

Diagnostic Ultrasound of the Shoulder: A Shoulder Scanning Protocol Instruction and Clinical Application

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1

Program Outline

- History of MSK ultrasound & APTA / AIUM / Inteleos guidelines
- Ultrasound physics, artifacts & knobology
- Standardized MSK ultrasound terminology
- ESSR evidence for the shoulder
- The shoulder scanning protocol — 8 stations
- Hands-on lab — ~3 hours
- Normal vs pathology & discussion / Q&A



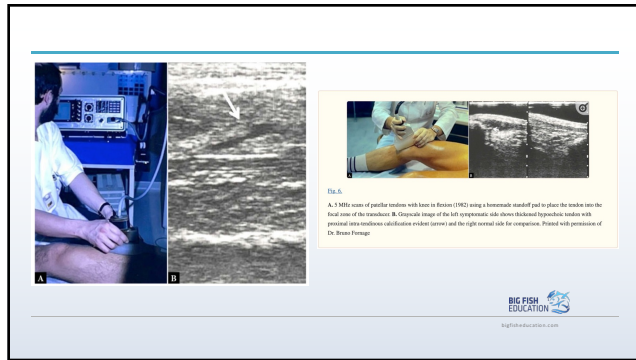
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History of MSK Ultrasound

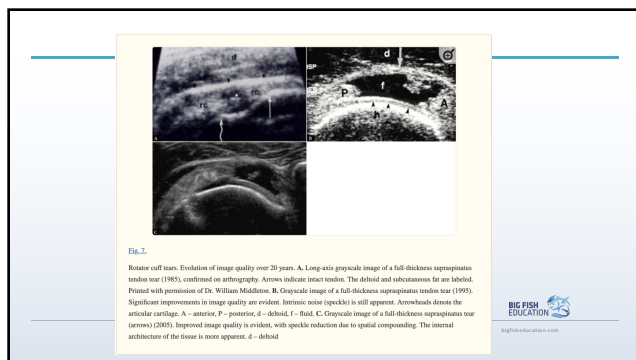
- First developed by Ian Donald at the University of Glasgow, 1958
- Major advances in the 1980s and again in the 2000s
- Adopted early in Europe by physiotherapists — as many as 1 in 6 Dutch physios trained in MSKUS
- Slower adoption in the USA



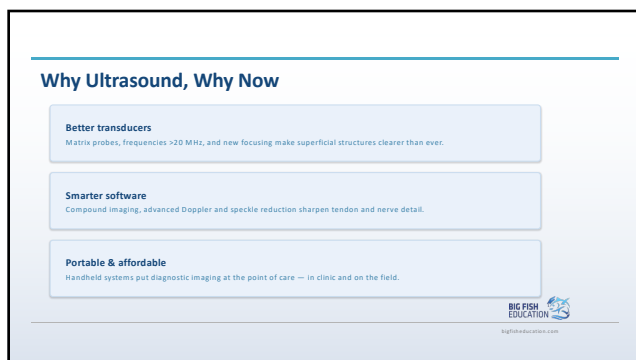
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6

Ultrasound Machines

The technology spans a wide range of cost and portability.

\$80K

Cart-based premium system
Highest image quality, full feature set,
hospital/clinic



\$40K

Mid-range portable
Strong MSK performance, laptop-style,
clinic-friendly



\$4K

Handheld / point-of-care
Probe + tablet/phone, increasingly
capable, field use



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Strengths & Limitations

Strengths

- Dynamic, real-time examination
- No ionising radiation
- Low cost & widely available
- Direct side-to-side comparison
- High resolution for superficial tissue

Limitations

- Strongly operator-dependent
- Limited penetration / deep joints
- Cannot see through bone
- Smaller field of view than MRI
- Requires dedicated training

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APTA Guidelines on MSK-US

2016 White Paper The APTA produced "Diagnostic and Procedural Imaging in Physical Therapy Practice."

Within PT scope With the FSBPT and AAOMPT, stated that ultrasound imaging is within the scope of physical therapist practice.

With a caveat FSBPT added it is not entry-level skill and requires additional training.

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AIUM, APTA & Inteleos

A collaborative pathway to recognize PT competency in MSK ultrasound.

