



**Tahoe Center  
for Orthopedics**  
Barton Health

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# PRINCIPLES OF ULTRASOUND GUIDED MUSCULOSKELETAL INTERVENTIONS

Jonathan Finnoff, DO  
Tahoe Orthopedics and Sports Medicine  
Director of Sports Medicine, Barton Health  
South Lake Tahoe, CA

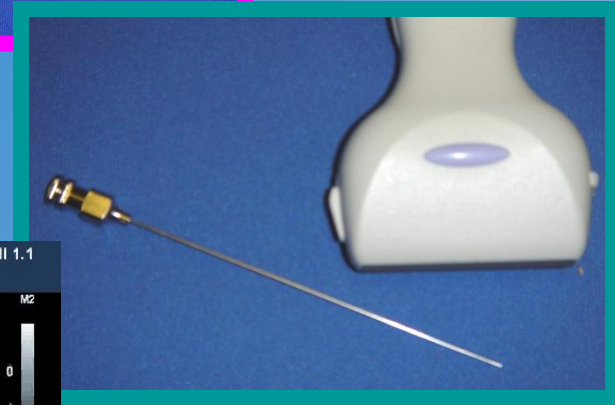
# Disclosures

- I have no financial disclosures

# USG MSK INTERVENTIONS

## Objectives

- Definition
- Why US-guidance?
- General Principles
  - Indications & contra-indications
  - Equipment
  - Set-up
  - Technique
  - Pitfalls & Pearls
- Conclusion

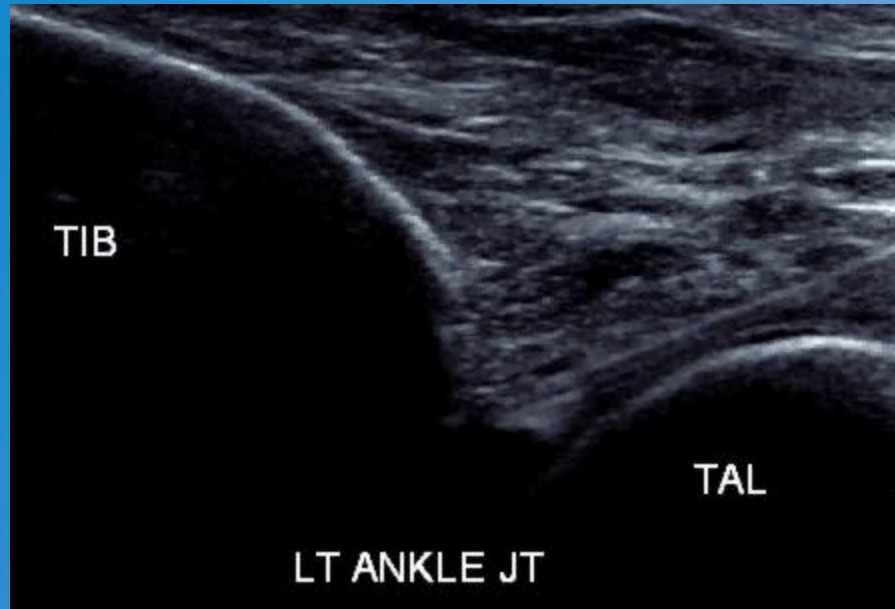


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# USG MSK INTERVENTIONS

## What Are We Talking About?

- Direct Ultrasound Guidance
  - **Real time** US visualization to guide the needle to the target area **safely** and **efficiently**
- **Targets**
  - Joints & Bursa
  - Muscles
  - Tendon sheaths
  - Masses
  - Perineural



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# USG MSK INTERVENTIONS

## Why US Guidance?

Table 1: Technique Differences and Accuracy of Needle Placement in Lower-Limb Muscles

