

The DUET Study Atlas



Copyright by GRAPPA, December 2025

All images presented in this atlas are property of GRAPPA

■■■■■
Created by:

Lihi Eder, University of Toronto, Canada

Sibel Aydin, University of Ottawa, Canada

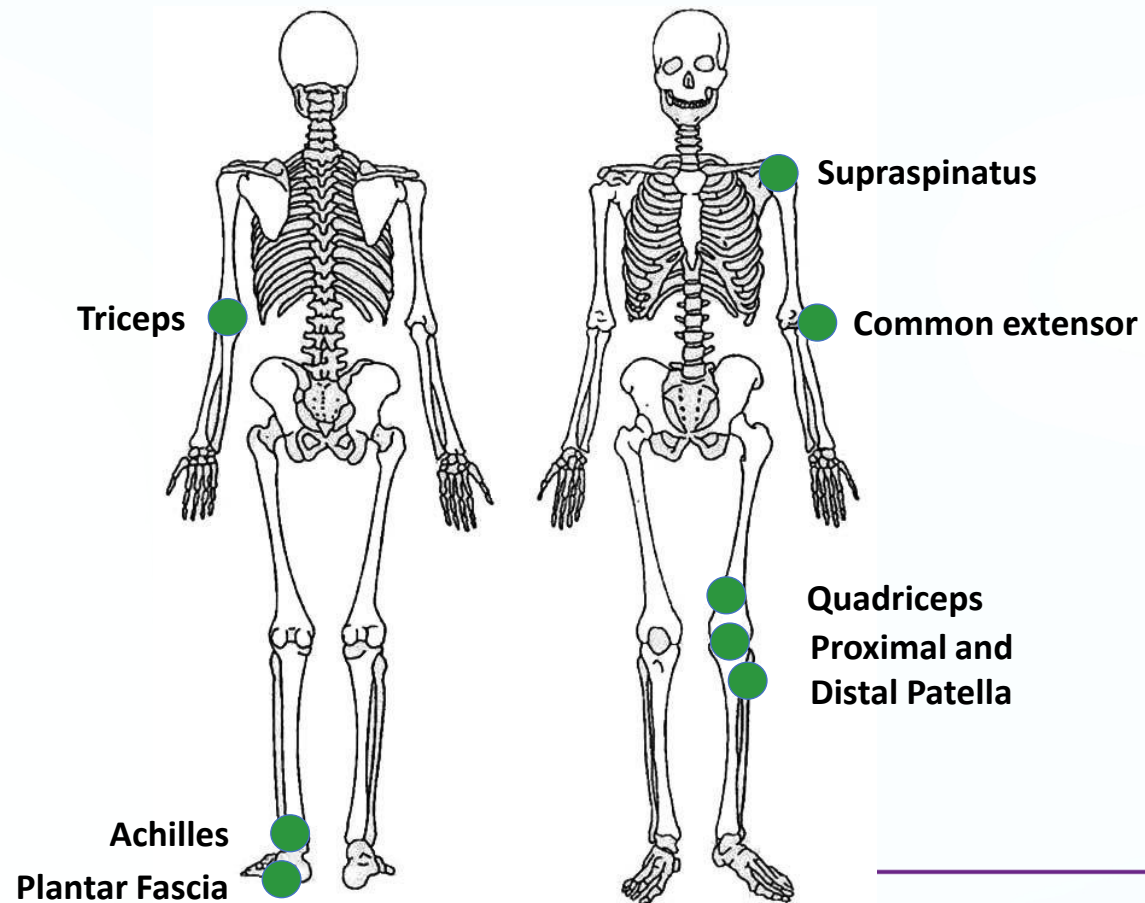
Gurjit Kaeley, University of Florida, US

Andre Lucas Ribero, Federal University of Rio Grande do Sul, Brazil



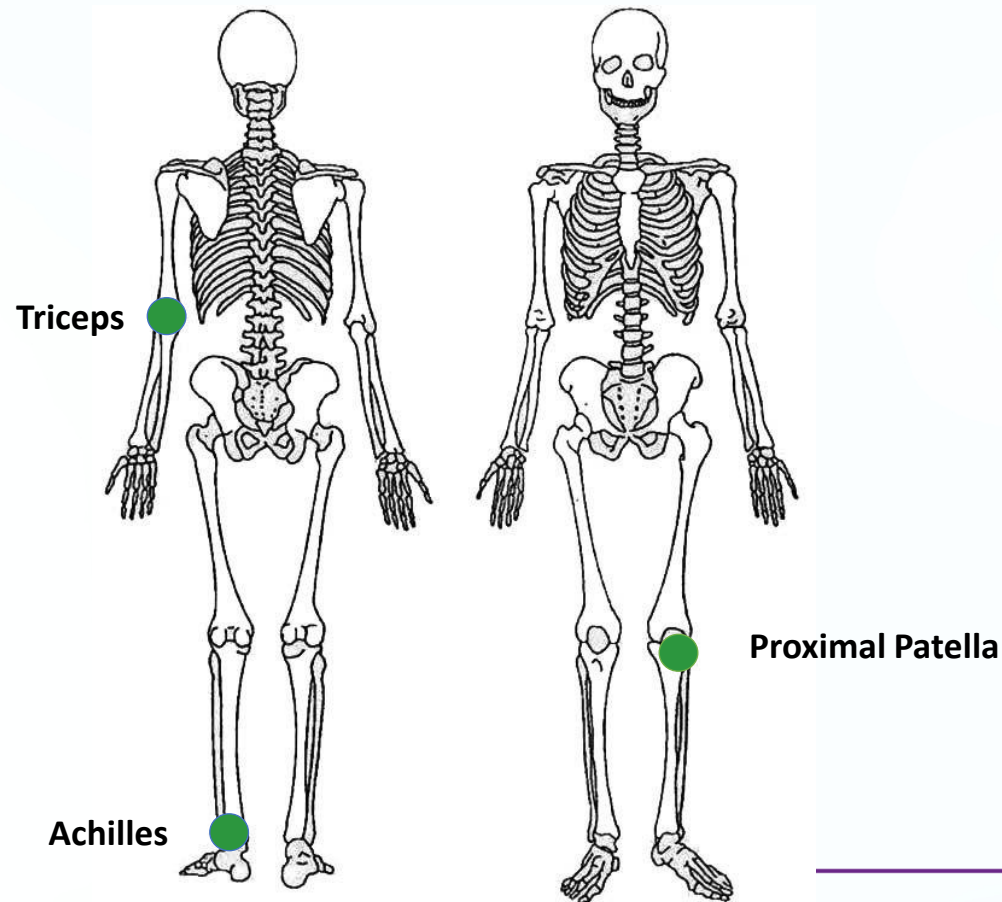
Entheseal sites scanned in the DUET study

In the DUET study, the following 8 bilateral enthesal sites (total of 16) were scanned:



Entheseal sites selected for the DUET score

In the final DUET Score, 3 bilateral enthesal sites were included (total 6 sites):

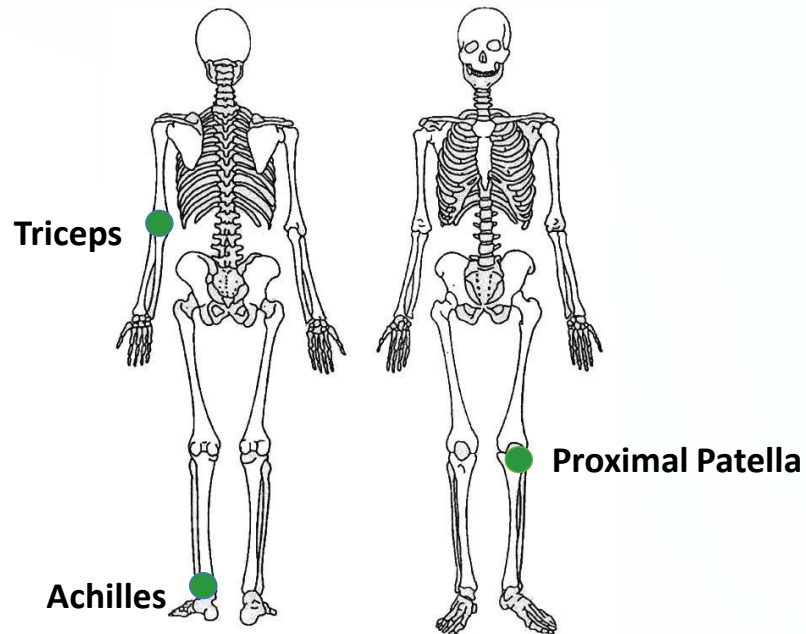


The final DUET score formula



The DUET score is a sum of the DUET formula (Inflammatory and structural sub-scores) at each of the 6 enthesal sites scanned

Enthesal Sites included bilaterally
(total 6 sites)



DUET Formula:

Inflammatory Sub-score:
Hypoechogenicity (0-1) +
Thickening (0-1) +
2 x PD Global Score (0-3)



Structural Sub-score:
Enthesophyte (0-3) +
3 x Erosion (0-1)



Positive Final Score:
≤ 55 years: > 5 || > 55 years: > 11

Recommended Scanning Position

- **Patellar tendon entheses**

Supine position with knees semiflexed to 30°

- **Triceps tendon entheses**

Elbow flexed to 60-90°

- **Achilles tendon entheses**

Prone position with the feet hanging over the end of the examination table

Position for Scanning of the Proximal Patellar Entheses



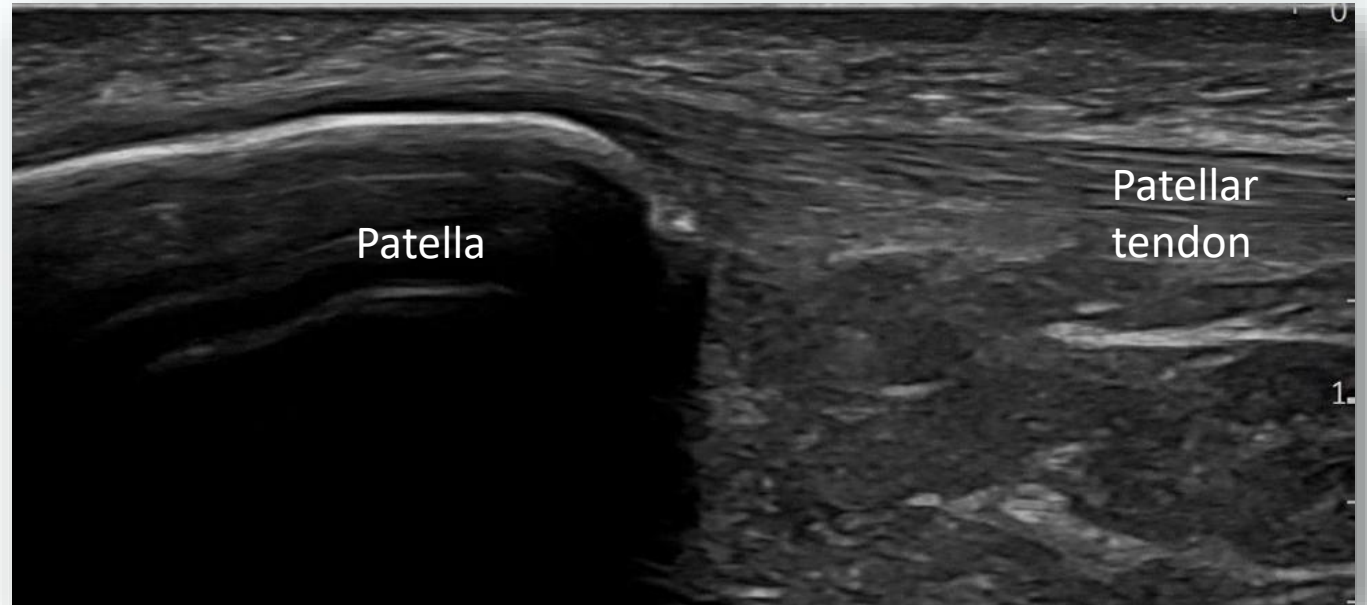
30° flexion of the knees for grayscale assessment of the knee entheses



Full extension for Doppler assessment of the knee entheses



Normal Proximal Patellar Tendon Insertion



Normal Achilles Tendon Insertion



Normal Triceps Tendon Enthesis



Scoring Entheseal Lesions



Boundaries of the Enthesis

The region of scoring abnormalities includes the area close to the insertion of the tendon/ligament to the bone.

For an elementary lesion to be related to enthesitis, enthesal lesions must affect the insertion.

Isolated sonographic abnormalities in B-mode or Doppler at the body of the tendon, in the absence of any pathology at the enthesis, should not be attributed to enthesitis.

Elementary Lesions Scored

Lesions score for the study:

- Hypoechogenicity
- Thickening
- Erosions
- Enthesophytes
- Calcifications
- Power Doppler signal (+location)
- Bursitis (exploratory)

Lesions included in the final score DUET:

- Hypoechogenicity
- Thickening
- Erosions
- Enthesophytes
- Power Doppler signal (only if close to the enthesis)

All elementary lesions were assessed for their presence or absence. Several lesions were scored for their severity using a semi-quantitative system (grade 0 to 3).

The OMERACT US group definitions for enthesal lesions were used as the basis for the elementary lesions with some minor modifications or clarifications when deemed necessary.

Hypoechogenicity

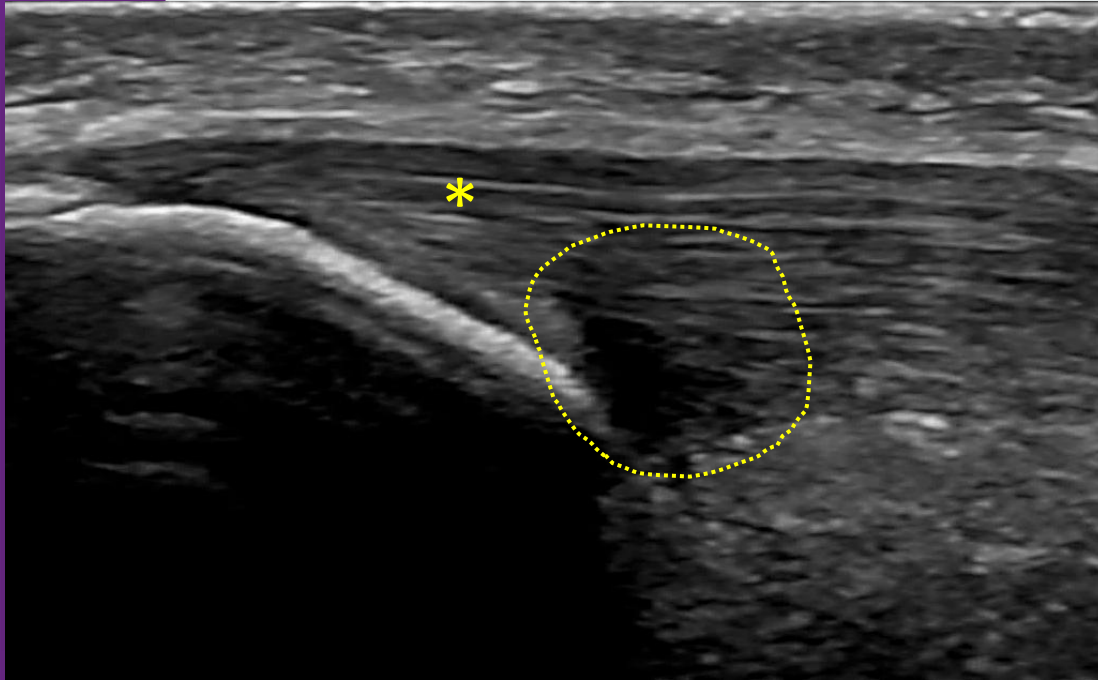
Definition: Distinct loss of homogenous fibrillar pattern with relative hypoechogenicity compared to the rest of the enthesis after correcting for anisotropy.