Collaboration In 2020 the APTA and AIUM committed to advancing education, performance, certification and accreditation of MSKUS in PT practice.

RMSK credential Completing the pathway lets PTs become Registered in Musculoskeletal (RMSK) sonography, improving eligibility for AIUM practice accreditation.

Shared goal Together APTA, AIUM and Inteleos help bridge the gap for PTs pursuing competency and practice accreditation.

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Utilization in PT Practice

Markowski et al., 2022 — all 23 MSK-US certified PTs surveyed.

Number of scans/week
7
average patients scanned per week

Body parts scanned
Knee most common region, then shoulder & wrist

Outcome
US findings directly impacted patient care, guiding treatment and identifying appropriate referrals

US imaging guided treatment, informed the diagnostic process, and supported appropriate referrals.

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Point-of-Care Ultrasound (POCUS)

- Performed at the same time the clinician evaluates the patient
- Information from the clinical exam guides and is confirmed by the MSK-US exam
- Contrasts with imaging performed separately by a sonographer with little clinical context
- Used extensively in other fields — e.g. cardiology and the F.A.S.T. trauma exam

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ESSR 2017 Evidence: Shoulder

The ESSR 2017 Delphi consensus found **no change to shoulder indications** — the evidence was already strong.

A

Full- & partial-thickness rotator cuff tears

Level A - Grade 3 — first-choice imaging

B

Biceps, calcific tendonitis, AC joint, GHJ instability

Level B - Grade 2-3 indication

C

Adhesive capsulitis

Indication grade raised 0 → 1 (2017)

Why it matters: rotator cuff tendon tears carry the highest evidence in all of MSK ultrasound — comparable to MRI for full-thickness tears, and the strongest case for PT point-of-care scanning.

Grades: 0 not indicated - 1 if other imaging unsuitable - 2 equivalent - 3 first-choice.

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Ultrasound Physics — The Basics

Sound in, echoes out.

- A piezoelectric crystal converts electrical energy into a sound wave and back again.
- Different tissues reflect and refract sound differently — the machine interprets returning echoes to build the image.
- Stronger reflectors appear brighter; fluid lets sound pass and appears dark.

Piezoelectric crystals

■ Piezoelectric crystal ⚡ Electrical current

Application of an electrical current to the crystal causes it to vibrate and thus generate ultrasound waves.

Reflected sound waves hit the crystals, causing it to vibrate and generate electrical current that is analyzed by the ultrasound machine.

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Echogenicity Spectrum

Anechoic (0 black)

Fluid — blood vessels, simple effusion

Hypoechoic (0-25%)

Muscle, hyaline cartilage, tendinosis

Hyperechoic (75-100%)

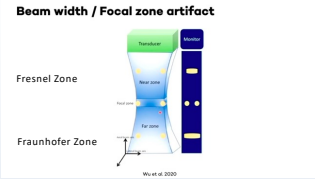
Bone surface, fat, fascia, nerve, calcification

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Resolution & the Focal Zone

- The beam is narrowest — and sharpest — at the focal zone.
- Place the focal zone at the depth of your target structure for the best lateral resolution.
 - Above or below the focal zone the beam widens and detail is lost.
 - Higher frequency = better resolution but less penetration; lower frequency = deeper but coarser.

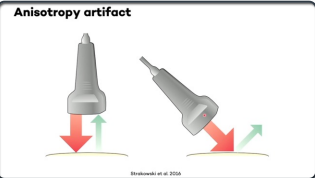


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Anisotropy — The #1 MSK Pitfall

- A normal tendon can look falsely dark (torn) if the beam is not 90° to its fibers.
- Anisotropy is the most common error in MSK ultrasound.
 - Without a perpendicular beam, the image is altered and clinical correlation suffers.
 - Fix: heel-toe or tilt the probe until the tendon brightens and the fibrillar pattern returns.



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Ultrasound Artifacts

Artifacts are predictable physics — recognizing them prevents misdiagnosis.

Anisotropy Tendon falsely dark off 90°. Fix: heel-toe / tilt to brighten.	Acoustic shadowing Dark band deep to bone or calcium. Use: confirms calcific deposits.	Posterior enhancement Bright zone deep to fluid. Use: confirms a cyst is fluid.
Reverberation Repeating lines from gas/metal. Use: locates a needle tip.	Edge Artifact Thin dark line off curved edges. Don't mistake for a tear.	Refraction Artifact A needle can appear bent when travels between two different areas of impedance. Can make a needle appear more superficial than it is. Depth assessment important.

