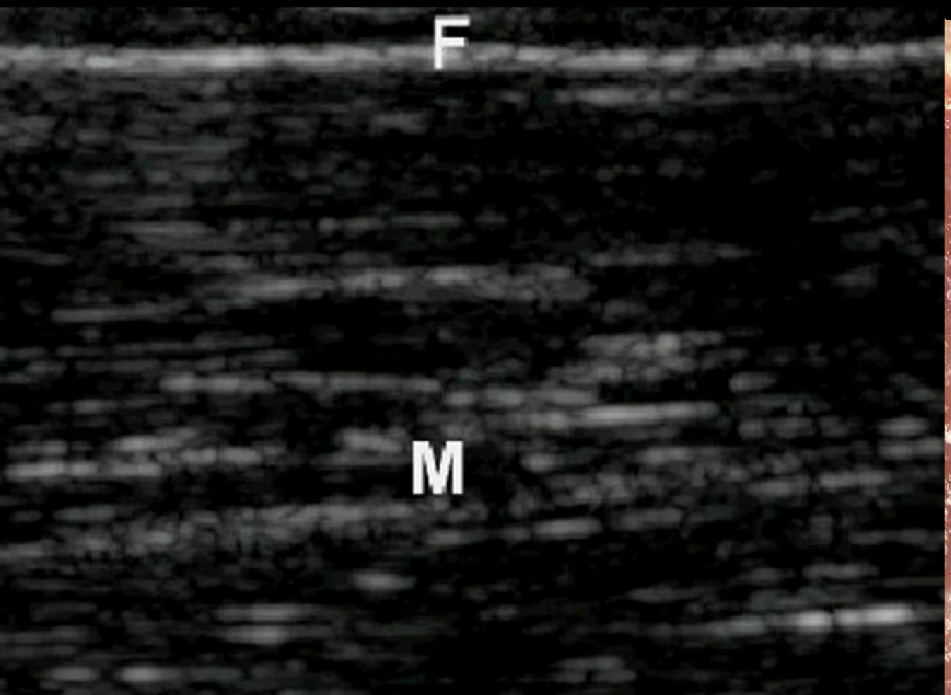
5. During isometric contraction, the muscle mass is increased and become more hypoechoic.

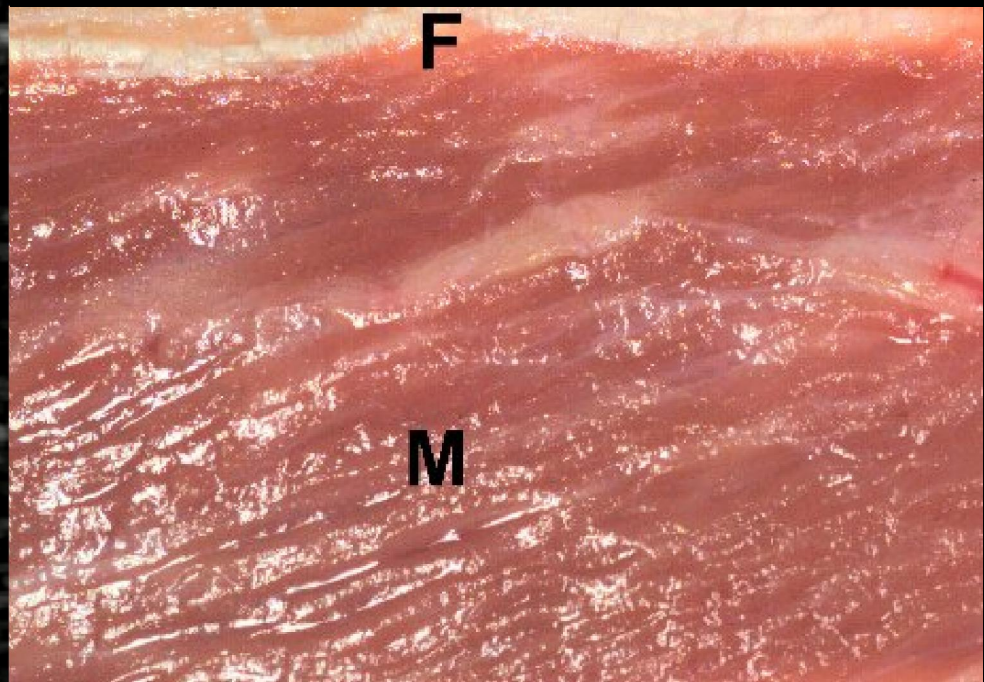




6. Trained muscle less hyperechoic due to hypertrophy of muscle bundles.

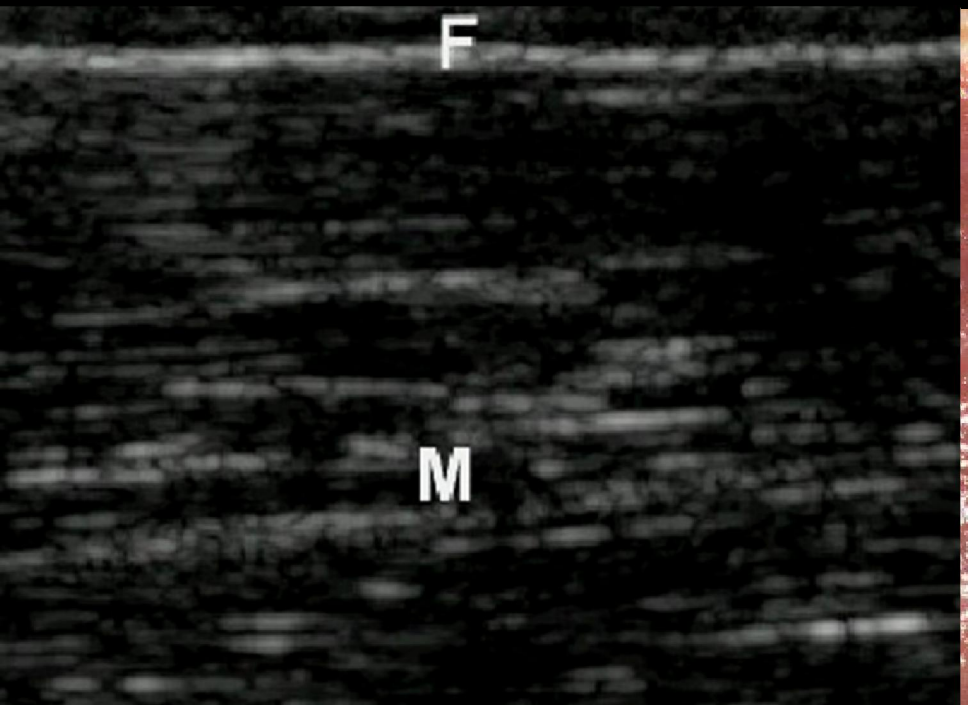
7. Under pressure of the transducer echogenicity increases in the muscle

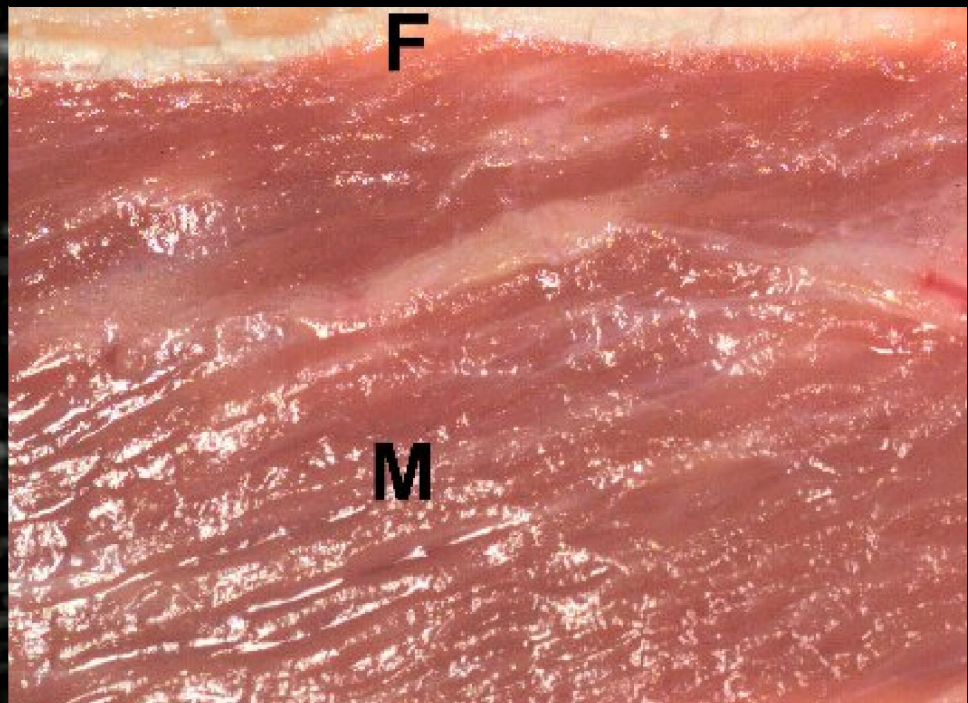




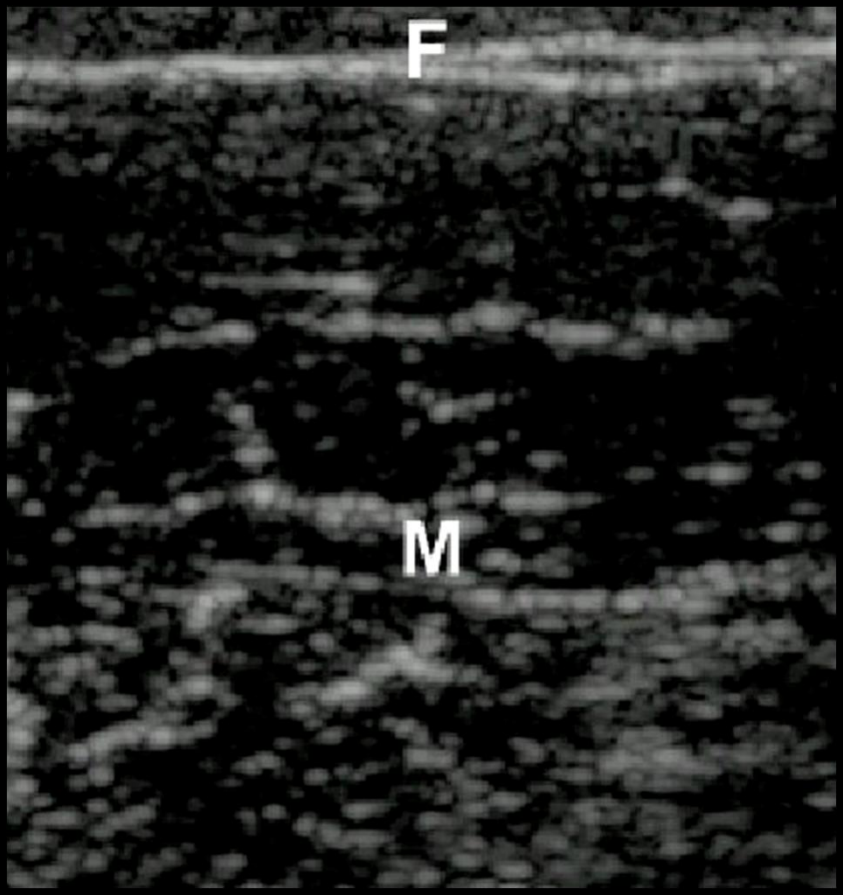
8. No intramuscular focal anechoic, hypoechoic or hyperechoic lesion detected.

9. Muscle structure not detected over the fascia or epimysium at rest, in standing position or during contraction.

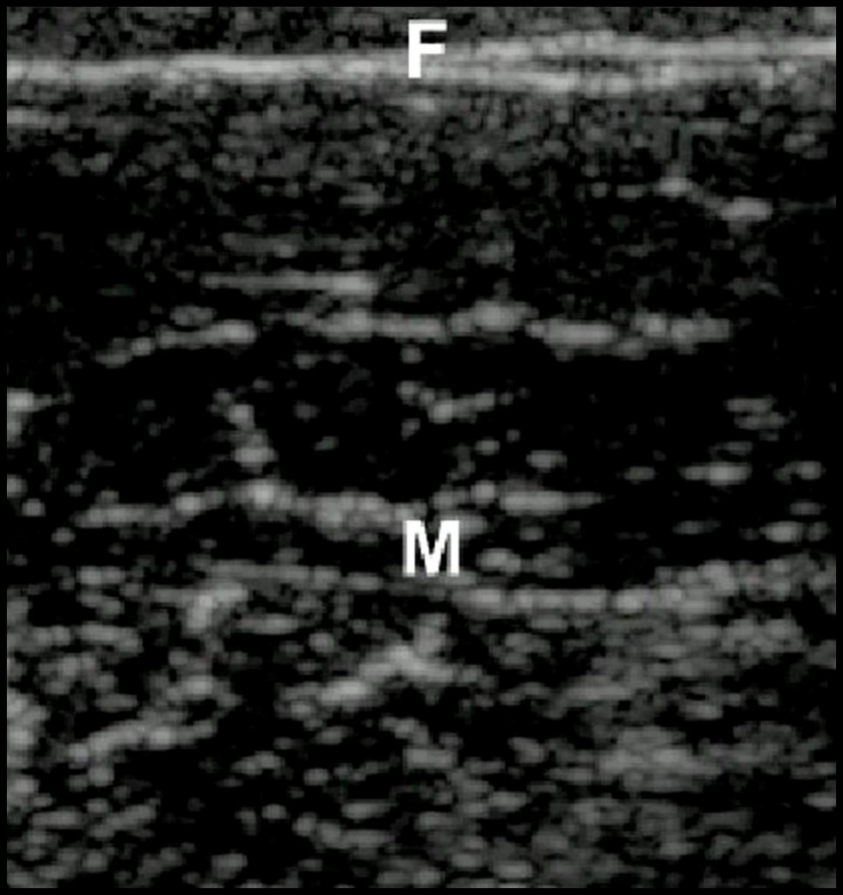


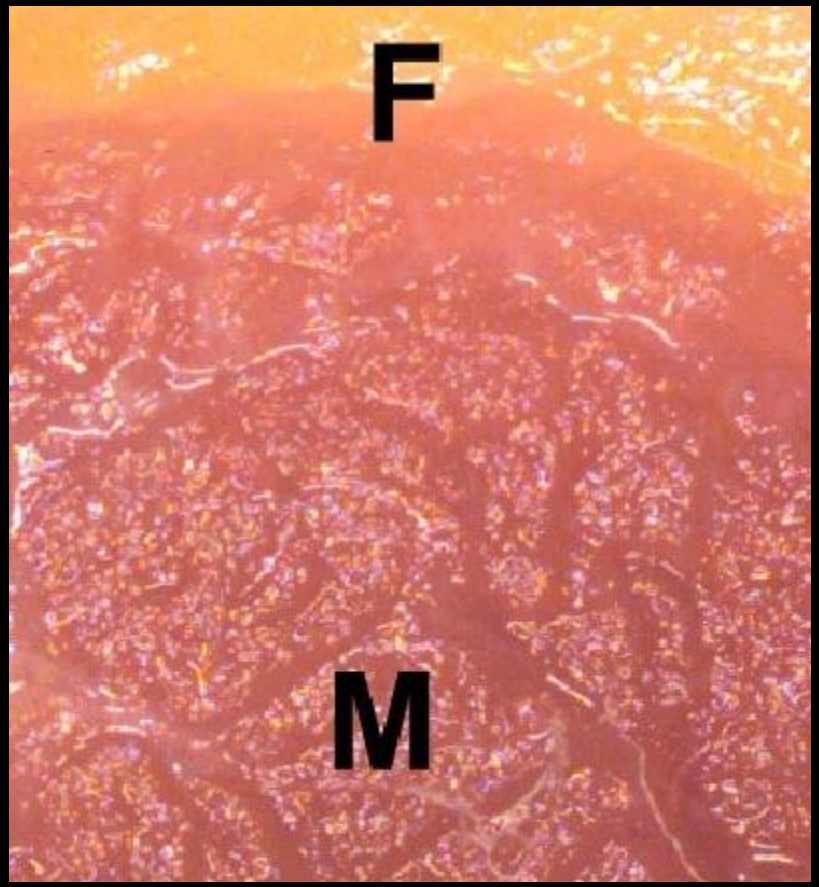


Muscle (transverse)

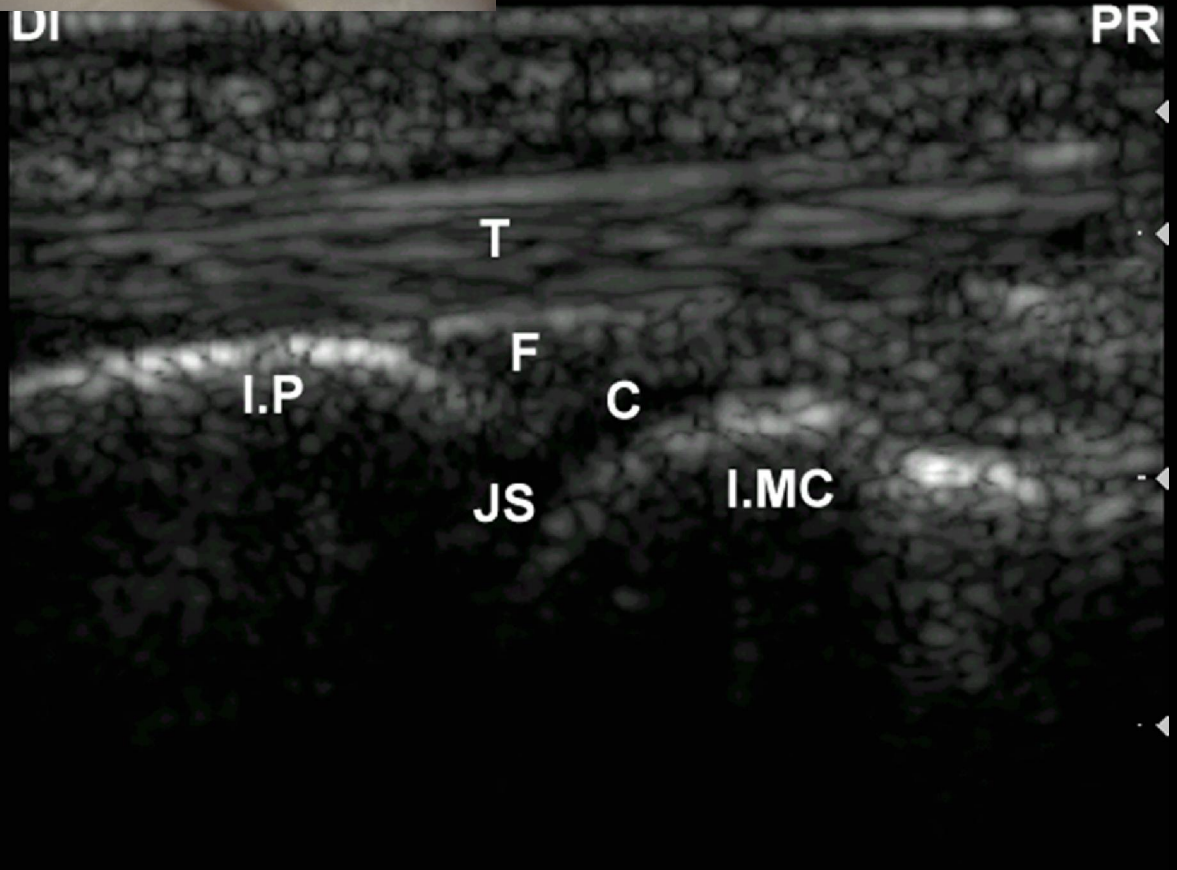


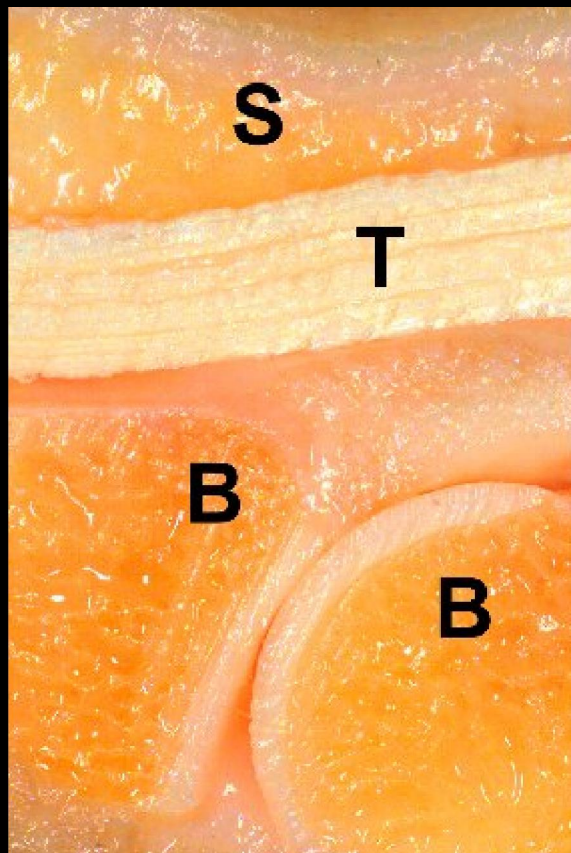
1. Speckled appearance due to cross-sections of perimysium and vessels.



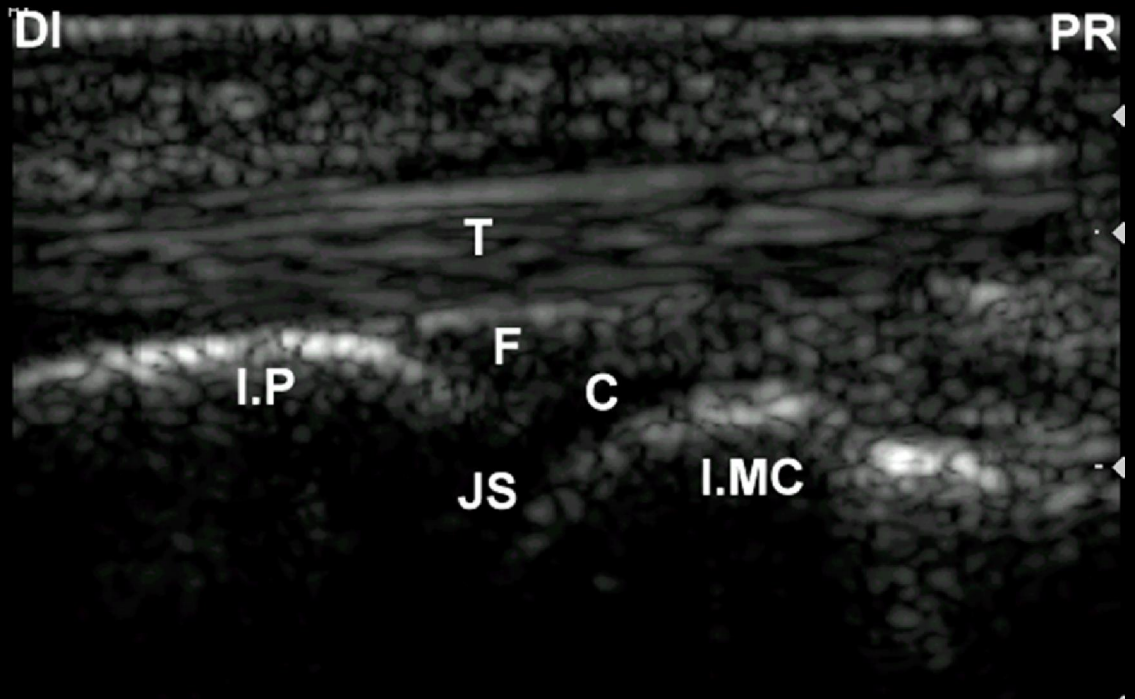


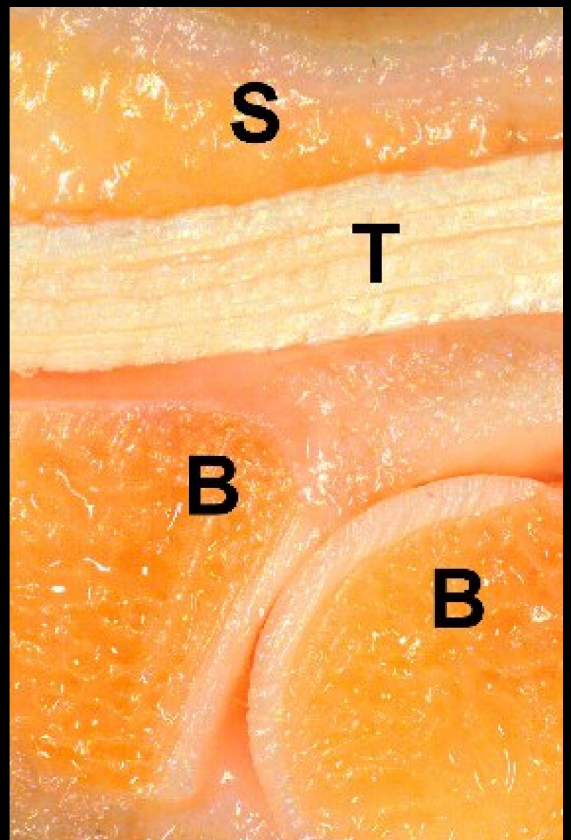
Tendon (longitudinal)





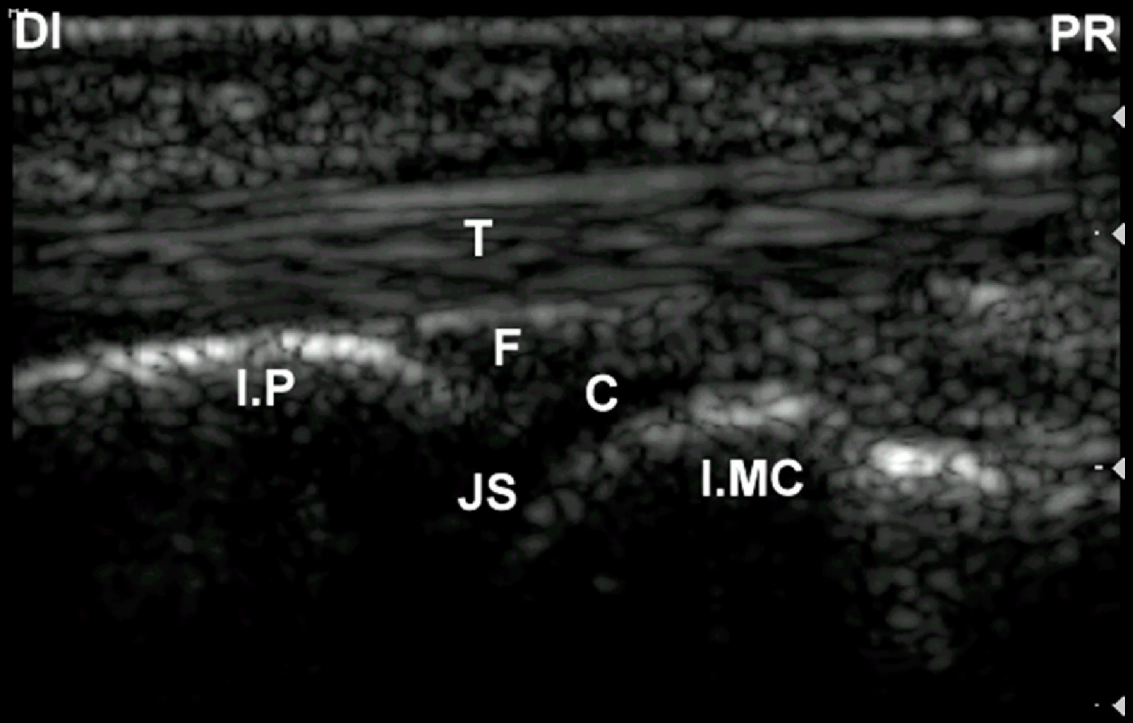
1. Highly hyperechoic, tightly packed, longitudinally, parallel orientated fibrillar texture along the axis of the tendon and through the whole width of the tendon.

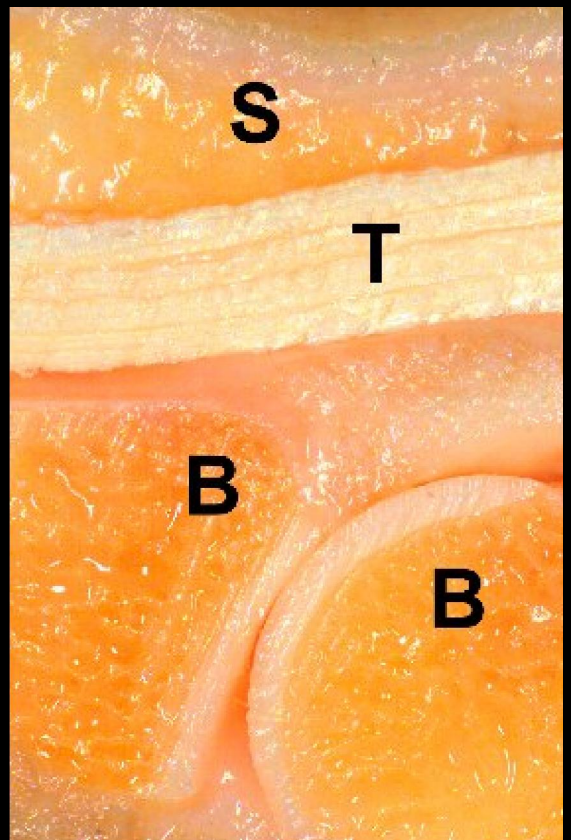




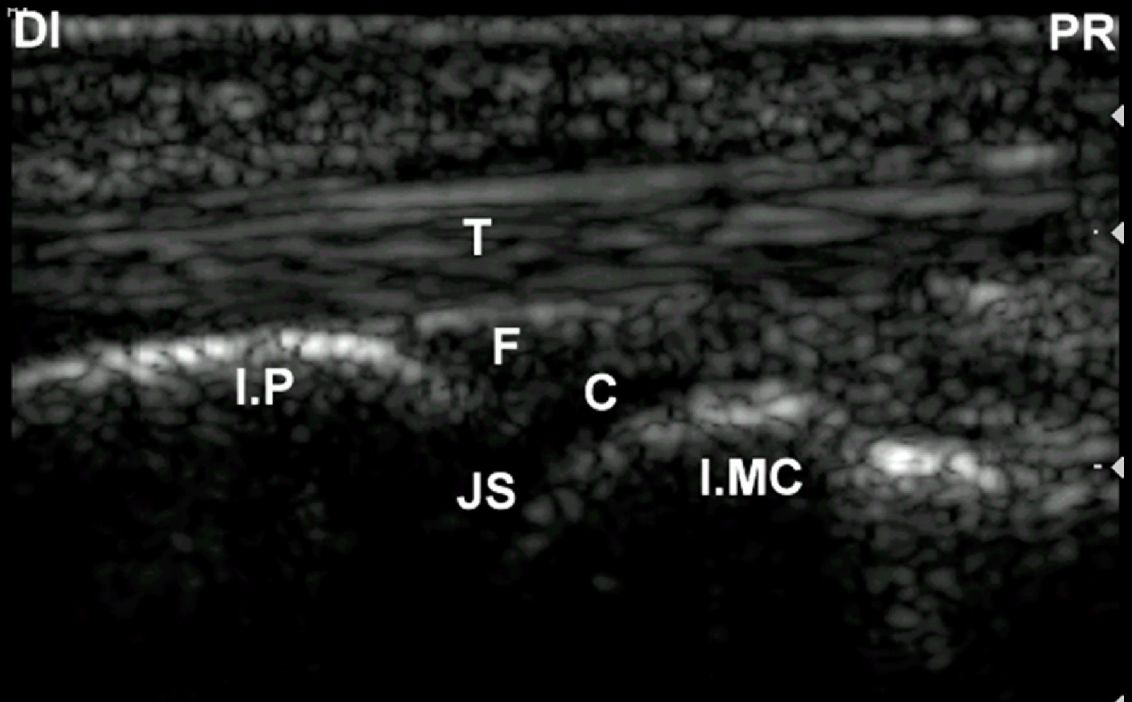
2. The fibrils run in the same directions, but cross each other like a spun pigtail.