Grading of Hypoechogenicity

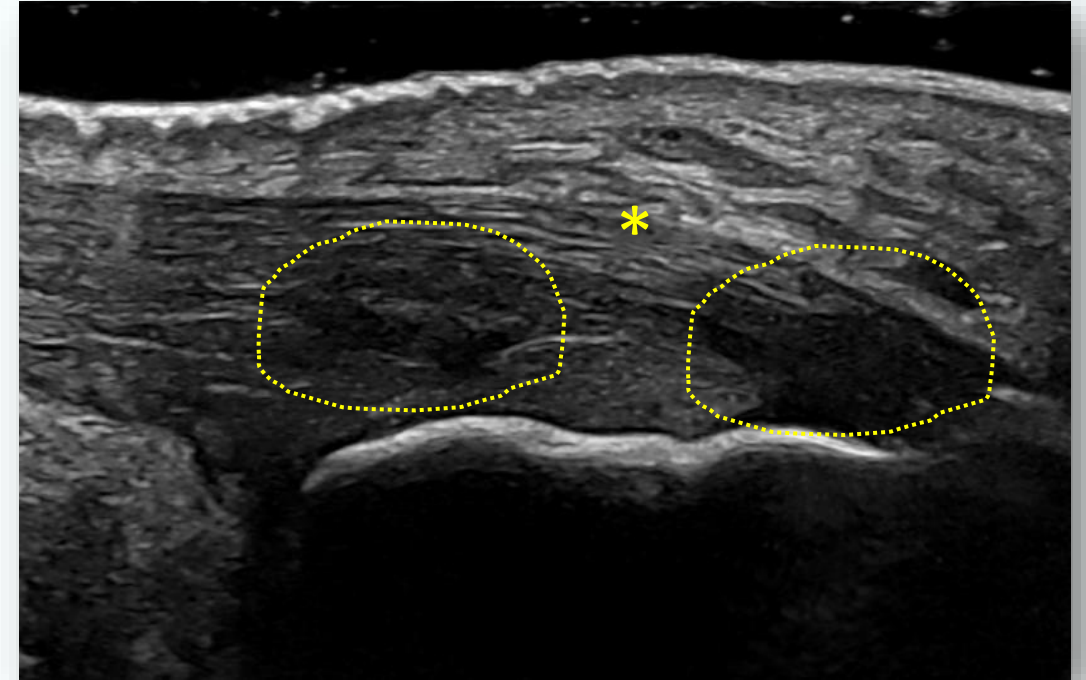
0 - Absent

1 - Present

Hypoechogenicity



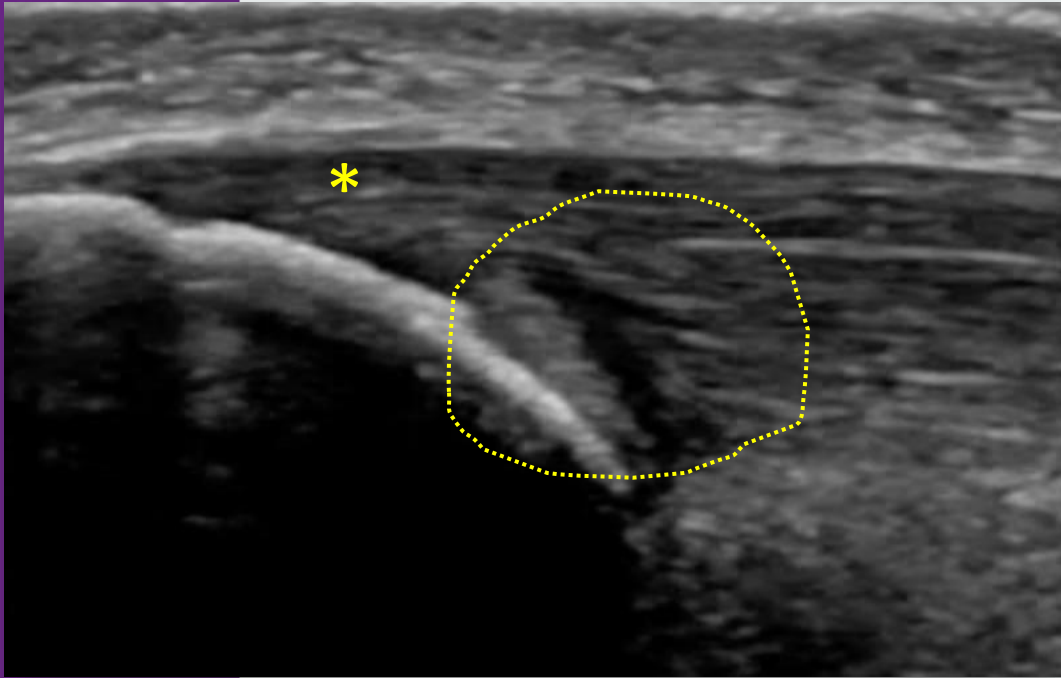
Proximal Patellar Tendon Insertion:
The area of hypoechogenicity is circled.
Asterix=area of normal echogenicity.



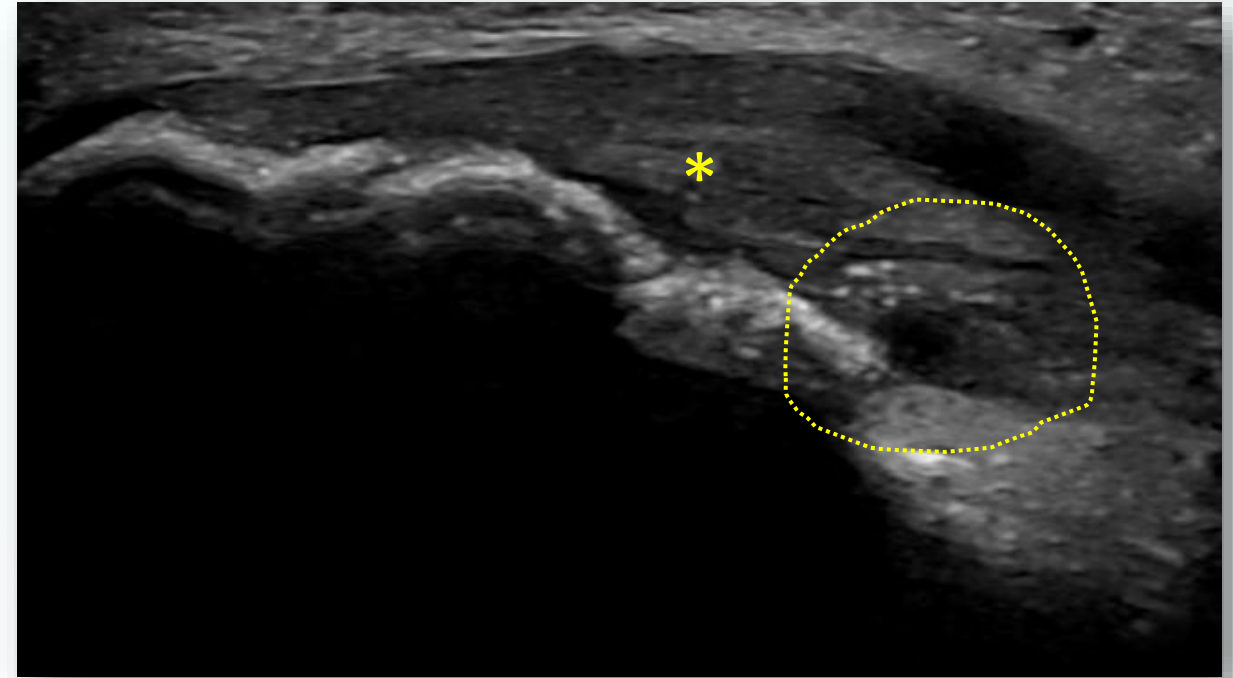
Achilles Tendon Insertion:
The area of hypoechogenicity is circled.
Asterix=area of normal echogenicity.



Hypoechogenicity



Proximal Patellar Tendon Insertion:
The area of hypoechogenicity is circled.
Asterix=area of normal echogenicity.



Achilles Tendon Insertion:
The area of hypoechogenicity is circled.
Asterix=area of normal echogenicity.



Thickening

Definition: Increased thickness of the tendon/ligament at the enthesis compared to its body.

Thickness may be difficult to judge and should be suspected when accompanied by other enthesal lesions, such as loss of fibrillary echotexture.

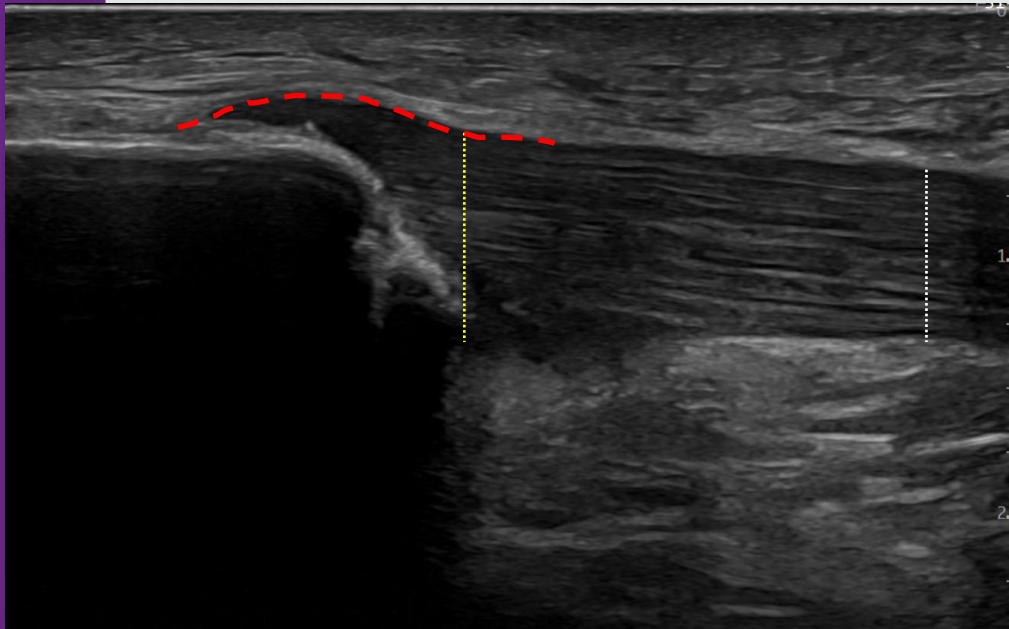
A convex shape appearance of the tendon at the insertion site is another sonographic clue for the presence of enthesal thickening

Grading of Thickening

0 - Absent

1 - Present

Thickening



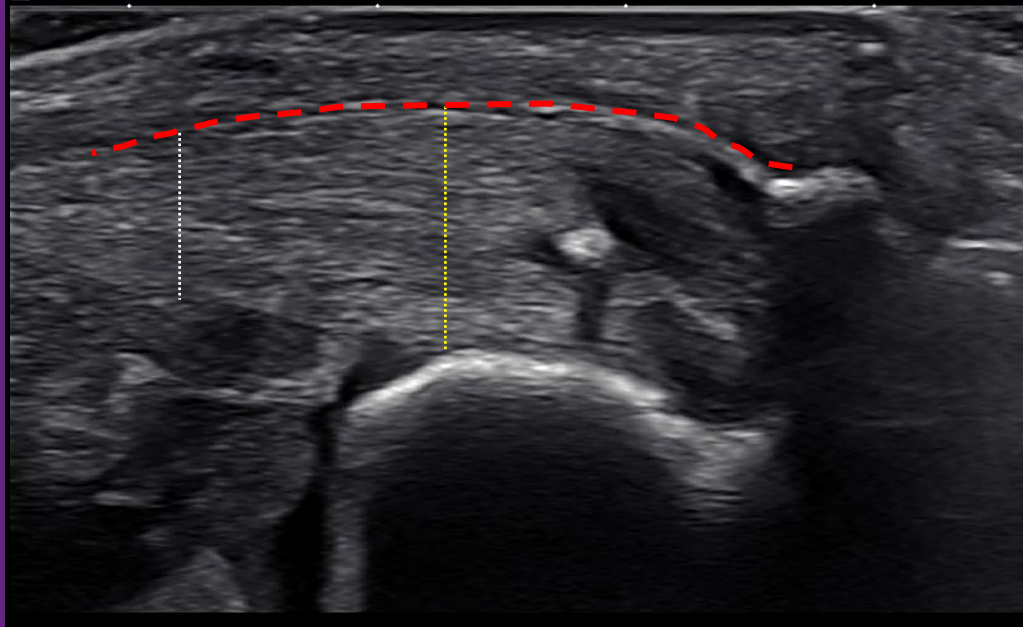
Patellar Tendon Insertion to the Patella:
Increased thickness of the enthesis (yellow line)
compared to the body of the tendon (white line).
Convex shape of the enthesis (red line).



Achilles Tendon Insertion:
Increased thickness of the enthesis
(yellow line) compared to the body of
the tendon (white line). Convex shape of
the enthesis (red line).

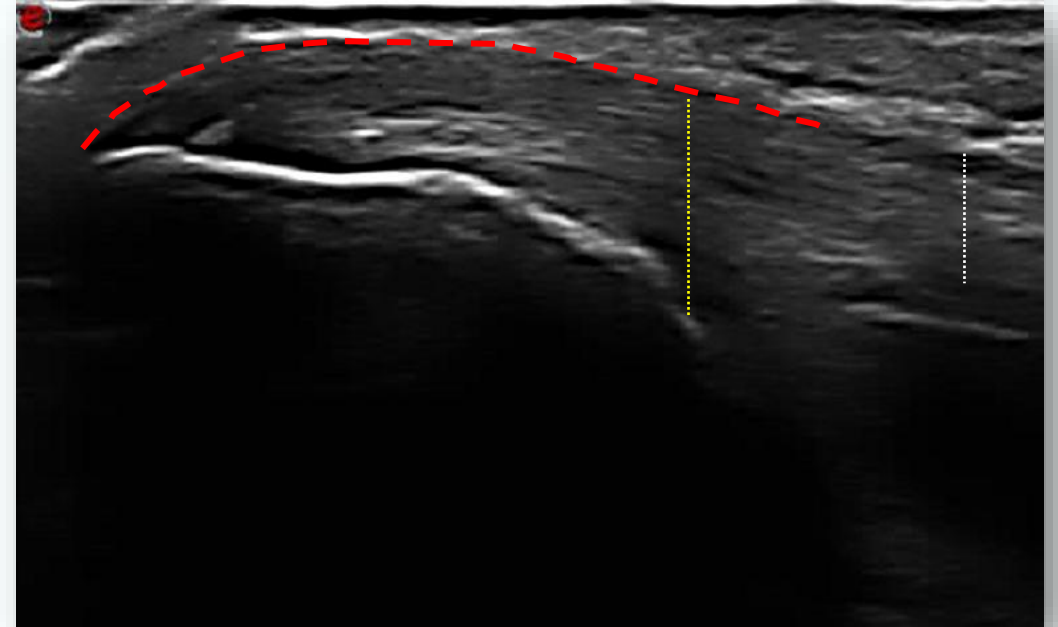


Thickening



Achilles Tendon Insertion:

Increased thickness of the enthesis (yellow line) compared to the body of the tendon (white line).
Convex shape of the enthesis (red line).



Triceps Tendon Insertion:

Increased thickness of the enthesis (yellow line) compared to the body of the ligament (white line). Concave shape of the enthesis (red line).



Erosion

Definition: A cortical defect confirmed with a step-down contour defect detected in two planes at the insertion of the tendon/ligament to the bone.