Muscle	Gieringer	Delagi	Trials	Hits	%	Endpoint	%	Cautions	%
<b>Foot muscles</b>									
Abductor digiti minimi	F	L	10	8	80	7	70	0	0
Abductor hallucis	F	L	10	9	90	7	70	4	40
First dorsal interosseous pedis	F	L	7	5	71	5	71	2	29
<b>Leg muscles</b>									
Tibialis anterior	F	P	10	9	90	9	90	1	10
Extensor digitorum longus	F	P	10	6	60	5	50	3	30
Extensor hallucis longus	F	P	10	8	80	7	70	3	30
Peroneus longus	F	P	10	5	50	5	50	1	10
Peroneus brevis	F	0	2	0	0	0	0	0	0
Peroneus tertius	F	0	2	0	0	0	0	1	50
Soleus	L	P	10	6	60	5	50	3	30
Lateral gastrocnemius	F	L	10	7	70	3	30	1	10
Medial gastrocnemius	F	L	10	9	90	3	30	1	10
Tibialis posterior	F	P	10	1	10	1	10	5	50
Tibialis posterior (lateral)	*	P	8	4	50	4	50	1	13
Flexor hallucis longus	F	0	4	1	25	1	25	2	50
Flexor digitorum longus	F/P	0	2	2	100	2	100	0	0
<b>Thigh muscles</b>									
Adductor longus	F	P	10	2	20	1	10	2	20
Adductor magnus	P	P	10	3	30	3	30	2	20
Gracilis	P	P	10	4	40	1	10	2	20
Biceps femoris long head	F	P	10	7	70	5	50	1	10
Biceps femoris short head	F	L	10	3	30	1	10	2	20
Medial hamstrings	F	P	4	3	75	0	0	1	25
Semimembranosus	L	P	6	4	67	4	67	2	33
Semitendinosus	P	P	3	1	33	1	33	0	0
Iliopsoas	F	P	7	6	86	6	86	3	43
Rectus femoris	P	P	7	3	43	3	43	0	0
Vastus lateralis	F	P	10	7	70	5	50	2	20
Vastus medialis	F	P	10	10	100	10	100	0	0
Popliteus	L	0	4	0	0	0	0	0	0
<b>Hip muscles</b>									
Gluteus maximus	P	P	10	8	80	8	80	1	10
Gluteus medius	M	P	8	4	50	4	50	0	0
Gluteus minimus	P	0	4	2	50	0	0	0	0
Tensor fascia lata	P	0	2	2	100	3	100	0	0
Obturator internus	P	0	4	0	0	0	0	0	0
Piriformis	P	0	4	0	0	0	0	0	0
Quadratus femoris	P	0	4	0	0	0	0	0	0
Summary			263	150	57	119	45	46	17

(Haig et al. Arch Phys Med Rehabil 2003)

# USG MSK INTERVENTIONS

## Why US Guidance?

TABLE 2. Compiled List of Results for Specific Muscles Targeted in the Lower Limb Study

Study: Lower Limb Muscles								
Muscle	Method	Attempts	Hits	Adjusted	Same Nerve	Cautions	Dangers	Structure Pierced
First dorsal interosseus	B/N	34	31	31	32	0	0	
Abductor digiti minimi	B	16	11	13	15	0	0	
Abductor hallucis	B	16	12	12	14	0	0	
Adductor longus	B	16	3	6	13	2	0	
Adductor magnus	B	16	7	7	9	1	0	
Biceps femoris longus	B	14	5	7	7	0	0	
Biceps femoris short	B	16	4	5	5	3	0	
Extensor digitorum longus	B	16	10	10	14	1	0	
Extensor hallucis longus	B	14	11	12	12	1	0	
Peroneus long	B	13	9	9	9	0	1	
Gluteus maximus	B/N	20	13	17	13	0	0	
Gluteus medius	B	13	7	7	8	0	0	
Gracilis	B	16	2	6	8	1	0	
Iliopsoas	B/N	19	12	12	12	1	2	Femoral nerve
Gastrocnemius lateral	B	16	5	13	13	0	2	Common peroneal nerve
Gastrocnemius medial	B	16	10	15	15	1	0	
Rectus femoris	B	12	5	8	11	0	0	
Medial hamstrings	B	22	14	14	15	0	0	
Soleus	B/N	28	22	24	27	3	1	Tibial nerve
Vastus lateralis	B	16	10	14	16	0	0	
Vastus medialis	B	16	16	16	16	0	0	
Tibialis posterior	B	27	11	12	24	5	2	Post tibial a., tibial n.
Tibialis anterior	B	13	10	11	11	1	0	

(Goodmurphy et al. J Clin Neurophysiol 2007)

# USG MSK INTERVENTIONS

## Why US Guidance?

TABLE 3. Compiled List of Results for Specific Muscles Targeted in the Upper Limb Study