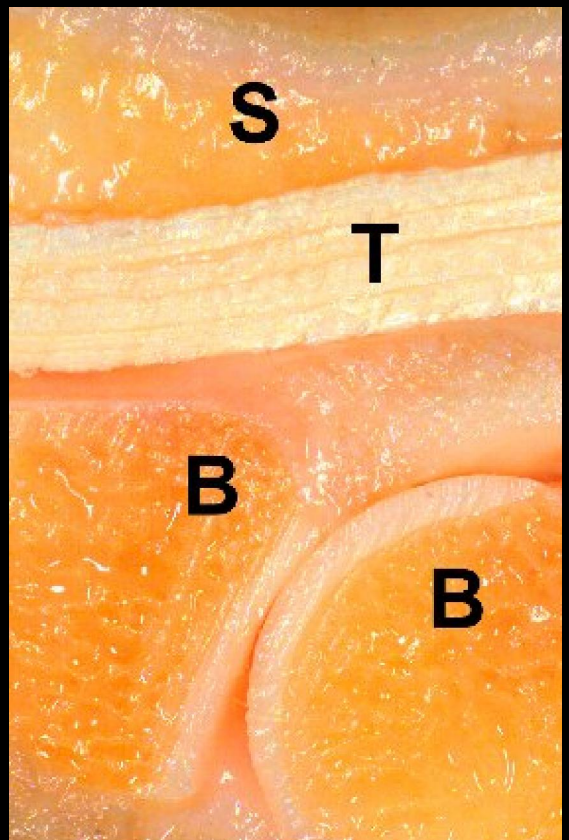
3. The straight orientation of fibrillar structure curves only where two tendons blend or the tendon direction is changed.





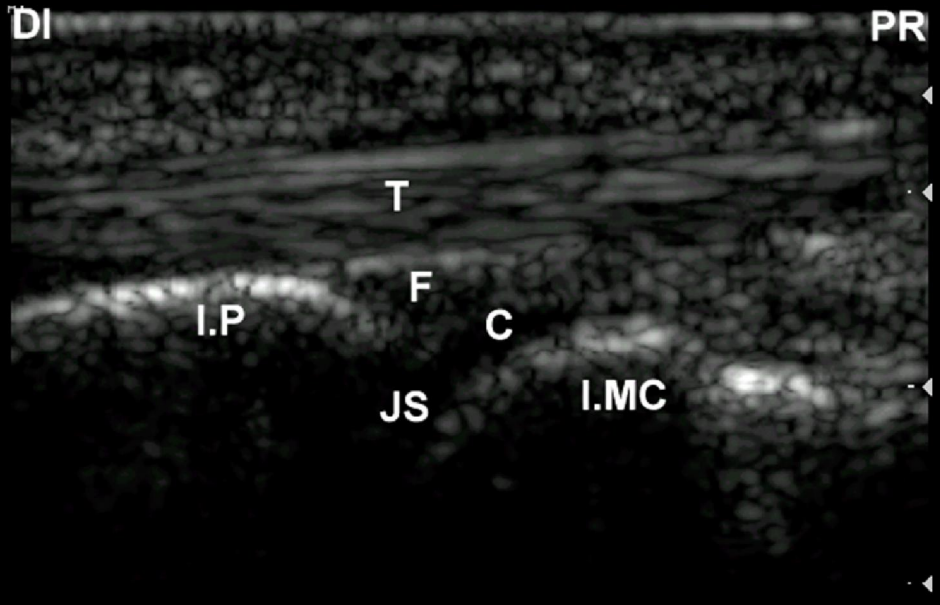
4. Between the fibrillar structure there is a very small amount of hypoechoic tissue material.

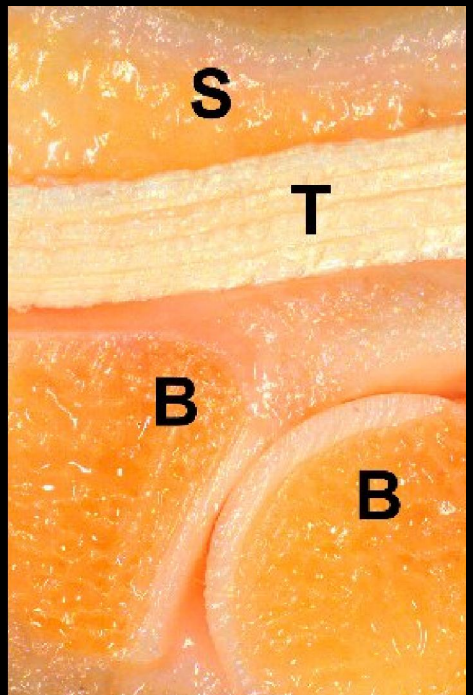




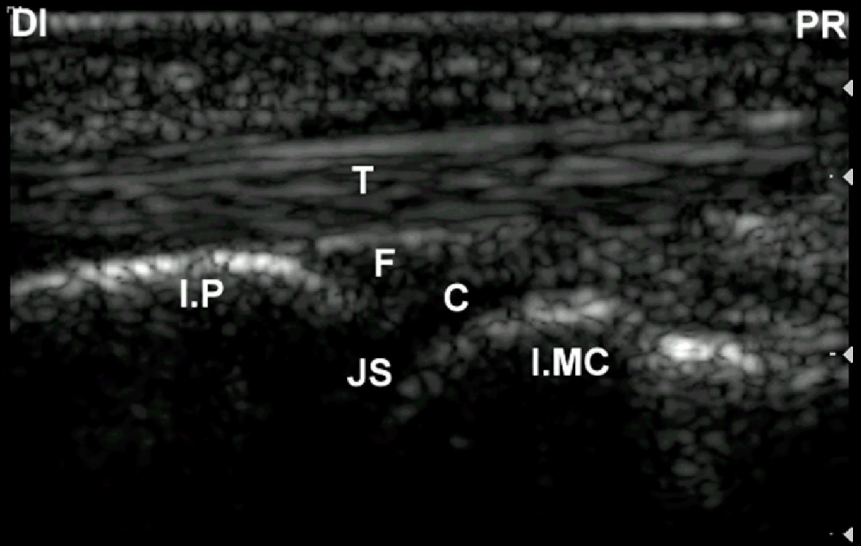
5. No focal hyper-, hyperechoic or anechoic areas are detectable in the tendon, except where sesamoid bones cause different echo pattern in some tendons.

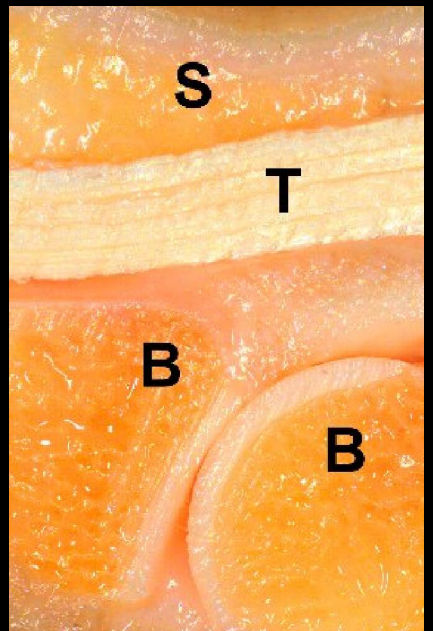
6. No discontinuity of the tendon, no marginal irregularity, no focal flattening or enlargement of the diameter.

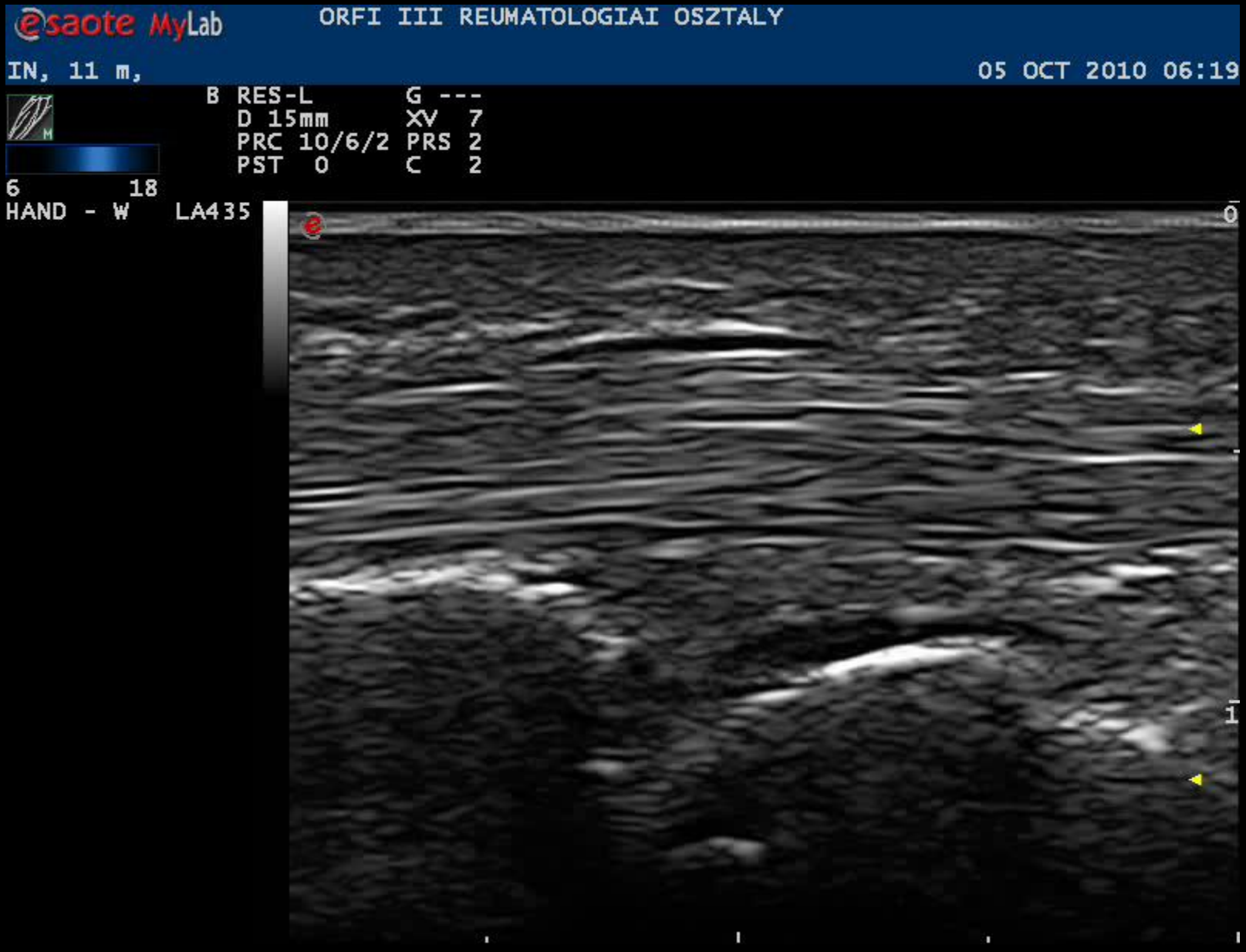




7. Vascularity not detected in the tendon.
8. Same tendon echostructure and size on the contralateral side in proper anatomic position.
9. Movement during passive and active dynamic examination.



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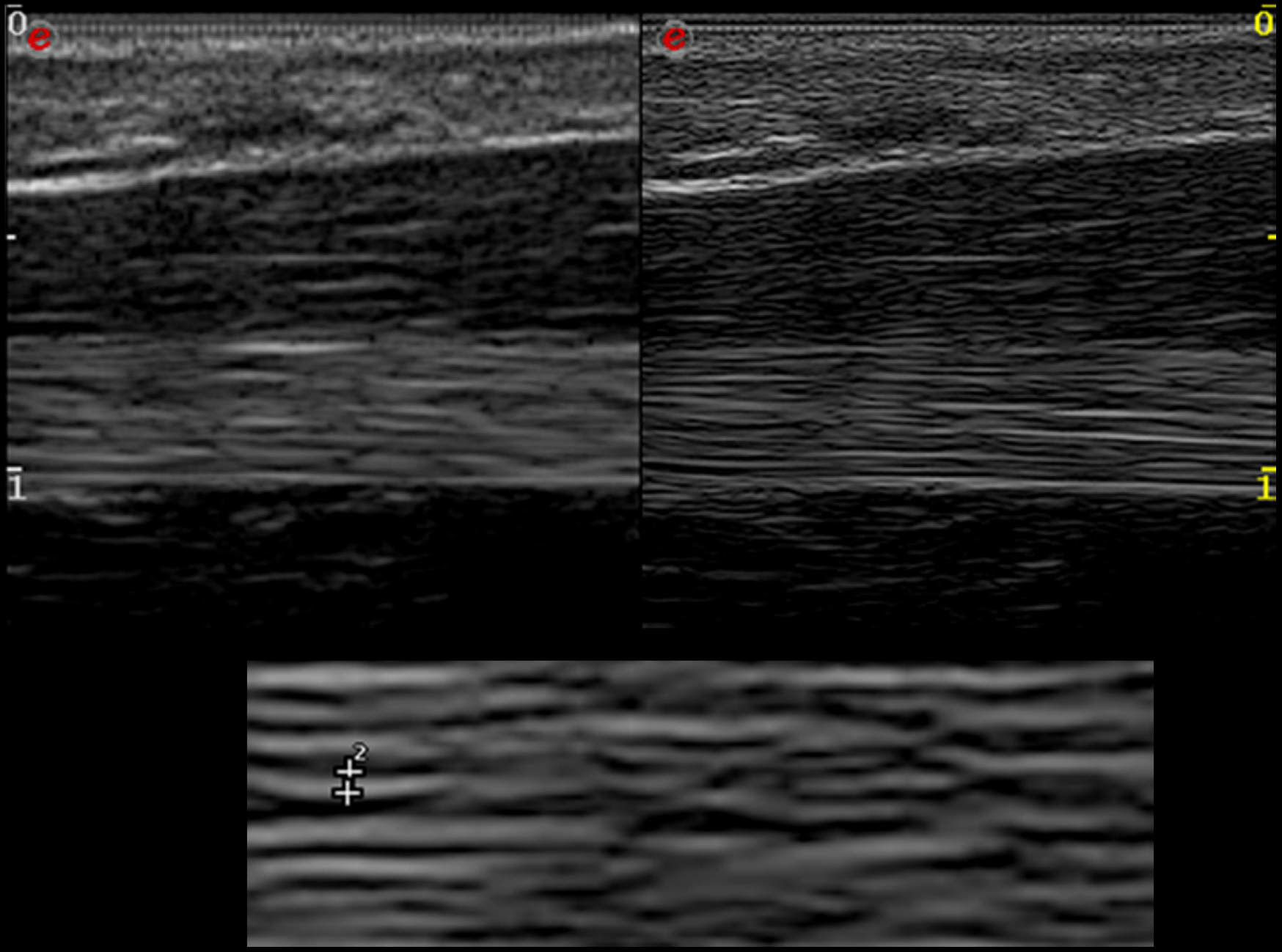
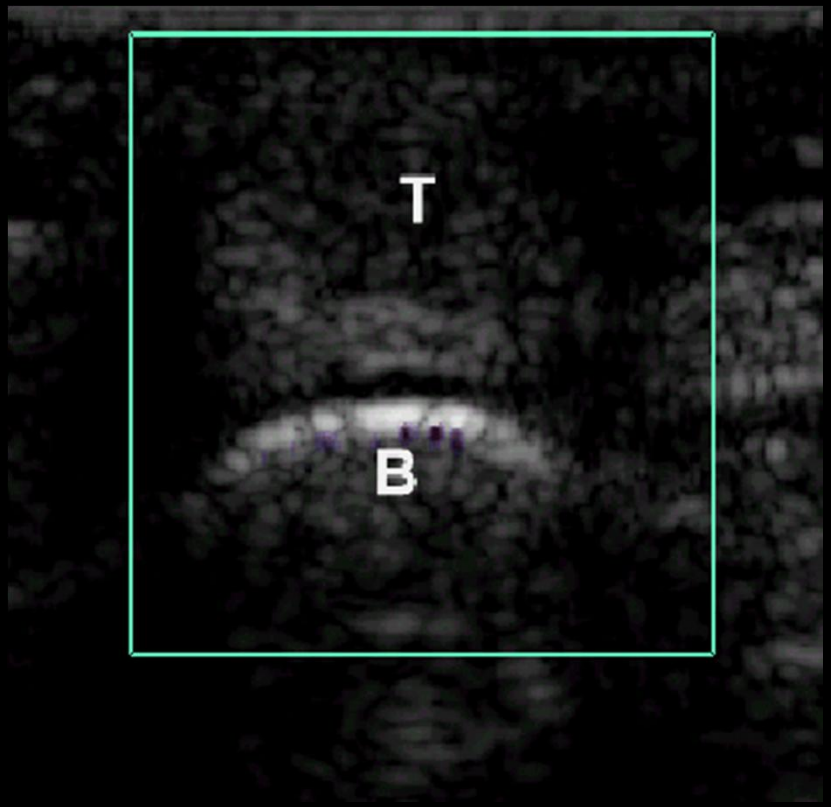
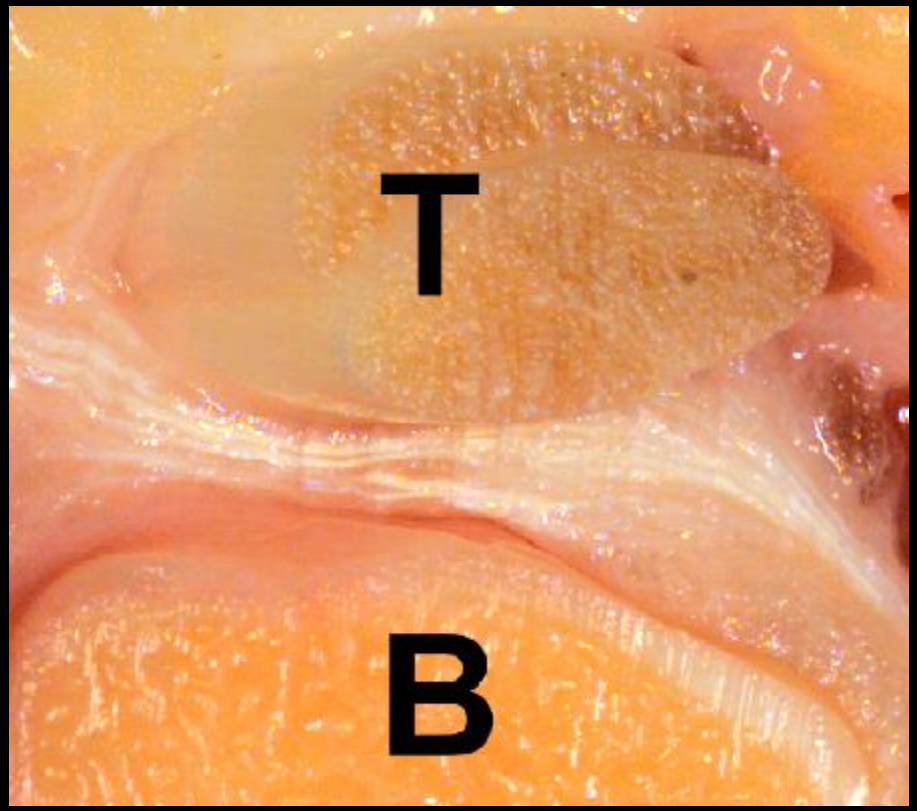


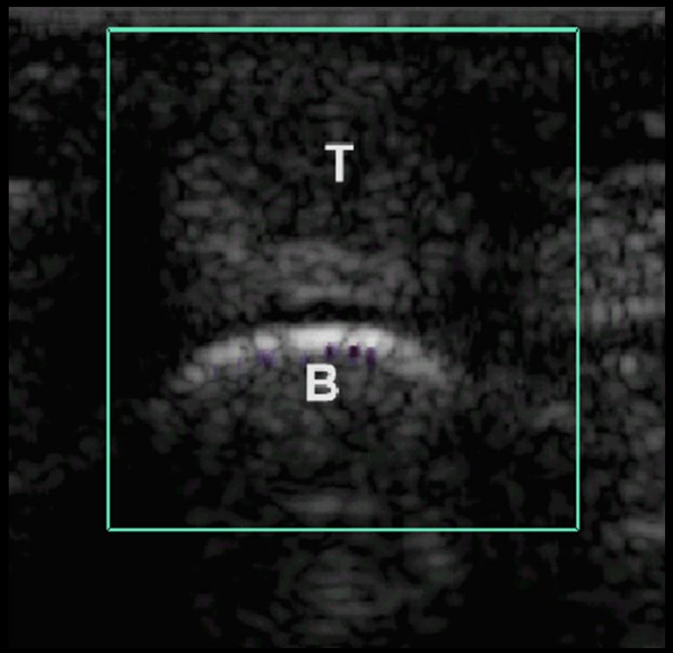
Different settings

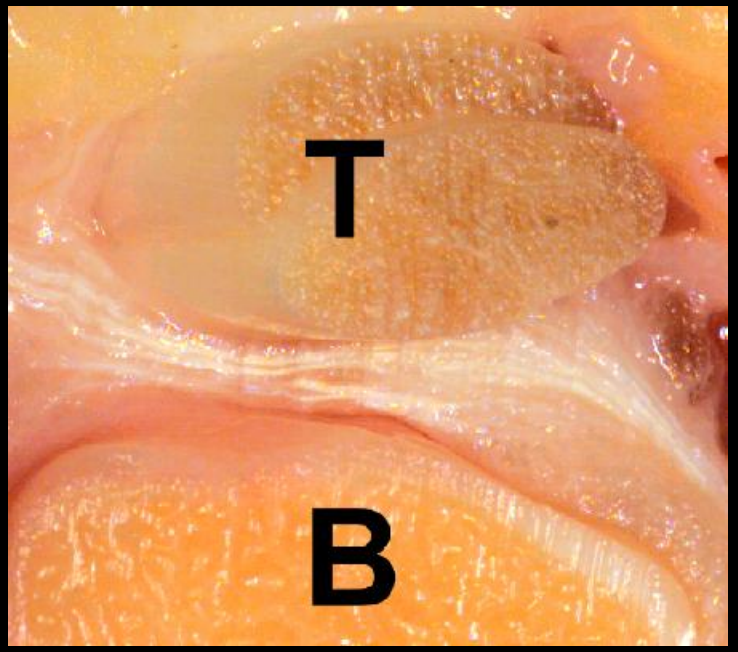
Tendon (transverse)



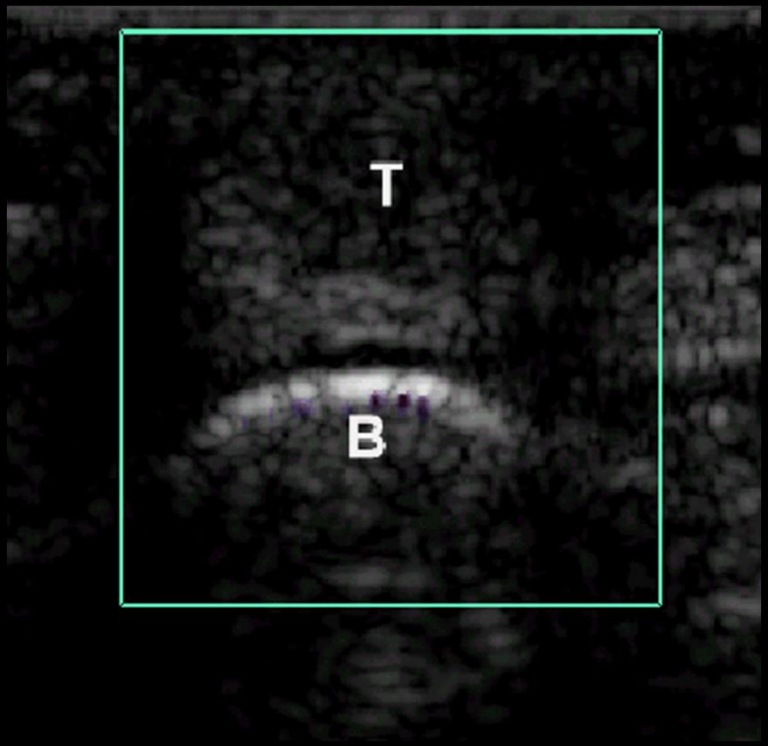


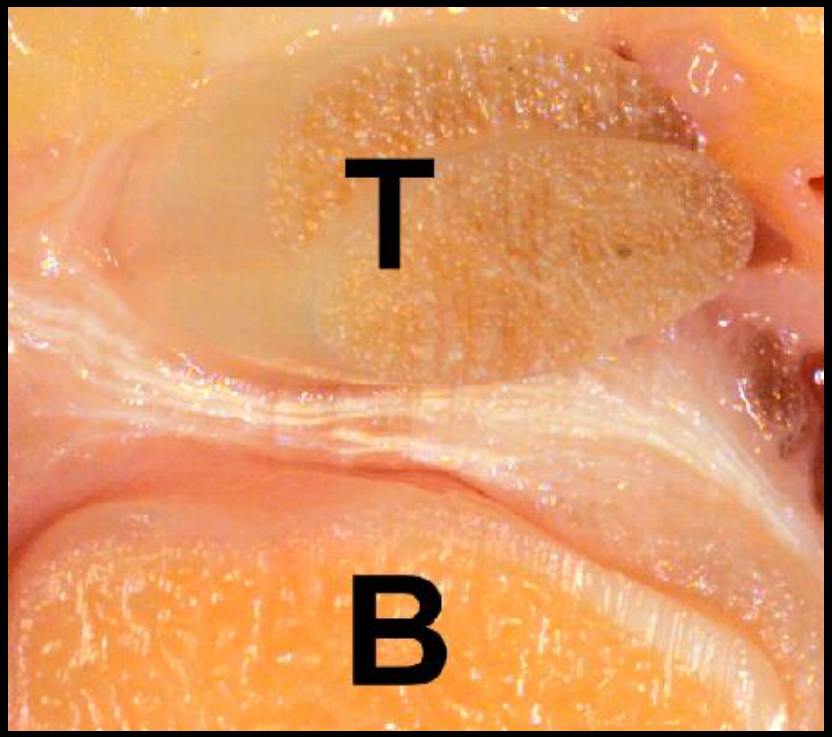
1. A mainly hyperechoic, well-limited shaped structure with densely punctuated pattern (corresponding to the longitudinal fibrillar pattern).



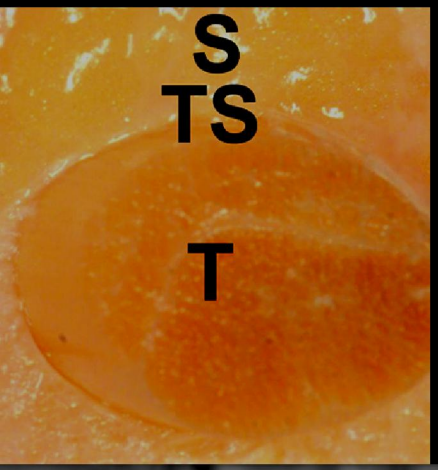


2. Tendon ultrasound cross-section shapes are the same as anatomical shapes: round, oval, flattened or semicircular.





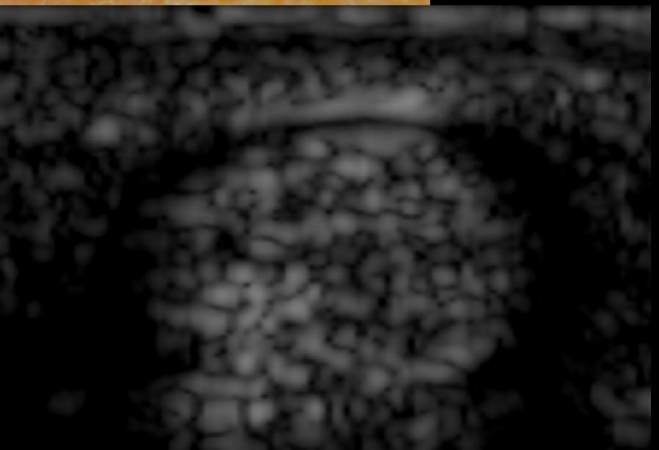
Tendon sheath, paratenon, extension of the joint capsule around the tendon

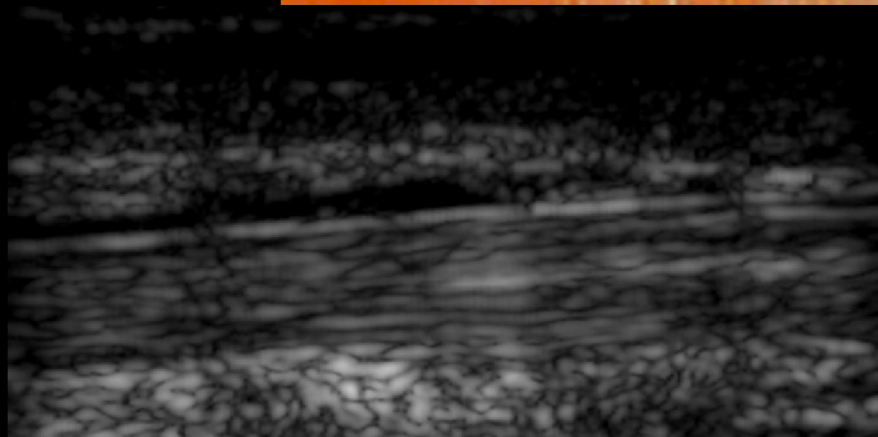


T: tendon,

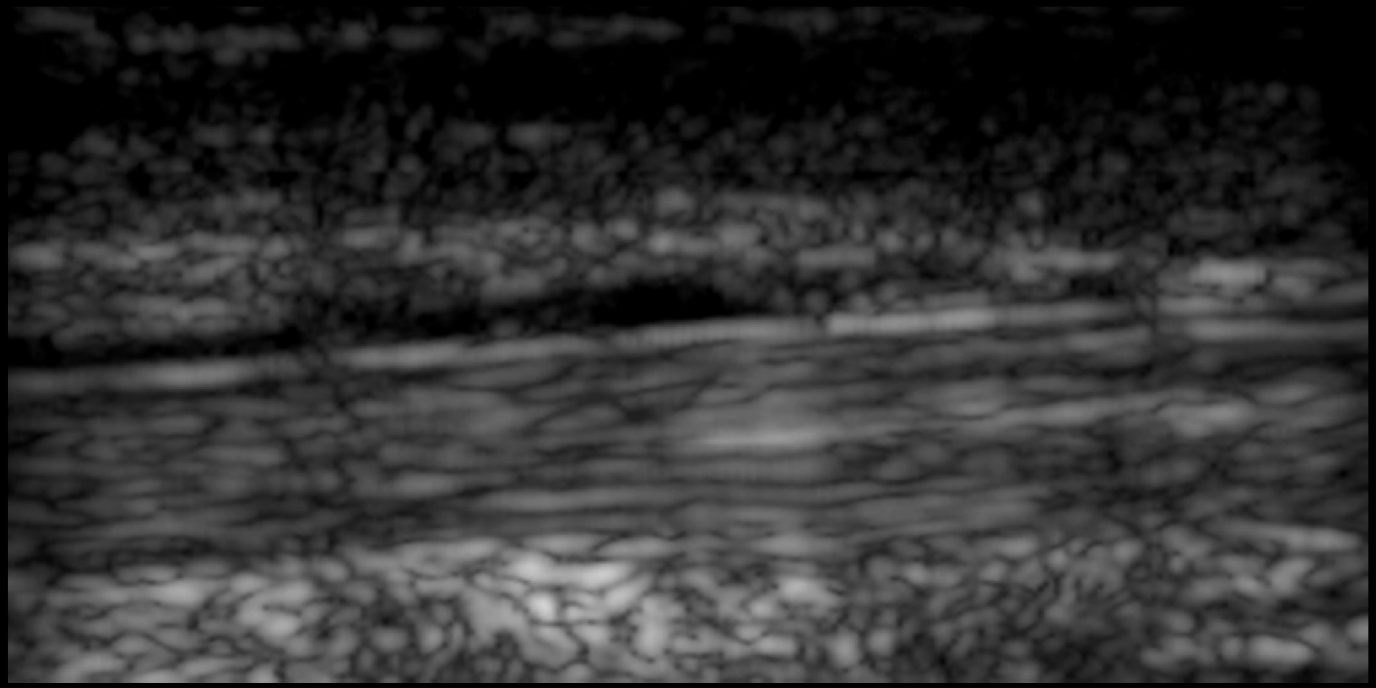
TS: tendon sheath,

S: subcutaneous tissue

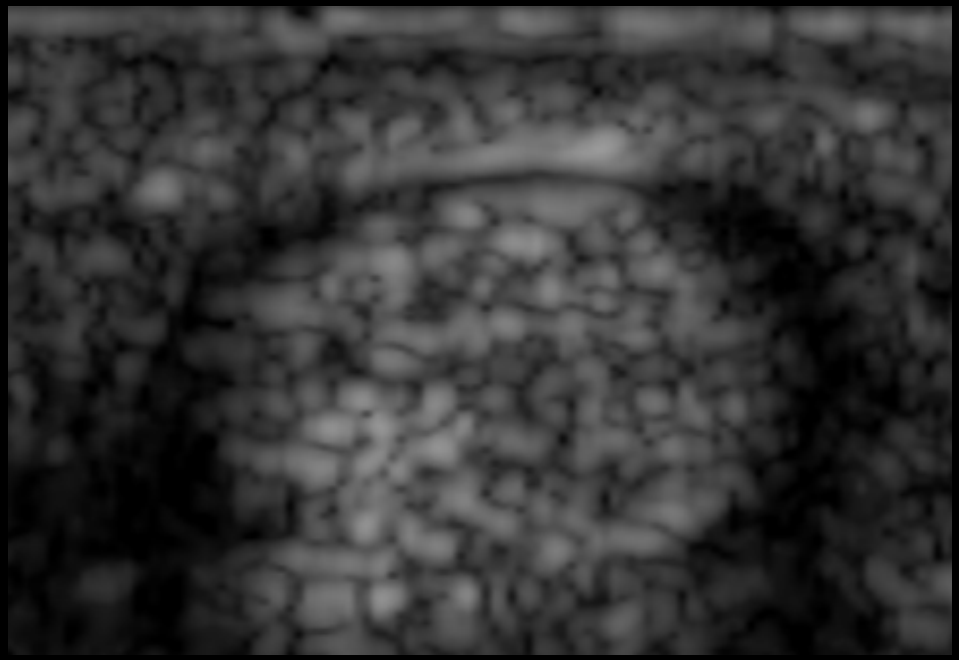




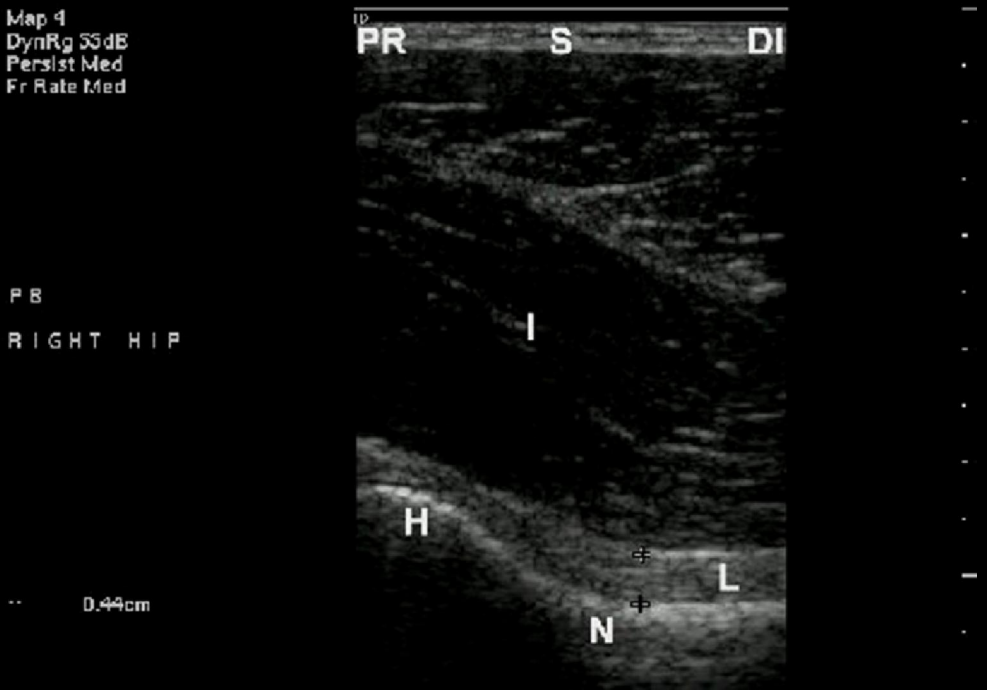
1. In proper anatomical localisation (under the retinaculum, protrusion of the joint capsule) over the tendon anechoic layer sometimes observed.