Grading of Erosion

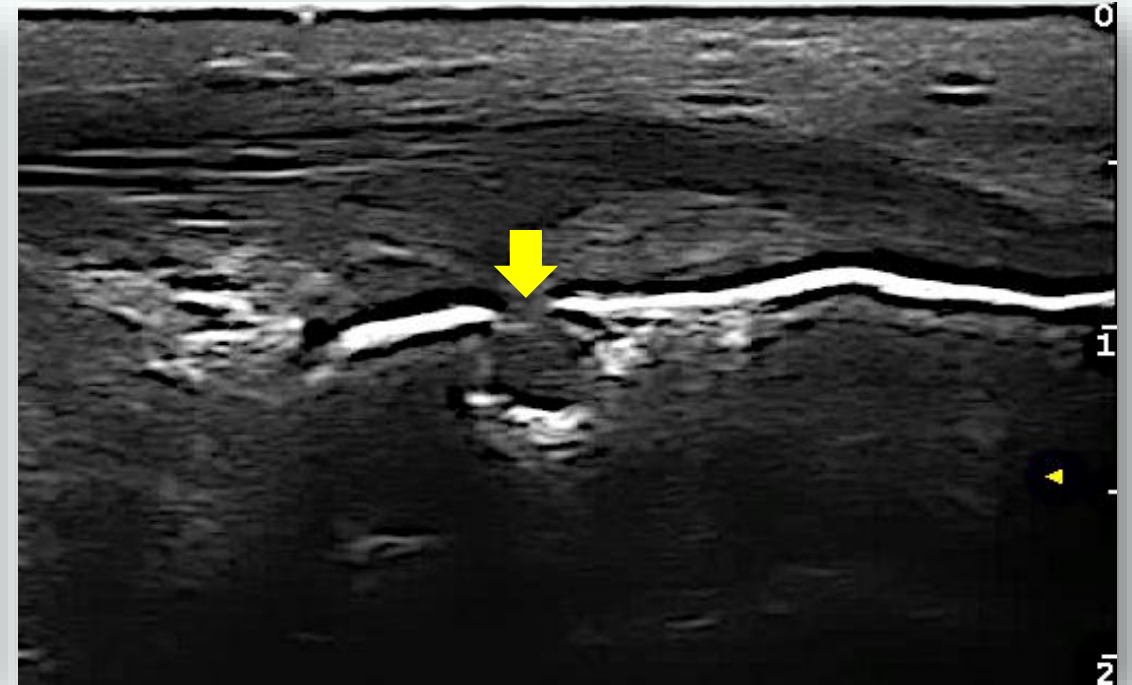
0 – Absent

1 - Present

Erosion



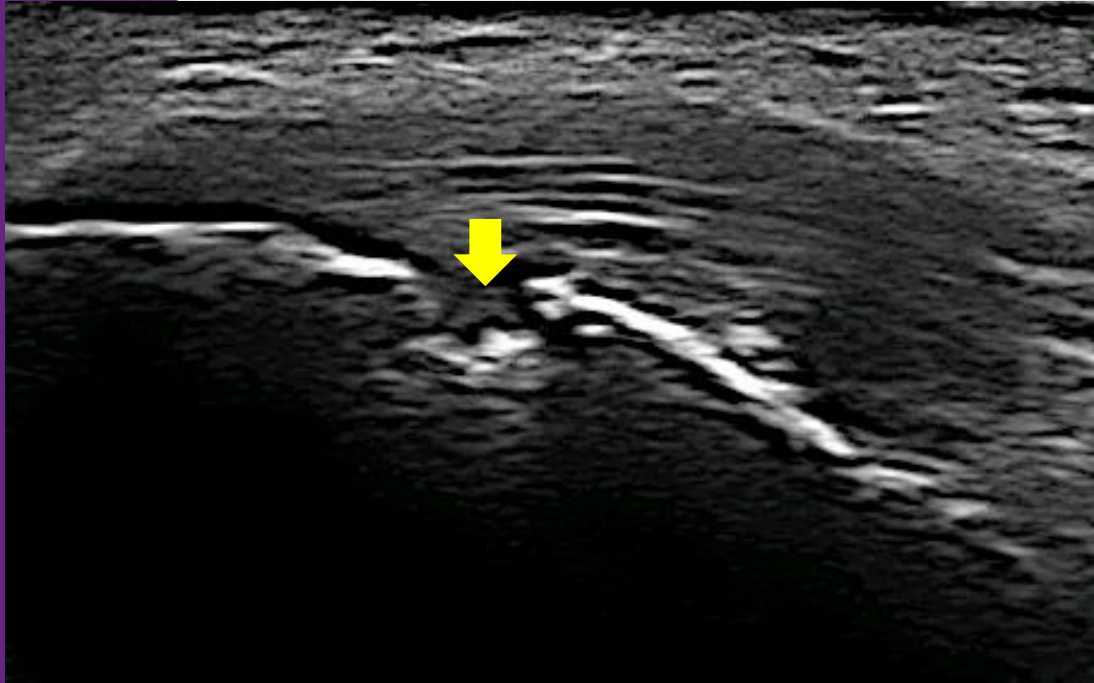
Achilles Tendon Insertion:
Erosion in the calcaneal bone (arrow).



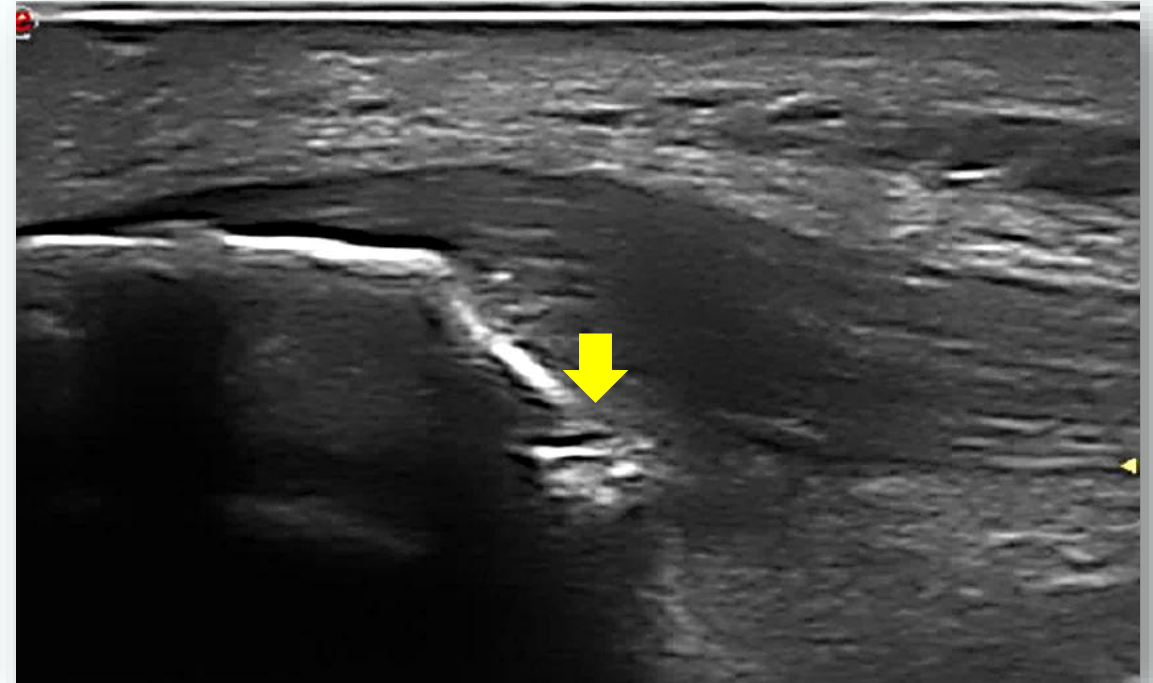
Achilles tendon insertion:
Erosion in the calcaneal bone (arrow).



Erosion



Achilles Tendon Insertion:
Erosion in the calcaneal bone (arrow).



Achilles tendon insertion:
Erosion in the calcaneal bone (arrow).



Enthesophyte

Definition: A step-up bony prominence at the normal bone contour. Grading was based on its size (length). Although the readers are not expected to measure the length of the enthesis we provided suggested cut off points to guide the grading of the enthesophytes.

Grading of Enthesophytes

Grade 0 : No enthesophytes

Grade 1 : Small enthesophyte (length <3 mm)

Grade 2: Medium enthesophyte (length 3-5 mm)

Grade 3: Large enthesophyte (length >5 mm)

Enthesophyte Grading



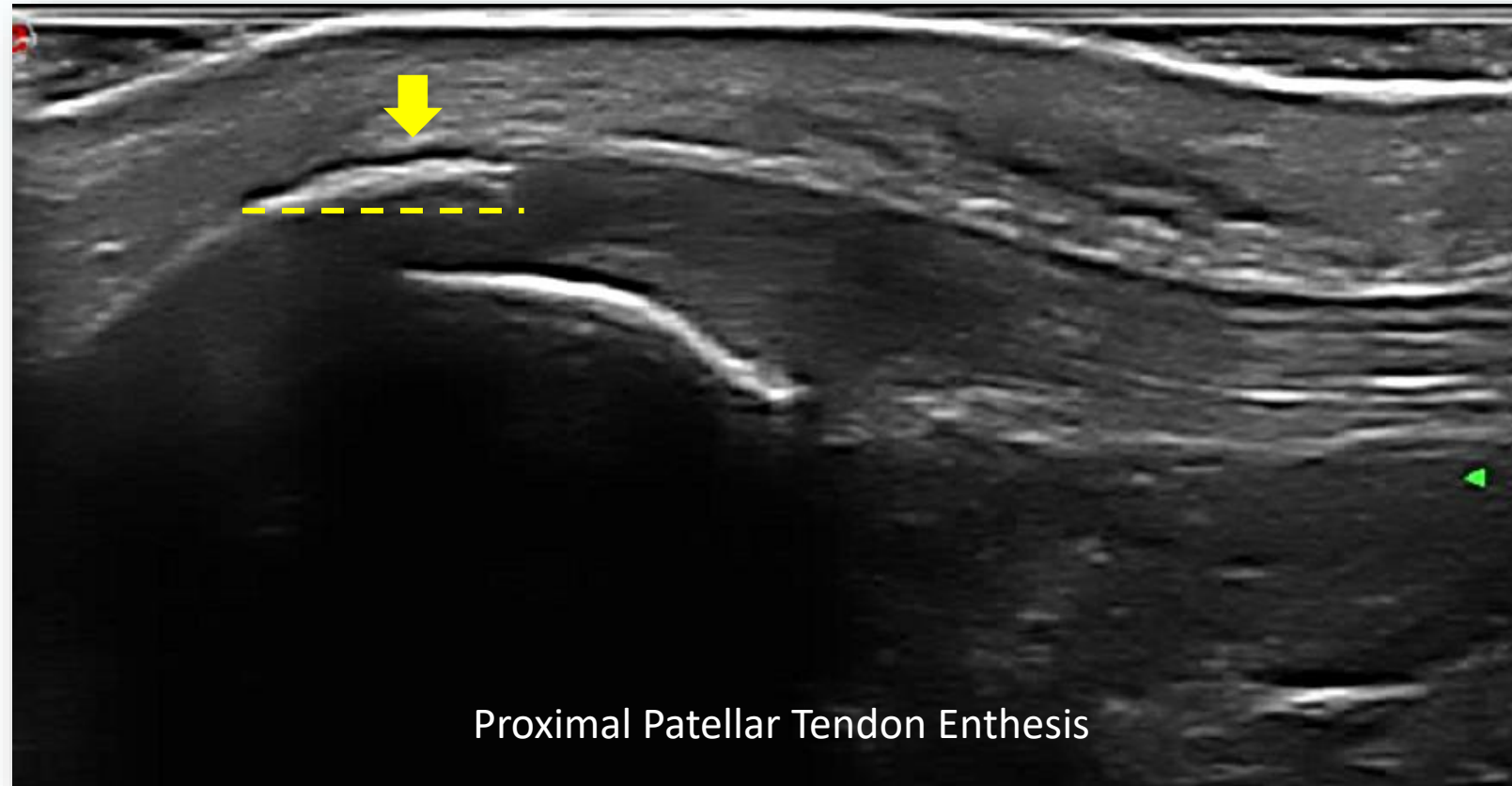
Note: We provide suggested cut off points for general guidance of the semiquantitative grading of the enthesophytes.

Linear measurement from most proximal to distal end of enthesophyte as parallel as possible to enthesal fibers

Grade 1: < 3 mm length

Grade 2: 3-5 mm length

Grade 3: $\geq$ 5 mm length

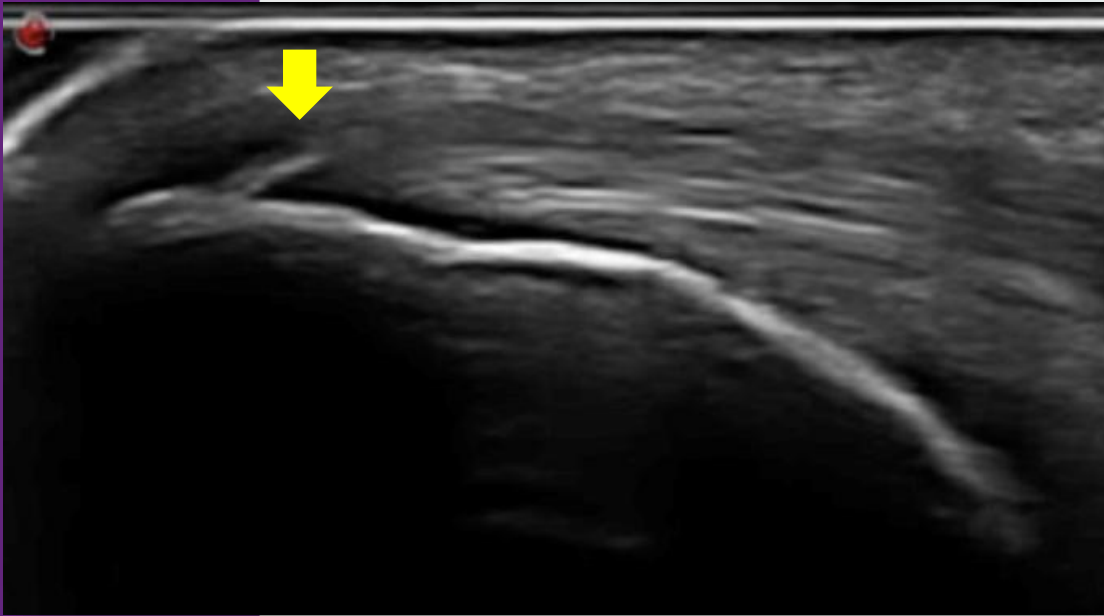


Proximal Patellar Tendon Enthesis

Enthesophyte – Grade 1



Small enthesophyte (length <3 mm)



Triceps Tendon Insertion:
Enthesophyte (arrow)



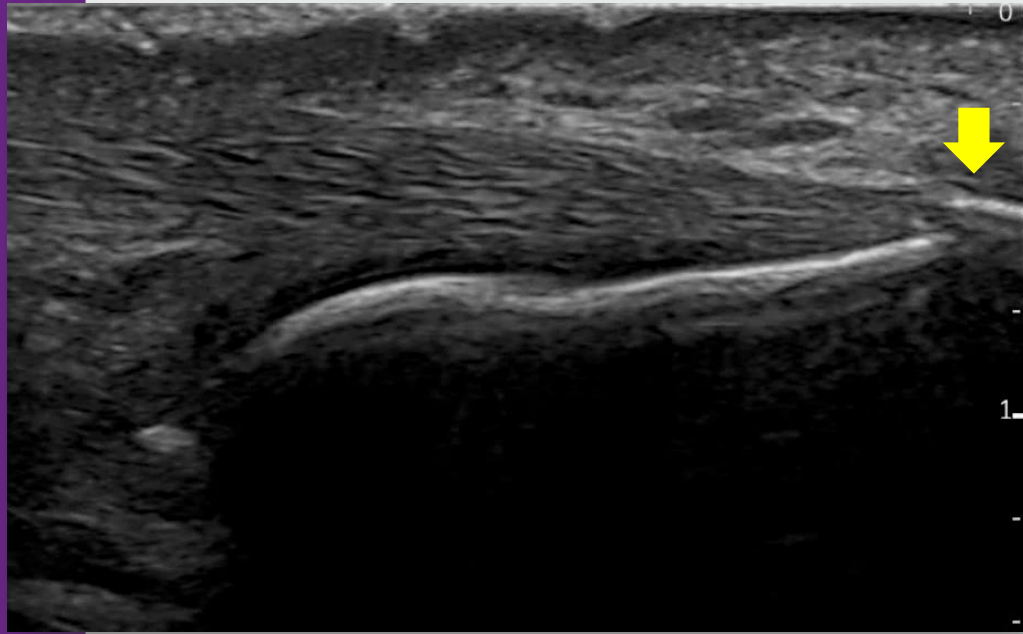
Proximal Patellar Tendon Insertion:
Enthesophyte (arrow).