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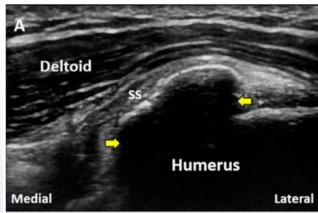
18

Ultrasound Artifacts

Acoustic Shadowing

Tendon calcification results in blocking of US
Results in a "shadow" underneath the area of calcification
Common in Supraspinatus tendon

Fix: No real "fix" per se but helps identify an area of calcification where one shouldn't be.



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Ultrasound Artifacts

Acoustic Enhancement

Tendon
Example in the shoulder is a "double contour sign" where there is a tear and the signal travels faster through the tear
Careful not to mistake for pathology, but also can be a sign of pathology elsewhere



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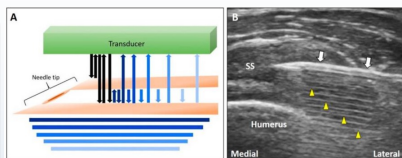
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Ultrasound Artifacts

Reverberation

Two closely reflecting surfaces result in repeating image reverberations resembling a comet tail
Typical around a needle or metal implant

Fix: None. But awareness when using needle important and when around implants etc.



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Ultrasound Artifacts

Edge Artifact

Thin dark line from a curved edge

Figure A showing the black lines coming from the edge of the curved structure resulting in a hypoechoic line on the image

Figure B showing a schwannoma on a nerve with black line artifact resembling a tear

Figure C showing an achilles with significant hypoechoic areas. It results in the "bending" of the needle making it appear more superficial. Also shows sutures and posterior acoustic shadow

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Ultrasound Artifacts

Refraction Artifact

When the needle passes through two different impedance areas it results in the "bending" of the needle making it appear more superficial

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Knobology — Optimizing the Image

A great image is operator-made. Five controls do most of the work.

- 1 Depth** Fill ~2/3 of the screen with your target.
- 2 Frequency** High (12–18 MHz) for superficial tendons; lower for deep.
- 3 Focal zone** Set the focal marker at the target depth.
- 4 Gain / TGC** Fluid black, tendon bright; even out with time-gain.
- 5 Probe handling** Pressure, tilt, heel-toe & rotation defeat anisotropy.

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Standardized MSK-US Terminology

2012 Delphi consensus (Hall et al.) — endorsed by AIUM, AMSSM, AOSSM, ESSR, SSR; value affirmed by AAPM&R.

Transducer manipulation

Slide — across the body surface

Heel-toe — angle in the long axis

Tilt — angle in the short axis

Compression — force toward the body

Rotation / Pivot — turn about an axis

Stand-off — on gel, off the skin

Sonopalpation — press to provoke symptoms

Planes & axes

Long axis = longitudinal (parallel)

Short axis = transverse (cross-section)

Directional terms

Proximal / distal, anterior / posterior, superior / inferior.
Use *subluxate* / *subluxation* — not “sublux.”



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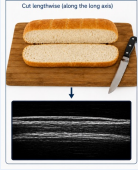
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LAX vs SAX

Simplest way to understand and explain Long axis versus Short axis

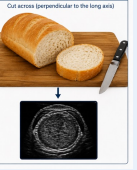
LONG AXIS

Cut lengthwise (along the long axis)



SHORT AXIS

Cut across (perpendicular to the long axis)





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Standardized Pathology Terms

Report what you see — “**tendinopathy**” is a clinical umbrella; prefer a precise imaging term.

Tendinosis — Chronic collagen degeneration: hypoechoic tendon, no fibre disruption, ± thickening.

Tendinitis — Inflammation; looks like tendinosis. Hyperaemia = neovascularity, not always acute.

Calcific tendinopathy — Hydroxyapatite: globular hyperechoic focus ± shadowing — common in supraspinatus.

Tenosynovitis — Sheath fluid ± synovial hypertrophy. Biceps sheath communicates with the GH joint.