Study: Upper Limb Muscles								
Muscle	Method	Attempts	Hits	Adjusted	Same Nerve	Cautions	Dangers	Structures Pierced
Biceps brachii longus	B	12	8	9	11	0	1	Musculocutaneous n.
Brachialis	B/N	20	14	14	20	1	0	
Anterior deltoid	B/N	19	11	12	17	0	0	
Middle deltoid	B	14	11	12	14	1	0	
Posterior deltoid	B	20	19	19	20	0	0	
Latissimus dorsi	B	14	10	14	12	0	0	
Pectoral major	B	13	4	12	7	0	0	
Major rhomb	B	14	5	7	9	0	0	
Serratus ant	B	20	11	12	12	0	0	
Supraspinatus	B	14	10	11	10	2	0	
Teres major	B	14	9	9	11	0	0	
Teres minor	B	14	4	4	4	0	0	
Infraspinatus	B	13	10	11	11	0	0	
Mid trapezius	B	13	2	11	5	0	0	
Latissimus head triceps	B	12	3	4	12	0	0	
Long head triceps	B	12	10	10	12	0	0	
Trapezius lower	B	14	7	12	6	0	0	
Infraspinatus	B	13	10	11	13	0	0	
Lavator scapula	B	11	6	6	9	0	0	
Rhomboid minor	B	13	3	9	6	0	0	
Abductor digit minimi	B	6	2	4	6	0	0	
Abductor pollicis brevis	B/N	13	2	2	13	0	0	
Abductor pollicis longus	B	11	3	4	5	0	0	
Adductor pollicis	B	6	6	6	6	0	0	
Anconeus	B	14	11	12	13	0	0	
Brachioradialis	B	14	4	10	14	3	0	
Extensor carpi ulnaris	B	14	5	11	12	0	0	
Extensor digitorum	B	14	5	13	14	0	0	
Extensor indicis	B/N	20	6	13	5	1	0	
Extensor pollicis longus	B	14	2	4	10	0	0	
Flexor carpi radialis	B	14	1	3	11	3	2	Median n.
Flexor carpi ulnaris	B/N	18	2	6	14	2	0	Ulnar n.
Flexor dig profundus	B/N	24	16	18	19	3	1	Ulnar n.
Flexor dig superficialis	B	10	2	8	3	0	1	Ulnar n.
Flexor pollicis longus	B	14	2	3	3	0	2	Radial a.
Opponens pollicis	B/N	12	10	10	12	0	0	Median n.
Pronator quadratus	B	14	5	7	8	2	0	
Pronator teres	B/N	20	12	13	17	2	0	

(Goodmurphy et al. J Clin Neurophysiol 2007)

# USG MSK INTERVENTIONS

## Why US-guidance?

**Table 1.** Accuracy of non-guided and ultrasound-guided fine wire placements.

Muscle	Non-guided			Ultrasound-guided		
	No. of attempts	Correct placement	Percent accuracy	No. of attempts	Correct placement	Percent accuracy
Rectus femoris	4	0	0	4	4	100
Gracilis	4	3	75	4	4	100
Short head biceps femoris	4	4	100	4	4	100
Long head biceps femoris	4	1	25	4	4	100
Semitendinosus	4	0	0	4	2	50
Popliteus	4	0	0	4	4	100
Tibialis anterior	4	4	100	4	4	100
Extensor hallucis longus	4	0	0	4	4	100
Peroneus longus	4	3	75	4	4	100
Peroneus tertius	4	3	75	4	4	100
Tibialis posterior	4	2	50	4	4	100
Flexor hallucis longus	4	1	25	4	4	100
Abductor hallucis	4	1	25	4	4	100
First dorsal interosseous pedis	4	0	0	4	4	100

(Boone et al. Muscle Nerve 2011,



# USG MSK INTERVENTIONS

## Why US-guidance?

<u>Accuracy</u>	<u>US</u>	<u>Palpation</u>	<u>Fluoro</u>
GH joint	95% <sup>1</sup>	79-83% <sup>1,4</sup>	
SA-SD bursa	100% <sup>1</sup>	63% <sup>1</sup>	60% <sup>2</sup>
AC joint	100% <sup>1,3</sup>	40-67% <sup>1,3,4</sup>	
Knee	96-100% <sup>1,5,6</sup>	55-79% <sup>1,5,6</sup>	
BT Sheath	100% <sup>7</sup>	66.6% <sup>7</sup>	
PIP & MCP jts	96% <sup>8</sup>	59% <sup>8</sup>	
Inf Arthritis Jt Injs	83% <sup>9</sup>	66% <sup>9</sup>	
GH Jt 1 <sup>st</sup> try	94% <sup>10</sup>		72% <sup>10</sup>