2. In proper anatomical localisation around the tendon anechoic layer (anechoic ring or halo) sometimes observed.



Ligament


Map 4
DynRg 33dB
Persist Med
Fr Rate Med
PB
RIGHT HIP
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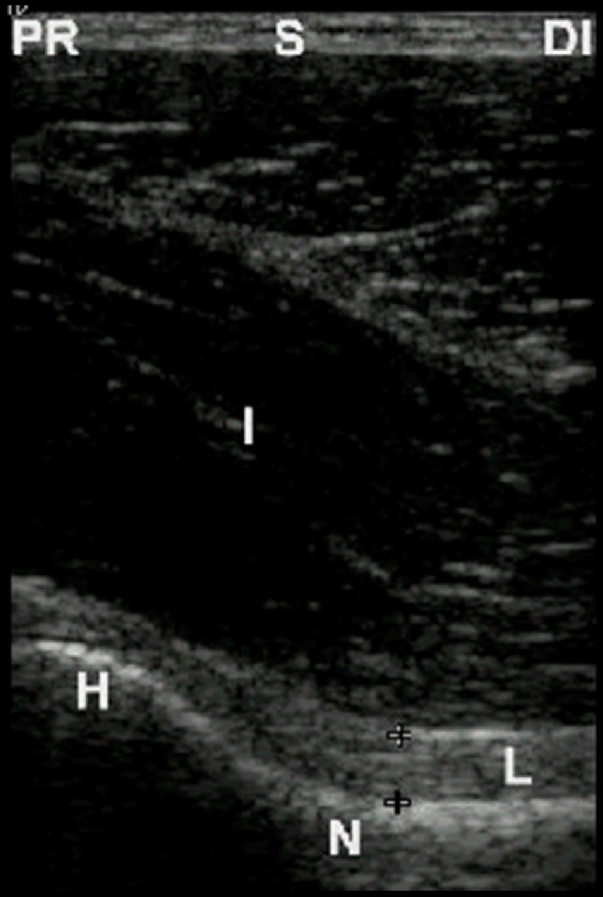
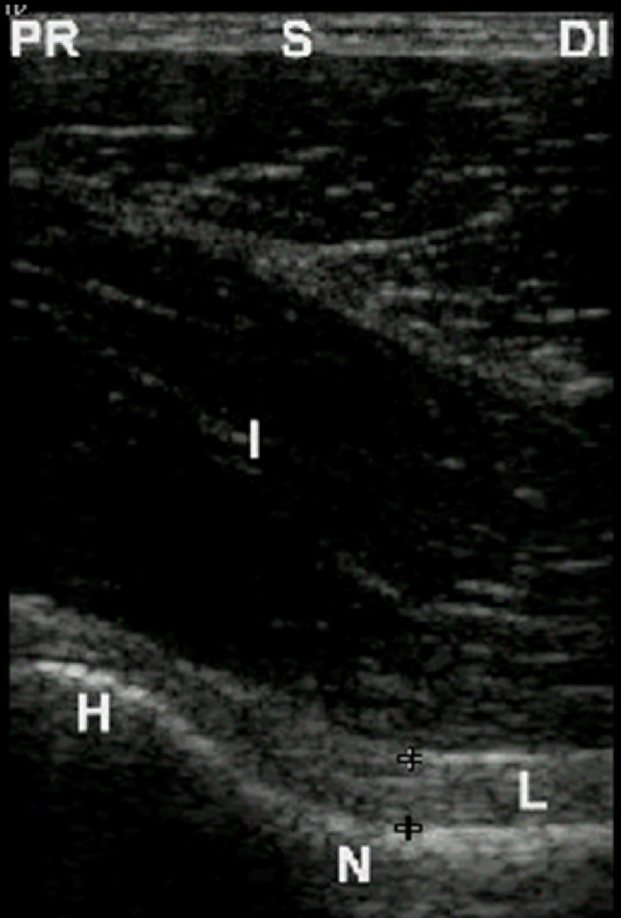
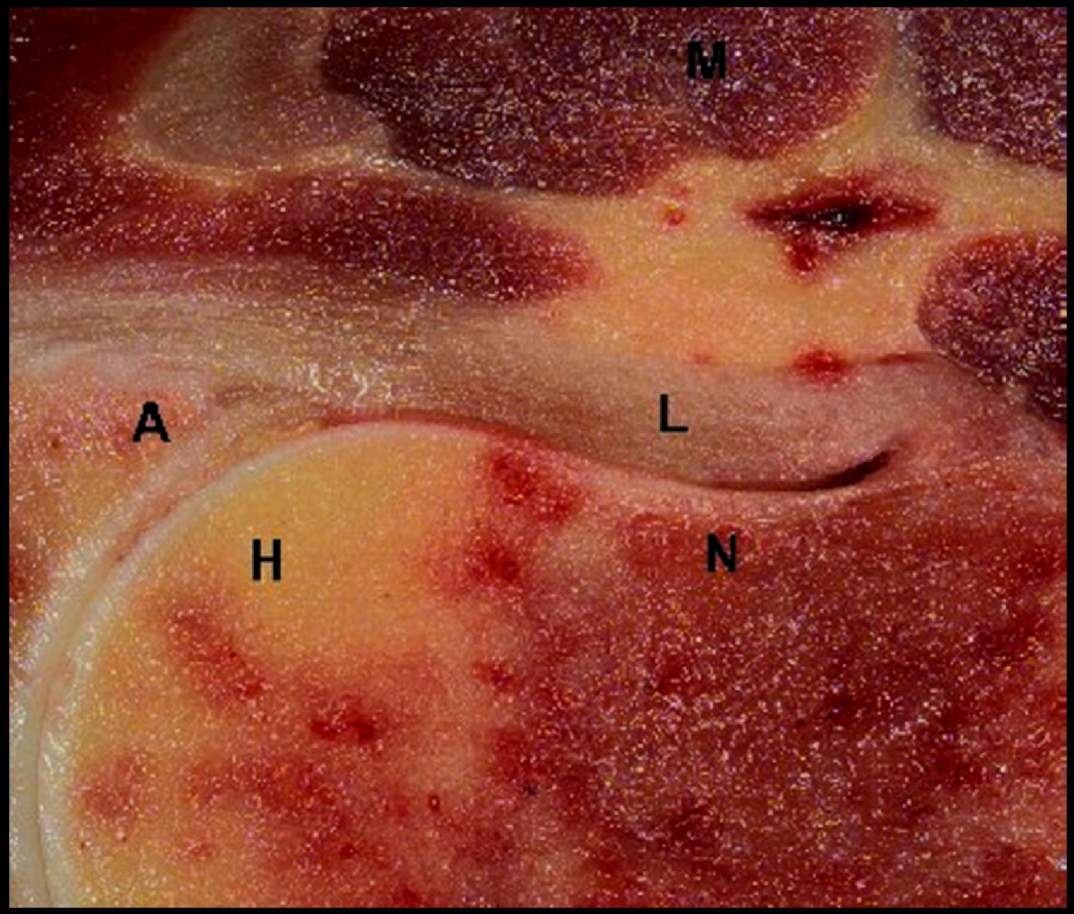
1. Ligaments have a hyperechoic parallel structure, similar to that of tendons.



2. Their structures are less regular with less margin definitions then tendons.

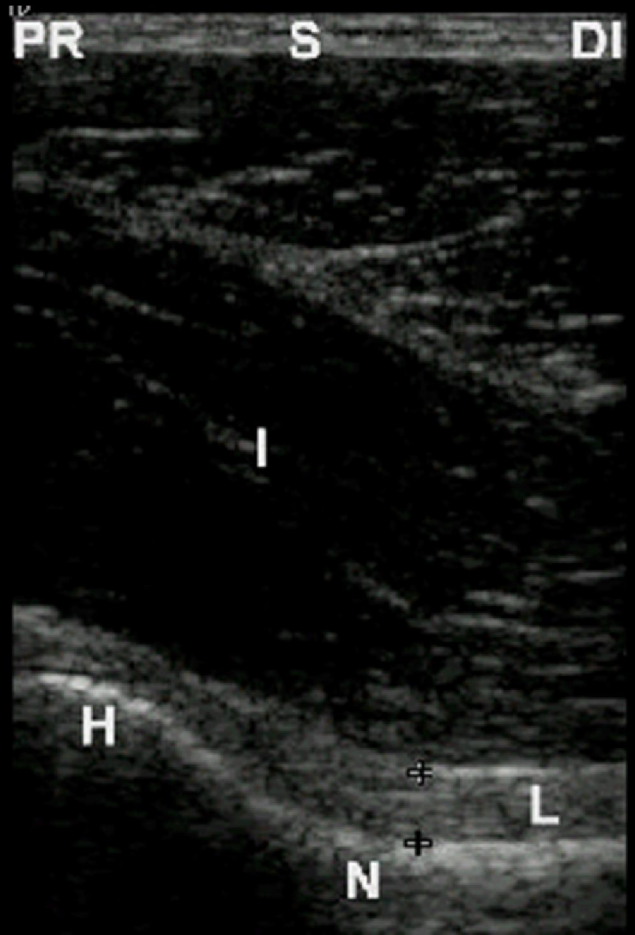
3. They are more flattened then tendons.



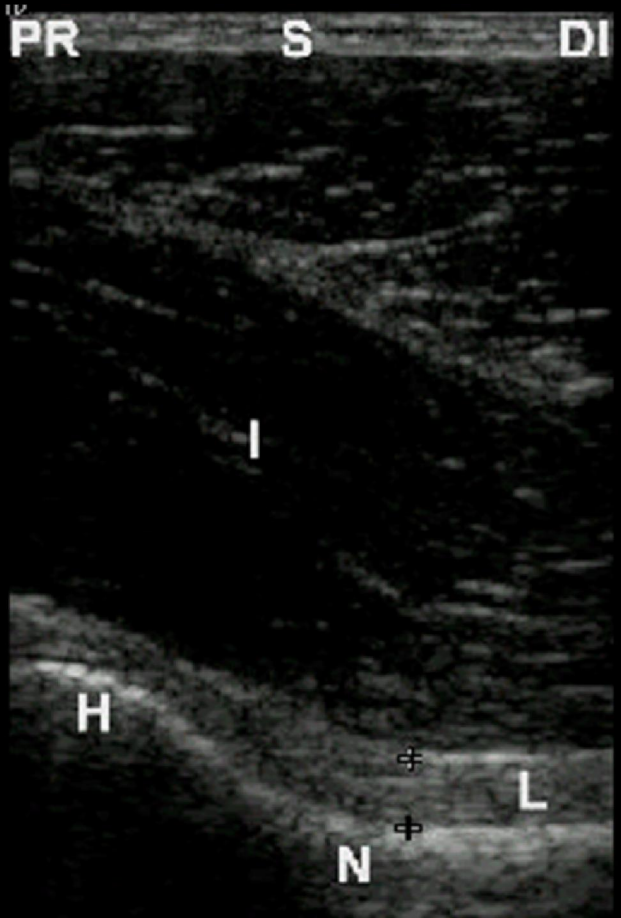


5. No focal hyper-, hypoechoic or anechoic area in the ligament.

6. No discontinuity of the ligament.

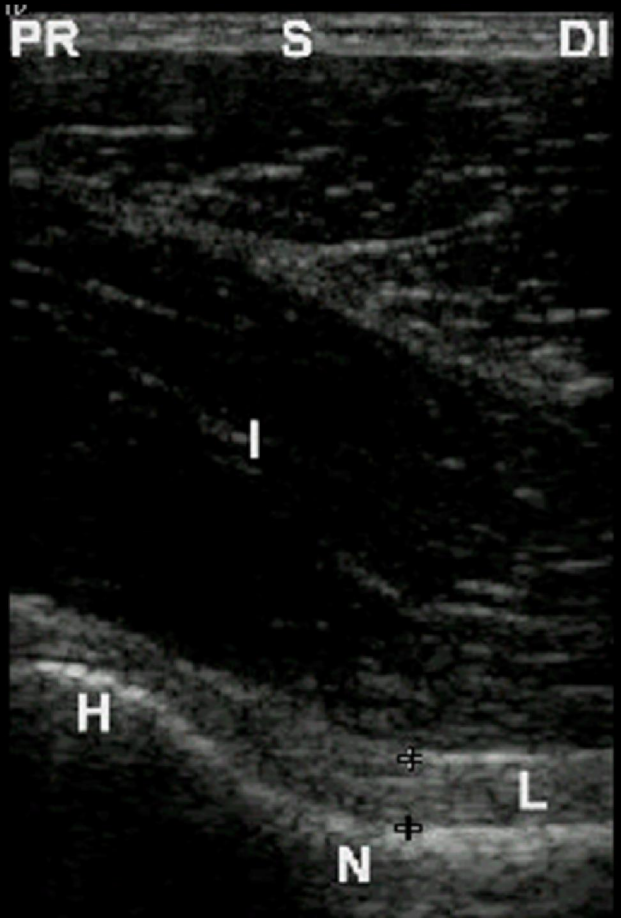


7. Vascularity not detected in the ligament

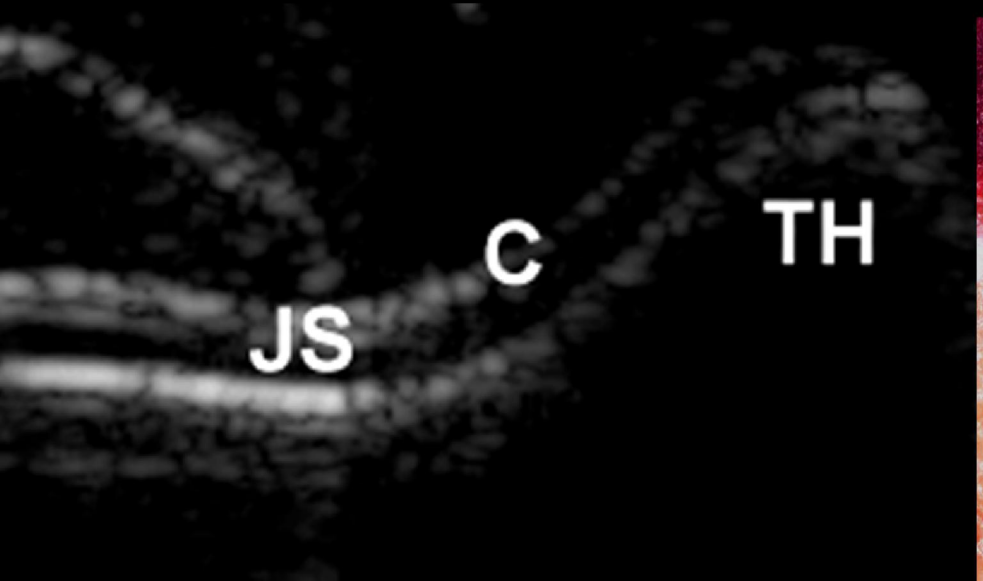


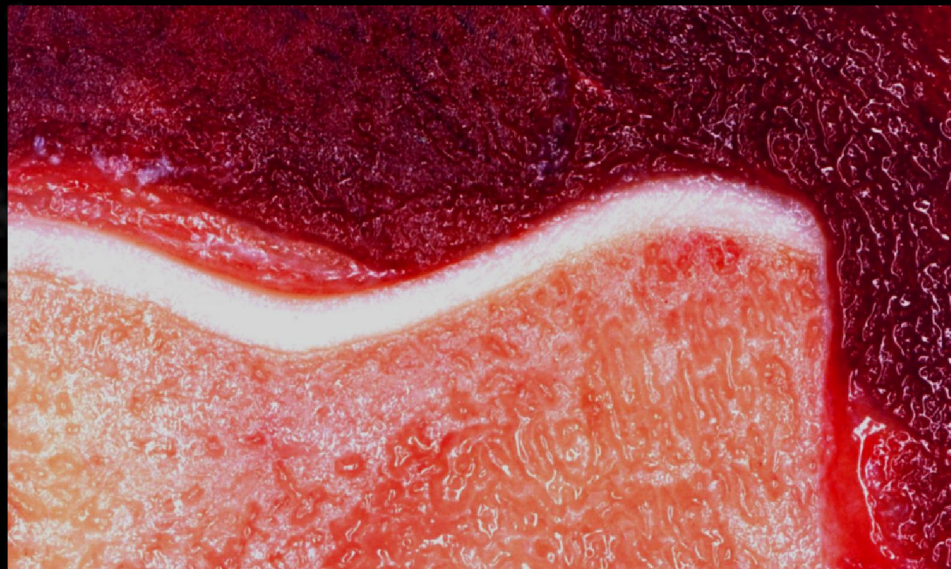
8. Same ligament echostructure on the contralateral side.

9. Detection in proper anatomic position between to bones.

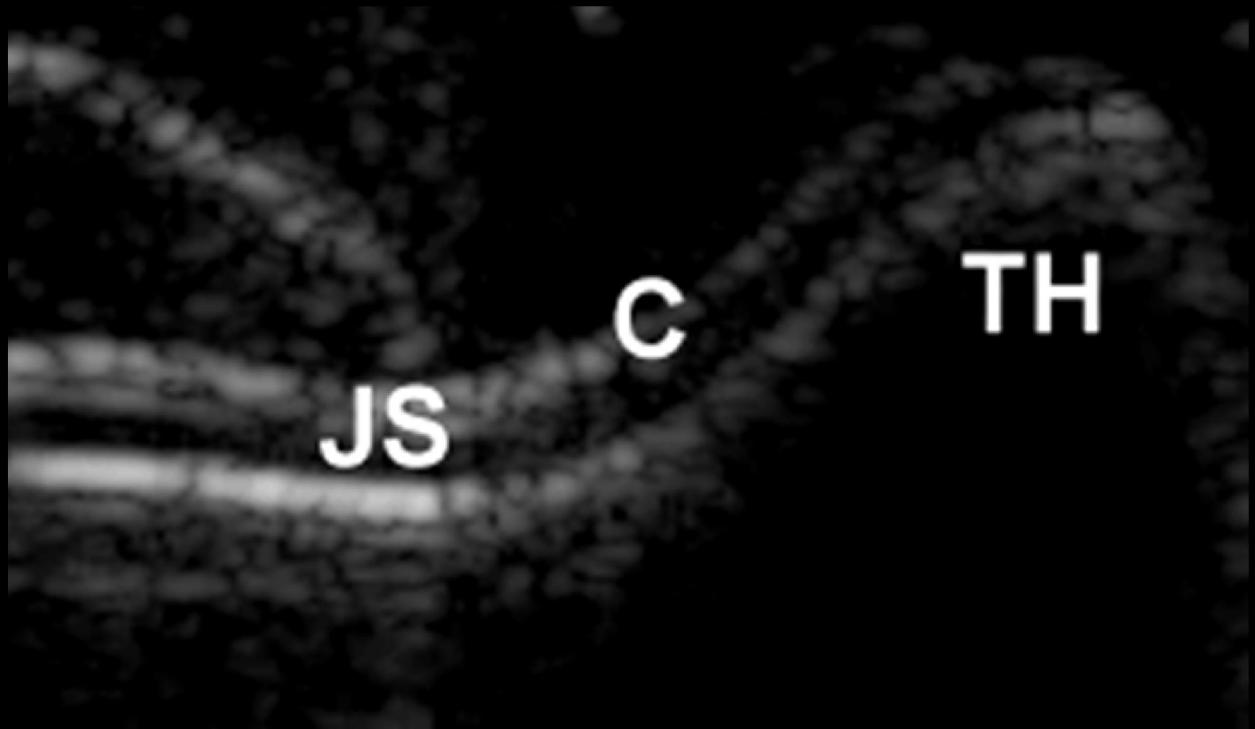


Capsule

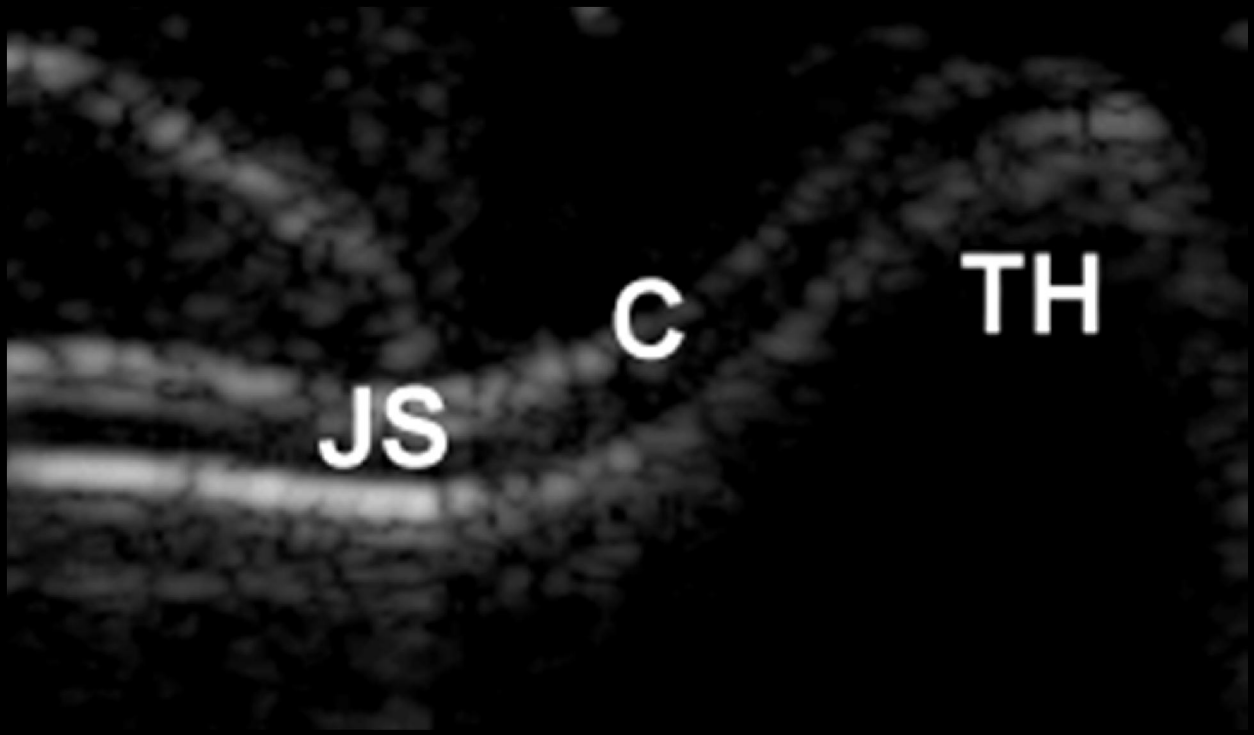




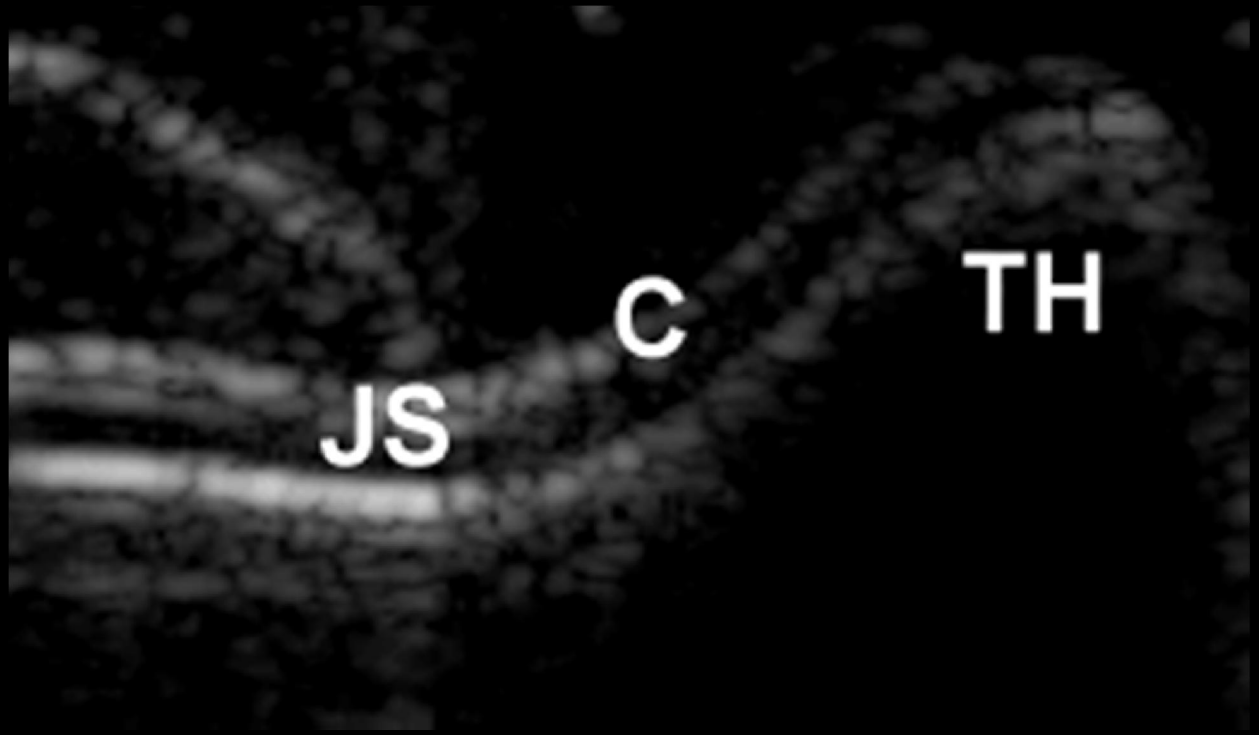
1. Very often runs together with the ligaments and they have a similar echostructure therefore often we cannot differentiate from each other. Over the bones and cartilage, around the joint the first hyperechoic layer is a capsule.



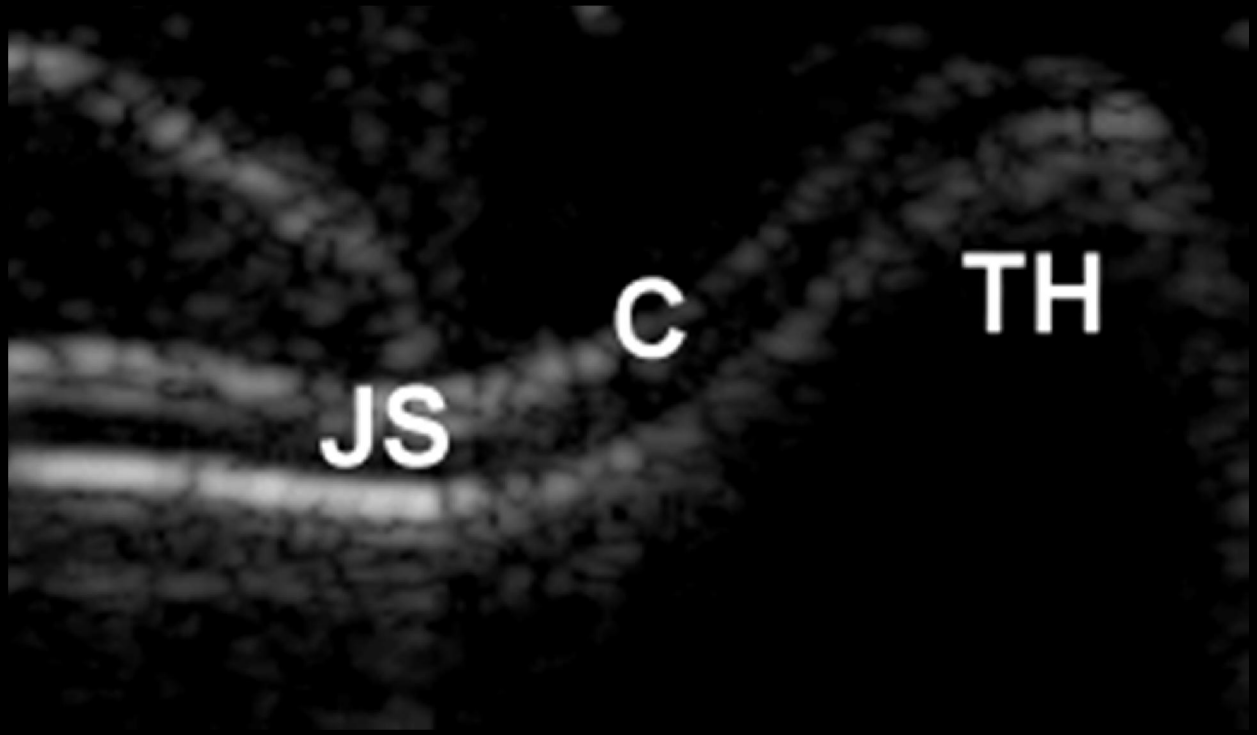
2. Capsular origin and insertion is also important to detect.