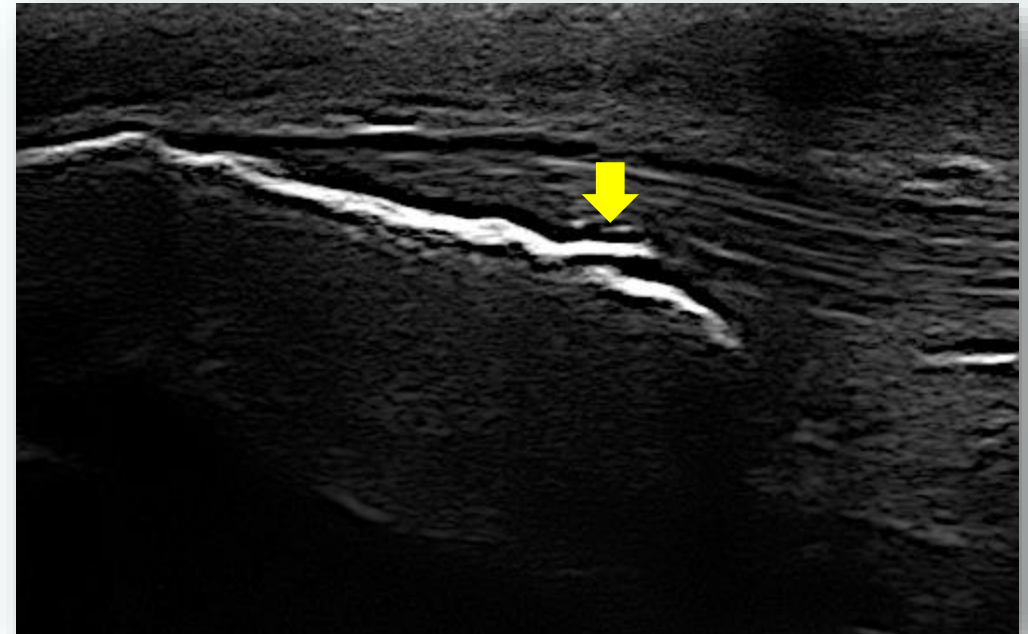
Enthesophyte – Grade 1



Small enthesophyte (length <3 mm)



Achilles Tendon Insertion:
Enthesophyte (arrow)



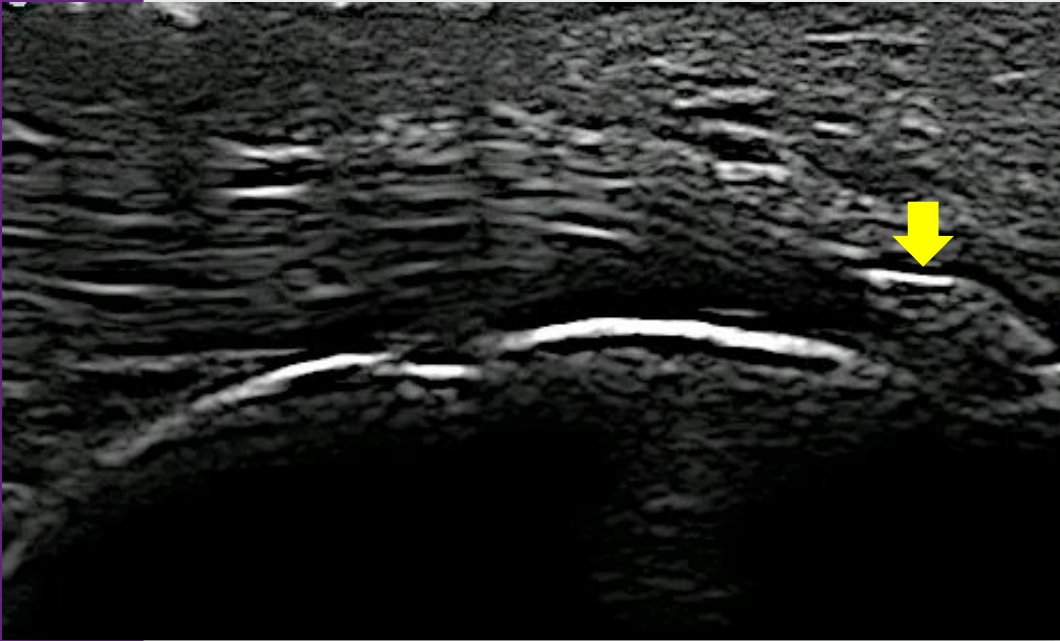
Proximal Patellar Tendon Insertion:
Enthesophyte (arrow).



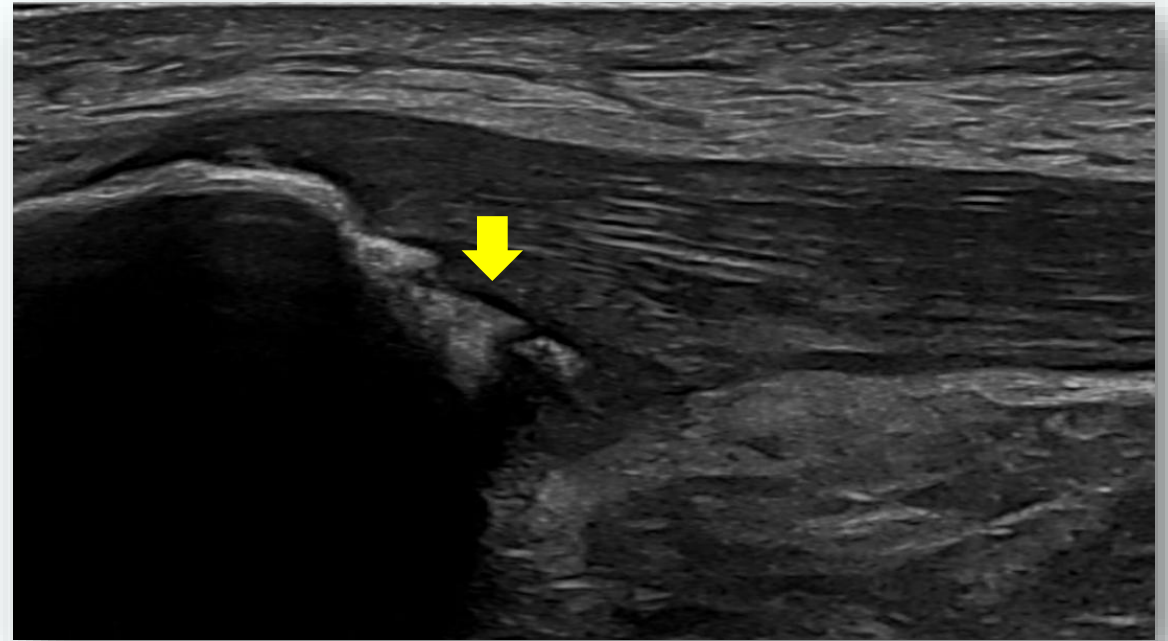
Enthesophyte – Grade 2



Medium enthesophyte (length 3-5 mm)



Achilles Tendon Insertion:
Enthesophyte (arrow)



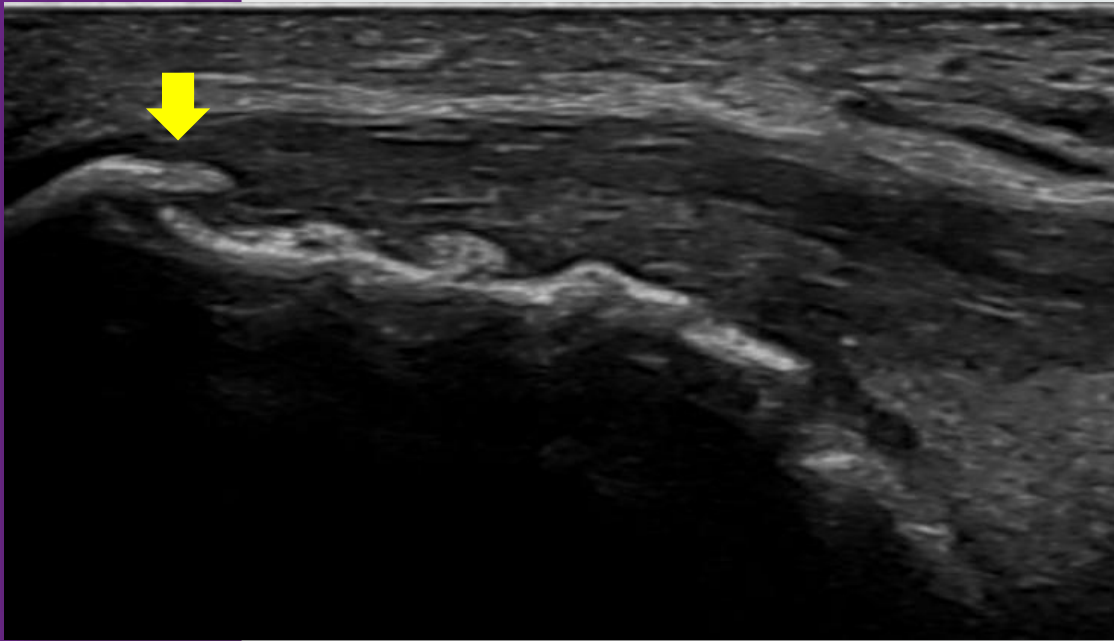
Proximal Patellar Tendon Insertion:
Enthesophyte (arrow)



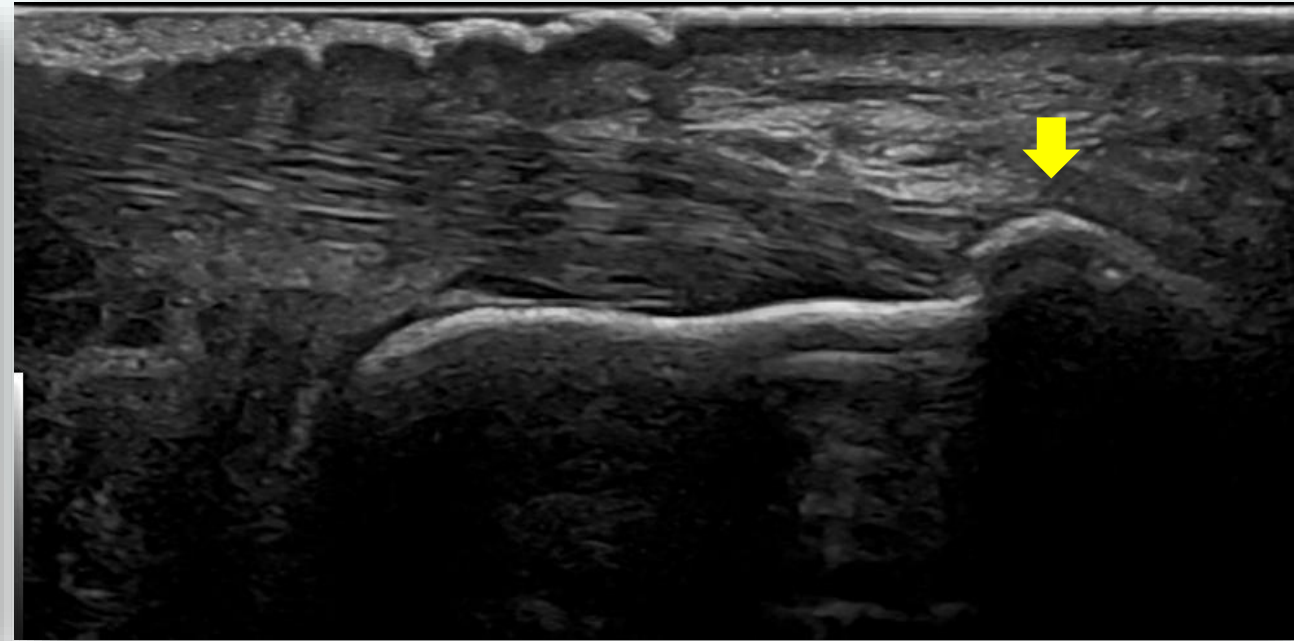
Enthesophyte – Grade 2



Medium enthesophyte (length 3-5 mm)



Triceps Tendon Insertion:
Enthesophyte (arrow)



Achilles Tendon Insertion:
Enthesophyte (arrow)



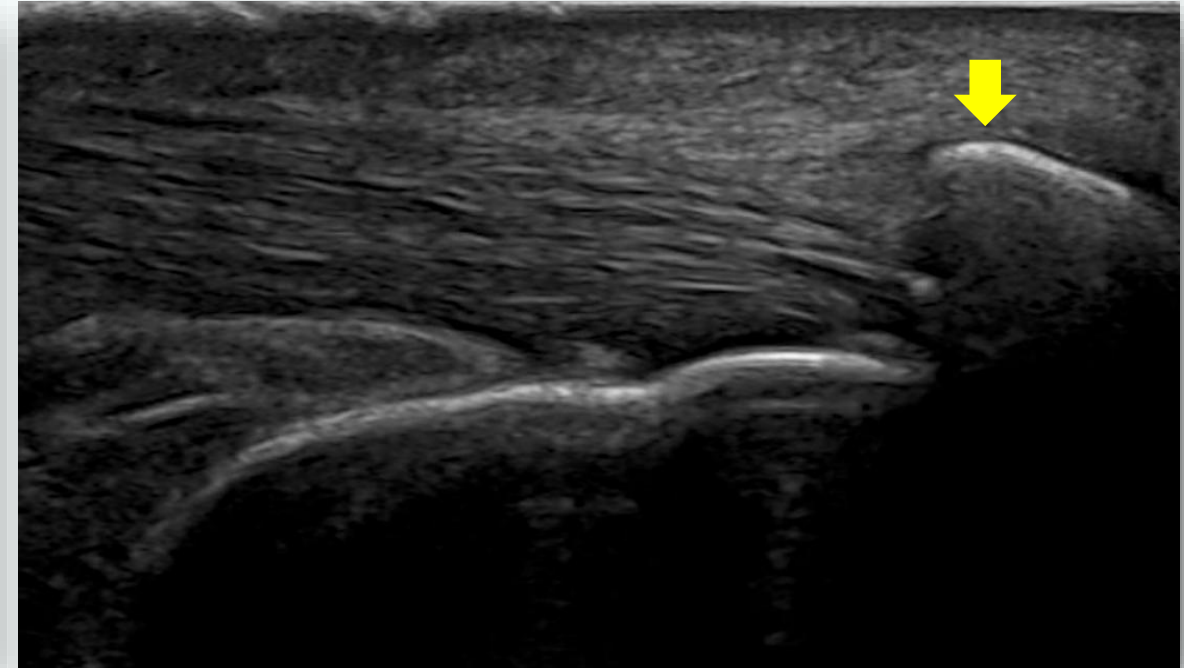
Enthesophyte – Grade 3



Large enthesophyte (length >5 mm)



Triceps Tendon Insertion:
Enthesophyte (arrow)



Achilles Tendon Insertion:
Enthesophyte (arrow)

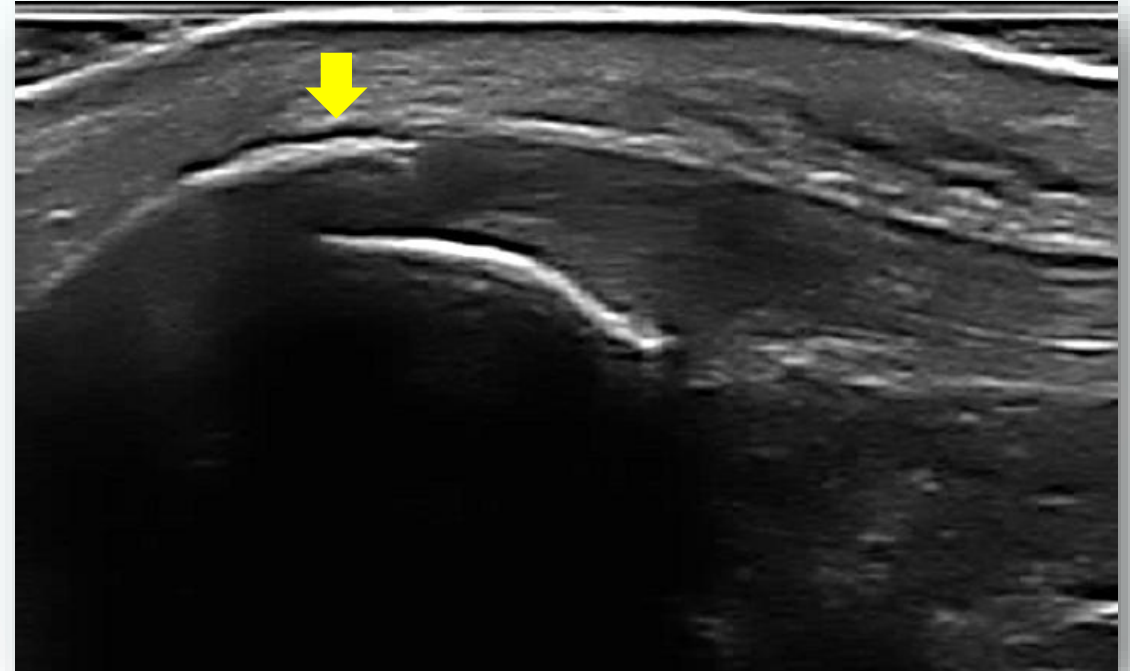
Enthesophyte – Grade 3



Large enthesophyte (length >5 mm)



Achilles Tendon Insertion:
Enthesophyte (arrow)



Proximal Patella Tendon Insertion:
Enthesophyte (arrow)



Doppler Signal

Definition: The presence of positive Doppler signal at the enthesis, confirmed in two perpendicular planes and distinguished from reflection of surface artifacts and nutritional vessel signal.