(<sup>1</sup>Daley EL AJSM 2011, <sup>2</sup>Mathews PV J Shoulder Elbow Surg 2005, <sup>3</sup>Peck E PMR 2010, <sup>4</sup>Partington PF J Shoulder Elbow Surg 1998, <sup>5</sup>Park YB J Clin Ultrasound 2011, <sup>6</sup>Curtiss HM PMR 2011 <sup>7</sup>Hashiuchi T J Shoulder Elbow Surg 2011, <sup>8</sup>Raza K Rheumatology 2003, <sup>9</sup>Cunnington J Arthritis & Rheumatism 2010, <sup>10</sup>Rutten MJ Eur Radiol 2009)

# USG MSK INTERVENTIONS

## Why US-guidance?

<u>Accuracy</u>	<u>US</u>	<u>Palpation</u>	<u>CT</u>
Per. Ten. Sheath <sup>1</sup>	100%	60%	
Piriformis <sup>2</sup>	95%	30%	
Pes Ans. Bursa <sup>3</sup>	92%	17%	
Lumbar facet jts <sup>4</sup>	100%		100%
STT jt <sup>5</sup>	100%	80%	
Flex. Ten. Sheath <sup>6</sup>	70%	15%	
Tibiotalar jt <sup>7</sup>	100%	85%	
Sinus Tarsi <sup>7</sup>	90%	35%	

(<sup>1</sup>Muir JJ Am J Phys Med Rehabil 2011, <sup>2</sup>Finnoff JT J Ultrasound Med 2008, <sup>3</sup>Finnoff JT PMR 2010, <sup>4</sup>Galiano K Reg Anesth Pain Med 2007, <sup>5</sup>Smith J J Ultrasound Med 2011, <sup>6</sup>Lee DH J Ultrasound Med 2011, <sup>7</sup>Wisniewski SJ PMR 2010)

# USG MSK INTERVENTIONS

## Why US-guidance?

- Mathews et al. evaluated the accuracy of anterolateral and posterior palpation-guided SA-SD bursa injection approaches.
- Used fluoro followed by dissection to confirm injectate location
  - Fluoro suggested accuracy rate of 90% for anterolateral approach, but dissection revealed only 60% were actually accurate
  - Take home point = fluoro couldn't accurately determine whether the injectate was or was not in the SA-SD bursa

(Mathews et al. J Shoulder Elbow Surg 2005)

# USG MSK INTERVENTIONS

## Why US-guidance?

<u>Efficacy</u>	<u>US-guided</u>	<u>Palpation-guided</u>
SA-SD Bursa <sup>1</sup>	VAS ↓ 4 Greater ↑ ROM	VAS ↓ 2
SA-SD Bursa <sup>2</sup>	VAS ↓ 34.9 SFA ↑ 15	VAS ↓ 7.1 SFA ↑ 5.6
SA-SD/GH Jt <sup>3</sup>	4 x greater benefit than palp guided	
SA-SD Bursa <sup>4</sup>	NRS 1.6 Good resp 81%	NRS 3.3 54%
SA-SD Bursa <sup>5</sup>	Signif ↑ abd ROM	No Δ in ROM

(<sup>1</sup>Ucuncu F Clin J Pain 2009, <sup>2</sup>Naredo E J Rheumatol 2004, <sup>3</sup>Eustace JA Ann Rheum Dis 1997, <sup>4</sup>Zufferey P J Bone Spine 2011, <sup>5</sup>Chen MJL Am J Phys Med Rehabil 2006)

# USG MSK INTERVENTIONS

## Why US-guidance?

- Efficacy

### Knee

#### US-guided vs Palpation-guided

48% less procedural pain<sup>1,2</sup>

42% more pain reduction<sup>1</sup>

183% more fluid aspirated<sup>2</sup>

107% more responders<sup>1</sup>

52% less non-responders<sup>1</sup>

### Carpal Tunnel<sup>3</sup>

77.1% less procedural pain

63.3% more pain reduction

84.6% more responders

51.6% less non-responders

71% longer pain relief

(<sup>1</sup>Sibbitt WL J Clin Rheumatol 2011, <sup>2</sup>Sibbitt WL Scand J Rheumatol 2011, <sup>3</sup>Chavez-Chiang NR Arth Rheum [S] 2010)