3. No sinus or fistula formation.

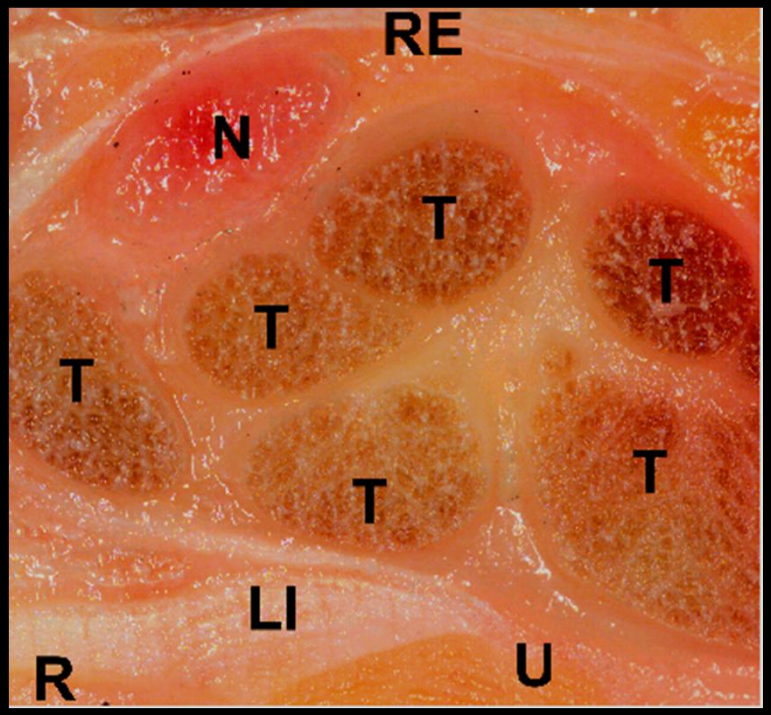


4. The normal synovial membrane is microscopic magnitude and we cannot detected in this time by ordinary ultrasound machines.



Retinaculum

Hyperechoic layer in proper position



RE: flexor retinaculum, N: median nerve, T: tendon, R: radius,

U: ulna, LI: ligament

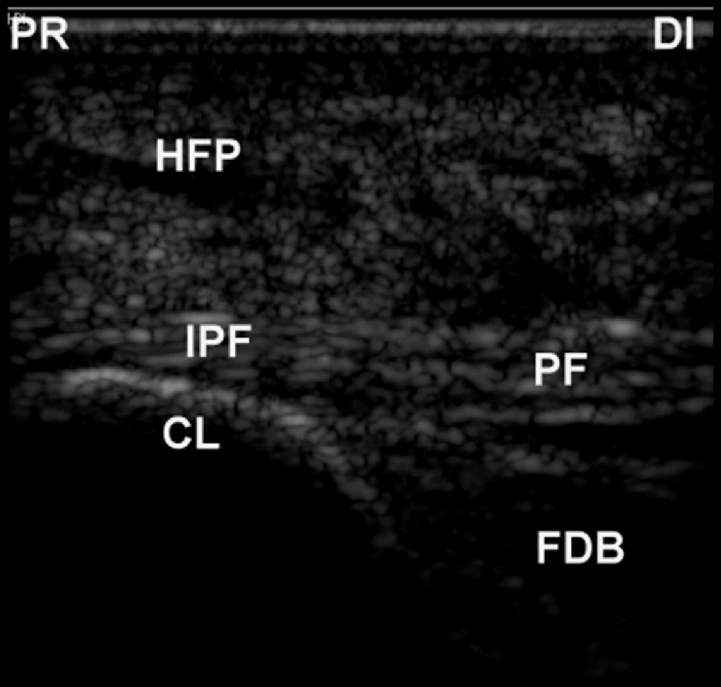
Fascia

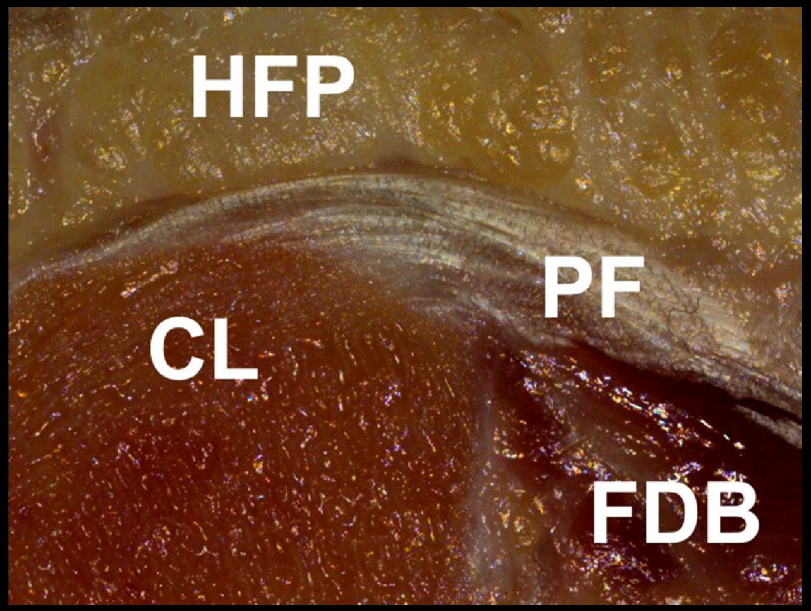
Hyperechoic layer covered the muscle

F: fascia, S: subcutaneous fat, M: muscle

Aponeurosis

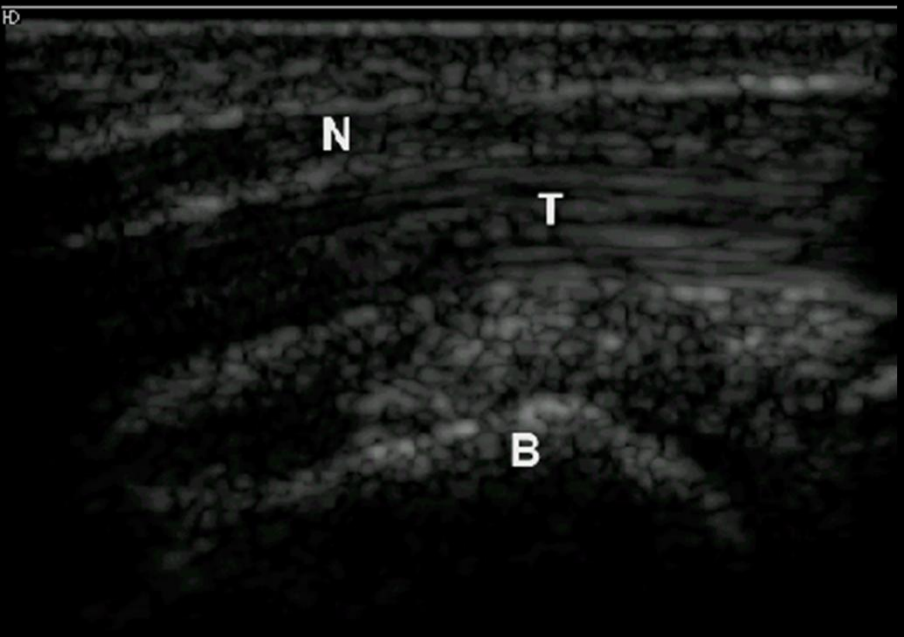
Hyperechoic layers in proper anatomical locations.

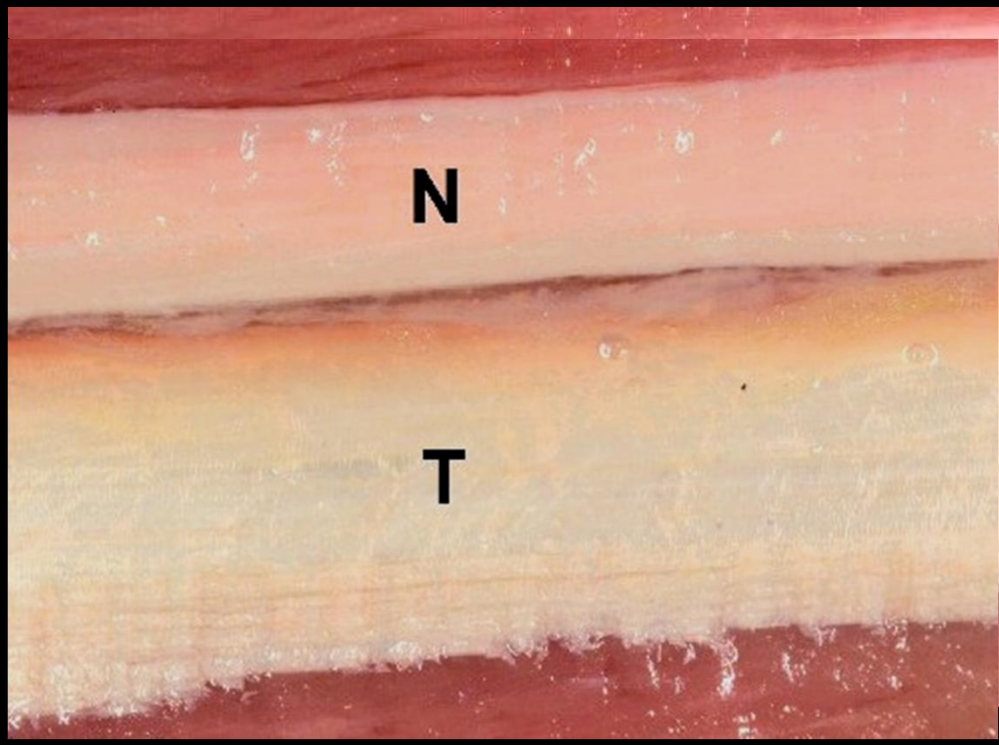




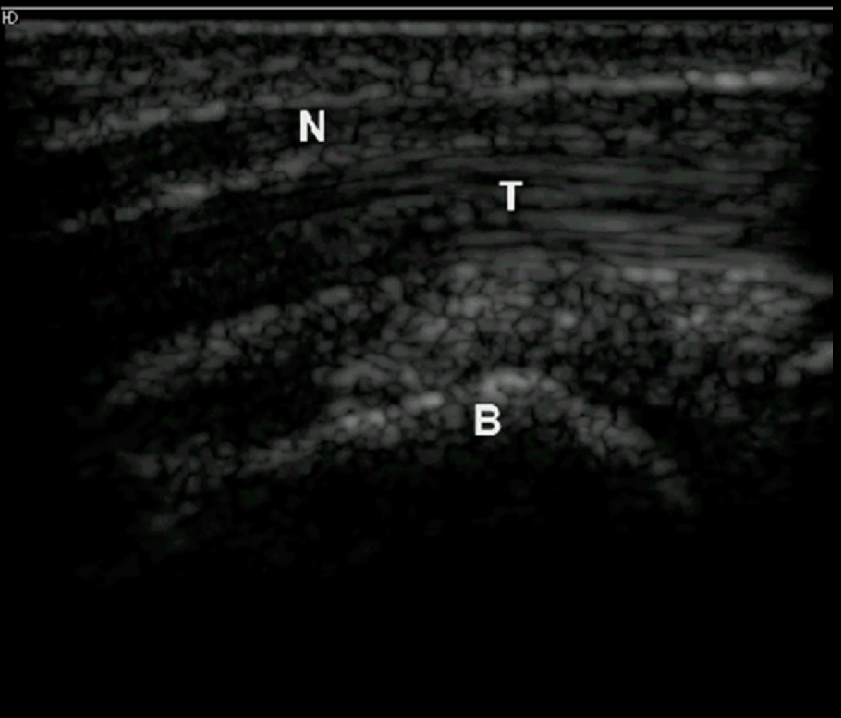
PR: proximal, DI: distal, HFP: heel fat pad, IPF: insertion of the plantar aponeurosis, PF: plantar aponeurosis, CL: calcaneus, FDB: flexor digitorum brevis muscle

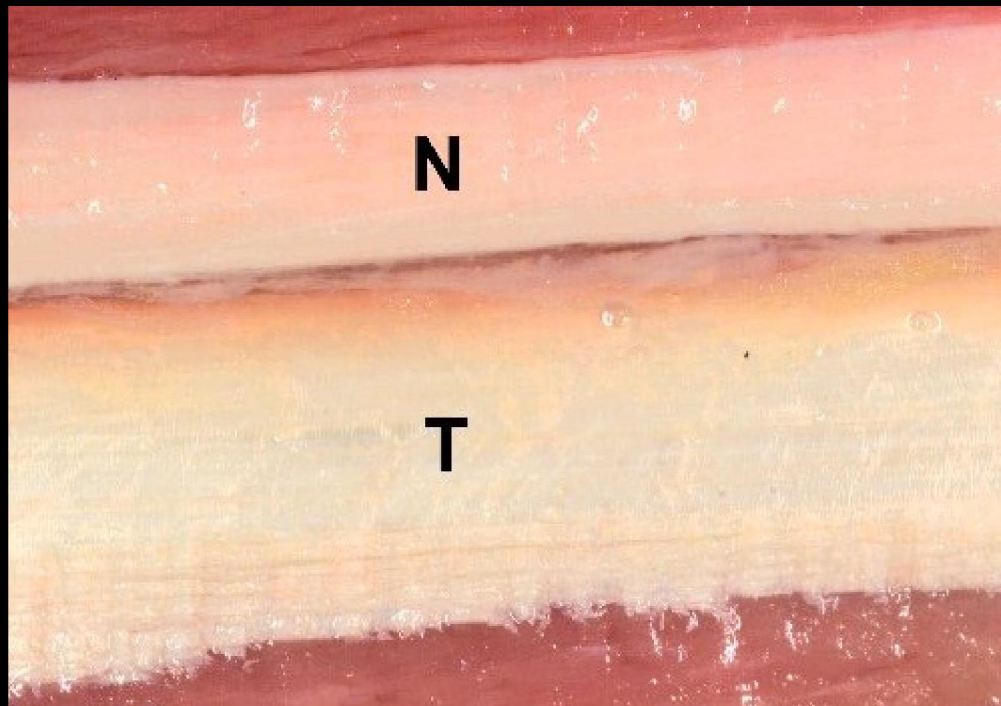
Nerve (longitudinal)



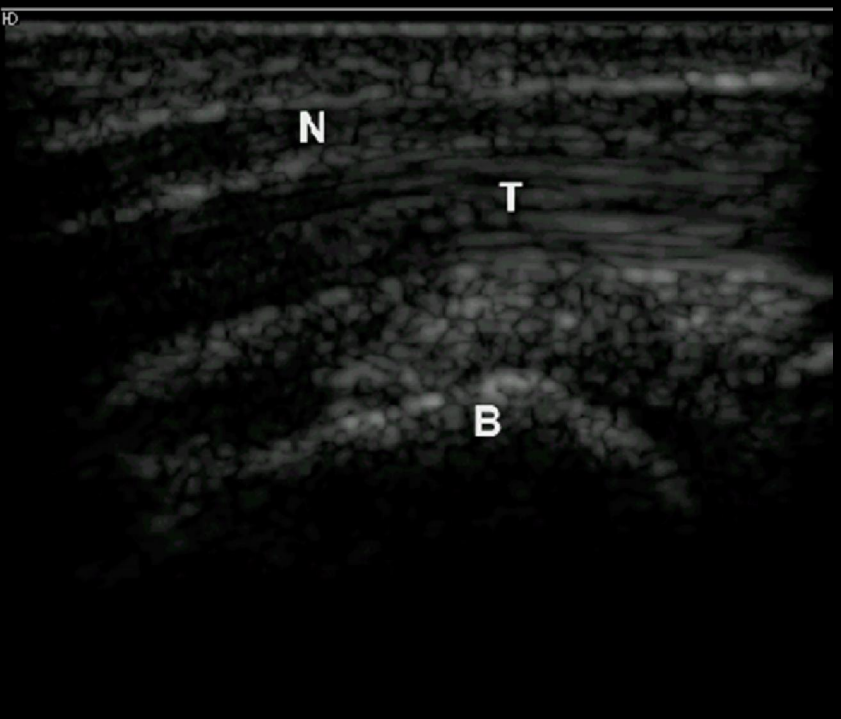


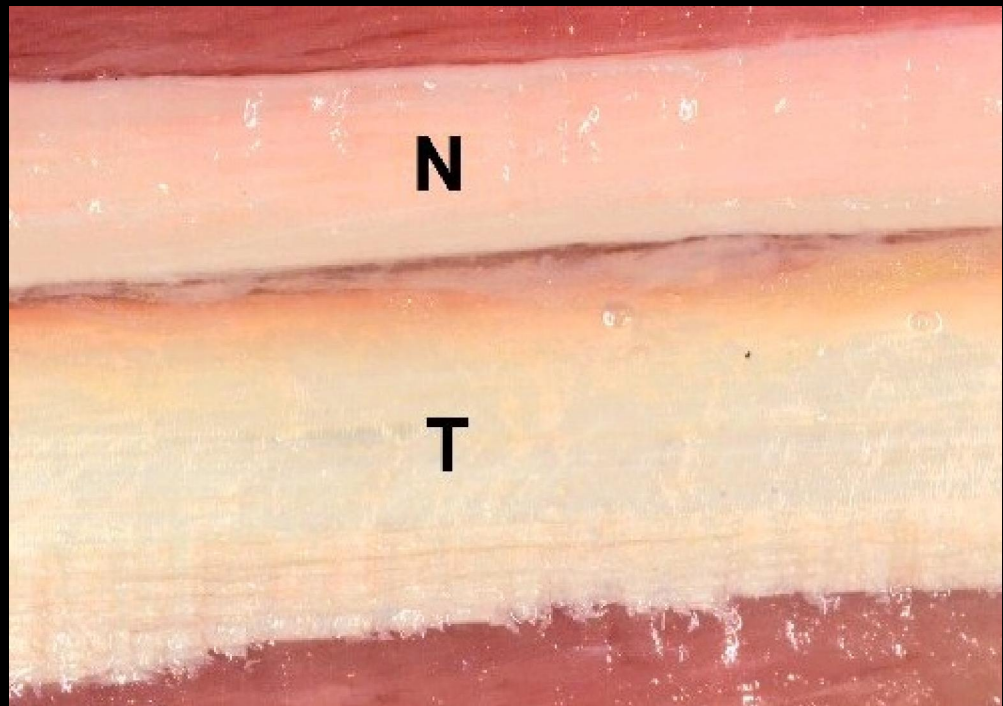
1. Hypoechoic fascicular pattern.
2. Parallel hyperechoic margin corresponding with the epineurum.





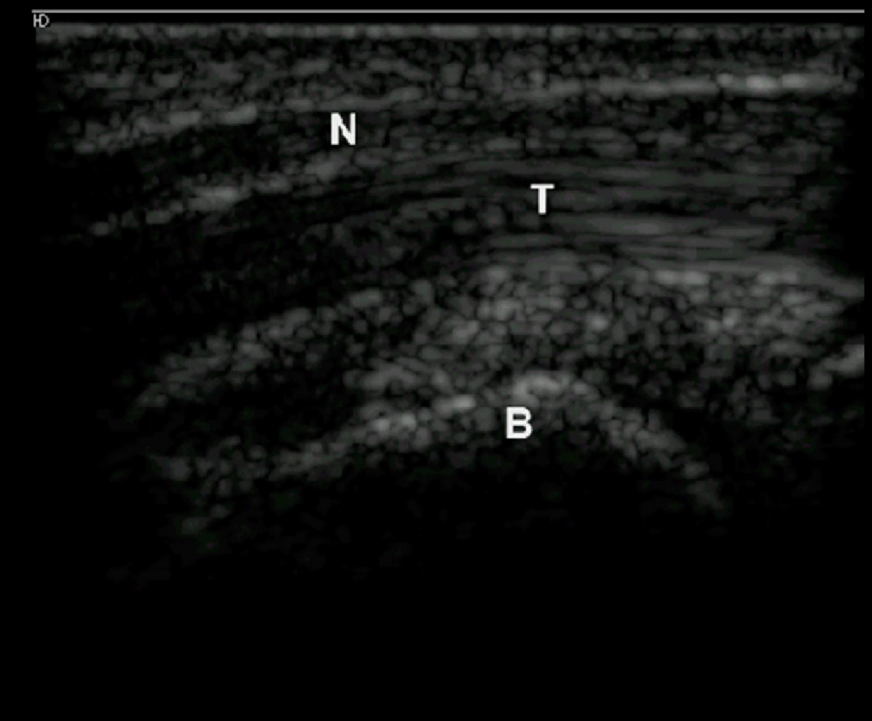
3. No focal hyperechoic or anechoic area in the nerve.
4. No marginal irregularity.

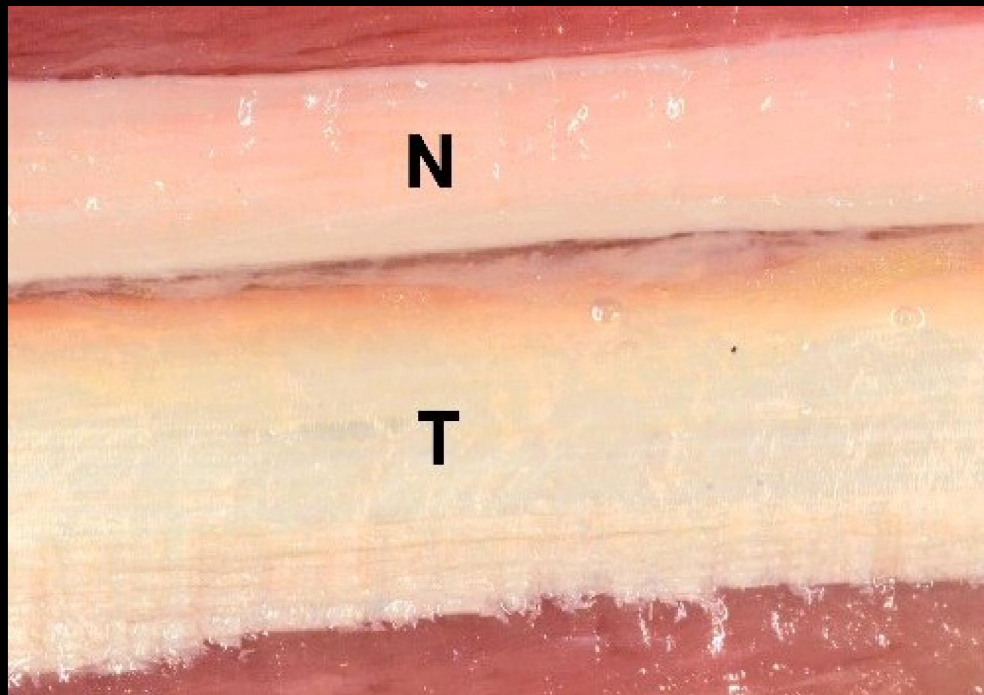




6. No focal flattening or enlargement of the diameter.

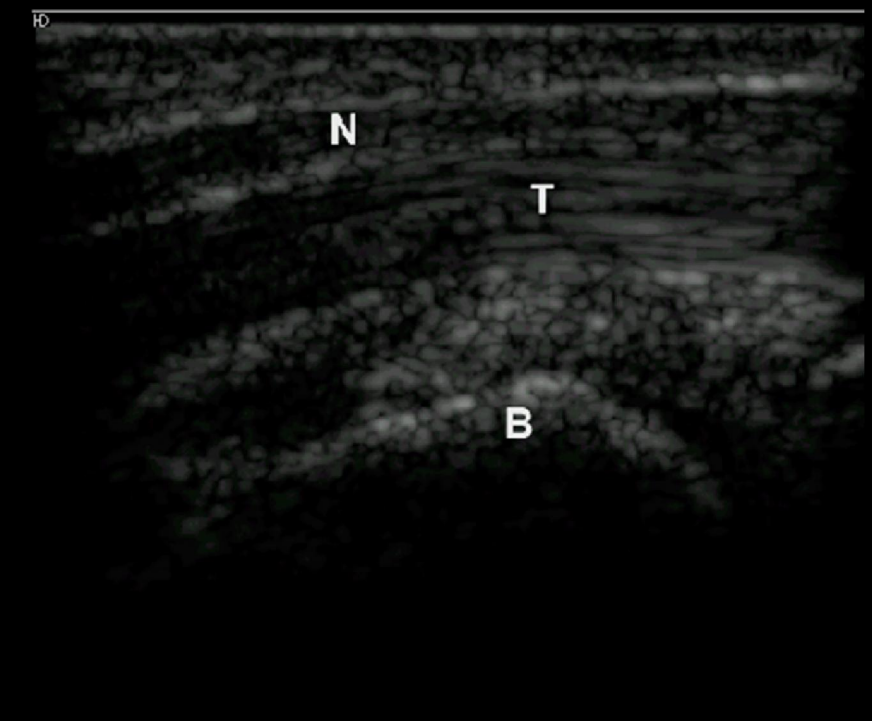
7. Vascularity not detected in the nerve.

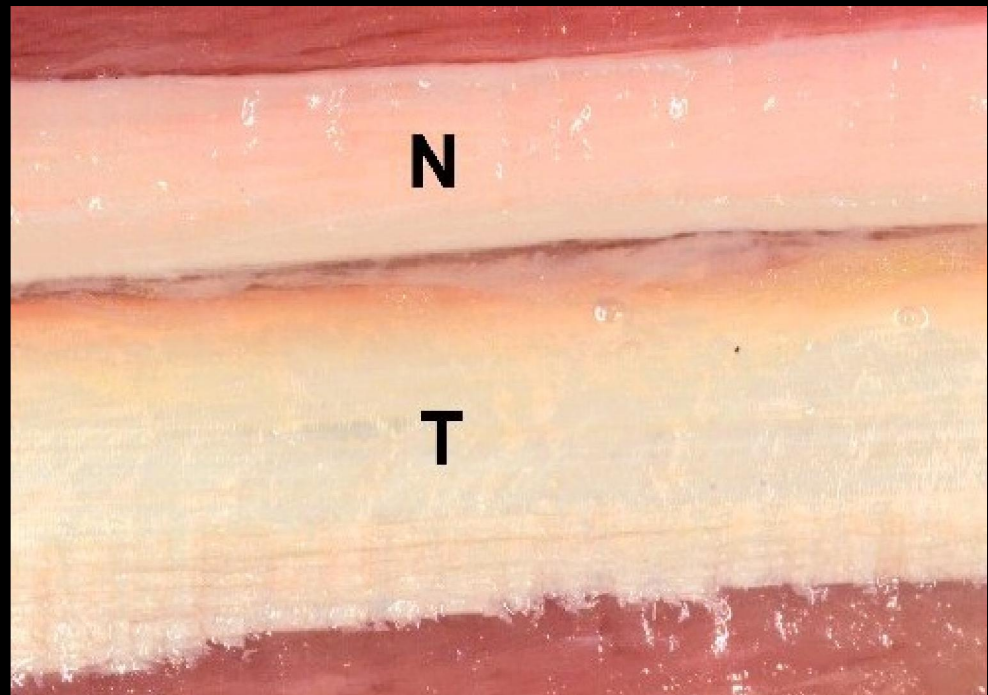




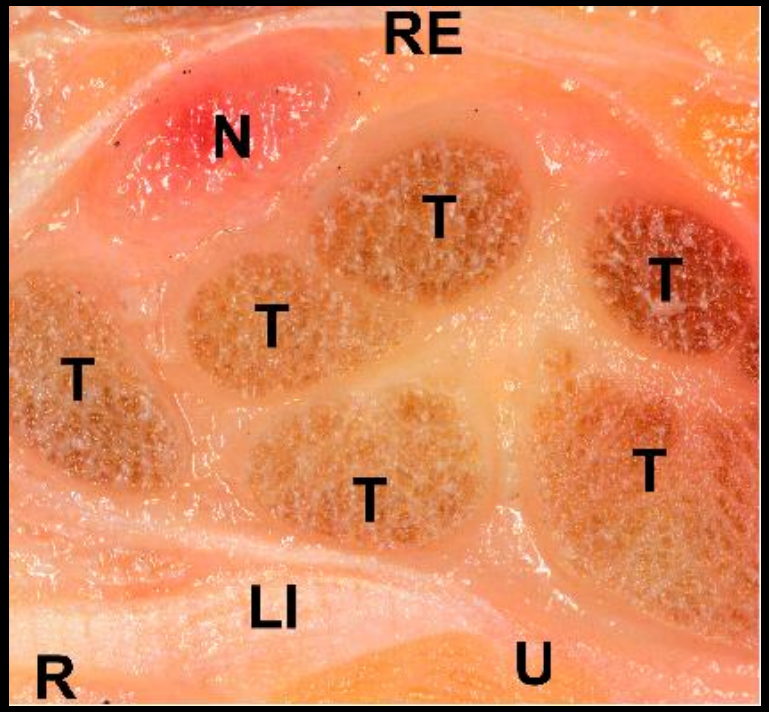
8. Same echostructure and size on the contralateral side.

9. Detection in proper anatomic position.

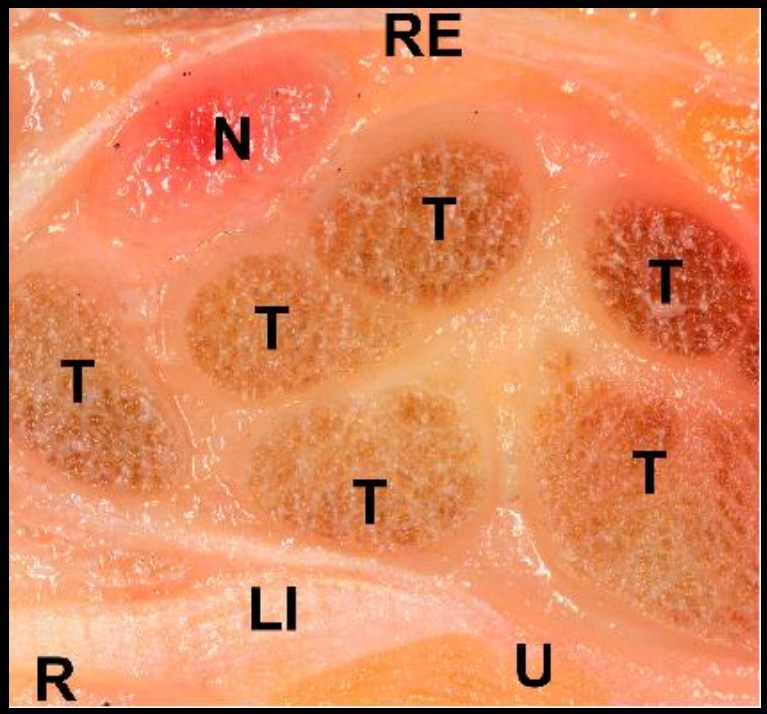




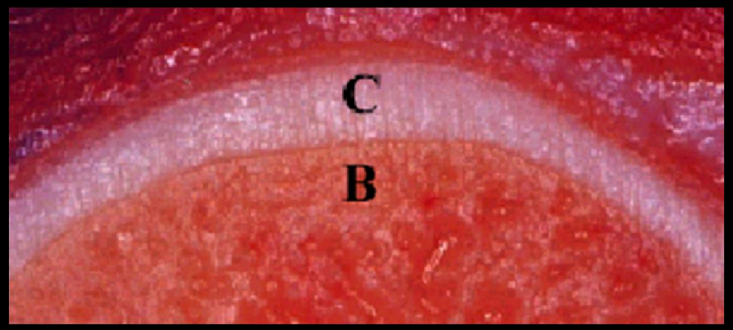
Nerve (transverse)

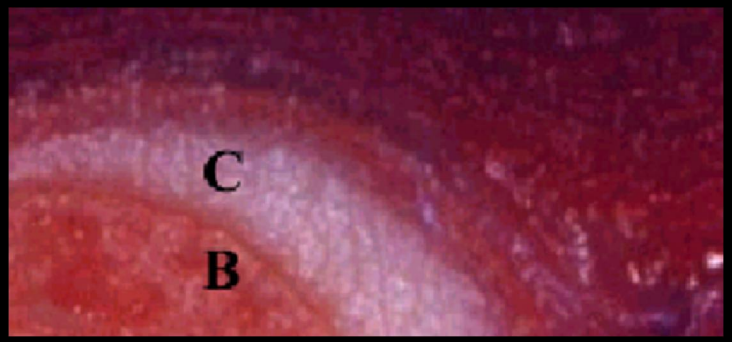


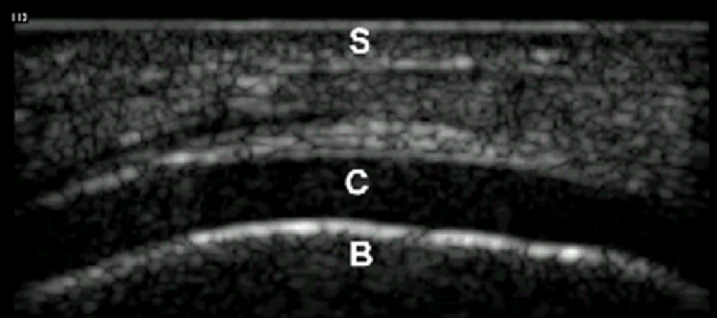
1. Speckled ovoid or rounded appearance.