Tear — Fibre disruption — partial thickness (interstitial/bursal/articular) or full thickness.

Doppler flow supports a diagnosis but is not required — it varies with equipment and technique.



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A Framework for Assessment: "One view is no view"

Structure of pathology

- Shape – is the morphology changed?
- Echogenicity – brighter or darker?
- Continuity – fibre disruption?
- Doppler – abnormal flow?
- Function – how does it move?

Interpret pathology

- Compare with the asymptomatic side.
- Confirm findings in two planes.
- Correlate with the clinical exam.
- Use precise, standardized terminology.



28

The Shoulder Scanning Protocol

A systematic, repeatable sweep — anterior to posterior — with the patient seated on a revolving stool.

- 1 Long head of biceps tendon
- 2 Subscapularis tendon
- 3 Coracoacromial ligament & anterior structures
- 4 Supraspinatus tendon
- 5 Subacromial impingement (dynamic)
- 6 Infraspinatus & teres minor
- 7 Posterior glenohumeral recess & labrum
- 8 Acromioclavicular joint

Patient position

Seated on a revolving stool so the examiner can reach anterior, lateral and posterior aspects by rotating the patient.



29

The Shoulder S

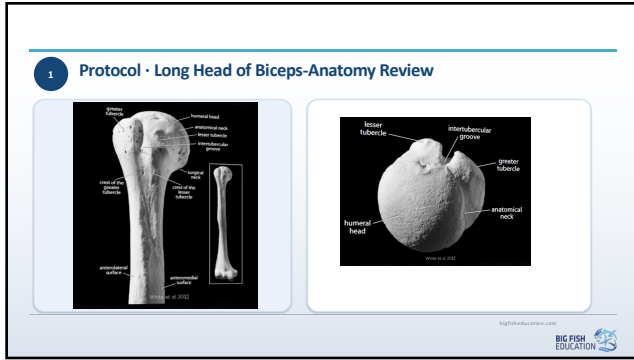
A systematic, repeatable sweep — anterior to posterior — with the patient seated on a revolving stool.

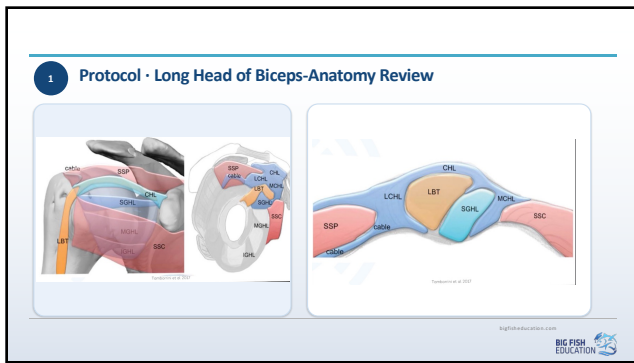
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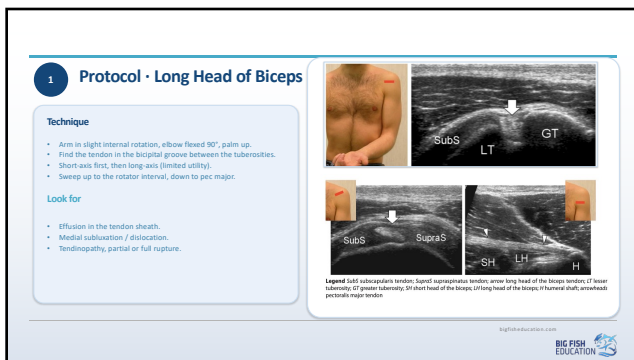
Examiner can reach anterior, lateral and posterior aspects by rotating the patient.