# USG MSK INTERVENTIONS

## Why US-guidance?

- Efficacy  
Infl. Arthritis Inj<sup>1</sup>      US-guided vs Palpation-guided  
81% less injection pain  
35% more pain reduction  
38% more responders  
34% less non-responders  
32% longer pain relief
- Infl. Arthritis Inj<sup>2</sup>      50% greater pain relief

(<sup>1</sup>Sibbitt WL J Rheumatol 2011, <sup>2</sup>Cunnington J Arthritis & Rheumatism 2010)

# USG MSK INTERVENTIONS

## Why US-guidance?

- Cost Effectiveness

US-guided vs Palpation-guided

Knee<sup>1</sup>

13% less cost/pt/yr

58% less cost/responder/yr

Carpal Tunnel<sup>2</sup>

20.8% less cost/pt/yr

59.3% less cost/responder/yr

Infl. Arthritis Inj<sup>3</sup>

8% less cost/pt/yr

33% less cost/responder/yr

(<sup>1</sup>Sibbitt WL J Clin Rheumatol 2011, <sup>2</sup>Chavez-Chiang NR Arth Rheum [S] 2010, <sup>3</sup>Sibbitt WL J Rheumatol 2011)

# USG MSK INTERVENTIONS

## Why US-guidance?

- More infections with US-guidance?
- NO!
- Study compared 402 pts who received IV's with US-guidance with 402 with palpation-guidance
  - Palpation infections = 3 = 7.8/1000
  - US-guidance infections = 2 = 5.2/1000

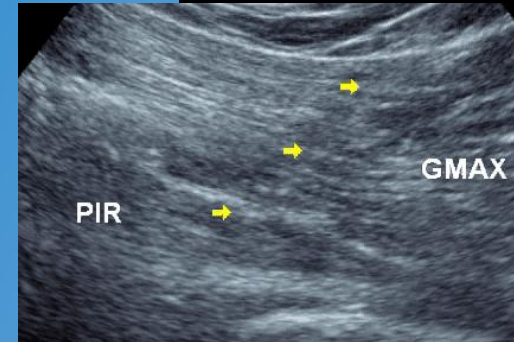
(Adhikari S J Ultrasound Med 2010)



# USG MSK INTERVENTIONS

## Indications For USG

1. **When accuracy is important**
  - a) Tibialis posterior
  - b) Short head of biceps femoris
  - c) Rhomboids
2. **Procedures that normally require guidance**
  - a) Deep target
  - b) Difficult to identify target
  - c) Avoid adjacent structures
  - d) Diagnostic injections
  - e) Certain therapeutic injections
3. **Assess anatomy**
  - a) Pathology
  - b) Variations
4. **Soft tissue procedures**
5. **High risk**
  - a) Lung
  - b) Neurovascular
  - c) Anti-coagulation/bleeding d/o
6. **Avoid radiation**



# USG MSK INTERVENTIONS

## Contraindications

- General procedural contraindications
- US generally safe
- Recognize limits
  - Skills
  - Equipment
  - Technique
- Unexpected
  - Masses



“r/o Baker’ s Cyst” v

# USG MSK INTERVENTIONS

## Plan Procedure

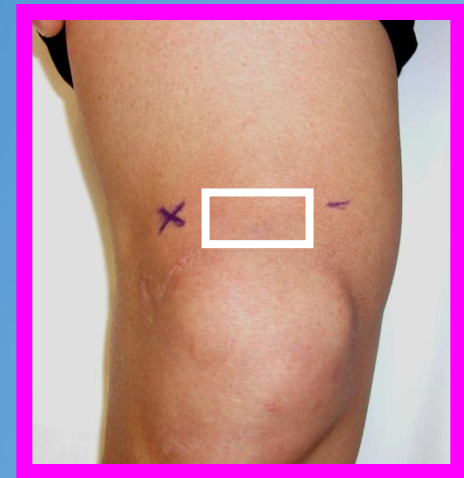
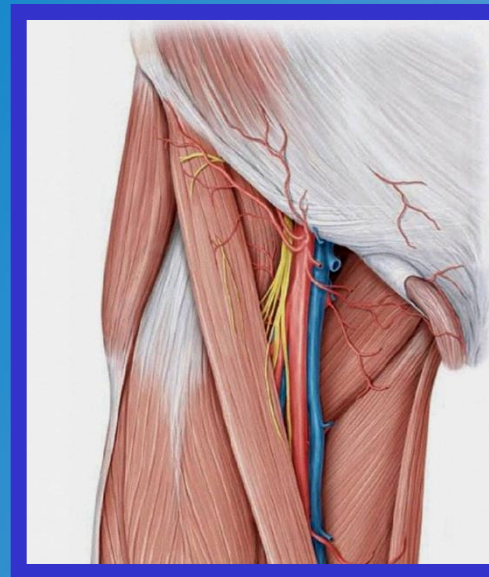
- Ergonomics
  - Patient lying
  - Get comfortable
- Choose transducer
  - Linear Array
    - Superficial structures
    - Needle angle not steep
  - Curvilinear Array
    - Deep structures
    - Steep needle angle