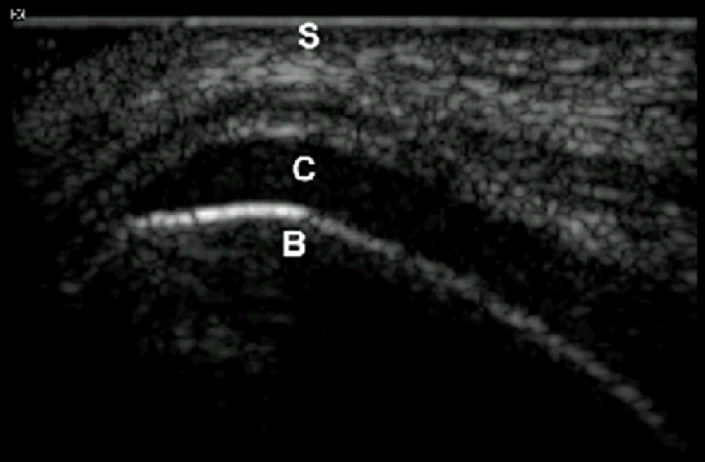


Hyaline cartilage



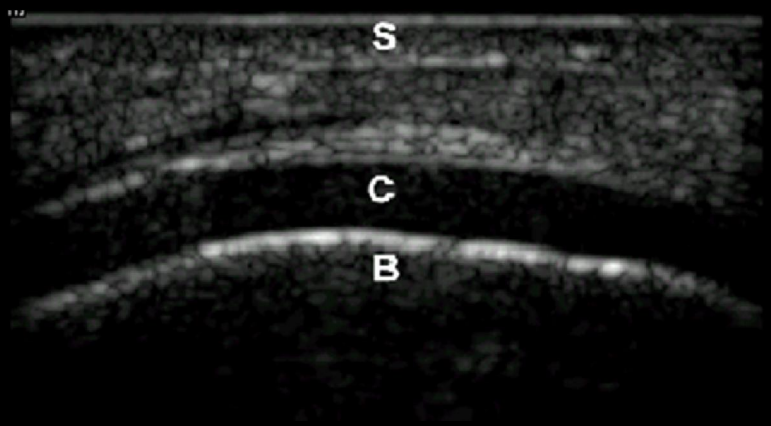


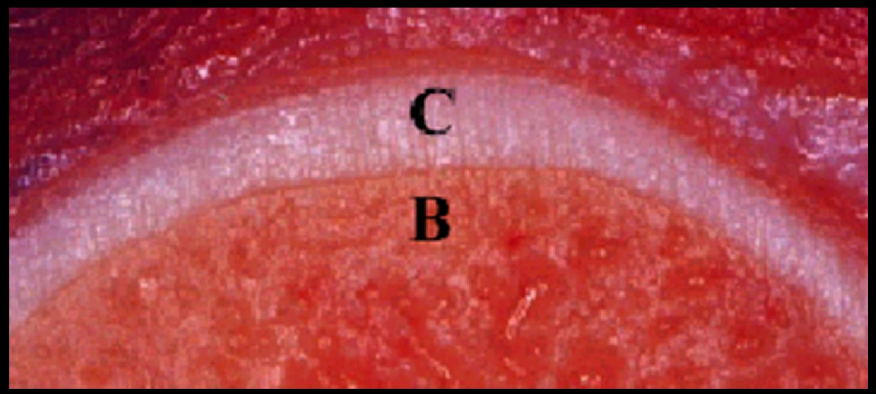




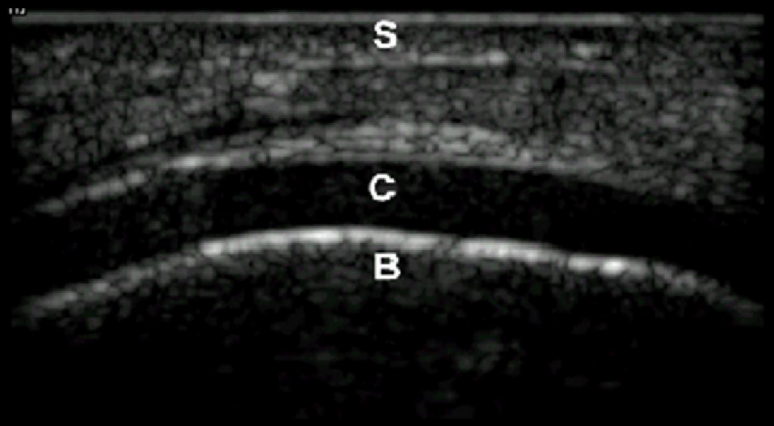
C: hyaline cartilage, B: bone, S: skin

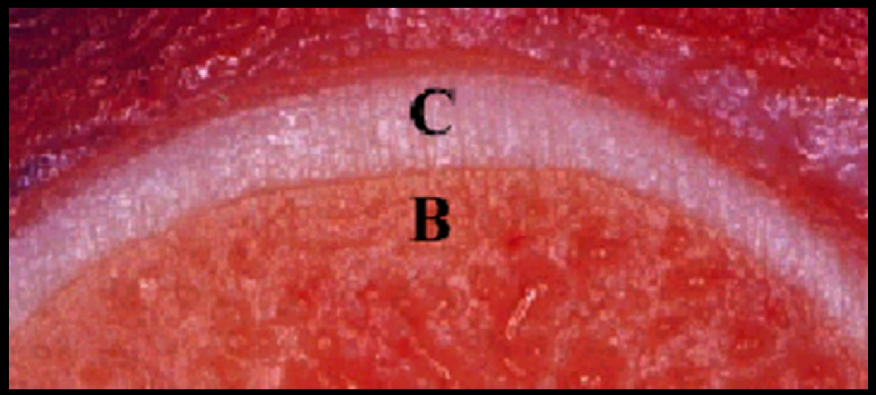
1. A homogeneous anechoic or hypoechoic layer covering the articular bone surface.
2. It is not possible to detect the whole convex articular surface.





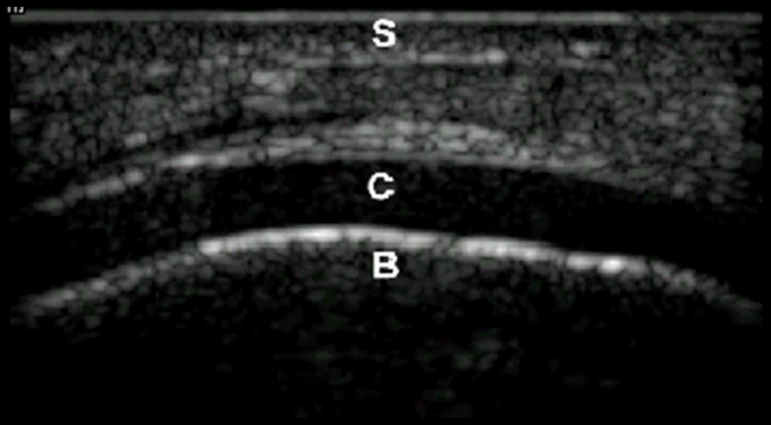
3. Echogenicity increases with age and thickness decreases with age (but different bones are covered with different thickness of cartilage).

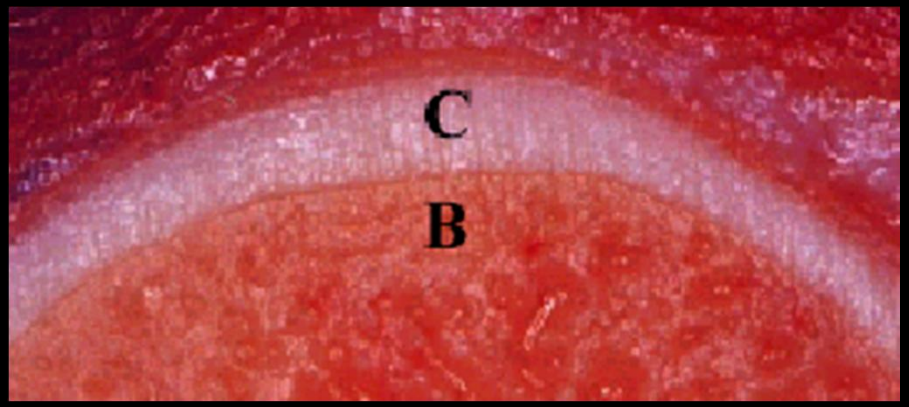




4. No marginal irregularity, sharp margin at both the articular and bone surfaces.

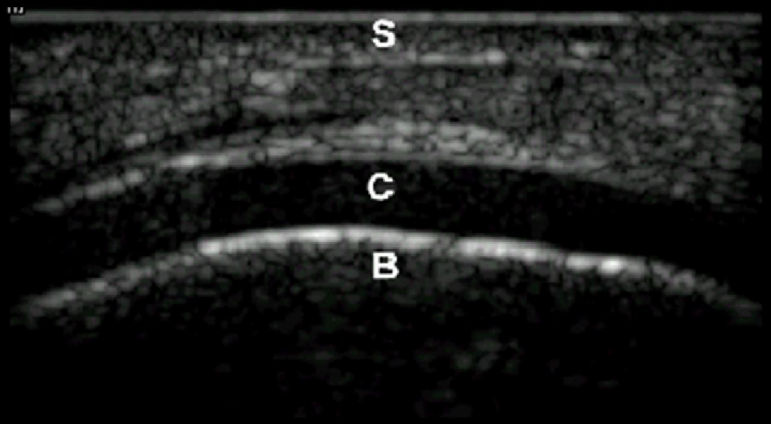
5. No focal internal echo sign. No vasularity.

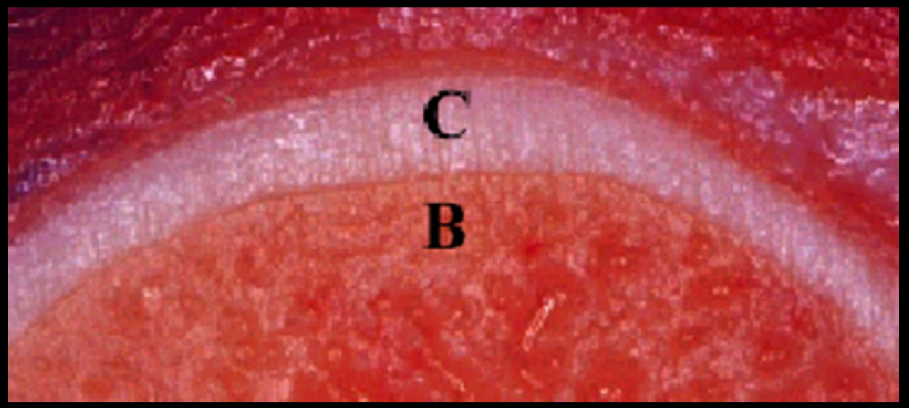




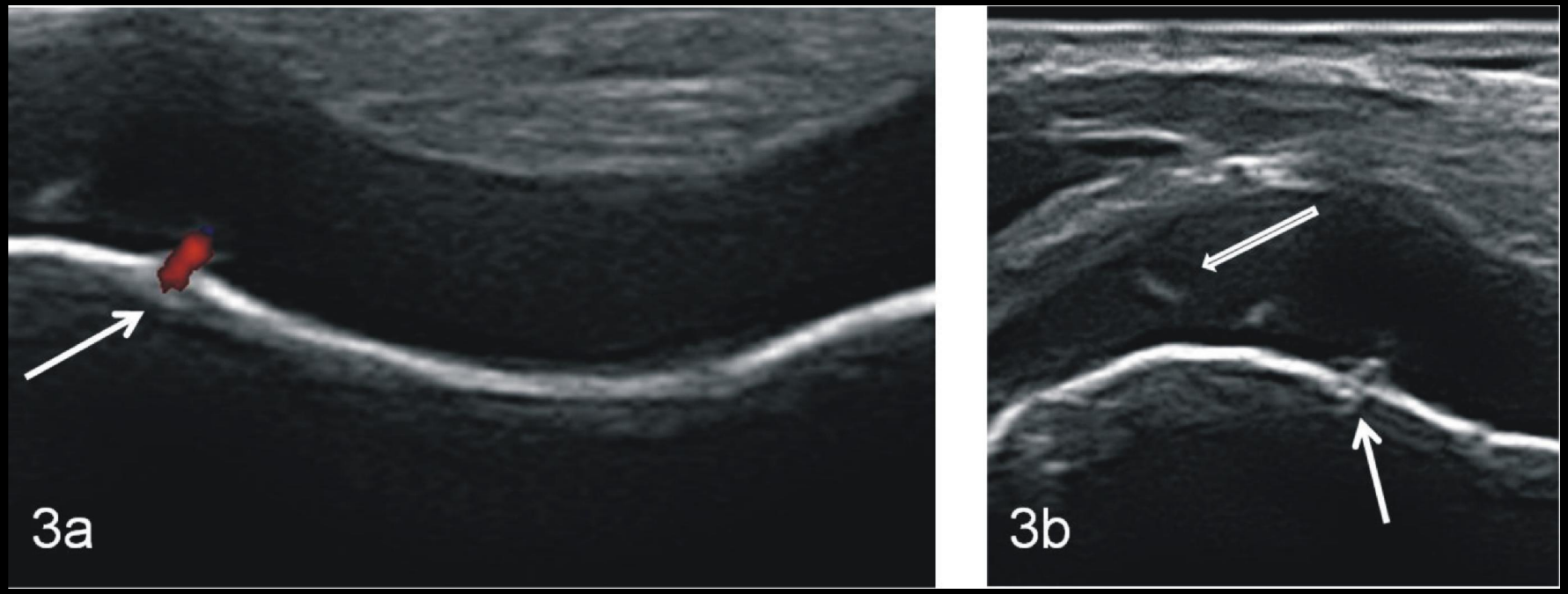
6. The same cartilage echostructure and thickness on the contralateral side.

7. The thickest part of the cartilage is centrally over the convex bone surface and the thickness decreases continuously towards the margin.



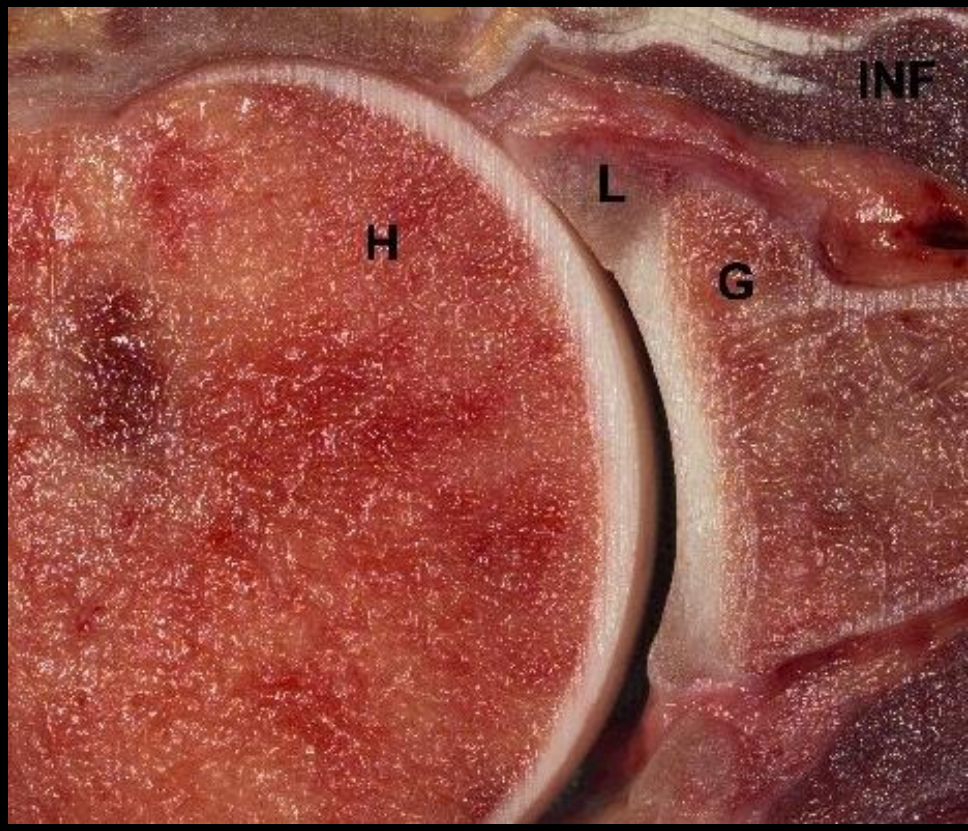


Ultrasound image of the hyaline cartilage of the femoral condyle in a 6-year-old girl.



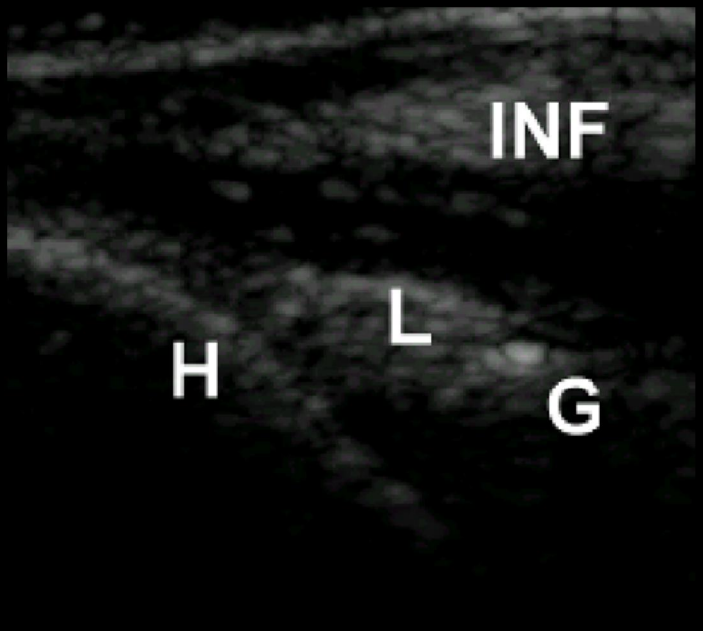
Mandl P, Benis S, Patonay L, Balint PV· The normal joint in eds. Maria Antonietta D'Agostino, Richard Wakefield Essential Applications of Ultrasound in Rheumatology, Elsevier

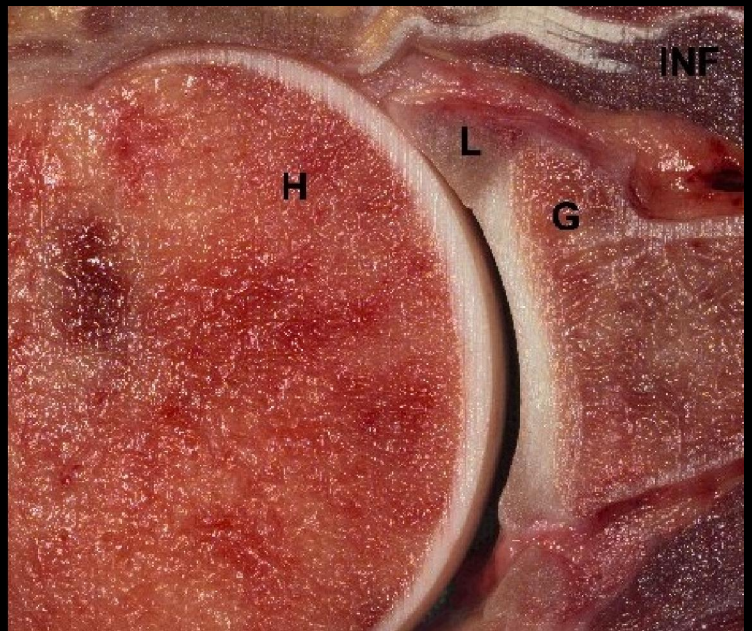
Fibrocartilage



H: humeral head, G: glenoid, INF: infraspinatus muscle, L: labrum

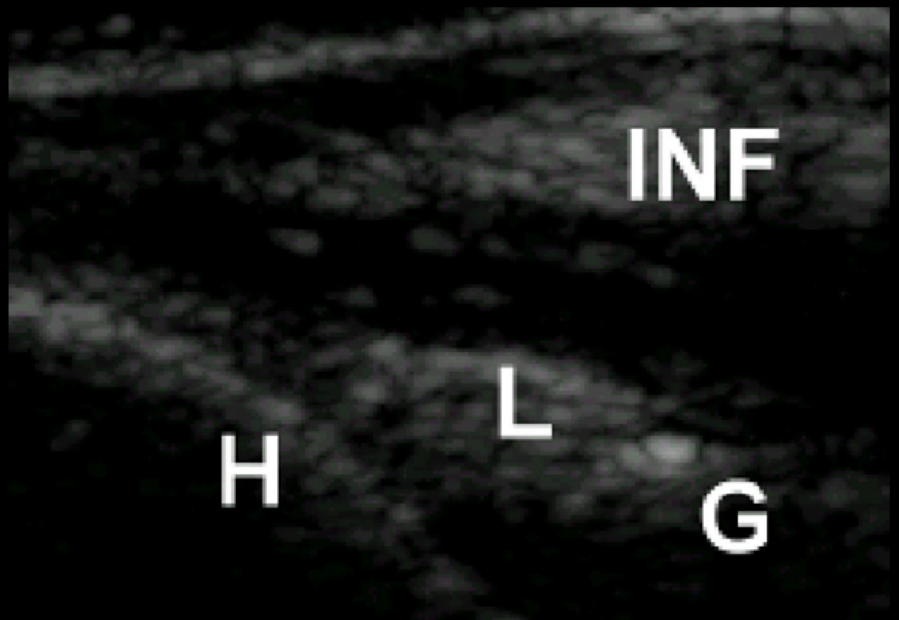
1. Homogenous hyperechoic structure in proper anatomical position, but some labra may be absent.
2. The shape is usually triangular or wedge shape.

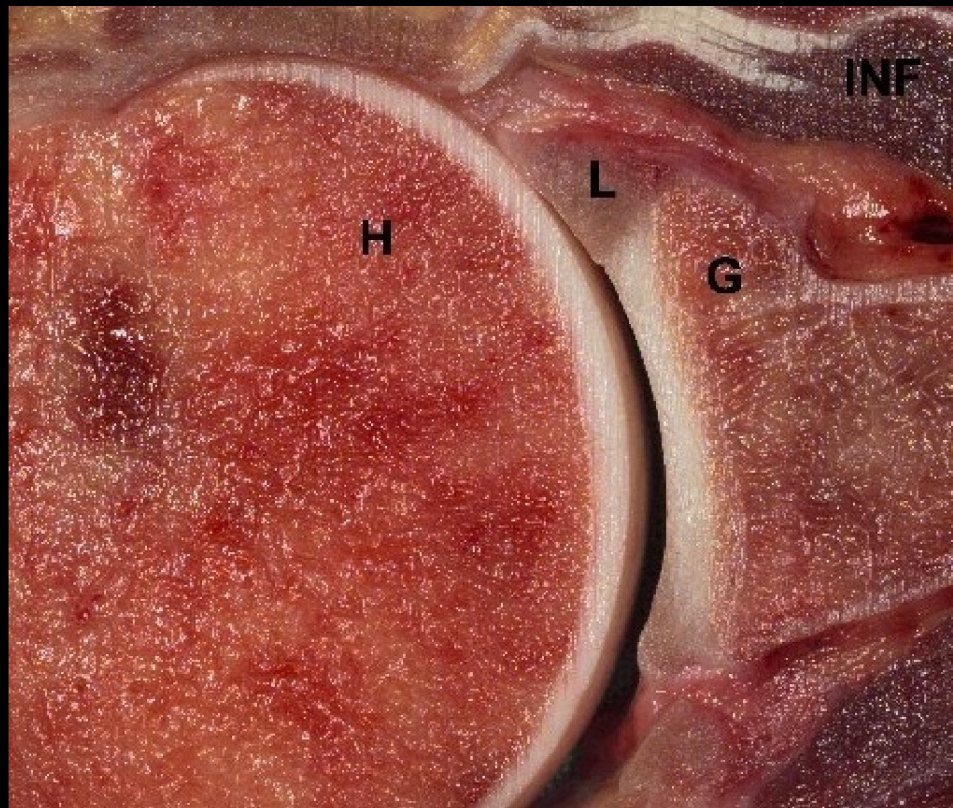




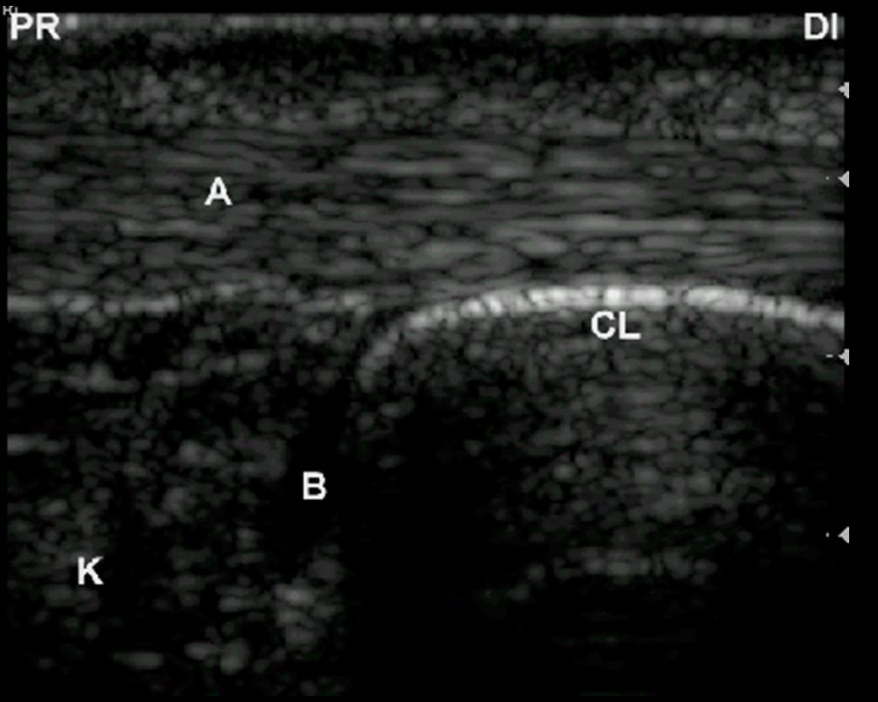
3. No vascularity.

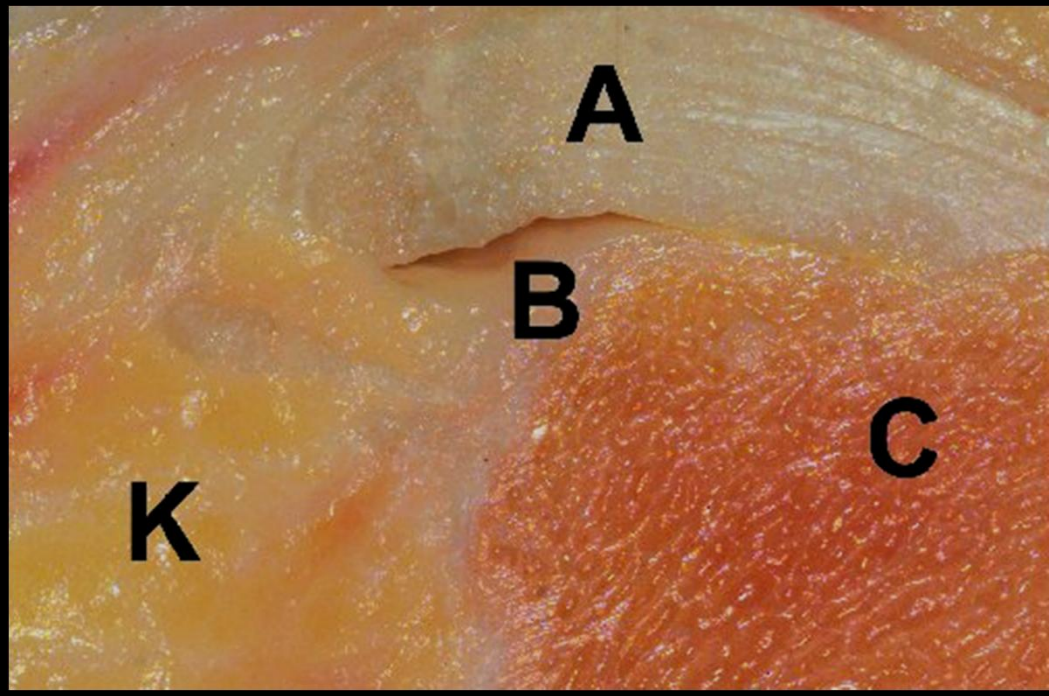
4. Normal labra do not contain anechoic areas.