Note: We will consider any Doppler signal at the enthesis area, including signals appearing beyond 2 mm of the bony cortex if there is signal also present near the bony cortex; however, isolated Doppler far from the enthesis and Doppler signals at the bursa will not be scored.

The intensity of the Doppler signal will be scored on a semi quantitative grading system:

Grading of Doppler signal:

Grade 0: No Doppler signal

Grade 1: A single confluent Doppler signal or up to 3 discrete Doppler spots

Grade 2: Doppler signal affecting less than half of the enthesis

Grade 3: Doppler signal covering more than half of the enthesis

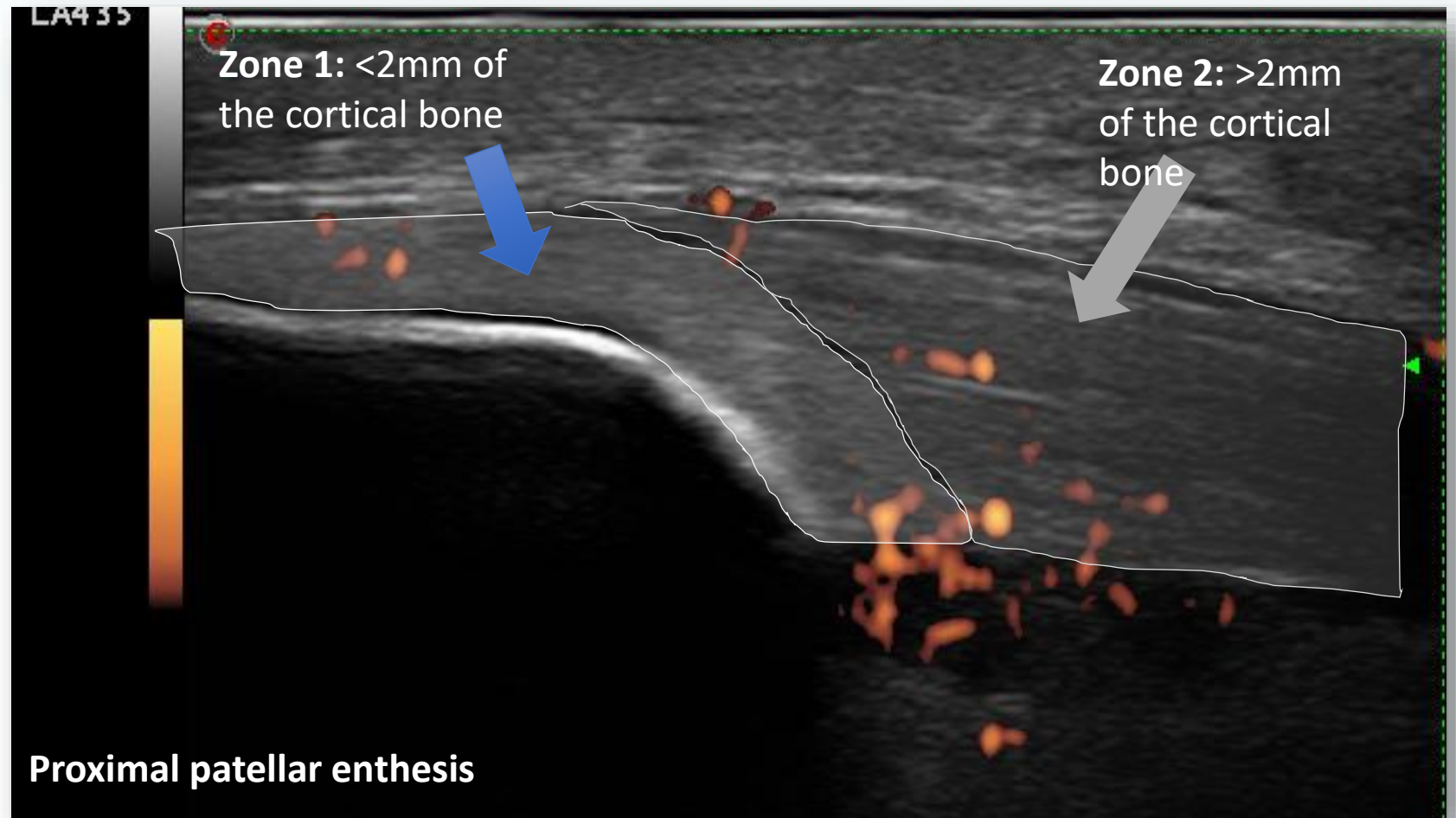
Doppler Signal Location



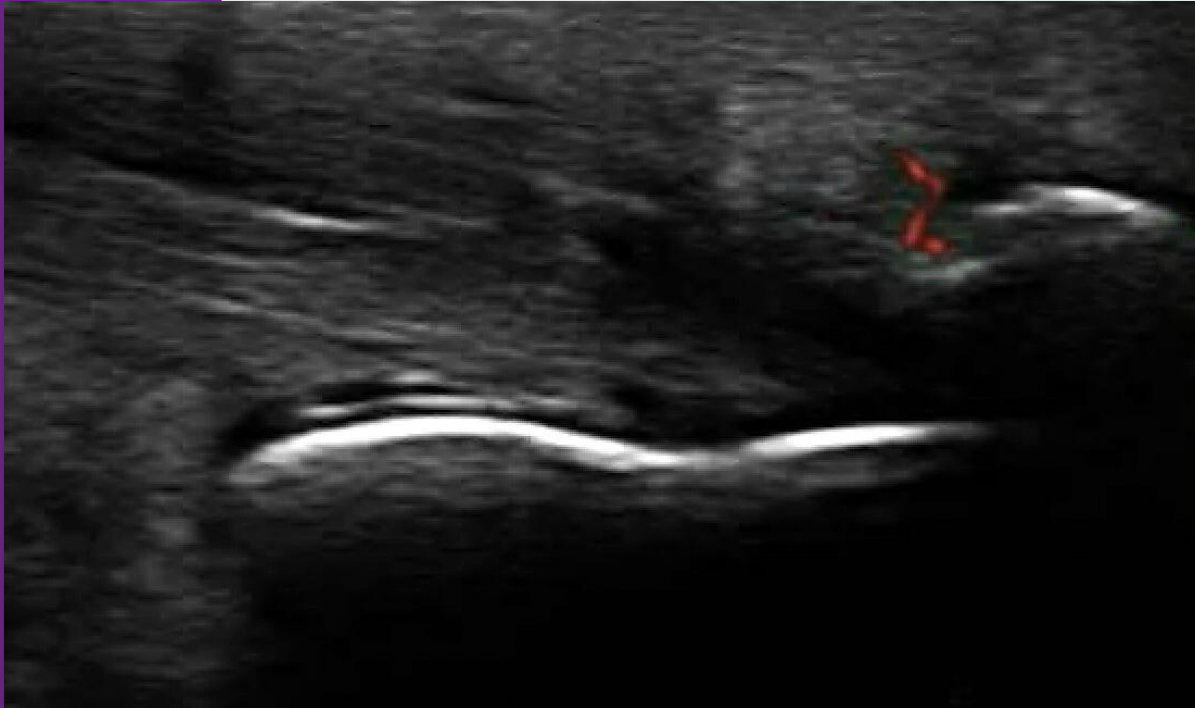
For each Doppler signal the location was recorded as:

$\leq 2\text{mm}$ from the bone cortex – Zone 1

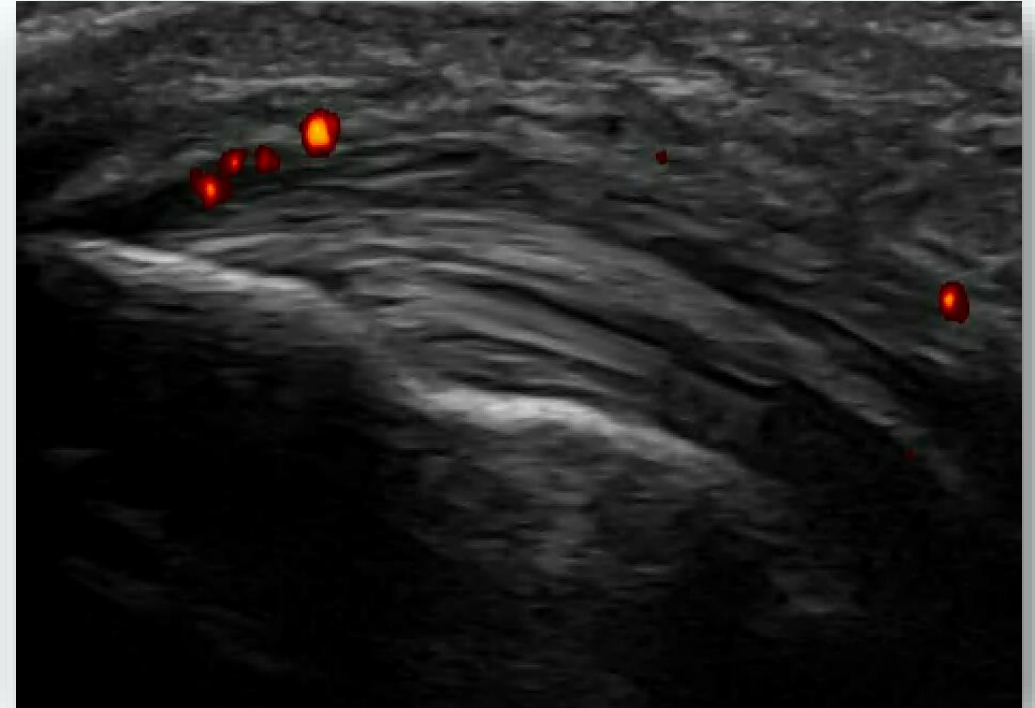
$> 2\text{mm}$ from the bone cortex – Zone 2



Doppler Signal – Grade 1



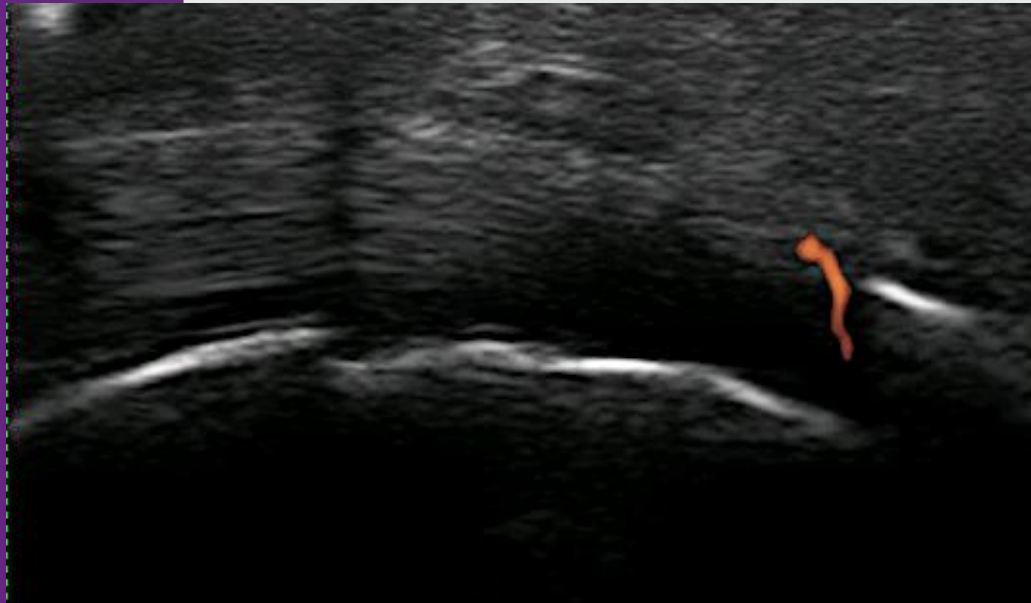
Achilles tendon insertion:
Grade 1 Doppler signal



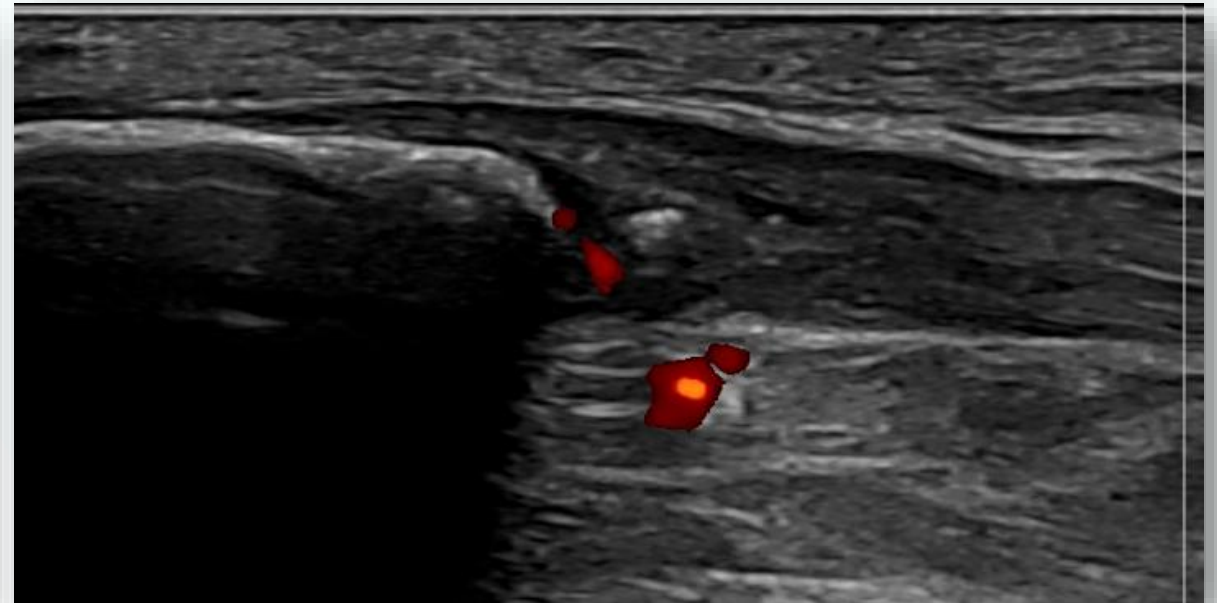
Triceps tendon insertion:
Grade 1 Doppler signal



Doppler Signal – Grade 1



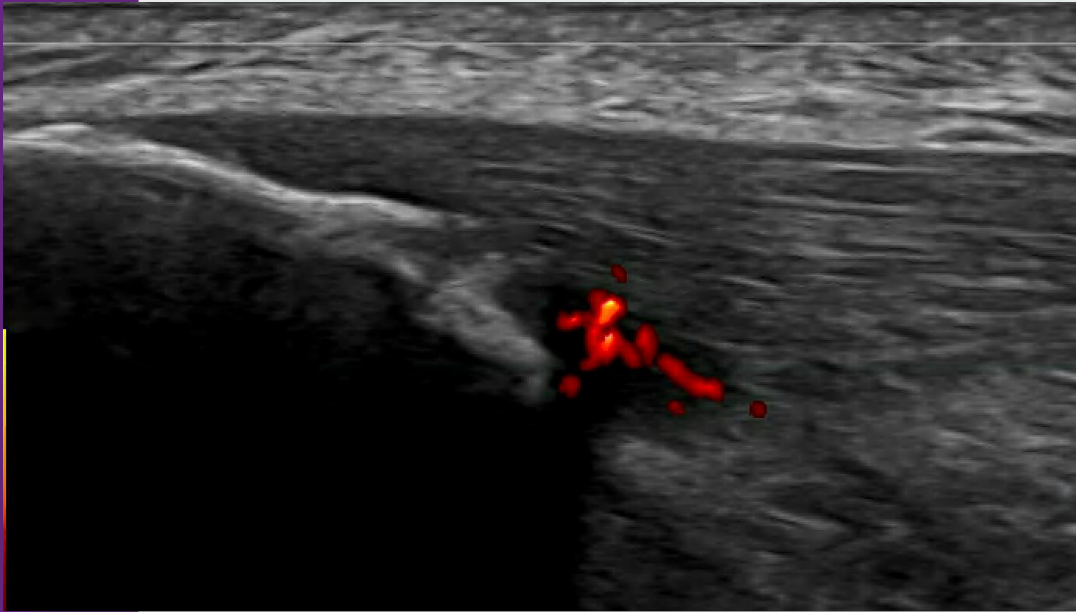
Achilles tendon insertion:
Grade 1 Doppler signal