# USG MSK INTERVENTIONS

## Plan Procedure

- Scan area
  - Identify
    - Target
    - Undesirables
    - Unexpected
- Determine needle approach/path
  - Doppler needle path
- Estimate needle length
- Save pre-procedure image of target
- Mark skin



# USG MSK INTERVENTIONS

## General Procedure – Set-up

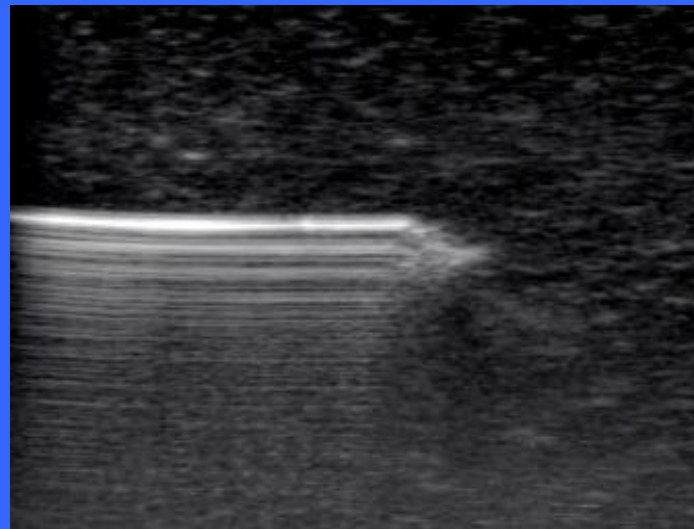
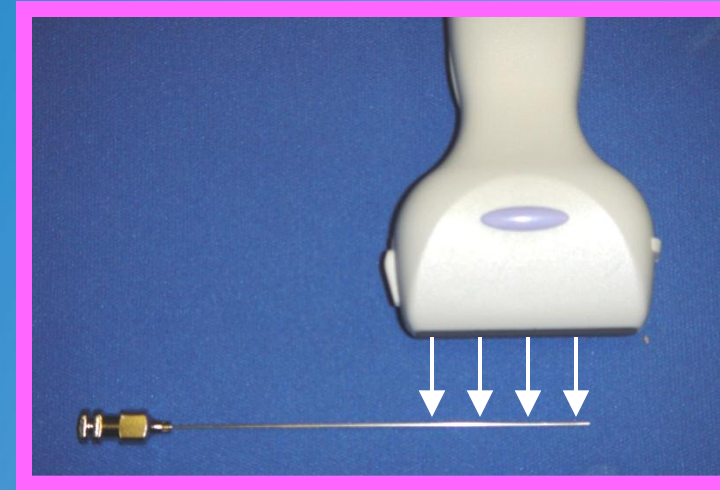
- **Aseptic technique**
  - Prep skin
  - Sterile probe cover
  - Sterile US gel
- **Ergonomics**
  - See injection site, needle & machine
- **Free-hand technique**
  - Non-dominant holds transducer
  - Dominant holds needle