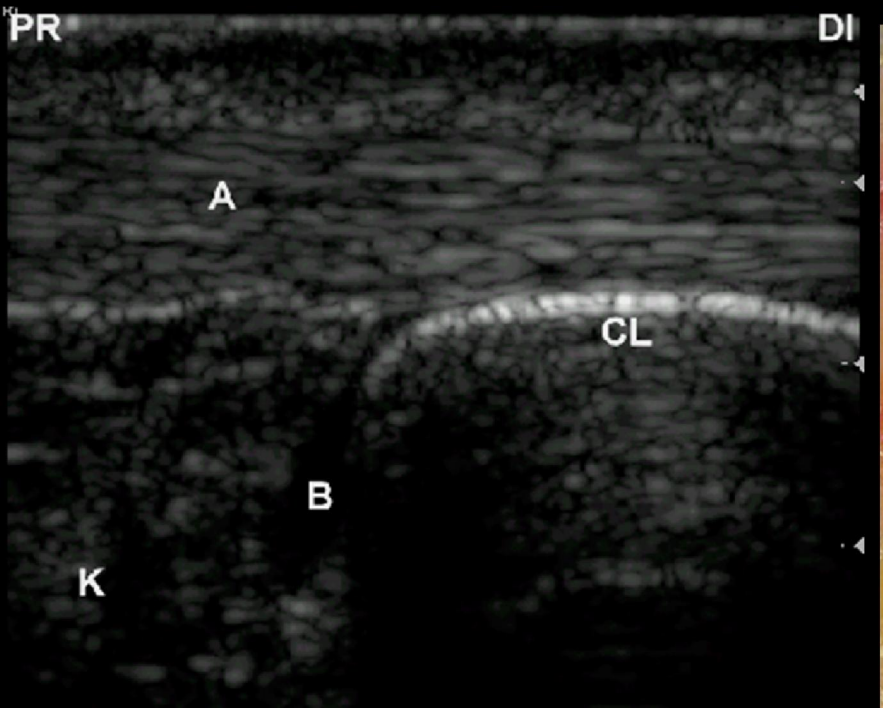
Bursa

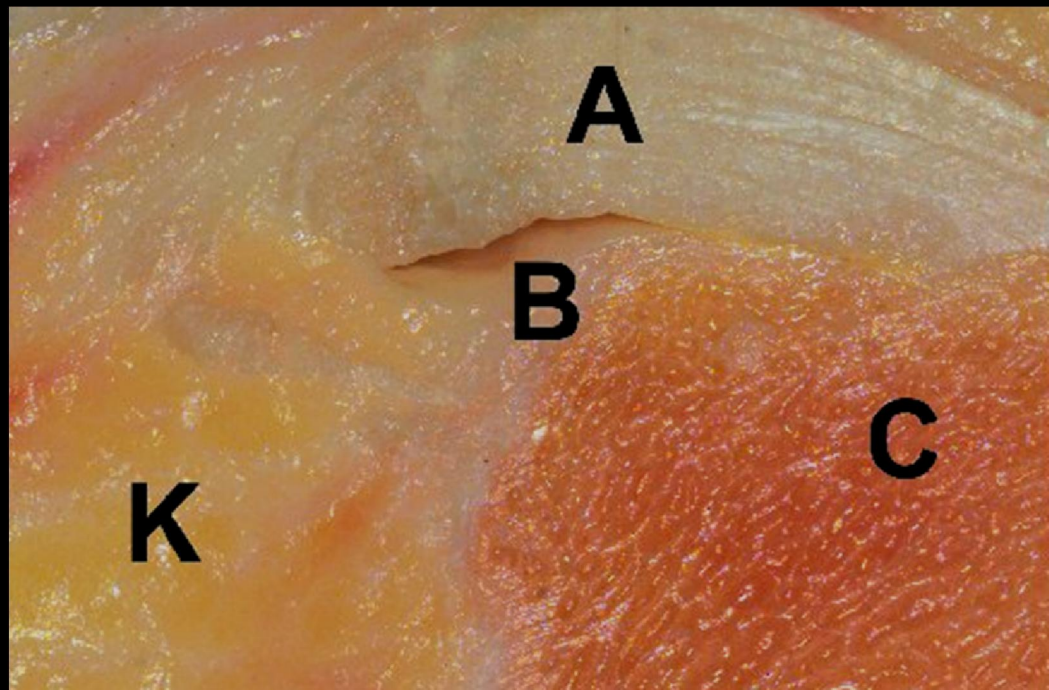




PR: proximal, DI: distal, A: Achilles tendon, B: retrocalcaneal bursa, C and CL: calcaneus, K: Kager's fat pad

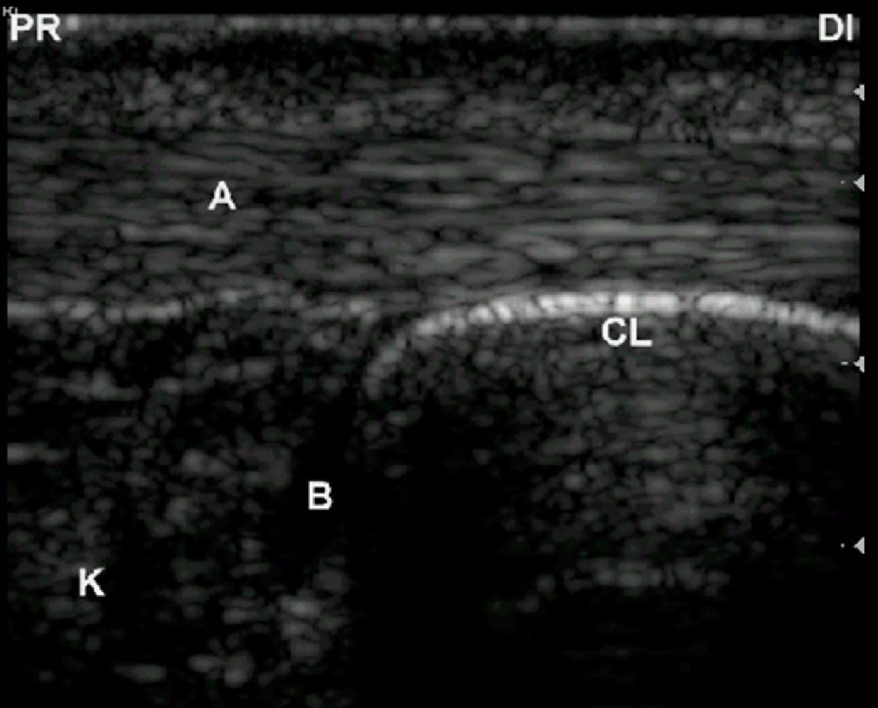
1. Normal bursae are not always visualised except for the suprapatellar bursa.
2. The normal bursa has a thin echoic wall.

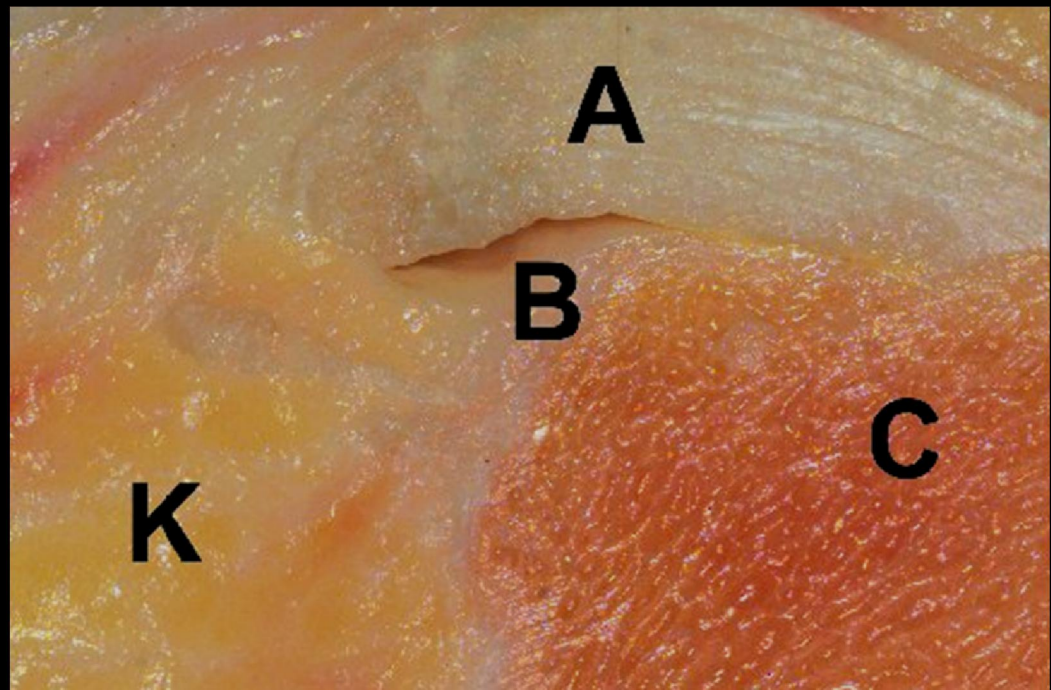




3. Between the two walls, there is a small anechoic line no thicker than 1-2 mm.

4. If there is a communication with the joint, during transducer pressure the anechoic line disappears, because fluid is forced into the joint.

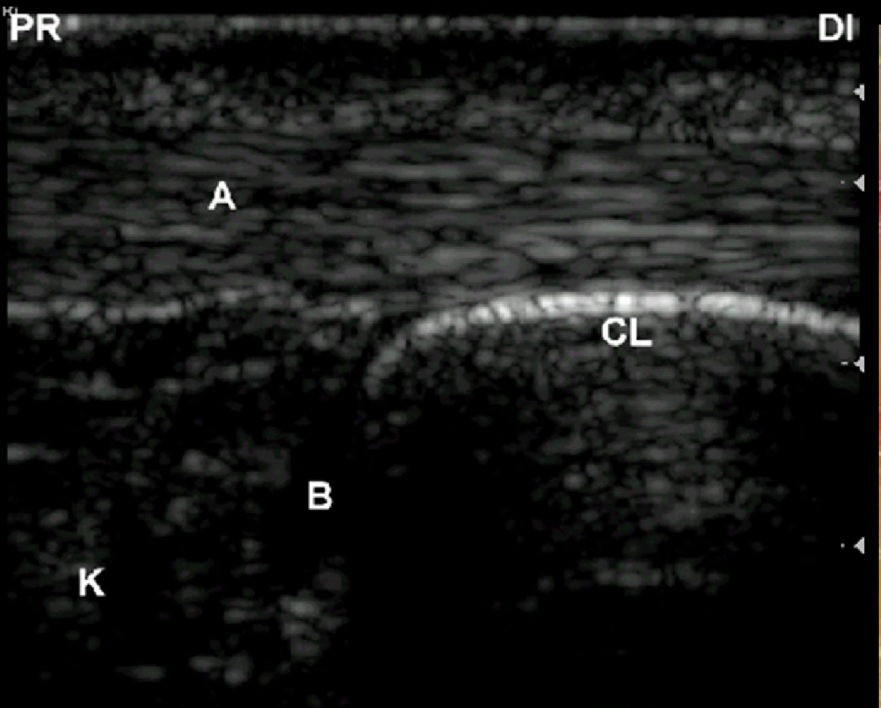


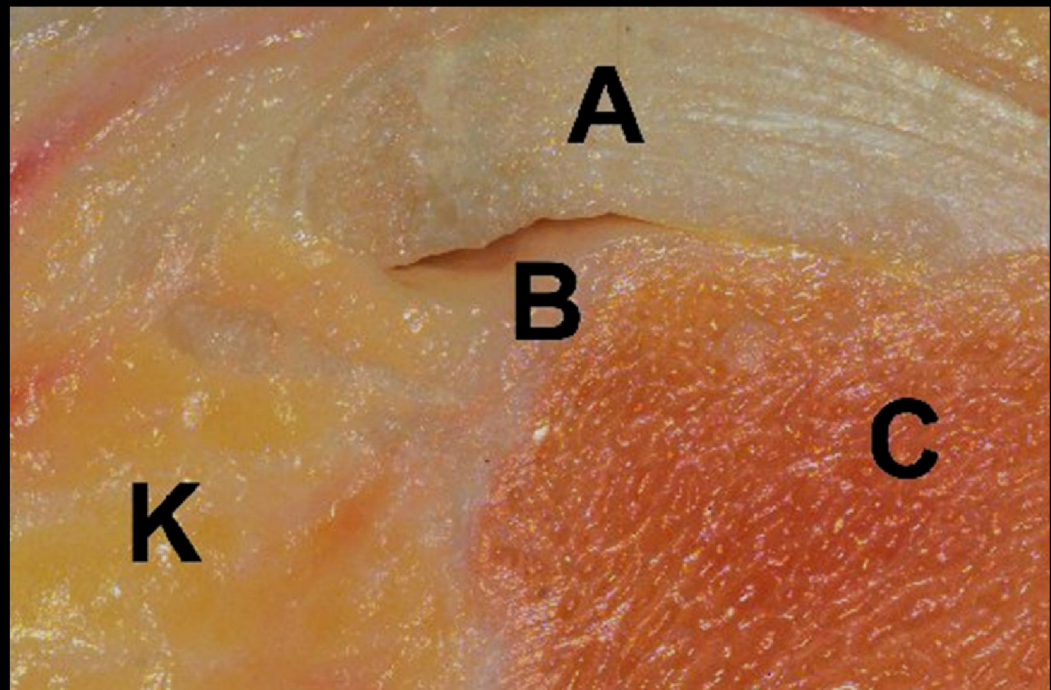


5. No internal echo in the anechoic layer.

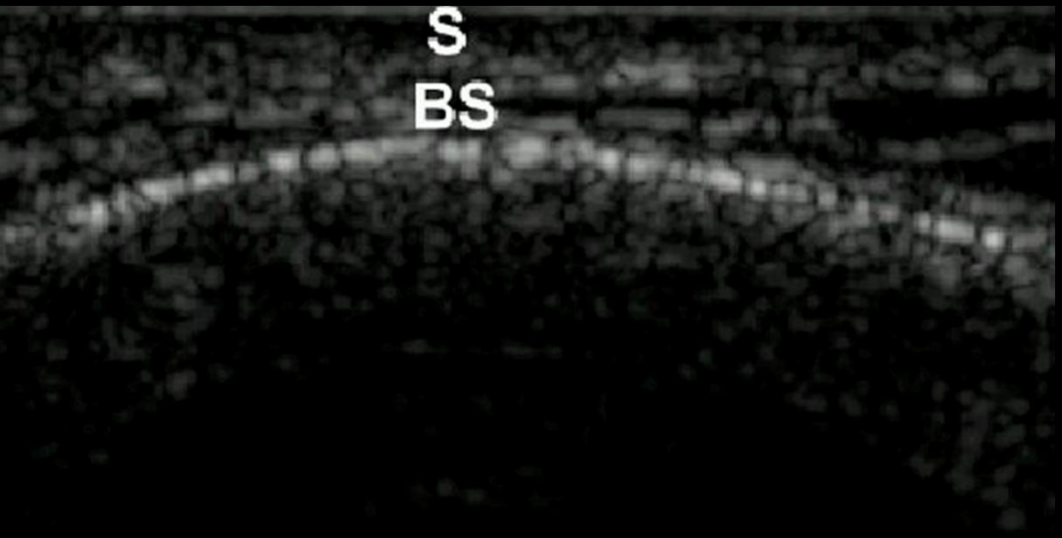
6. Peribursal fat usually detected around the bursa.

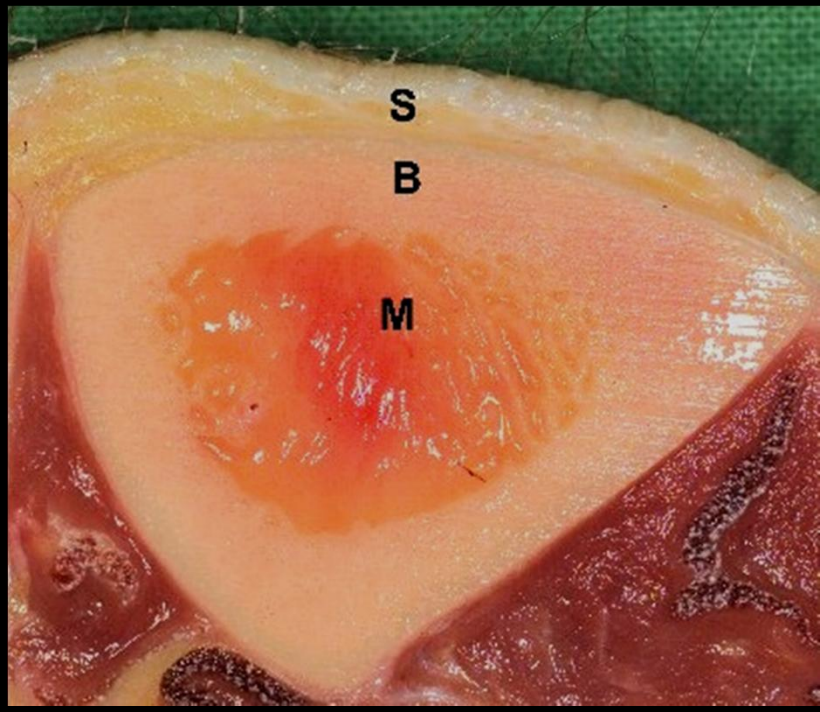
7. Same position (subtendineous, submuscular, subfascial, subcutaneous) and same appearance on the contralateral side.





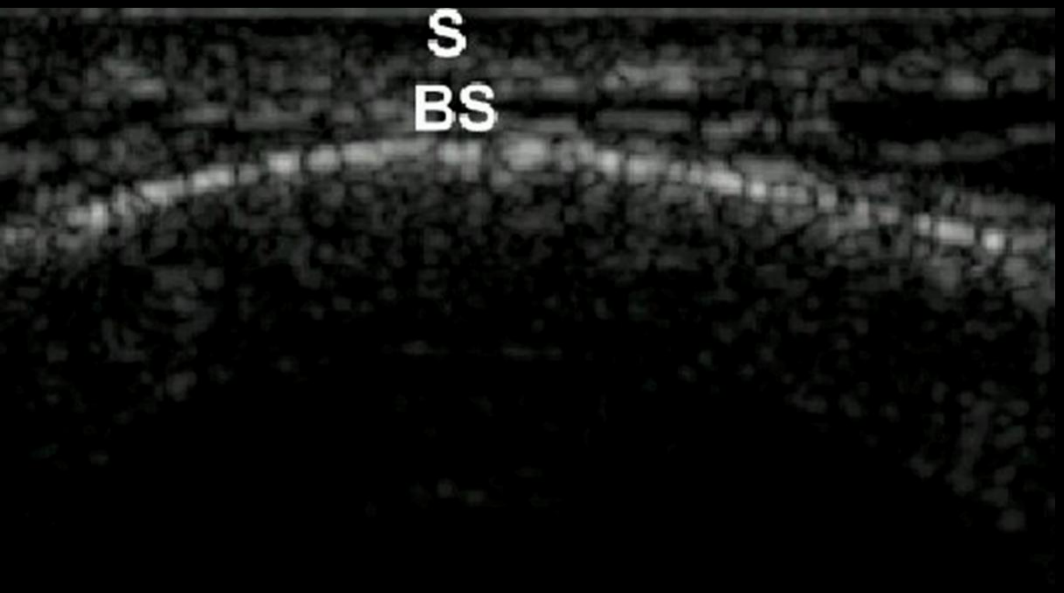
Bone (transverse)

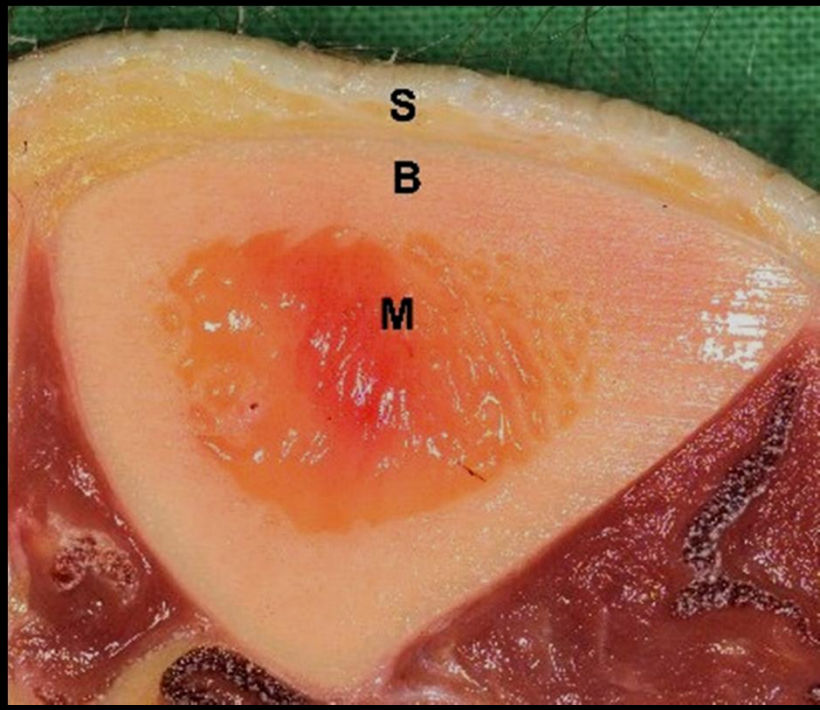




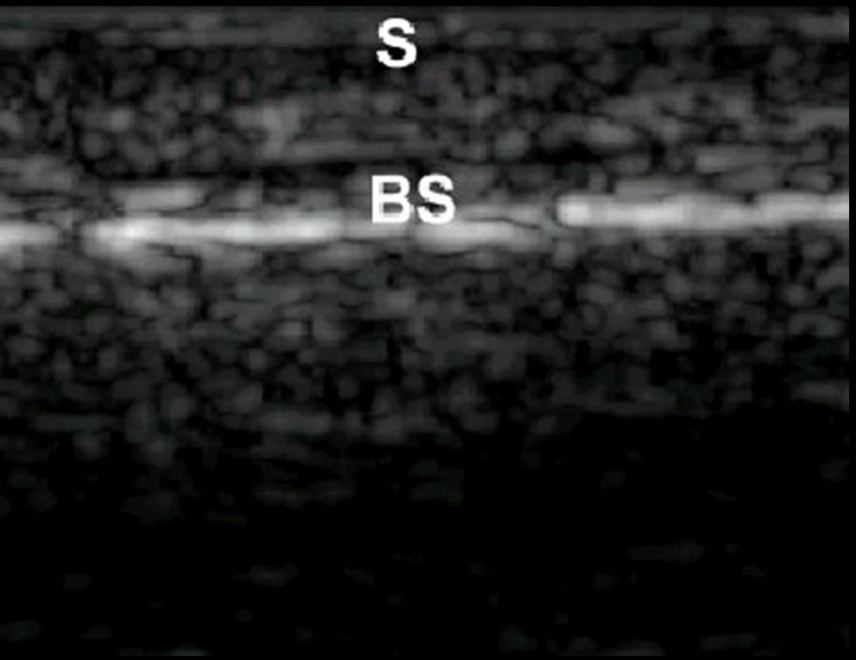
B: bone, BS: bone surface, S: skin, M: bone marrow

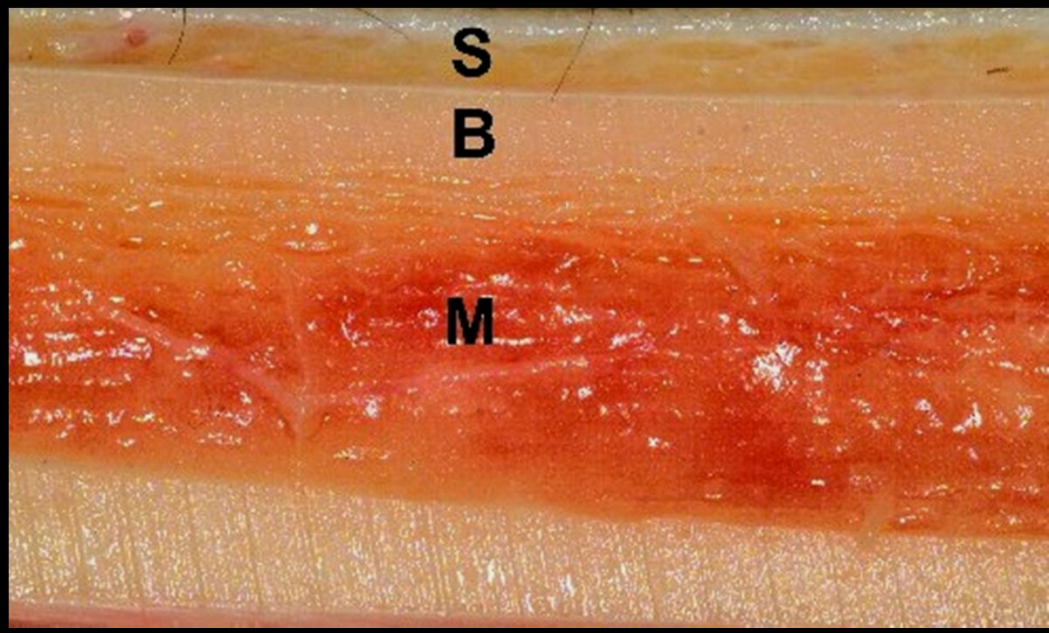
1. Only the bone surface is visible as a hyperechoic line with acoustic shadow
2. The normal periosteum is rarely detected.





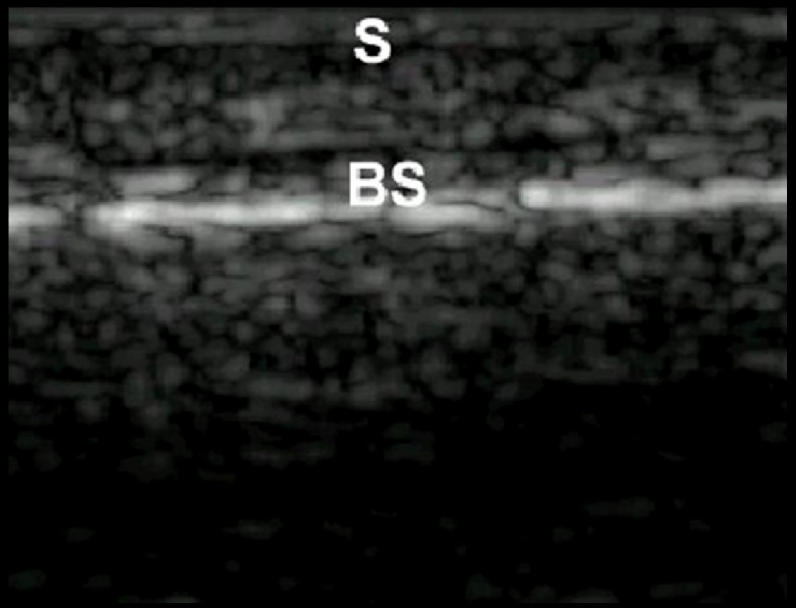
Bone (longitudinal)

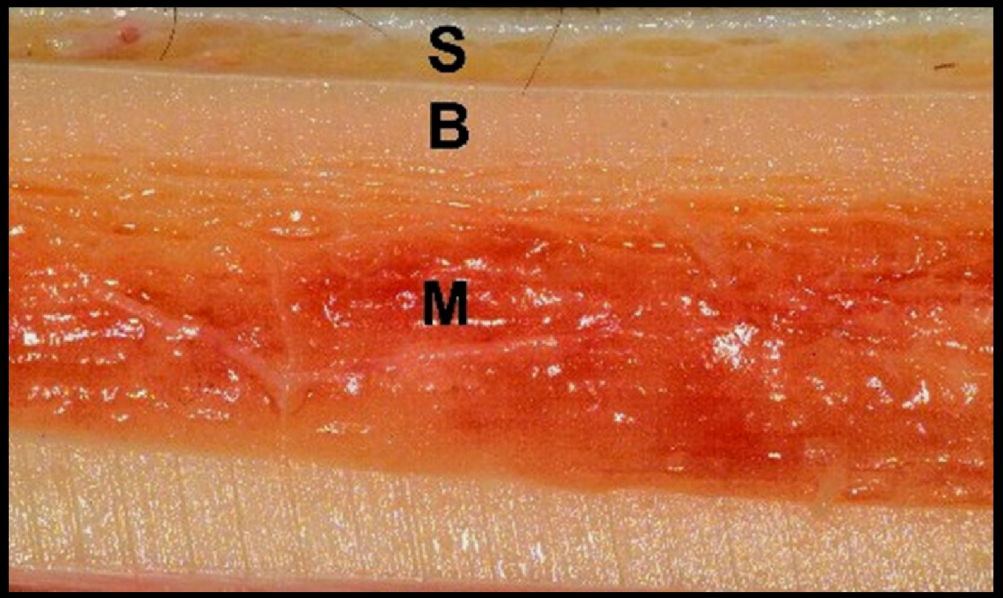




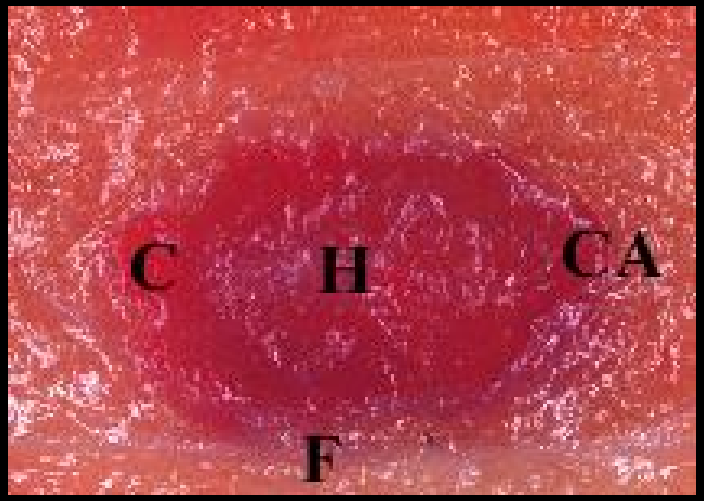
B: bone, BS: bone surface, S: skin, M: bone marrow

3. The bone surface is smooth and not disrupted except where there is groove for tendon attachment, ridge for tendon and muscle attachment, persistent epiphyseal plate, foramen nutrition.