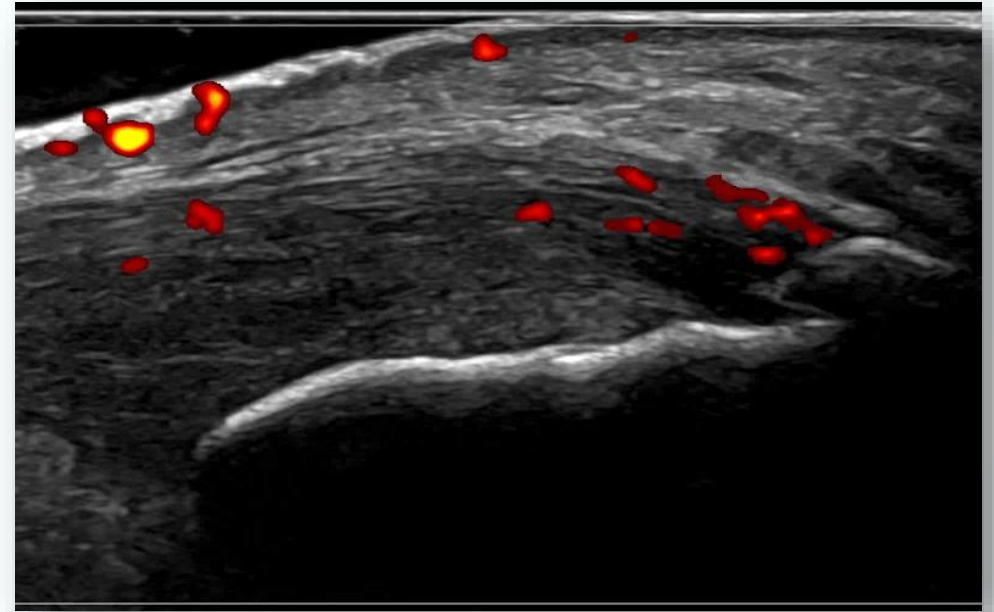
Proximal Patellar tendon insertion:
Grade 1 Doppler signal



Doppler Signal – Grade 2

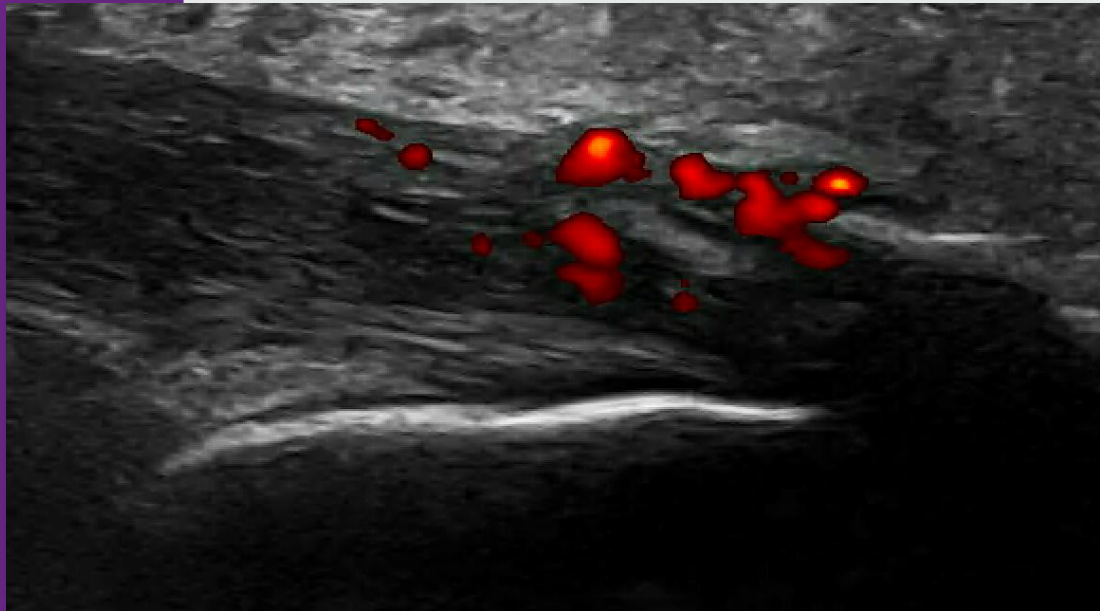


Proximal Patellar tendon insertion:
Grade 2 Doppler signal

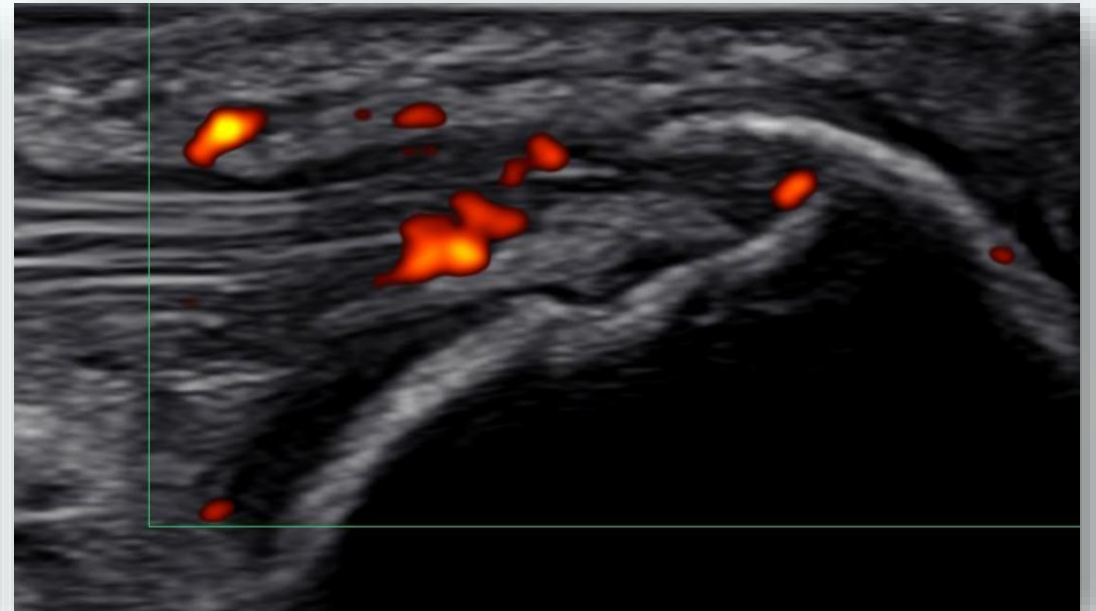


Achilles tendon insertion: Grade 2
Doppler signal

Doppler Signal – Grade 2

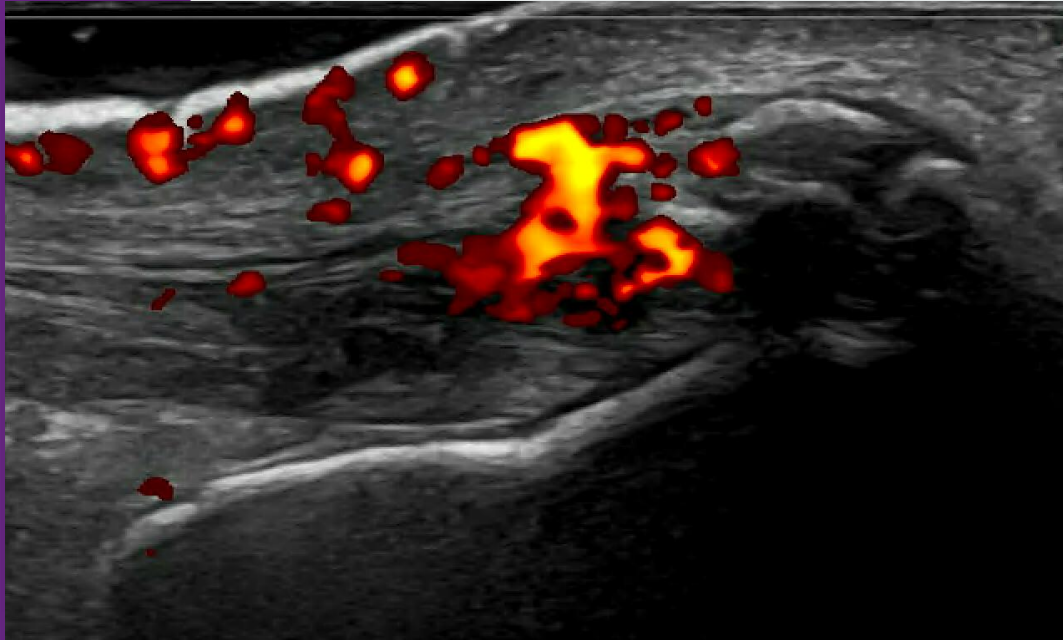


Achilles tendon insertion:
Grade 2 Doppler signal

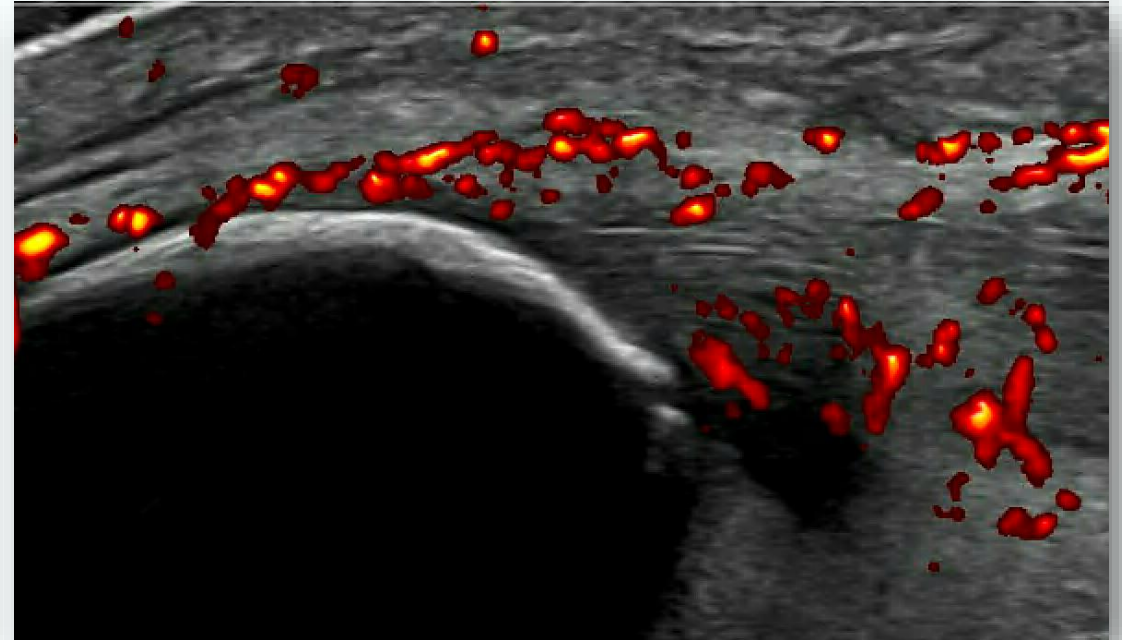


Triceps tendon insertion: Grade 2
Doppler signal

Doppler Signal – Grade 3



Achilles tendon insertion:
Grade 3 Doppler signal

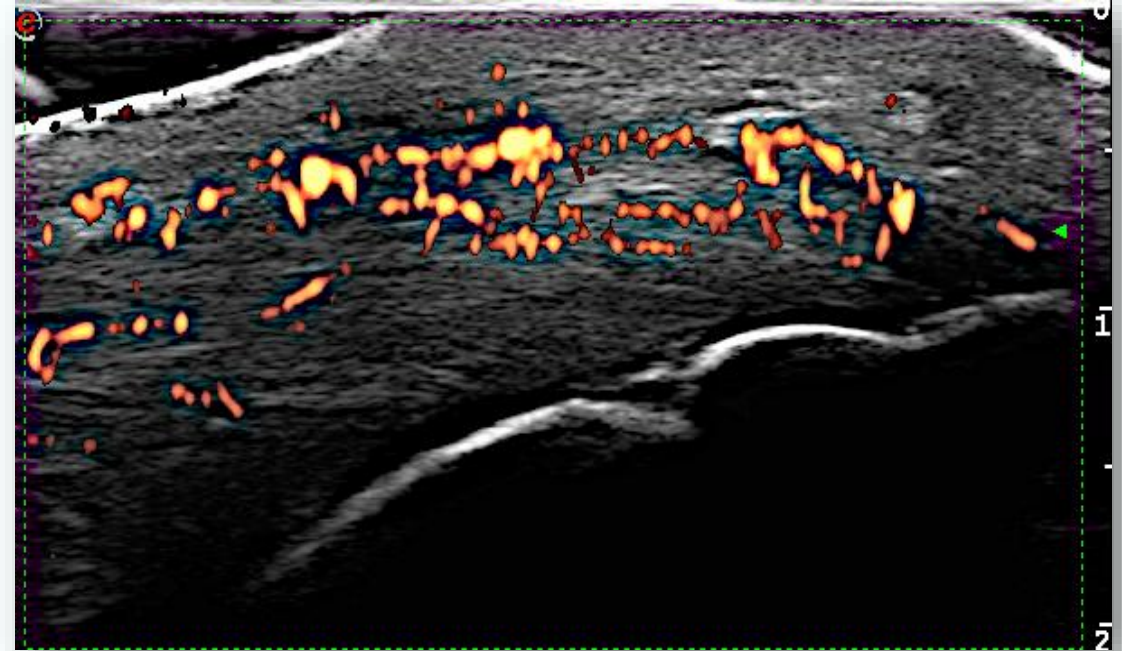


Proximal Patellar tendon insertion:
Grade 3 Doppler signal

Doppler Signal – Grade 3



Triceps Tendon Insertion:
Grade 3 Doppler signal



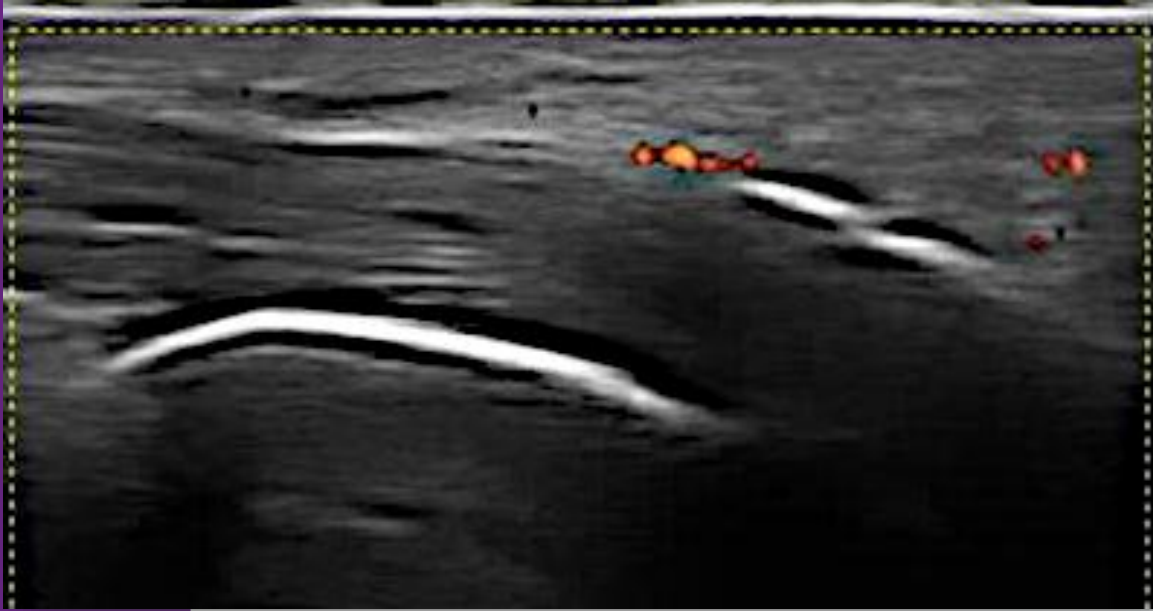
Achilles Tendon Insertion: Grade 3
Doppler signal