# USG MSK INTERVENTIONS

## In Plane Approach

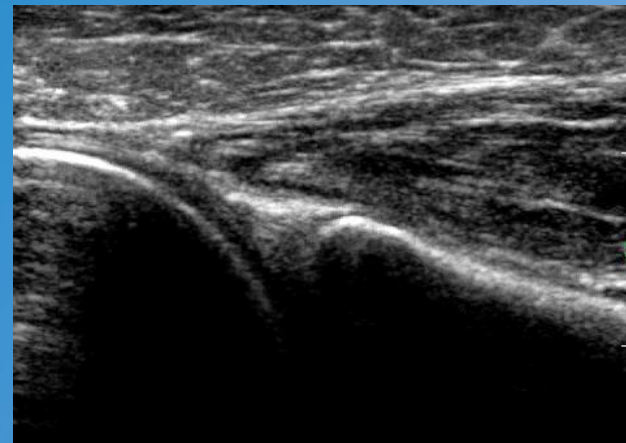
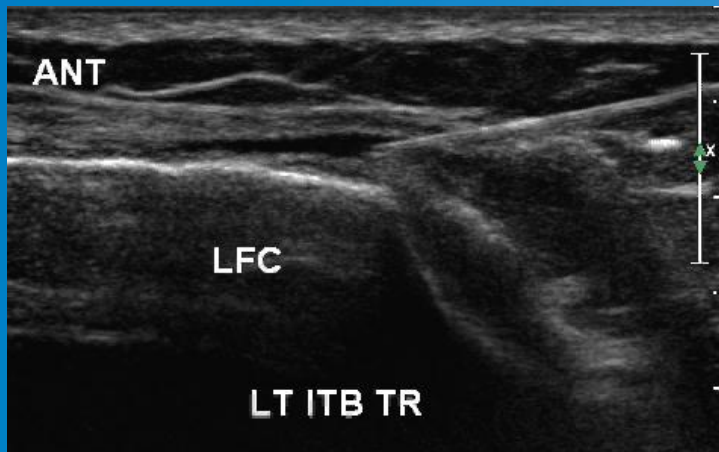
- Also called:
  - Long axis
  - Longitudinal
- Needle co-linear with transducer
- Visualize tip & shaft
- Preferred



# USG MSK INTERVENTIONS

## In Plane Approach - Pitfalls

- Visualization depends on obliquity



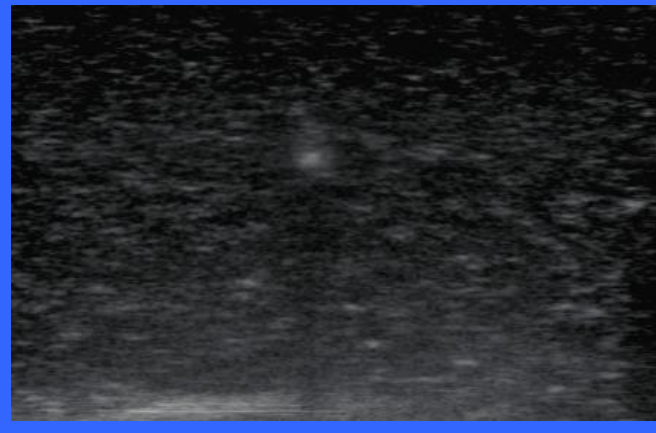
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# USG MSK INTERVENTIONS

## Out of Plane Approach

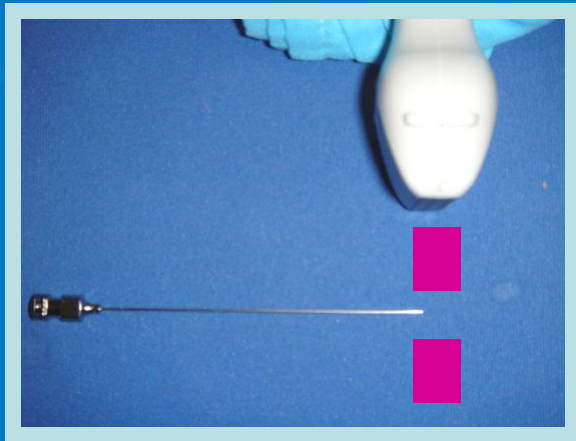
- Also called:
  - Short axis
  - Transverse
- Needle perpendicular to transducer
- Appears as dot
- Challenging – use prn
  - Superficial joints