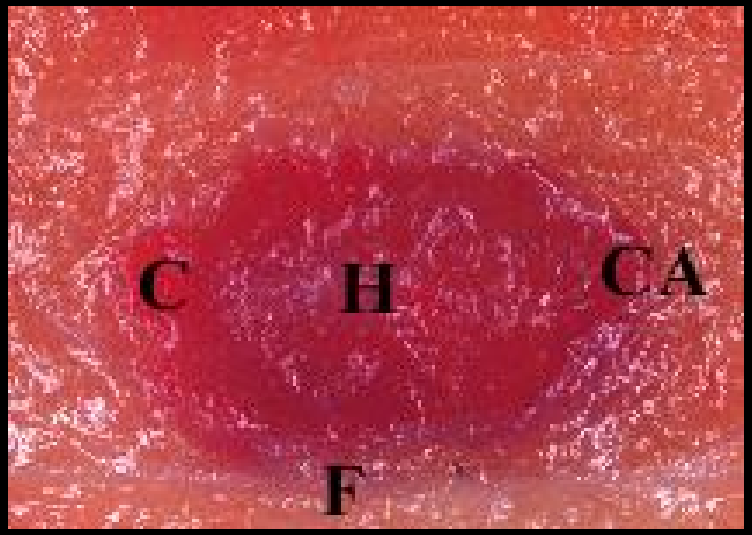


Lymph node

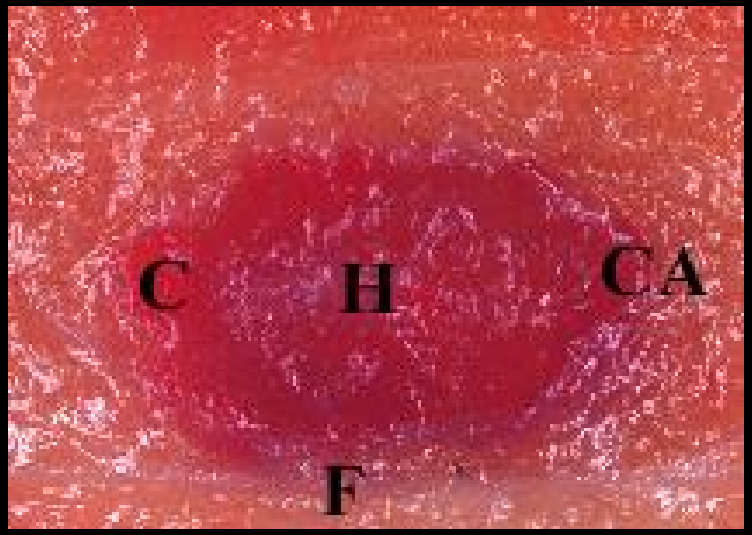


S: skin, H: hilum, C: cortex, CA: capsule, F: fascia

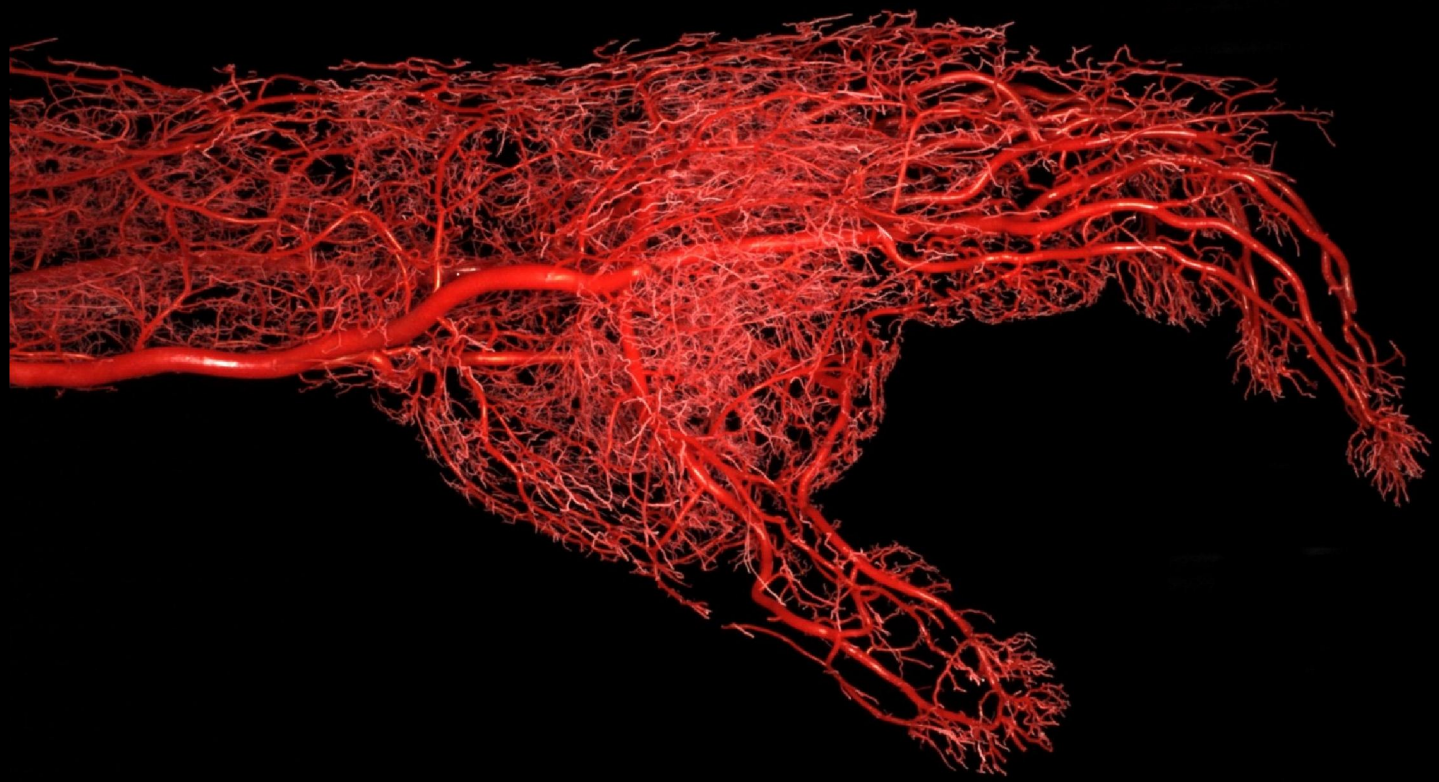
1. Oval shape, longitudinal diameter parallel with the skin, often around the blood vessels.
2. Hyperechoic central hilum
3. Hypoechoic cortex



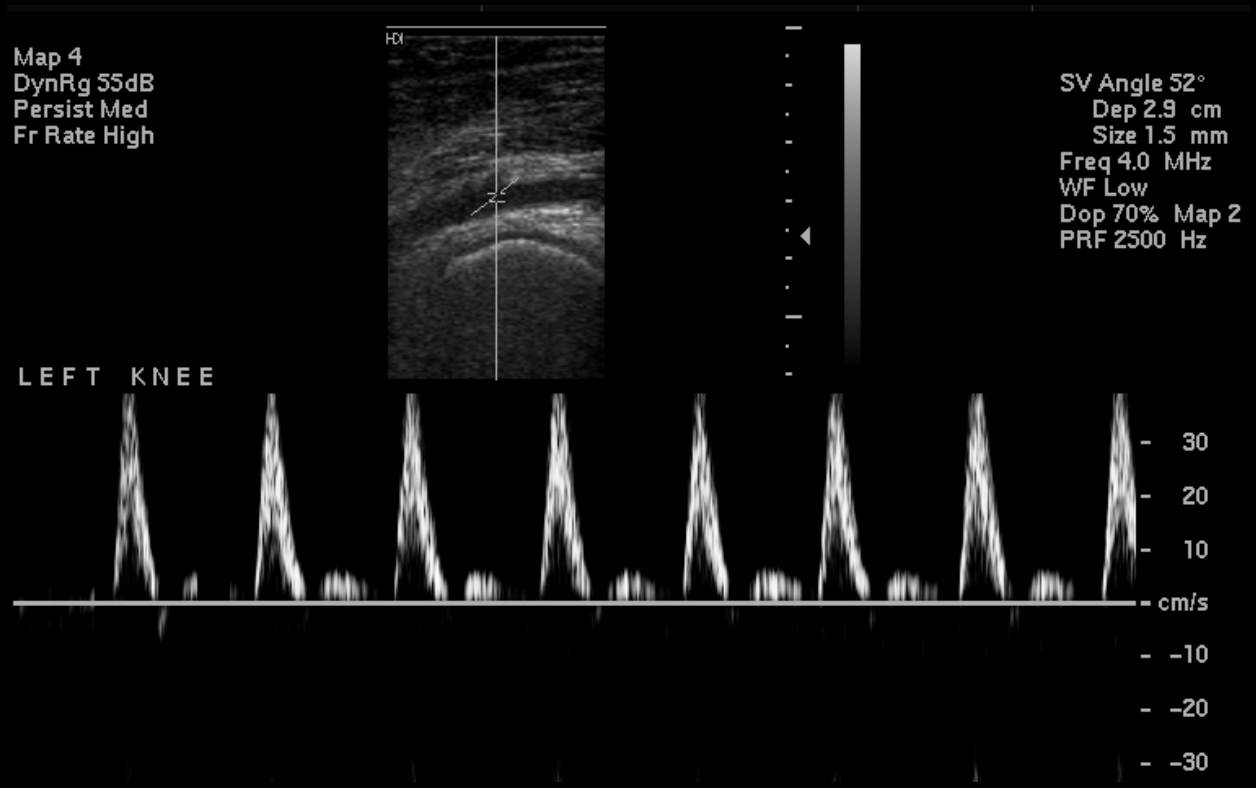
4. Hyperechoic capsule
5. Blood flow only at the hilum, not in the cortex
6. No extracapsular extension



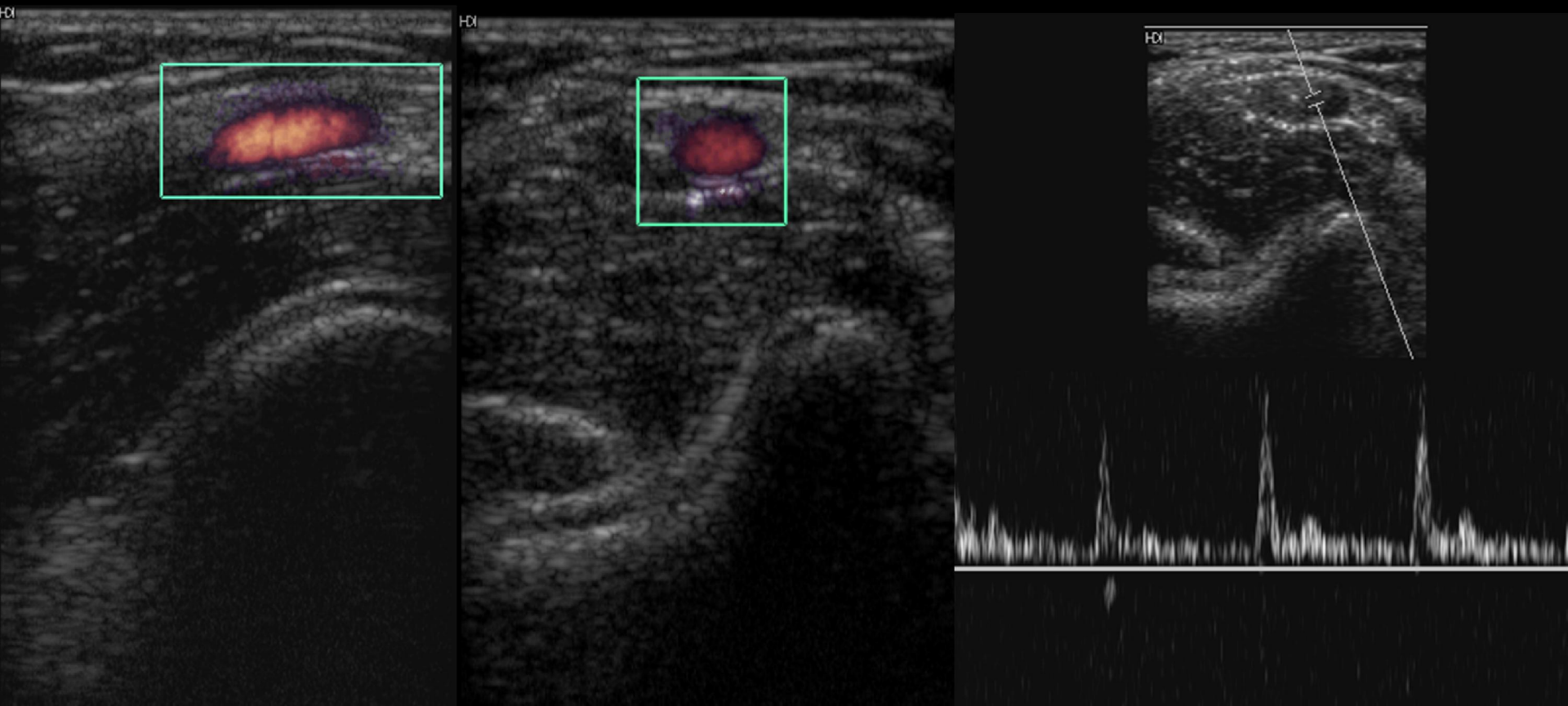
VASCULAR ANATOMY IS GETTING MORE AND MORE IMPORTANT



Arterial flow

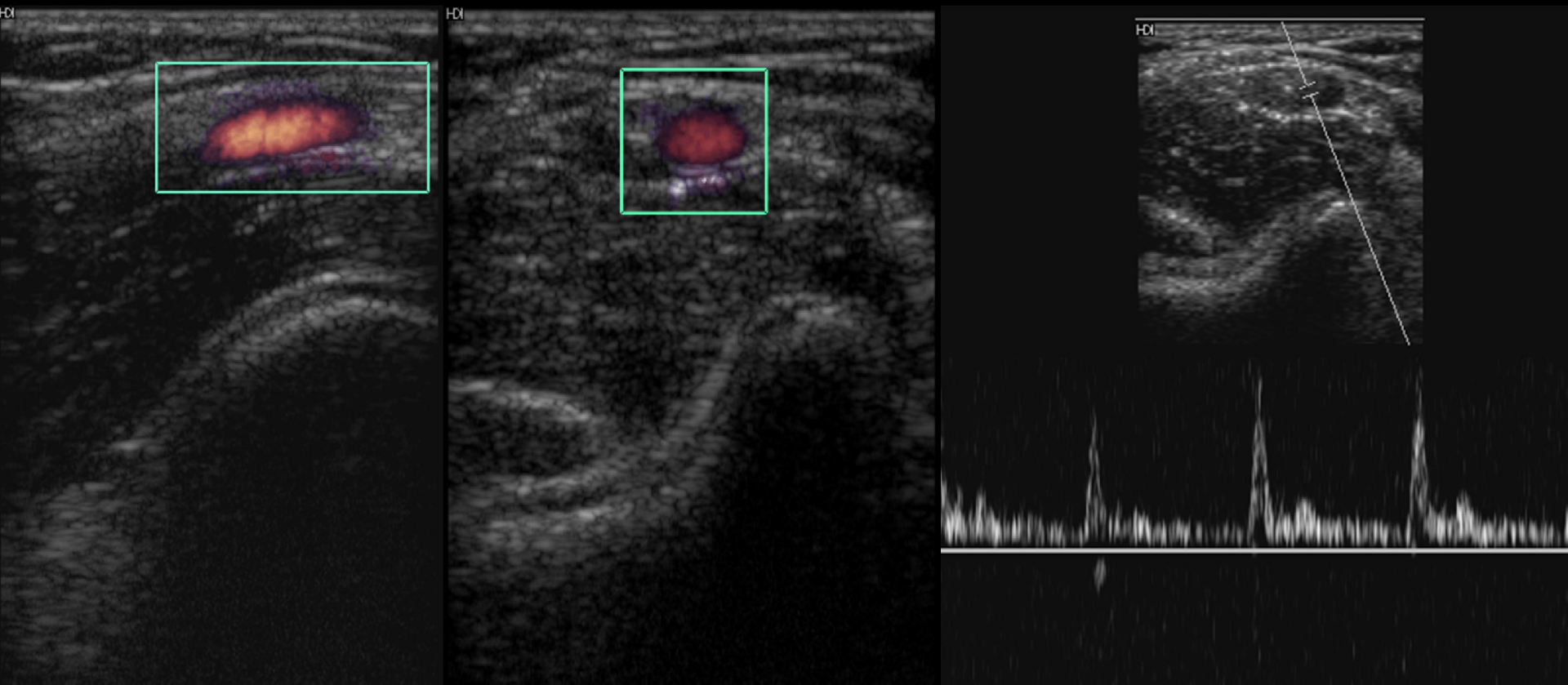


1. Linear or rounded hypoechoic or anechoic structure with hyperechogen walls. Pulsed flow.
2. Color sign with Color or Power methods



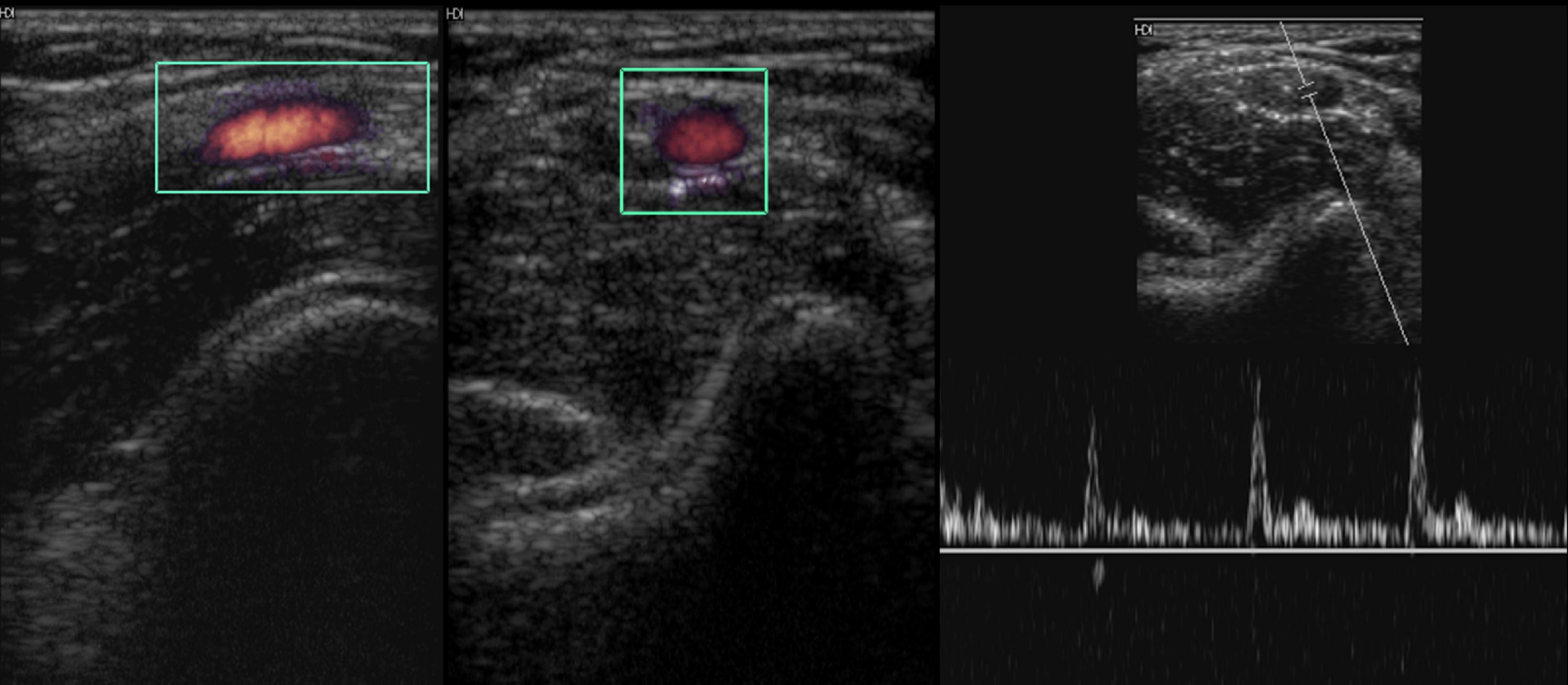
3. Typical wave's form and audible sound with Doppler scan.

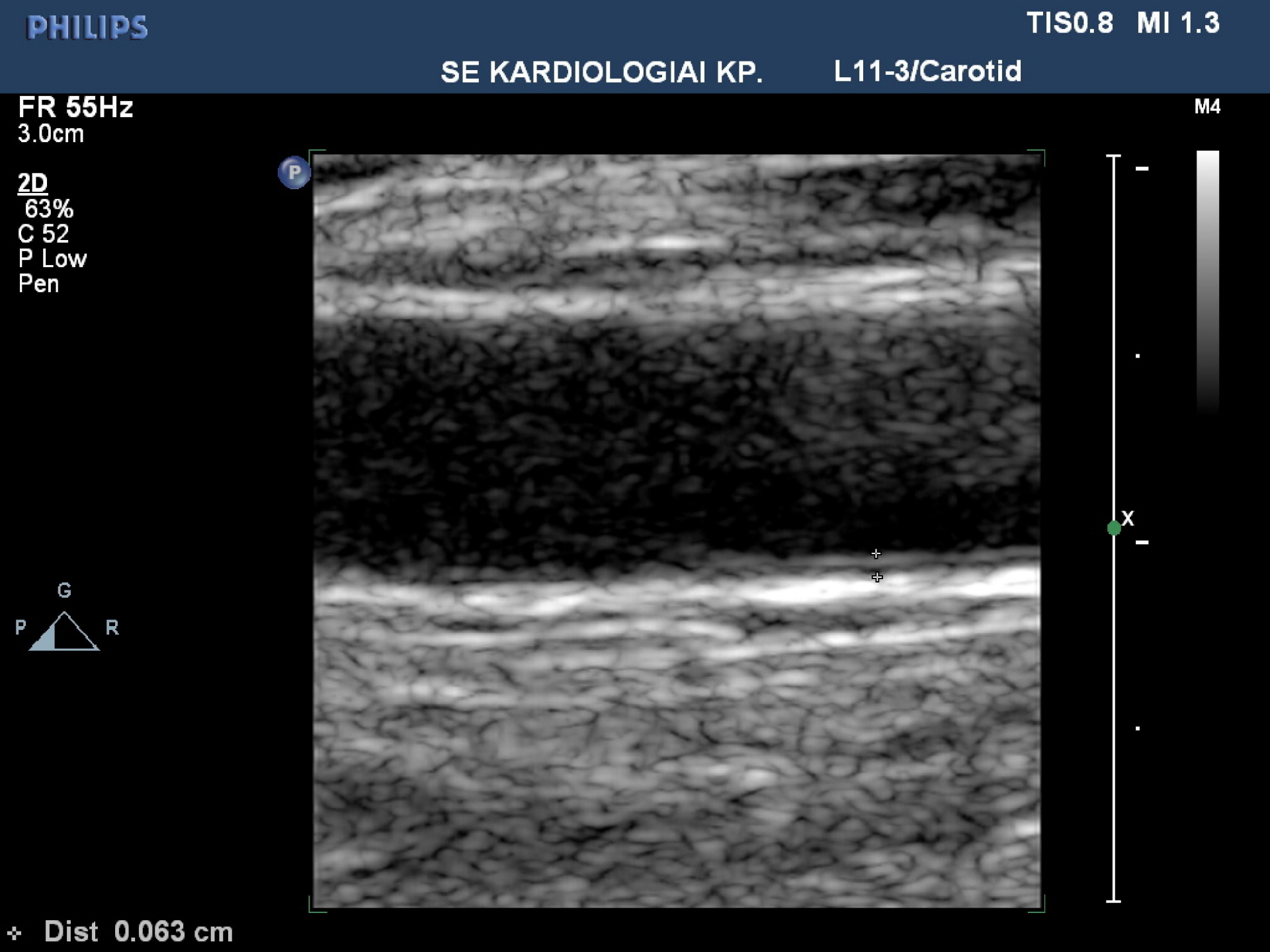
4. No abrupt fluctuation (enlargement or narrowing) of the diameter, following the vessels divided branches is detected.



5. Compression is hard.

6. In proper anatomical position, same structure and location in the contralateral side




PHILIPS
TIS0.8 MI 1.3
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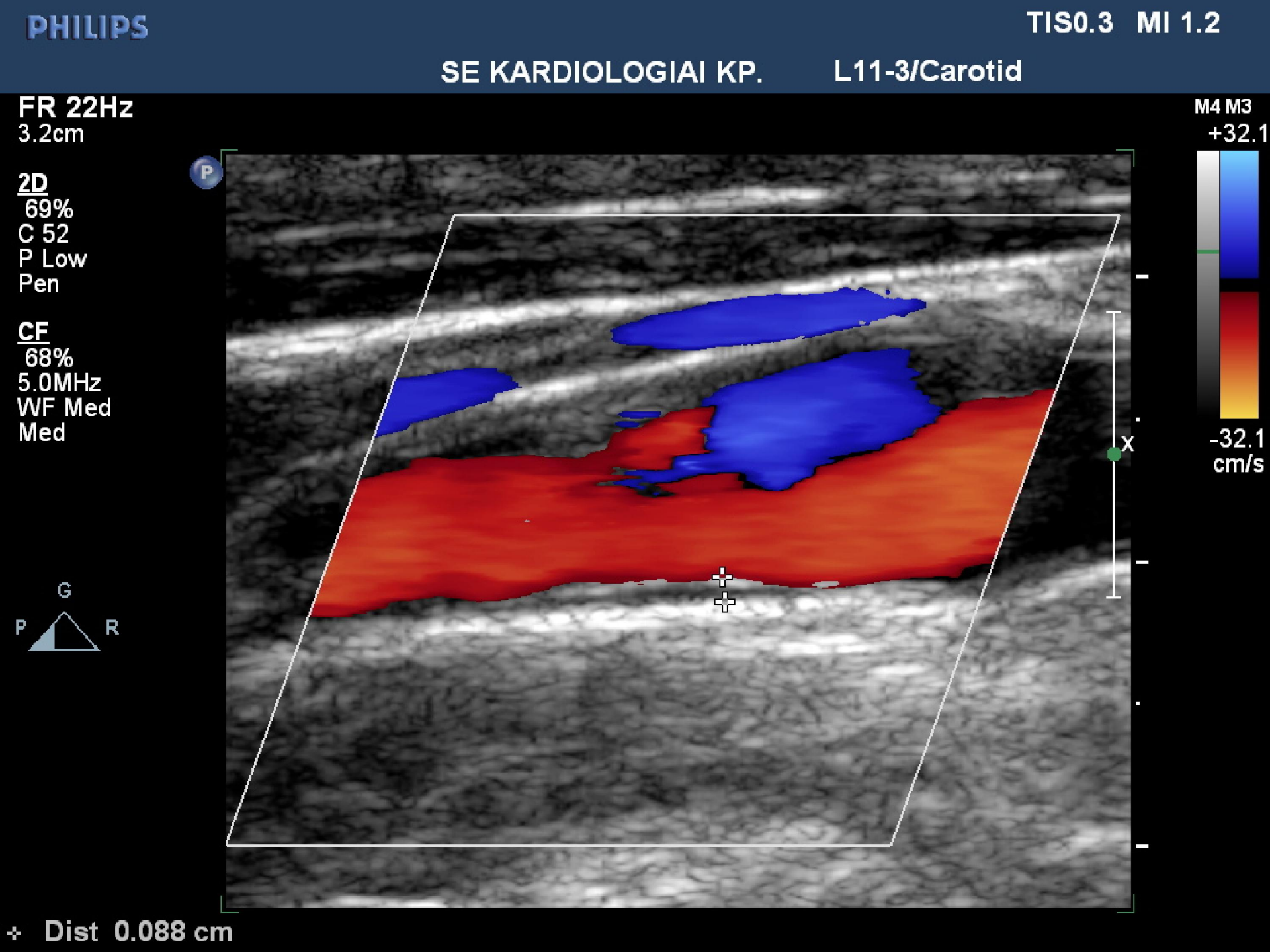
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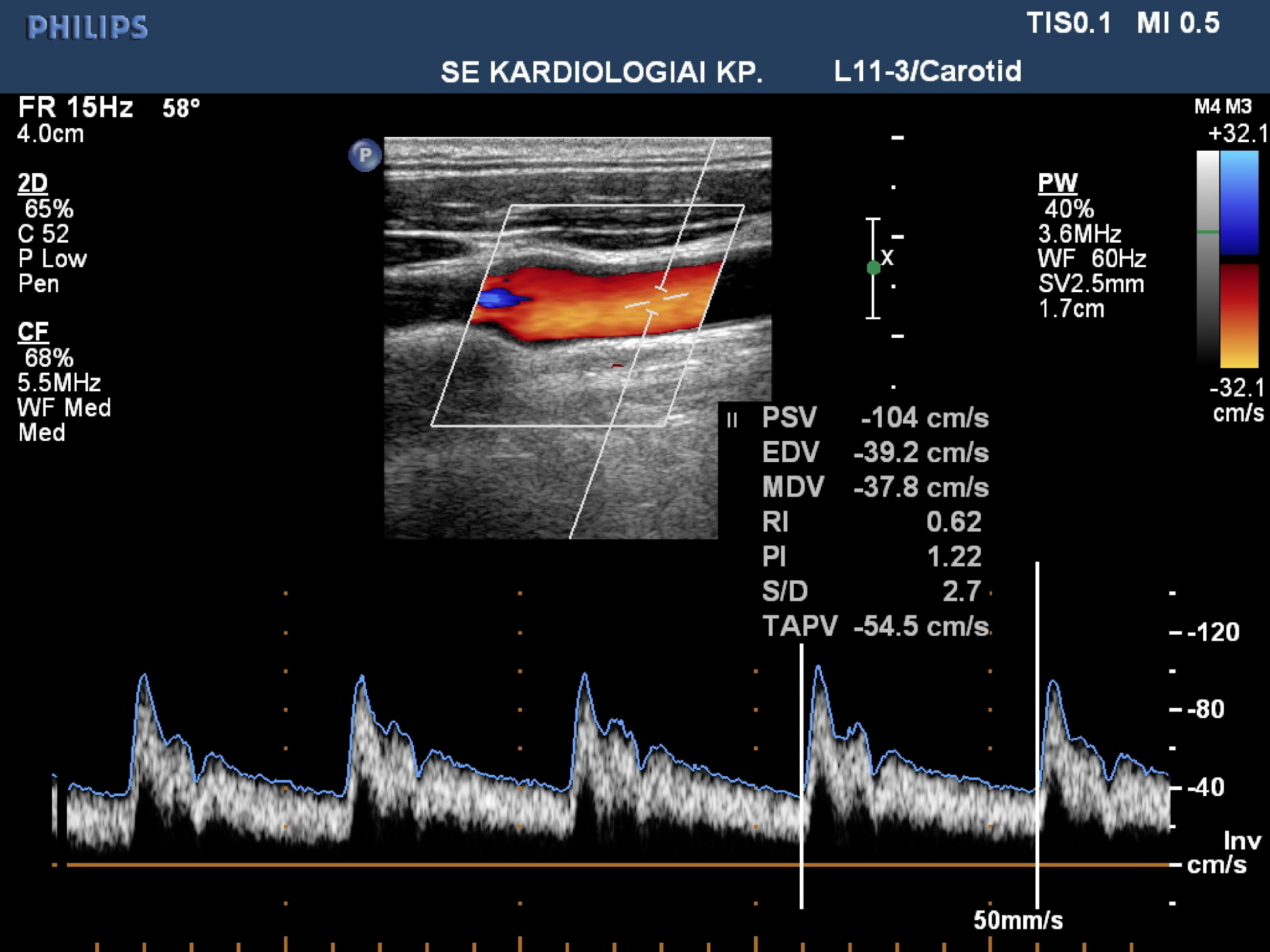
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Med
M4 M3
+32.1
PW
40%
3.6MHz
WF 60Hz
SV2.5mm
1.7cm
-32.1
cm/s
PSV -104 cm/s
EDV -39.2 cm/s
MDV -37.8 cm/s
RI 0.62
PI 1.22
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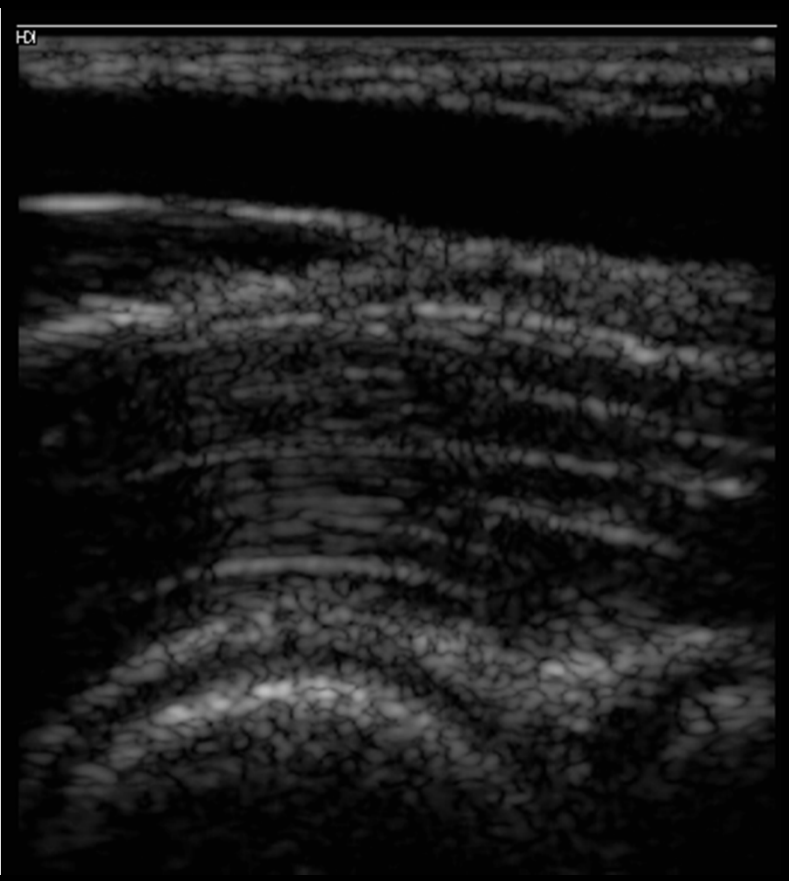
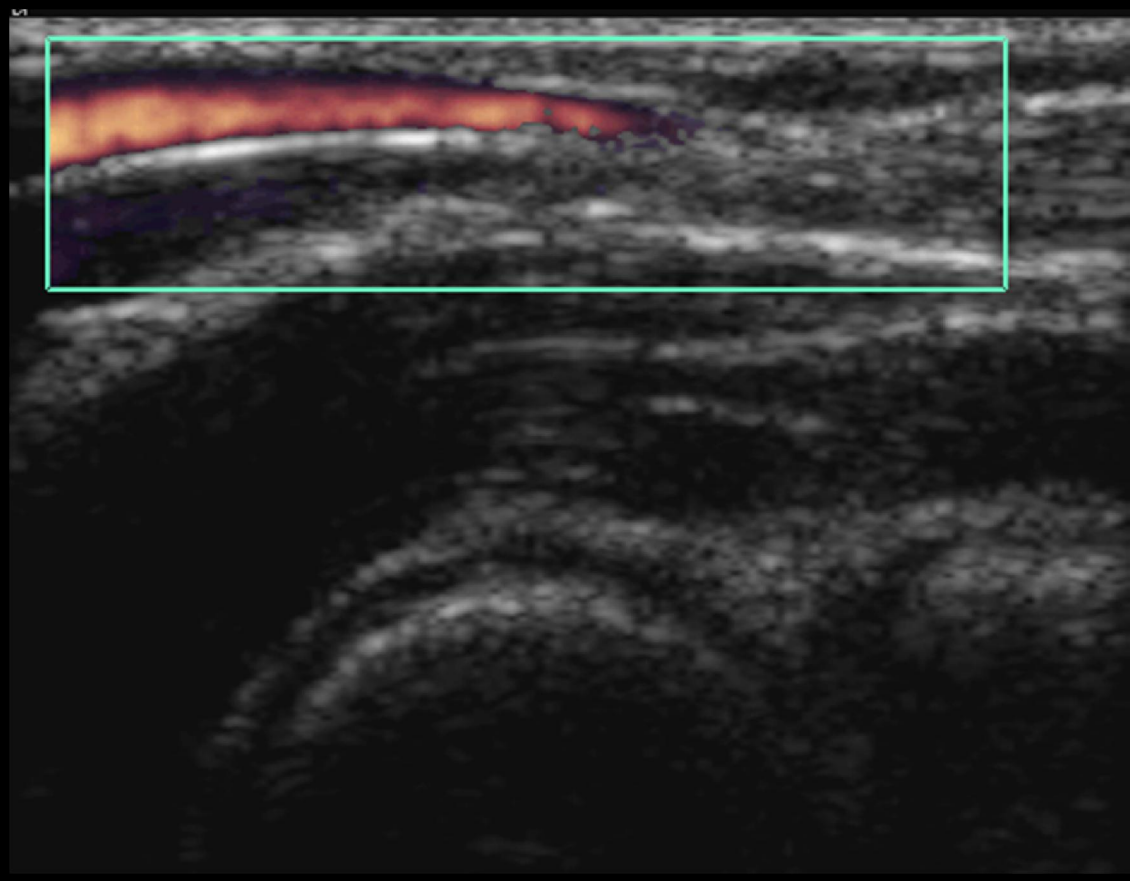
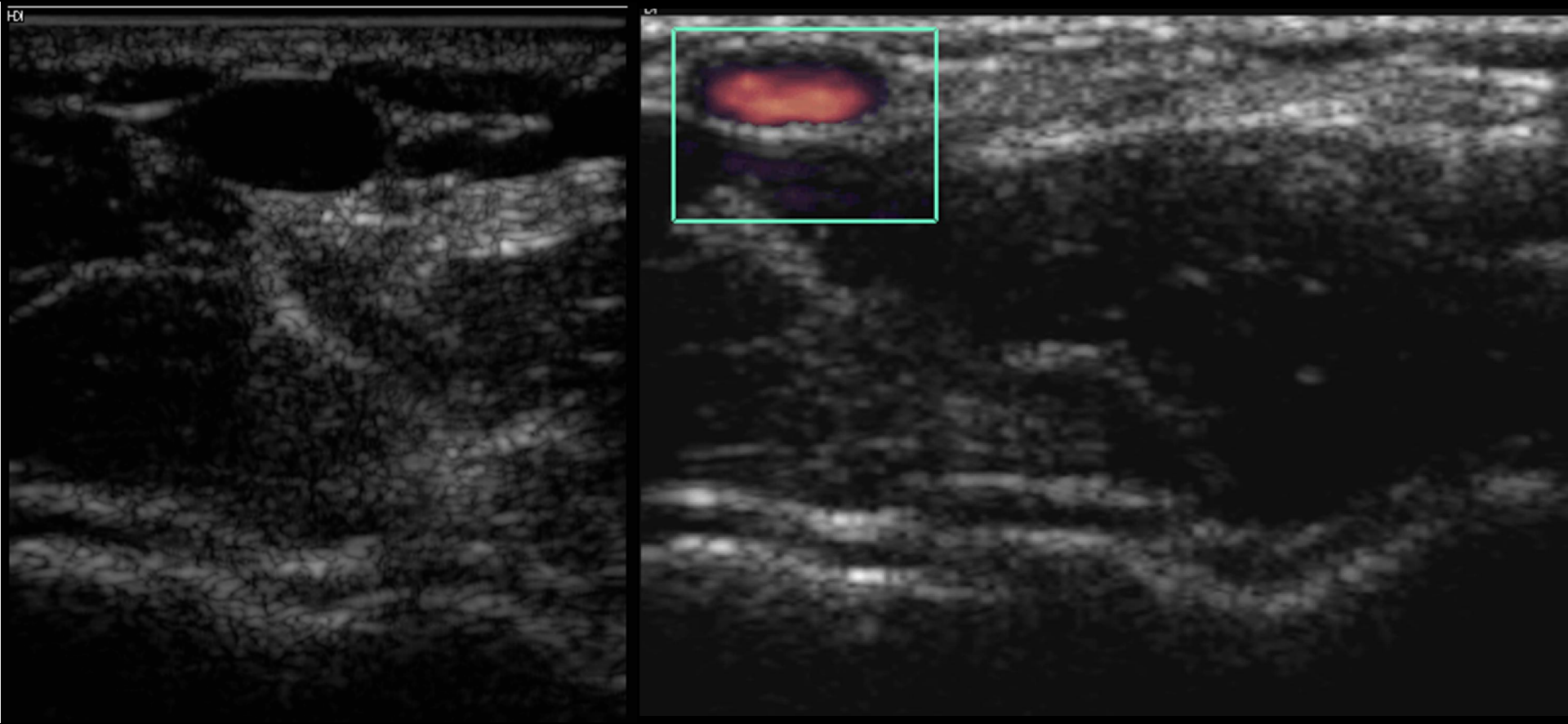
Inv
cm/s
50mm/s