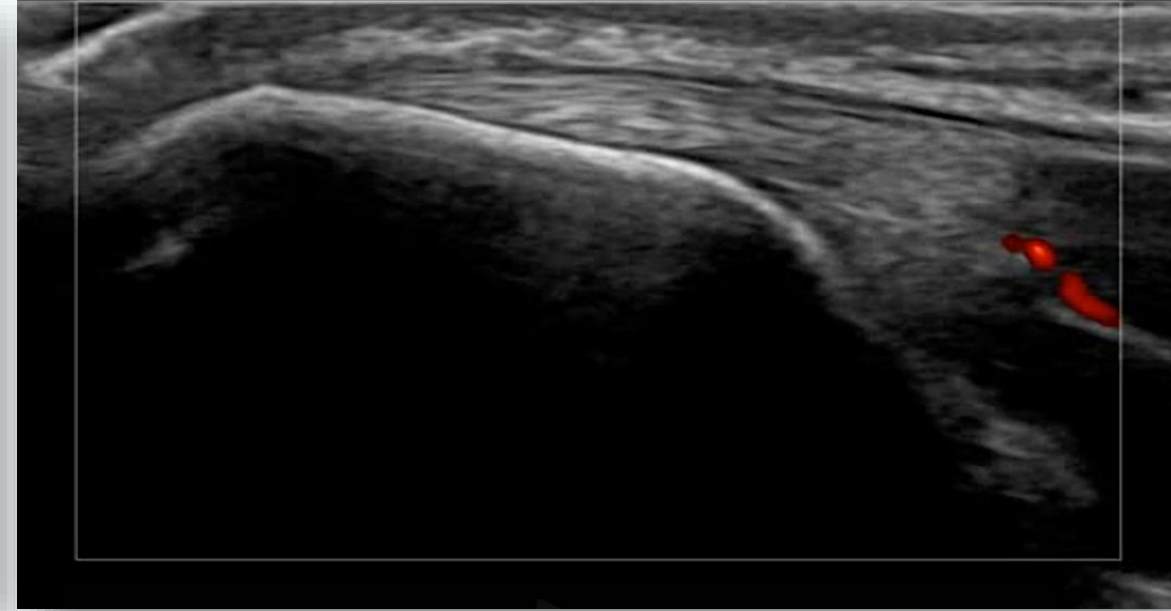
Pitfalls of Doppler Signal Scoring



The following findings were not scored:



Normal feeding vessels: Appear as confluent vascular signal adjacent to the tendon, but outside of its borders.



Only Doppler Signal far from the bony cortex (> 2 mm) without any other abnormalities in B-mode



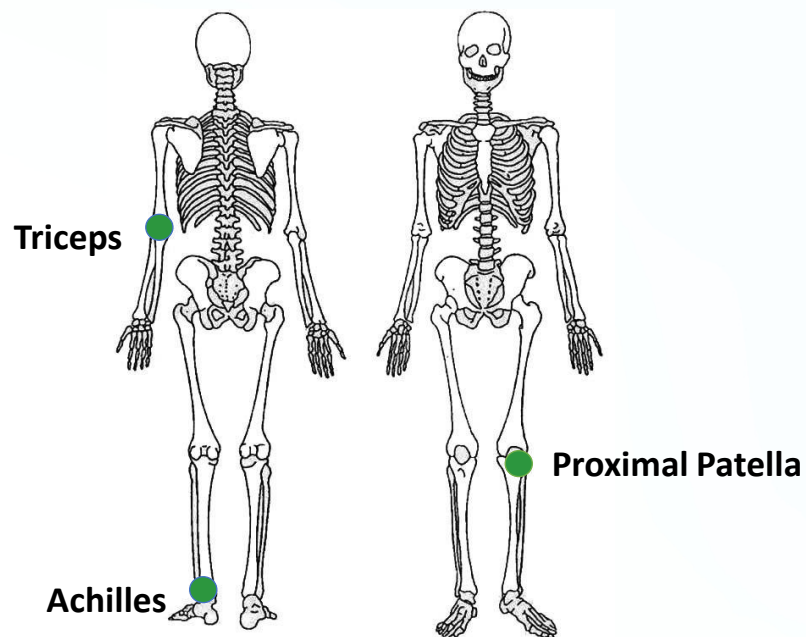
Case Studies

The final DUET score formula



The DUET score is a sum of the DUET formula (Inflammatory and structural sub-scores) at each of the 6 enthesal sites scanned

Enthesal Sites included bilaterally
(total 6 sites)



DUET Formula:

Inflammatory Sub-score:
Hypoechogenicity (0-1) +
Thickening (0-1) +
2 x PD Global Score (0-3)

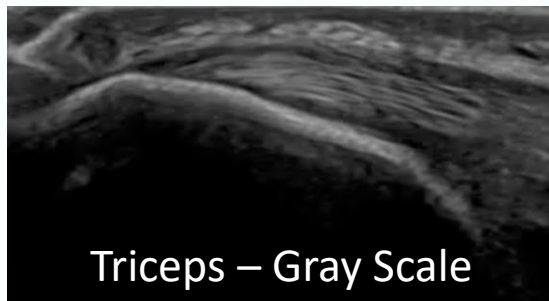


Structural Sub-score:
Enthesophyte (0-3) +
3 x Erosion (0-1)

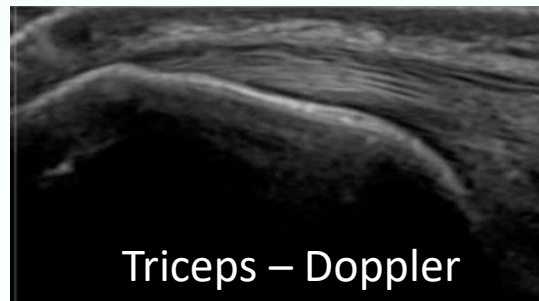


Positive Final Score:
≤ 55 years: > 5 || > 55 years: > 11

CASE 01



Triceps – Gray Scale



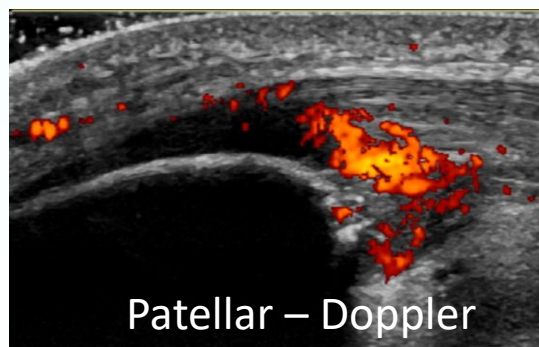
Triceps – Doppler

Triceps tendon

- Hypoechogenicity 0/1
- Thickening 0/1
- Enthesophyte 0/3
- Erosion 0/1 (x3)
- PD 0/3 (x2)



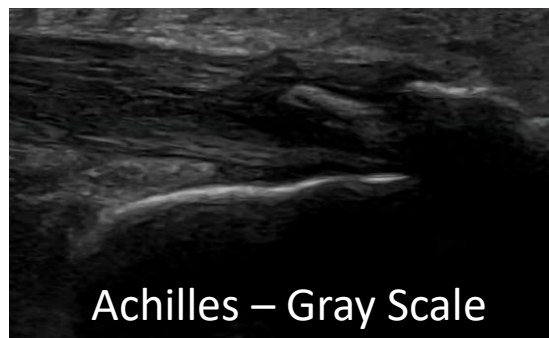
Patellar – Gray Scale



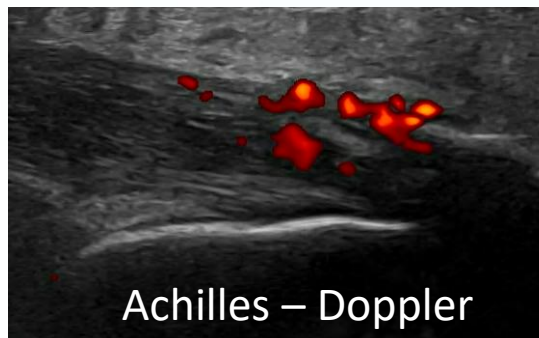
Patellar – Doppler

Prox. Patellar tendon

- Hypoechogenicity 1/1
- Thickening 1/1
- Enthesophyte 1/3
- Erosion 0/1 (x3)
- PD 3/3 (x2)



Achilles – Gray Scale



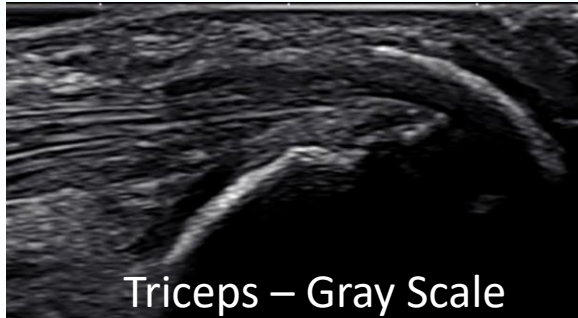
Achilles – Doppler

Achilles tendon

- Hypoechogenicity 1/1
- Thickening 1/1
- Enthesophyte 3/3
- Erosion 0/1 (x3)
- PD 2/3 (x2)



CASE 02



Triceps – Gray Scale

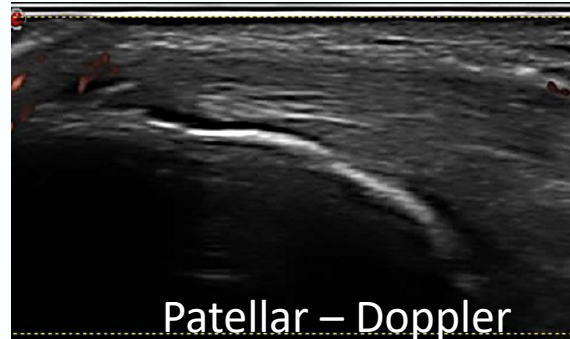


Triceps – Doppler

- Triceps tendon**
- Hypoechogenicity 1/1
 - Thickening 1/1
 - Enthesophyte 3/3
 - Erosion 0/1 (x3)
 - PD 2/3 (x2)

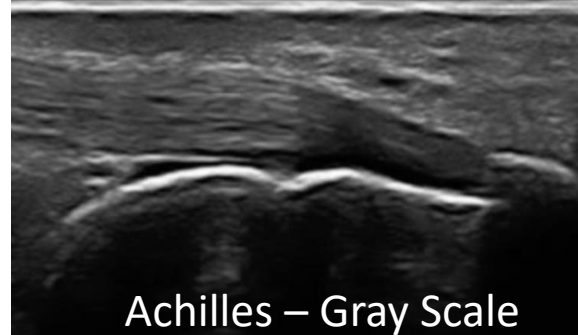


Patellar – Gray Scale



Patellar – Doppler

- Prox. Patellar tendon**
- Hypoechogenicity 1/1
 - Thickening 1/1
 - Enthesophyte 1/3
 - Erosion 0/1 (x3)
 - PD 1/3 (x2)



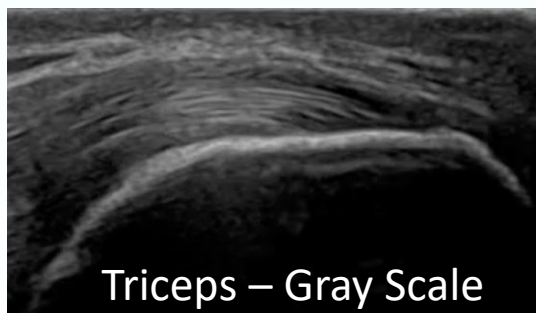
Achilles – Gray Scale



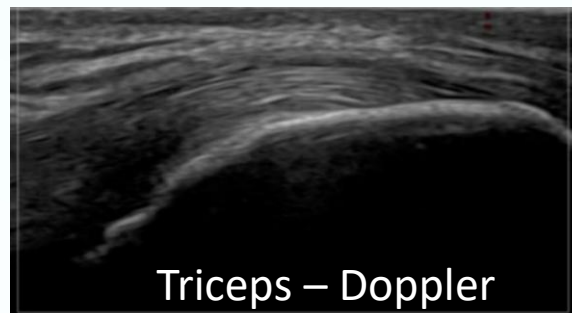
Achilles – Doppler

- Achilles tendon**
- Hypoechogenicity 0/1
 - Thickening 0/1
 - Enthesophyte 1/3
 - Erosion 0/1 (x3)
 - PD 0/3 (x2)

CASE 03



Triceps – Gray Scale



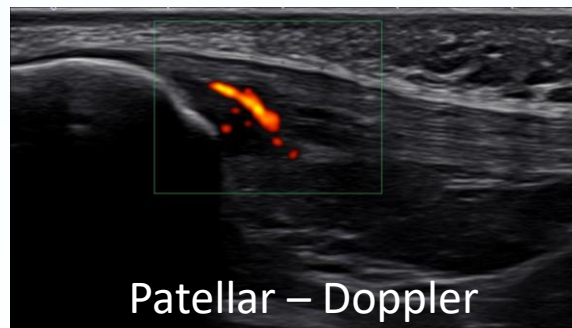
Triceps – Doppler

Triceps tendon

- Hypoechogenicity 0/1
- Thickening 0/1
- Enthesophyte 0/3
- Erosion 0/1 (x3)
- PD 0/3 (x2)



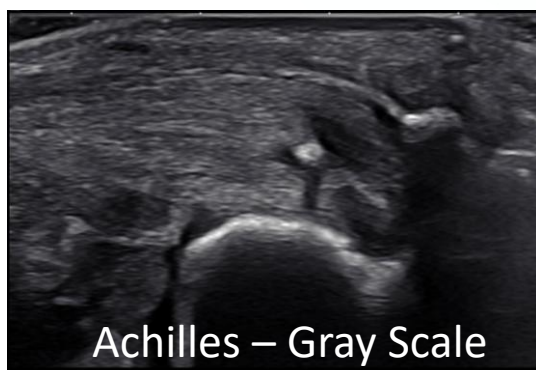
Patellar – Gray Scale



Patellar – Doppler

Prox. Patellar tendon

- Hypoechogenicity 1/1
- Thickening 1/1
- Enthesophyte 1/3
- Erosion 0/1 (x3)
- PD 2/3 (x2)



Achilles – Gray Scale



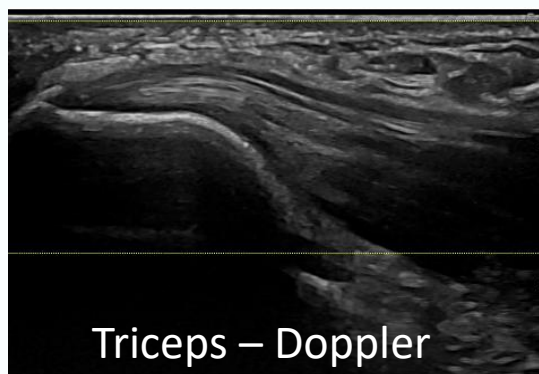
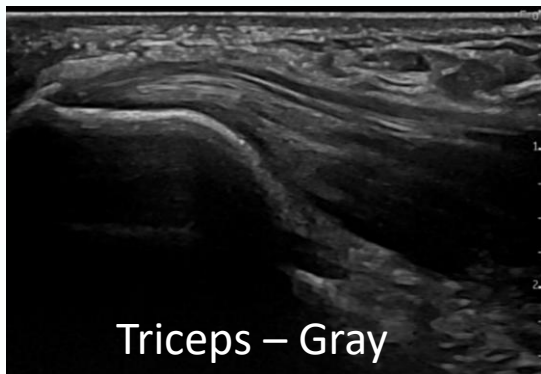
Achilles – Doppler

Achilles tendon

- Hypoechogenicity 1/1
- Thickening 1/1
- Enthesophyte 3/3
- Erosion 1/1 (x3)
- PD 3/3 (x2)