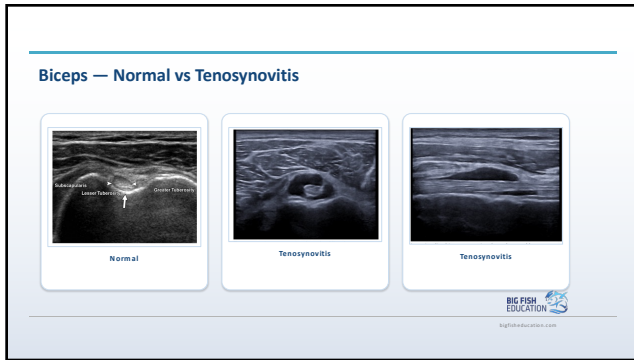


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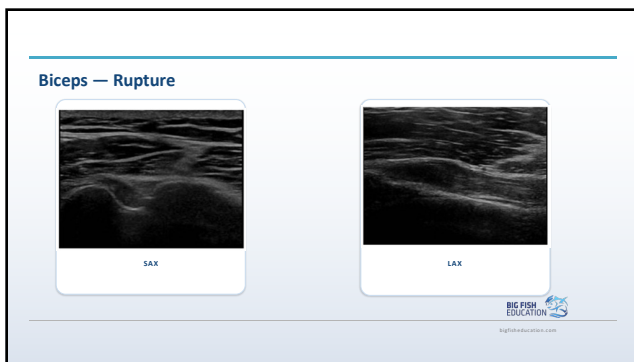




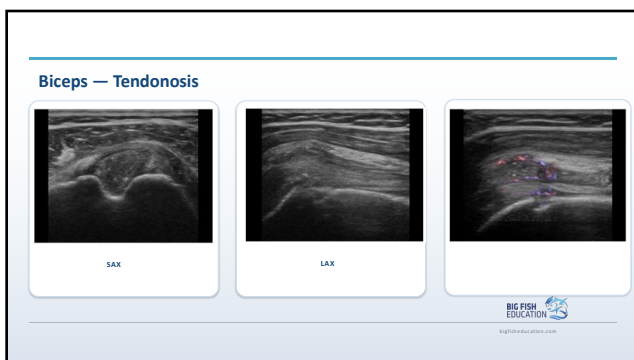




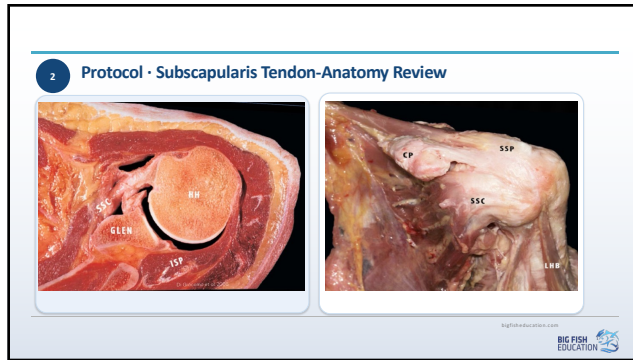
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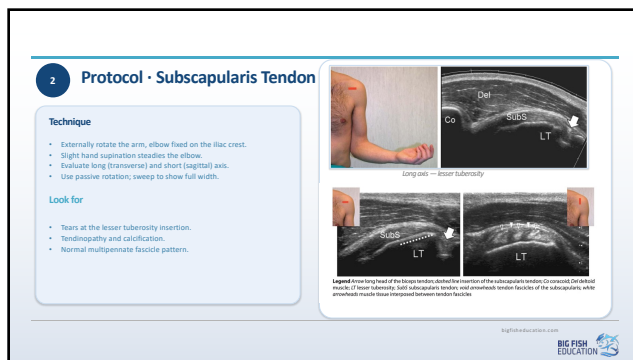
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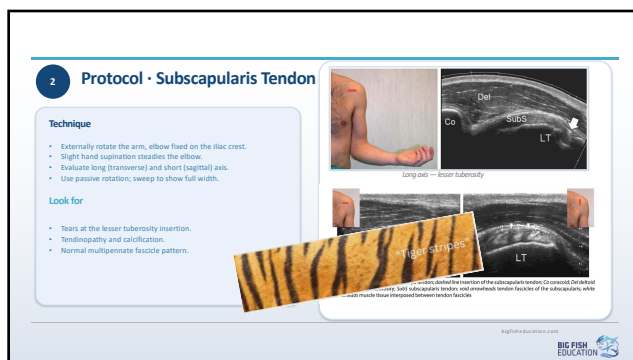
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Protocol • Coracoacromial Ligament

Technique

- Move medially on transverse planes onto the coracoid.
- Medial edge on coracoid, sweep laterally to the acromion.
- Assess conjoint tendon & anterior subacromial-subdeltoid bursa.
- Check subscapularis recess & subcoracoid bursa for fluid.