Vein (longitudinal)



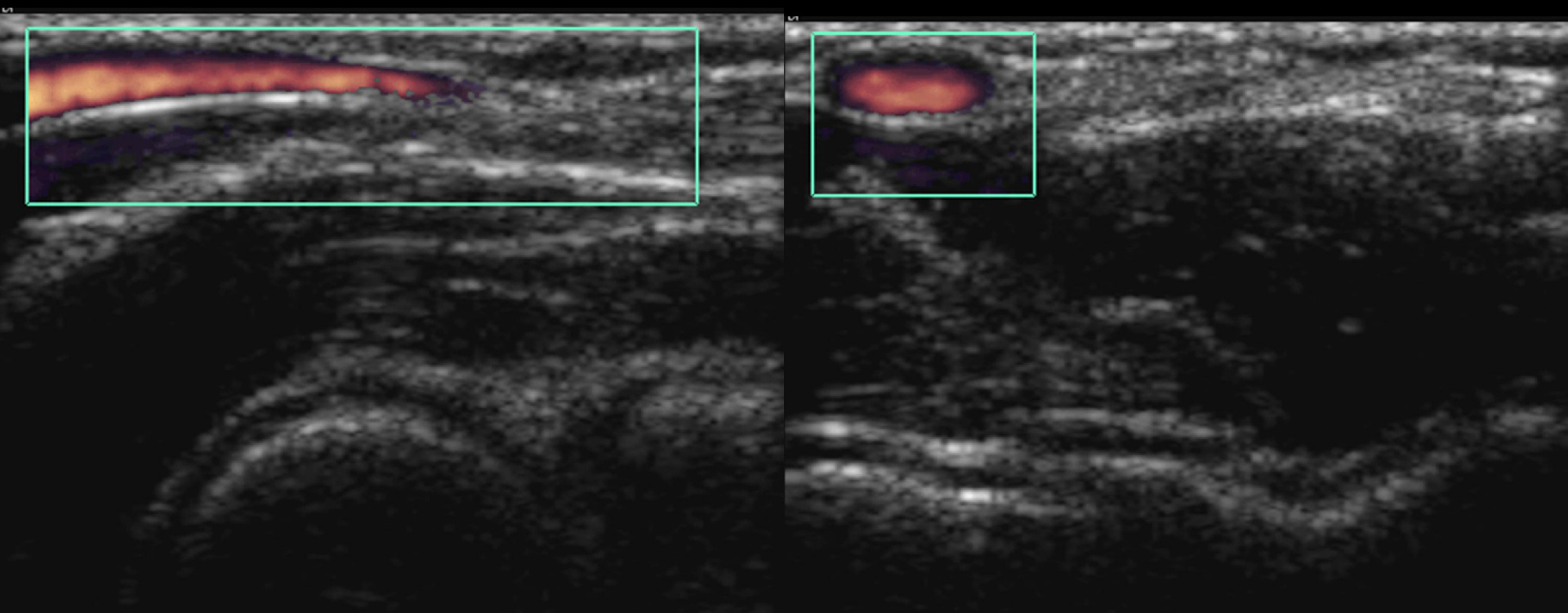


Vein (transverse)



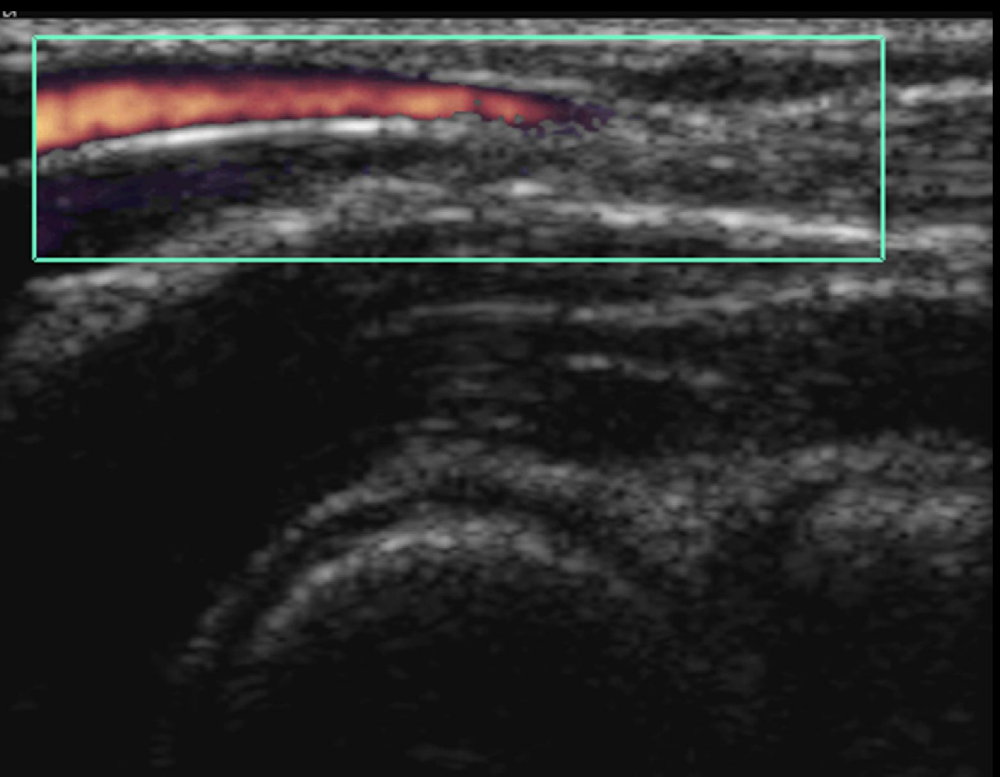
1. Linear hypoechoic or anechoic structure with hyperechogen walls. Flow without pulsation.

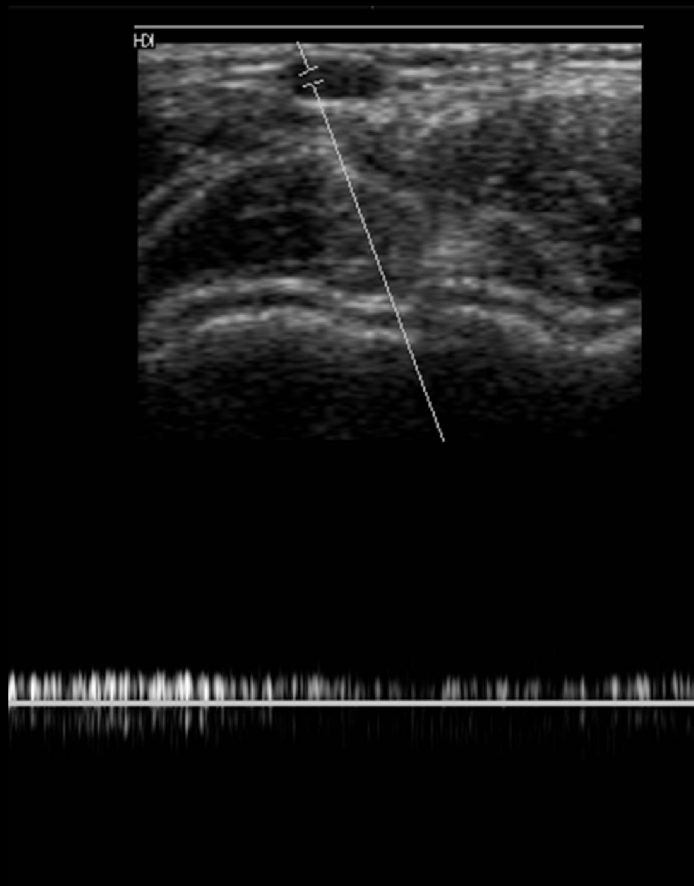
2. Color sign with Color or Power methods



3. Typical wave's form and audible sound with Doppler scan.

4. No abrupt fluctuation (enlargement or narrowing) of the diameter, following the vessels divided branches is detected.

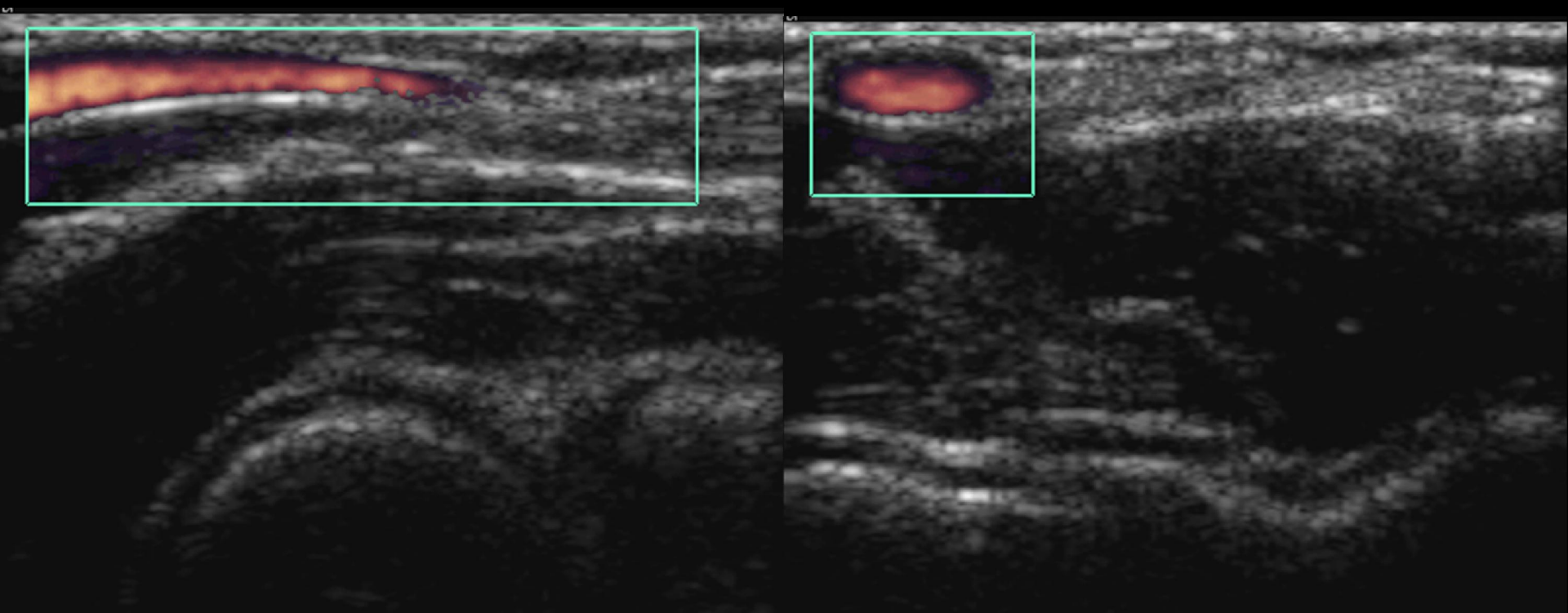




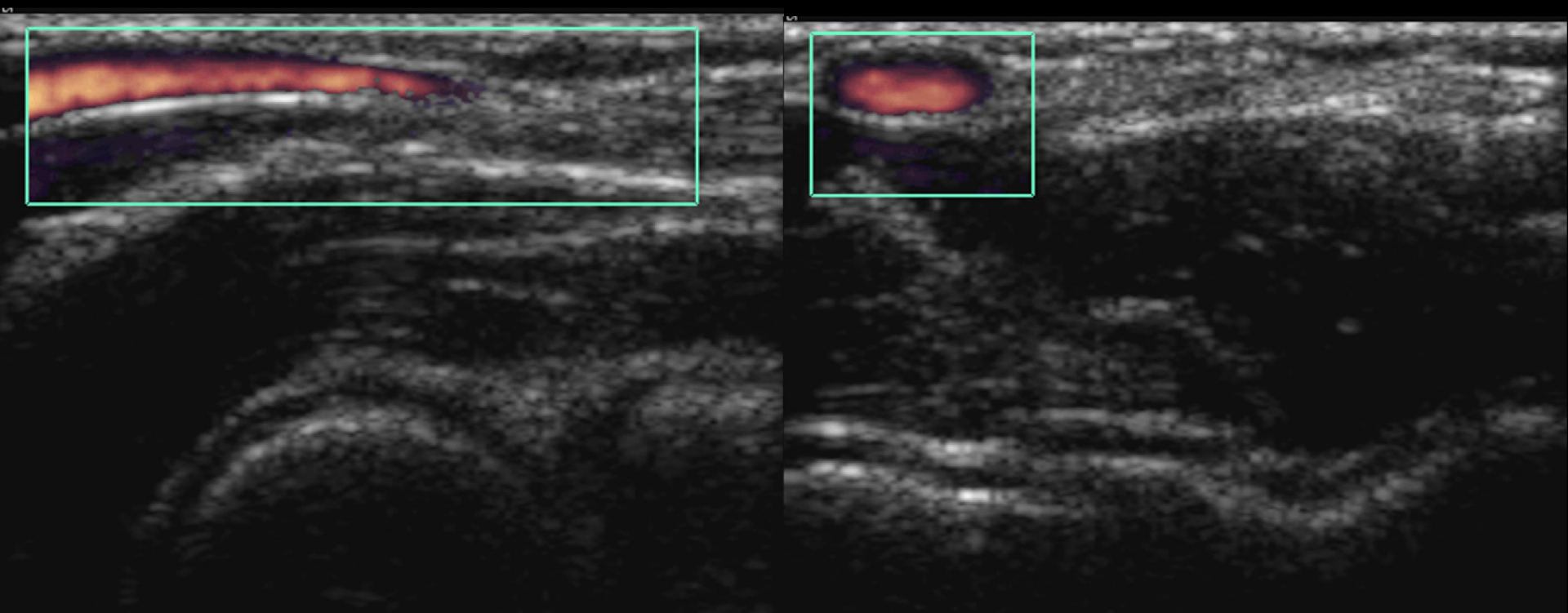
5. Compression is easy.

6. Echoic valve of vein is possible to detect.

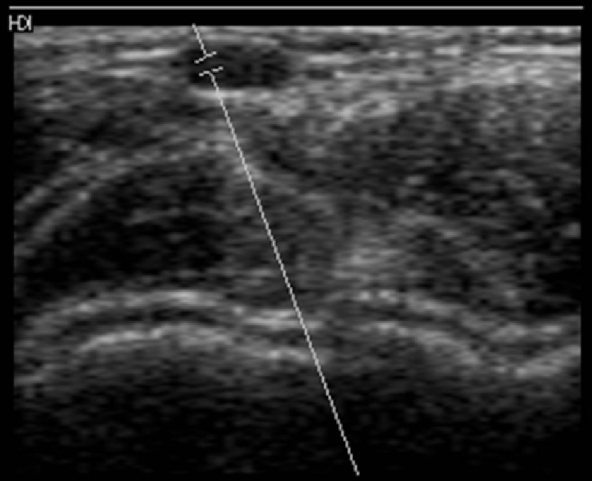
7. No other focal hyperechoic area inside the vein.

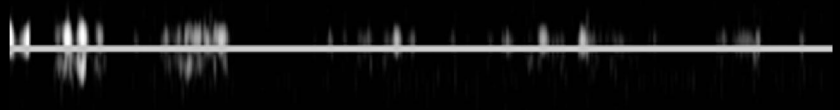


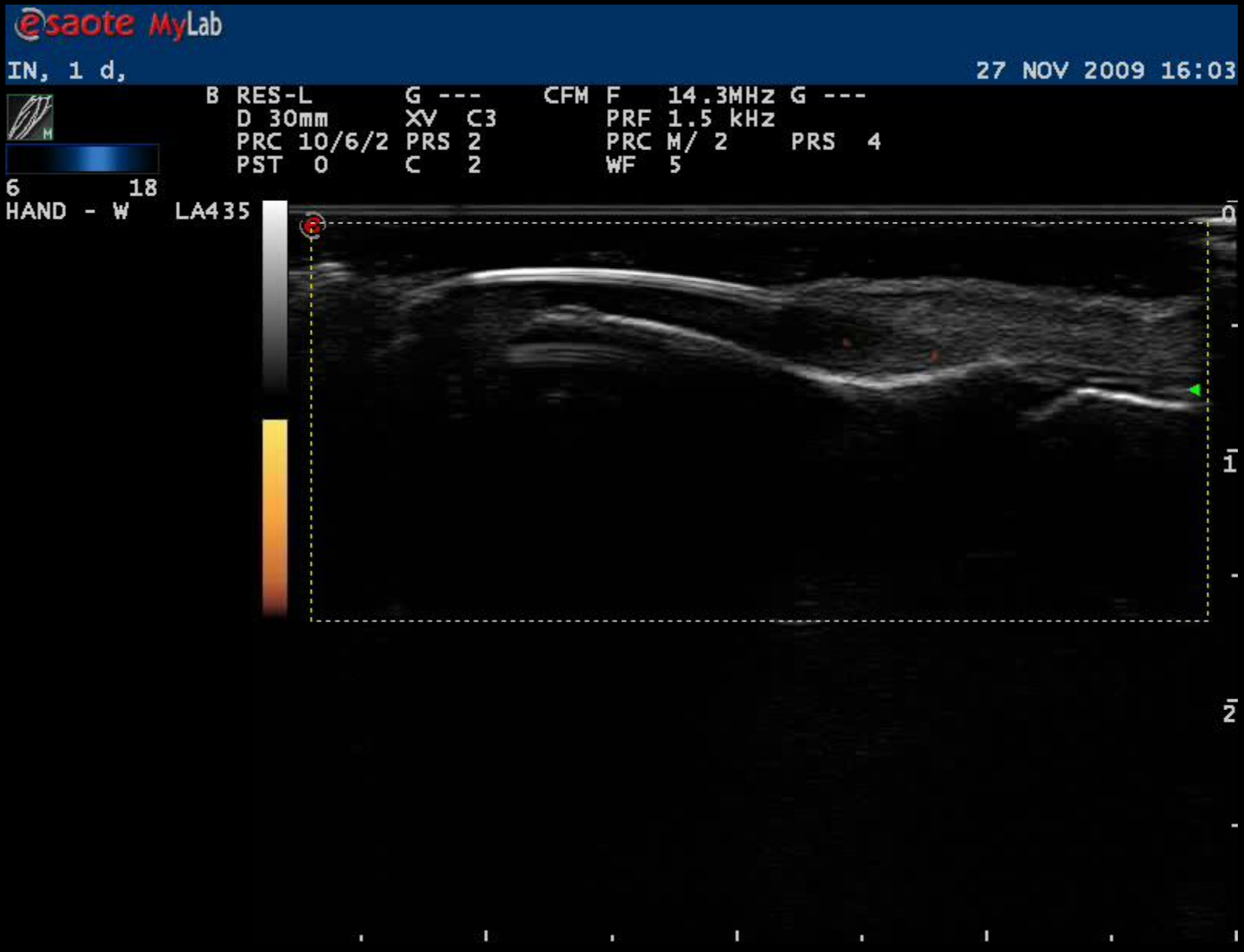
8. Valsalva maneuver or distal compression result dilatation of vein.Trendelenburg position leads the evacuation of the vein, opposite manoeuvre supports filling the vein.



Spectral Doppler






esaote MyLab
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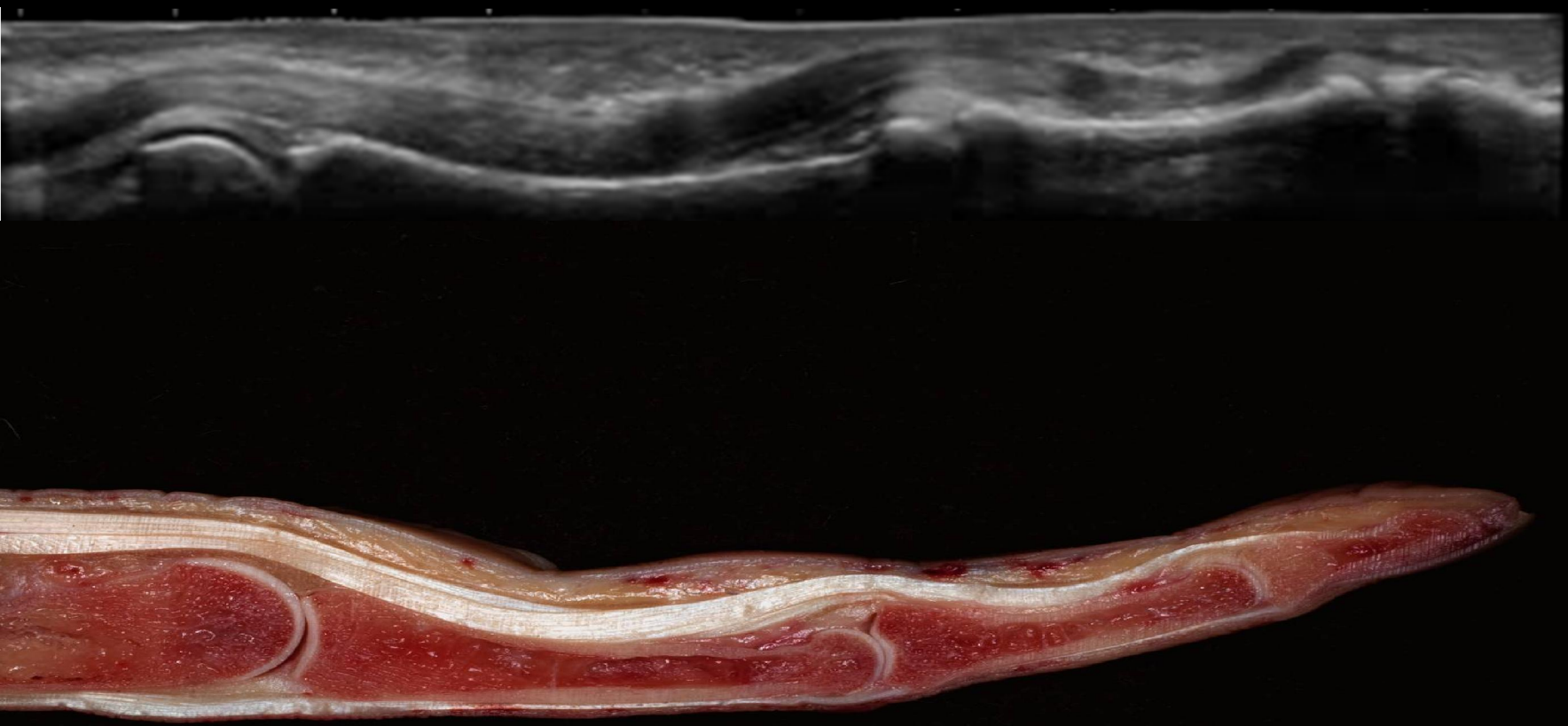
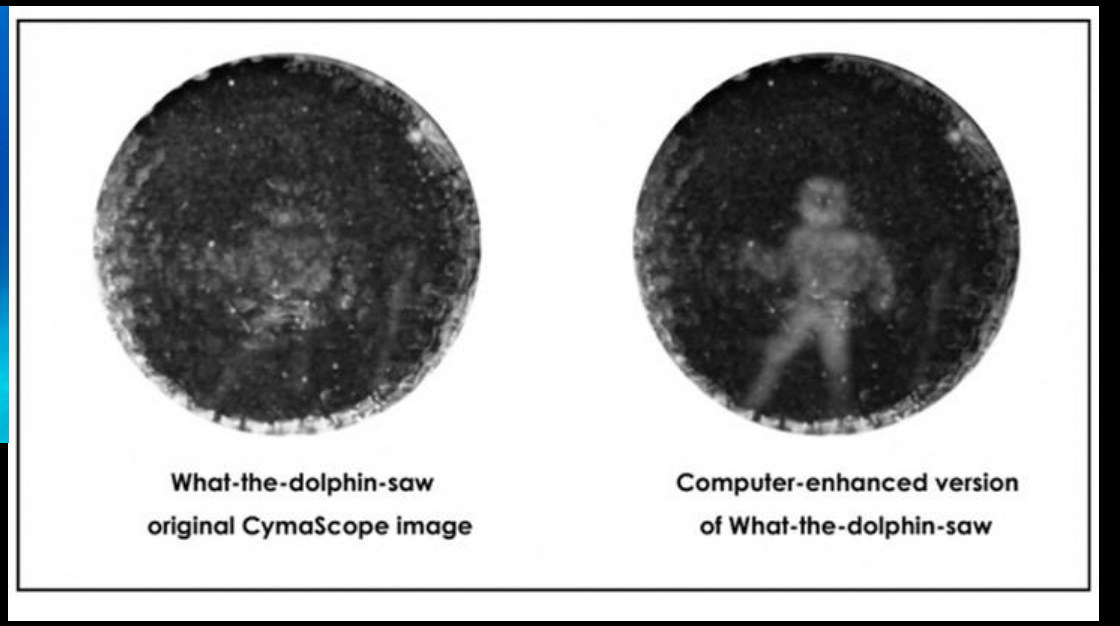
27 NOV 2009 16:03
B RES-L G --- CFM F 14.3MHz G ---
D 30mm XV C3 PRF 1.5 kHz
PRC 10/6/2 PRS 2 PRC M/ 2 PRS 4
PST 0 C 2 WF 5
6 18
HAND - W LA435

Panoramic image



Newly released image reveals how dolphins 'see' people



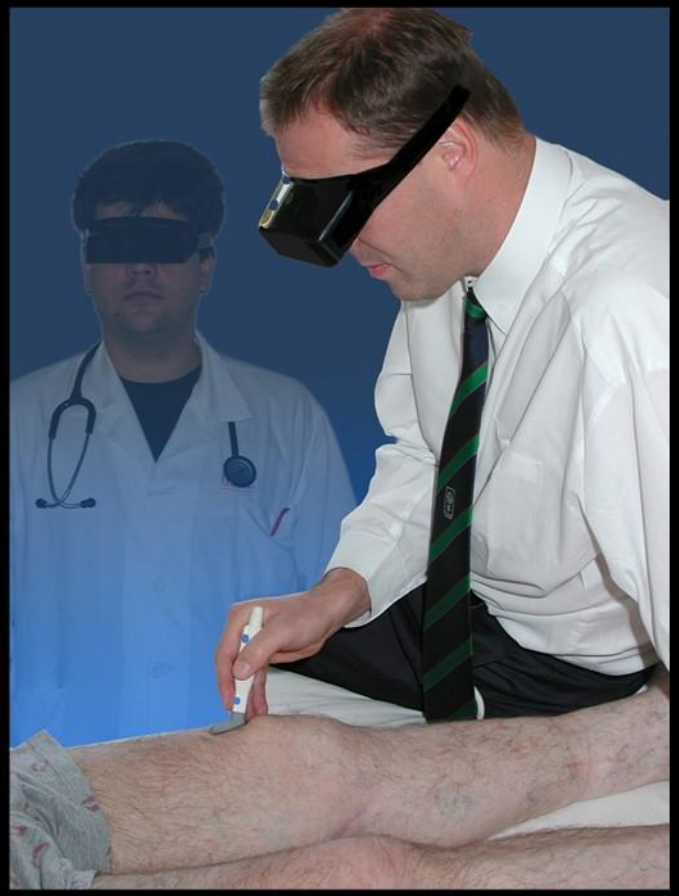
Mexico Puerto Aventuras – Dolphin research Centre
Jack Kassewitz and Jim McDonough
Amaya dolphin

Sharing an image between dolphins?

Underwater ultrasonic gloves

IrukaTact – Tsukubai University, Japan

FUTURE TRENDS IN MEDICINE



Increasing human senses with technics
Technics become a „part” of the physicians

„Humanization” of technics.
„Substitution” of the physicain

Péter Mandl
Dóra Niedermayer
Éva Ruzicska

Réka Kurucz
Katalin Áts
György Hittner

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