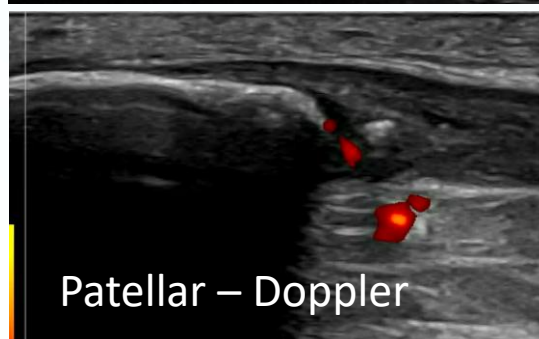


CASE 04



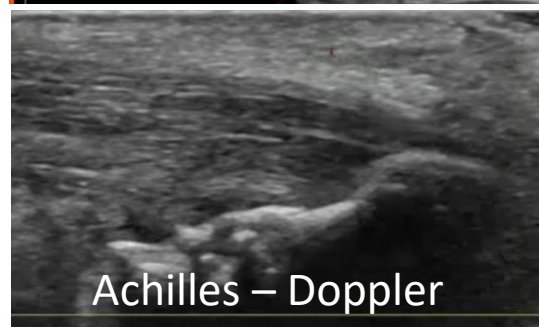
Triceps tendon

- Hypoechogenicity 0/1
- Thickening 0/1
- Enthesophyte 1/3
- Erosion 0/1 (x3)
- PD 0/3 (x2)



Prox. Patellar tendon

- Hypoechogenicity 1/1
- Thickening 1/1
- Enthesophyte 2/3
- Erosion 0/1 (x3)
- PD 1/3 (x2)



Achilles tendon

- Hypoechogenicity 1/1
- Thickening 1/1
- Enthesophyte 1/3
- Erosion 1/1 (x3)
- PD 0/3 (x2)



CASE 05



Triceps – Gray Scale



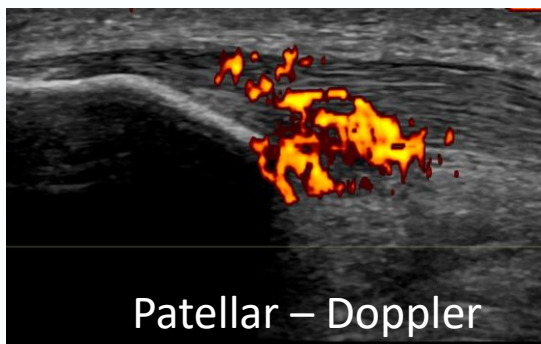
Triceps – Doppler

Triceps tendon

- Hypoechogenicity 0/1
- Thickening 0/1
- Enthesophyte 0/3
- Erosion 0/1 (x3)
- PD 0/3 (x2)



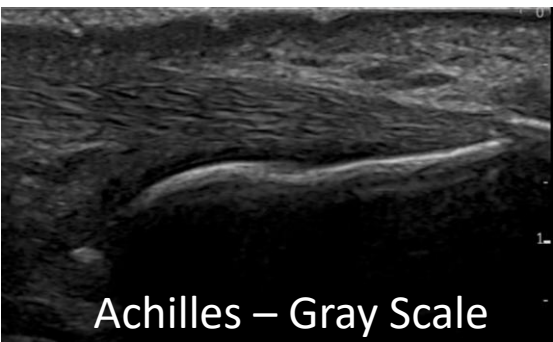
Patellar – Gray Scale



Patellar – Doppler

Prox. Patellar tendon

- Hypoechogenicity 1/1
- Thickening 1/1
- Enthesophyte 1/3
- Erosion 0/1 (x3)
- PD 3/3 (x2)



Achilles – Gray Scale



Achilles – Doppler

Achilles tendon

- Hypoechogenicity 0/1
- Thickening 0/1
- Enthesophyte 1/3
- Erosion 0/1 (x3)
- PD 0/3 (x2)



**Other elementary lesions
evaluated in the study but not
selected to the DUET score**

Calcifications

Definition: Hyperechoic linear structures detected within the tendon/ligament at the insertion to the bone but with no congruency with the bone.

Grading of calcifications:

Grade 0 : No calcifications

Grade 1 : Punctate hyperechoic area

Grade 2: Linear calcification without acoustic shadow

Grade 3: Egg-shell calcification with posterior acoustic shadow

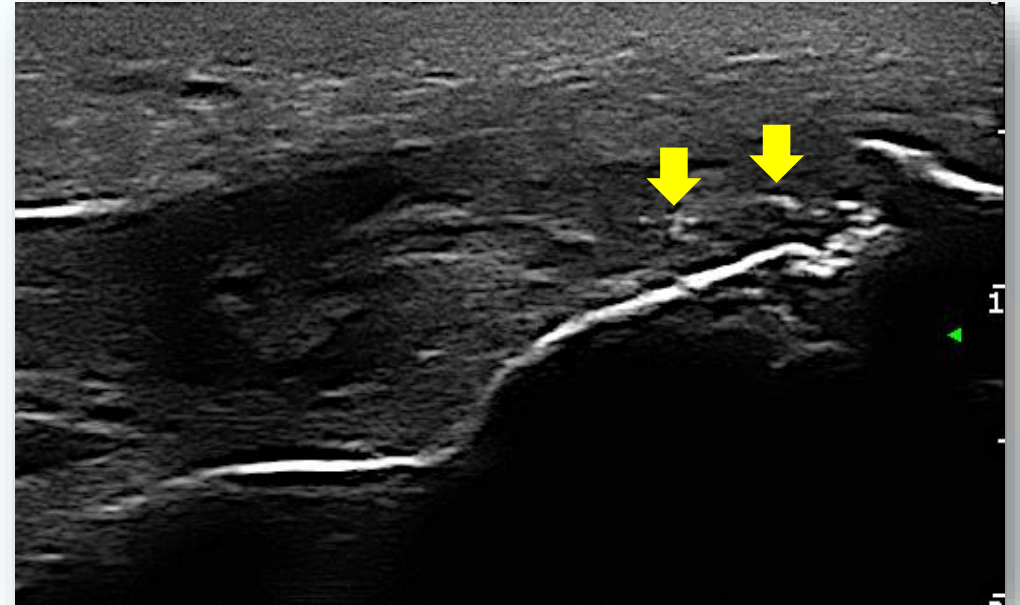
Calcifications – Grade 1



Punctate hyperechoic area



Patellar tendon insertion to patella:
Calcification (arrow)



Patellar tendon insertion to tibia:
Calcification (arrow)



Calcifications – Grade 2



Linear calcification without acoustic shadow



Patellar tendon insertion to tibia:
Calcification (arrow)

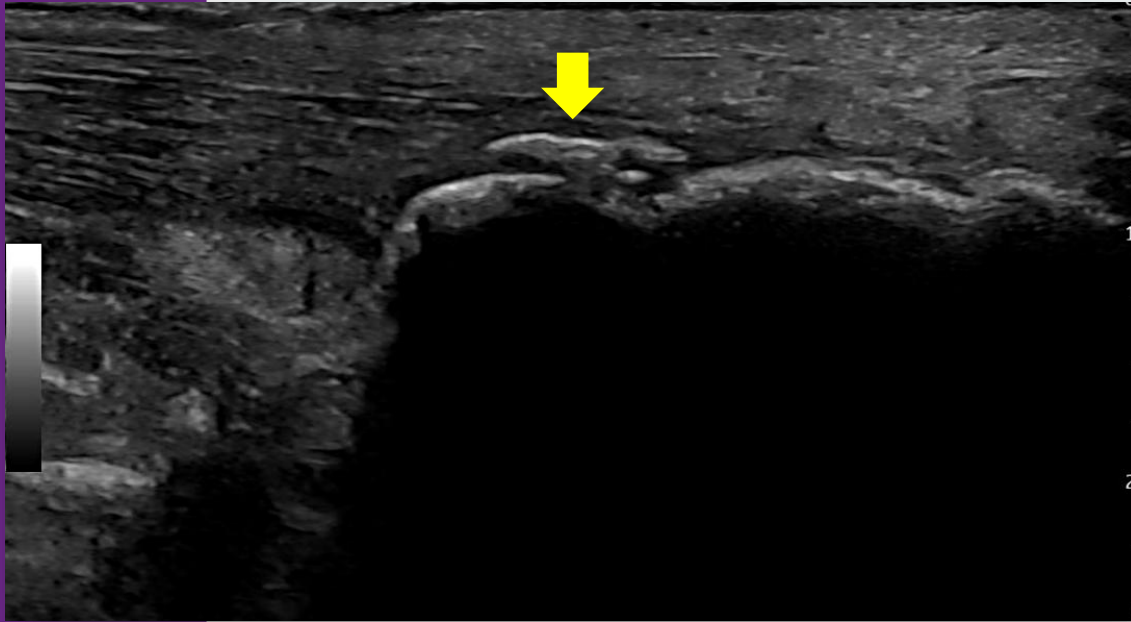


Quadriceps tendon insertion:
Calcification (arrow)

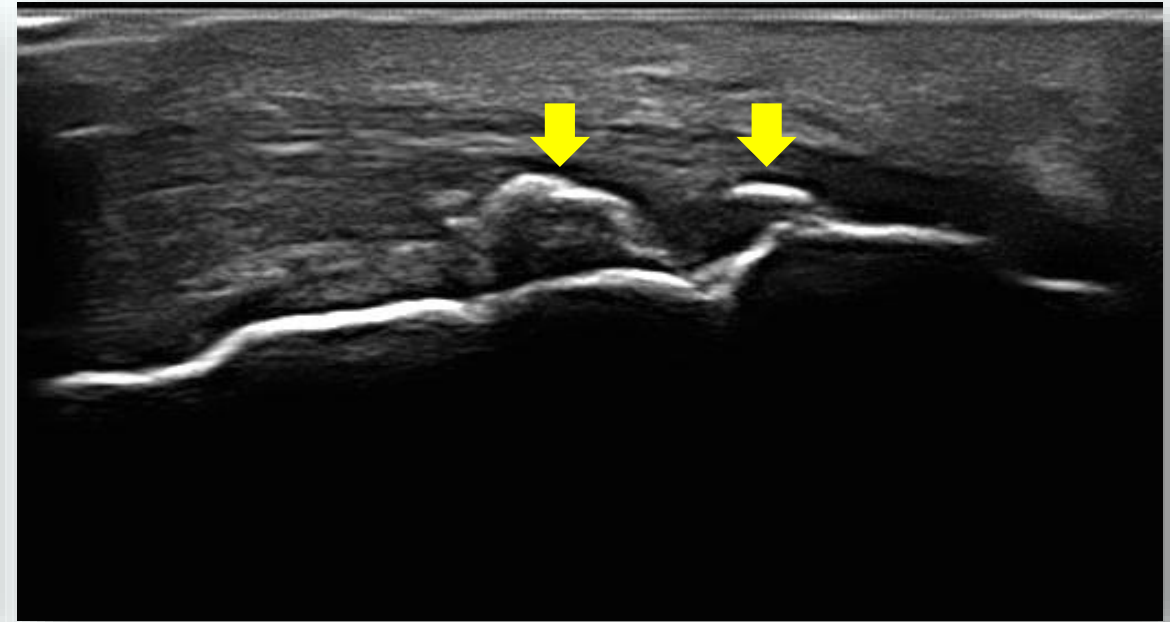
Calcifications – Grade 3



Egg-shell calcification with posterior acoustic shadow



Achilles tendon insertion:
Calcification (arrow)



Triceps tendon insertion:
Calcification (arrow)



Bursitis

Definition: Hypoechoic area located within a known anatomic bursa. The presence of Power Doppler in the bursa will also be evaluated.

Two areas will be assessed for the presence of bursitis:

- I) Bursa below the distal patellar insertion to the tibial tuberosity;
- II) Retro calcaneal bursa close to the Achilles tendon insertion

Bursitis will be defined as any fluid beyond the superior pole of the calcaneus (retrocalcaneal bursa) or beyond the tibial tuberosity.

Grading of Bursitis:

Grade 0: Absent

Grade 1: Bursitis present in B mode, no Doppler signal

Grade 2: Bursitis present in B mode and Doppler signal is present in the bursa

Bursitis – Grade 1



Grade 1: Bursitis present in B mode, no Doppler signal



Patellar tendon insertion to tibia:
Infra patellar bursitis grade 1



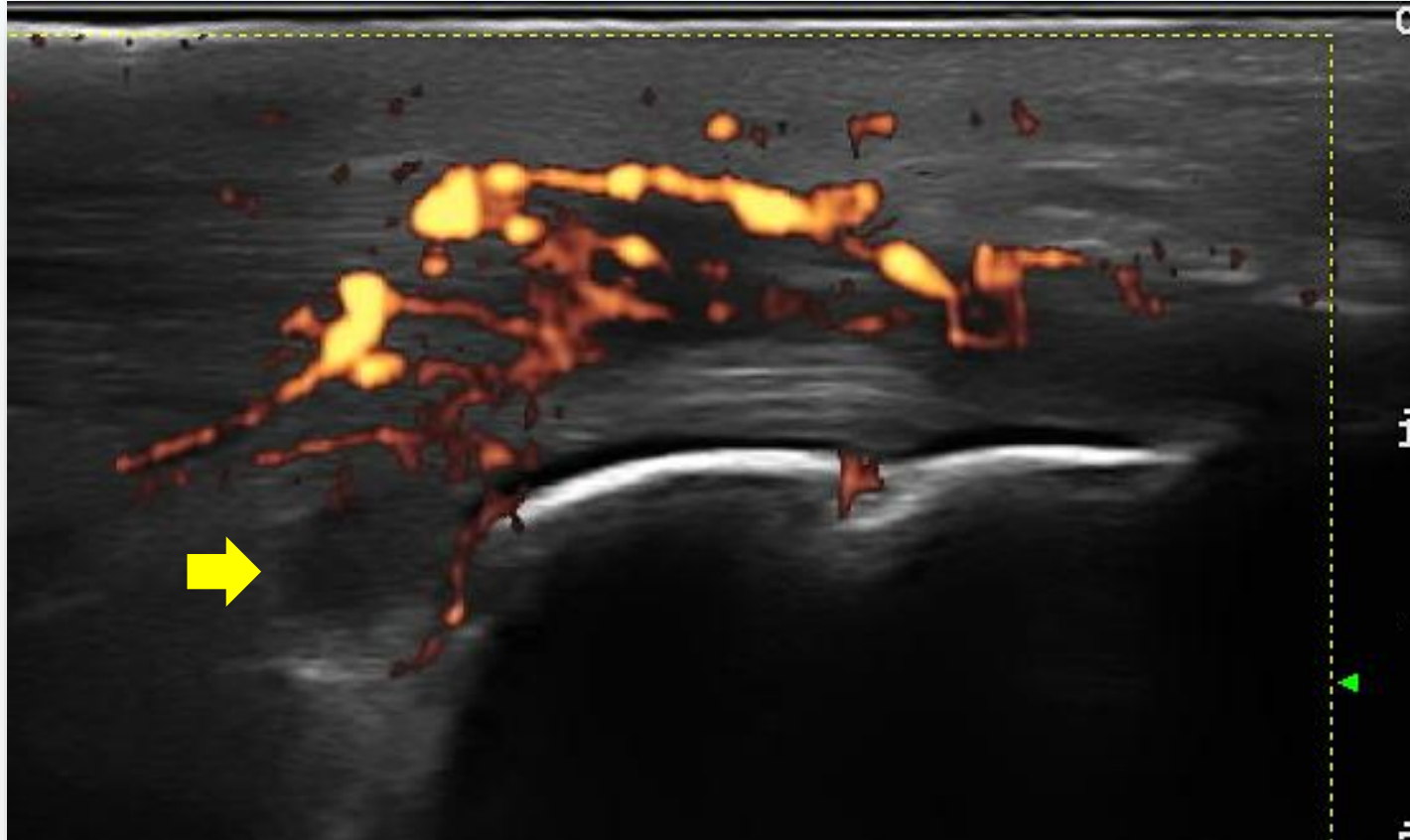
Achilles tendon insertion:
Retro-calcaneal bursitis grade 1



Bursitis – Grade 2



Bursitis present in B mode and Doppler signal is present in the bursa



Achilles Tendon Insertion:
Retro-calcaneal bursitis grade 2