Look for

- Coracoacromial ligament thickening.
- Anteromedial impingement.
- Bursal fluid or thickening.

Legend Acr acromion; arrows short head of the biceps; arrowheads coracoacromial ligament; Co coracoid; CoBr coracoclavicular; HH humeral head; SubS subscapularis tendon; SupraS supraspinatus

43

4
Protocol • Supraspinatus Positioning

Technique

- Cross / modified Cross: palm on the iliac wing, elbow back.
- Forced internal rotation: dorsum of hand on the back pocket.
- No gap between the elbow and the chest wall.
- Caution: internal rotation may overestimate tear size.

Look for

- Best exposure of the cuff footprint.
- Reproducible landmark off the biceps.
- Patient comfort & repeatability.

44

4
Protocol • Supraspinatus Tendon

Technique

- Use the intra-articular biceps as a landmark — tendons run parallel.
- Rotate until the biceps is elongated, then shift up & posterior.
- Tilt gently at the insertion to avoid anisotropy.
- Cuff is uniform ~2 cm behind biceps; beyond = infraspinatus.

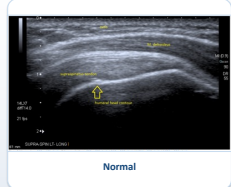
Look for

- Full- vs partial-thickness tears.
- Subacromial-subdeltoid bursa as a thin band.
- Calcific tendinopathy at the footprint.

Probe will make an "M" position and not a "V" position when using the Modified Cross for Supraspinatus scanning

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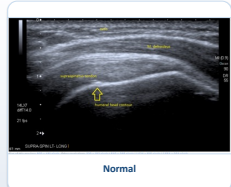
Supraspinatus — Normal vs Pathology



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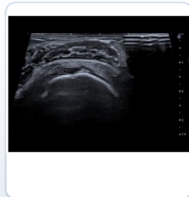
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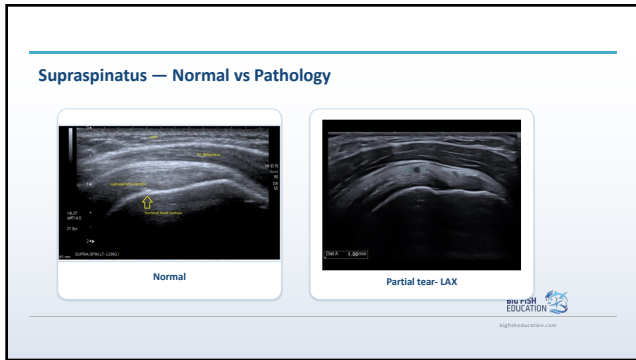
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Supraspinatus — What is the pathology?

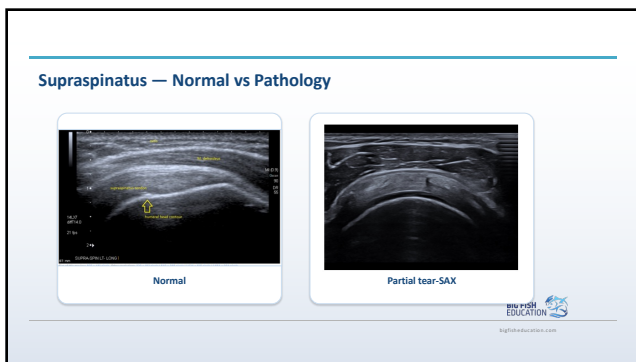


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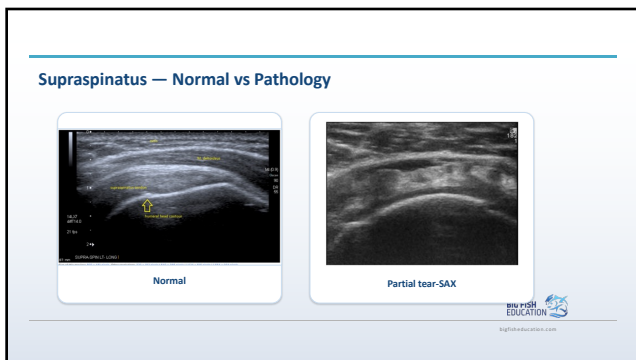
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49

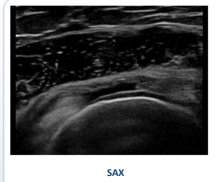
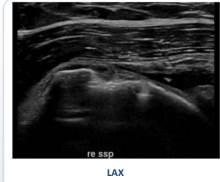


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51

Supraspinatus — Full Thickness Partial Width Tear

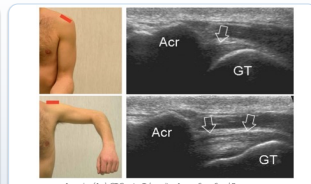


52

5 Protocol • Subacromial Impingement

Technique

- Coronal plane, medial margin at the lateral acromion.
 - Patient abducts the arm while in internal rotation.
 - Watch Suprot & bursa pass deep to the coracoclavicular arch.
 - A true dynamic test — a key advantage over MRI.
- Look for**
- Non-smooth glide of the bursa under the acromion.
 - Bursal fluid pooling laterally on abduction.
 - Reproduction of the patient's symptoms.



Acromion (Acr) GT Greater Tuberosity. Arrows Suprot and Bursa

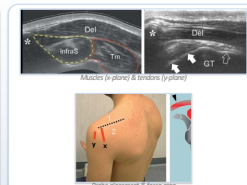


53

6 Protocol • Infraspinatus & Teres Minor

Technique

- Probe over the posterior C6 joint, hand on opposite shoulder.
 - Use the scapular spine to separate the two fossae.
 - View muscles filling the fossa deep to deltoid (x-plane).
 - Sweep to the greater tuberosity to see both tendons (y-plane).
- Look for**
- Infraspinatus tendon tears (less common).
 - Muscle atrophy / fatty change.
 - Teres minor as a distinct inferior structure.

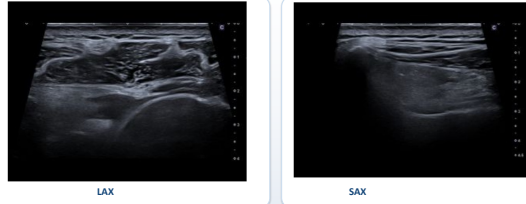


Probe placement & fossa map



54

Infraspinatus – Full rupture and muscle atrophy



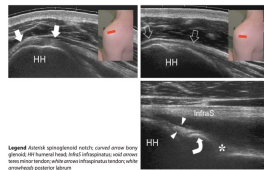
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7 Protocol • Posterior GH Recess & Labrum

Technique

- Probe over the posterior GH joint during rotation.
 - Examine the posterior labrum-capsular complex.
 - Check the posterior recess for effusion during rotation.
 - Move medial to see the spinoeloid notch – deepen the field.
- Look for
- Posterior recess effusion / synovitis.
 - Posterior labral tear & paralabral cysts.
 - Spinoeloid notch cyst (suprascapular n.).

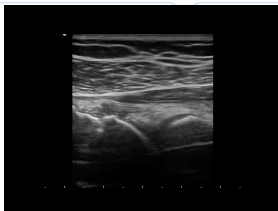


Legend: Acoustic spinoeloid notch cysts covered over long ground off humeral head, and oblique line and arrow below show tendon, white areas (effusion) a tendon, white area (cyst) posterior labrum

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Glenohumeral Joint – Labral Tear!



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Protocol · Acromioclavicular Joint

Technique

- Coronal plane over the AC joint.
- Sweep anterior-posterior to assess for an os acromiale.
- Shift posterior to view the supraglenoid muscle.
- Compare with the contralateral side.

Look for

- Capsular distension / effusion, osteoarthritis.
- Widening with AC separation (trauma).
- Superior AC ligament integrity.

Distance (C) = AC joint - acromion (Acr)

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AC Joint Laxity

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Putting It Together

Ultrasound's edge is the **dynamic, point-of-care, bilateral** exam.

Always dynamic

- Biceps subluxation in rotation
- Impingement in abduction
- Cuff tears — compress & rotate

Always compare

- Scan the asymptomatic side
- Tendon thickness & echotexture
- AC joint width

Always correlate

- Match the clinical exam
- POCUS in the same visit
- Document & guide referral

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