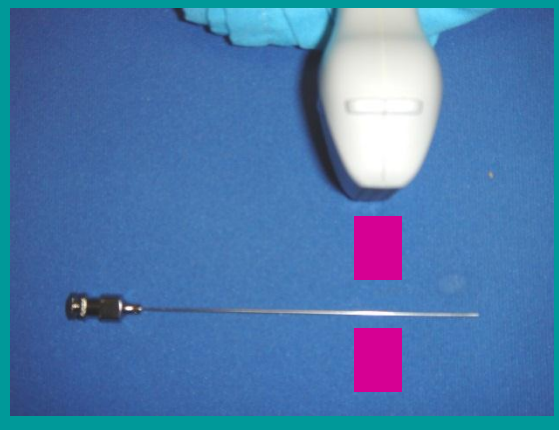


# USG MSK INTERVENTIONS

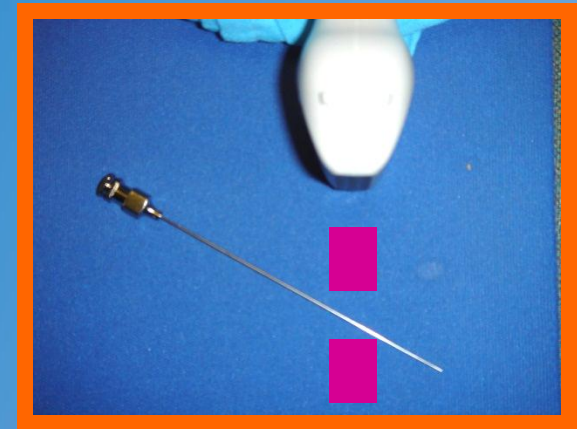
## Out of Plane Approach - Pitfalls



Tip Under Tx



Tip Past Tx



Tip Oblique &  
Past Tx

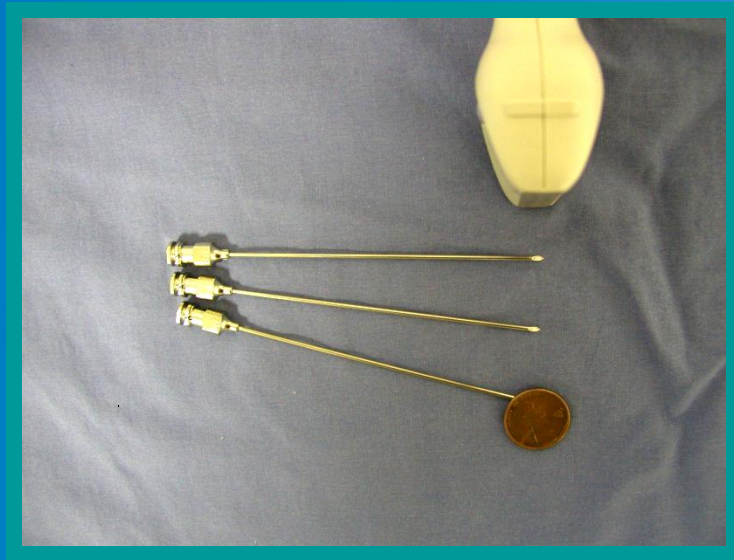
All Look Same



# USG MSK INTERVENTIONS

## Out of Plane Approach - Solution

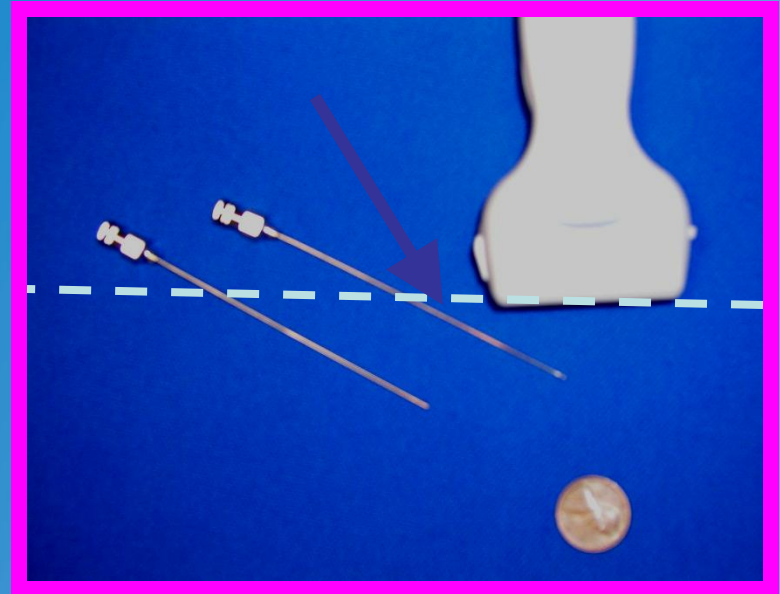
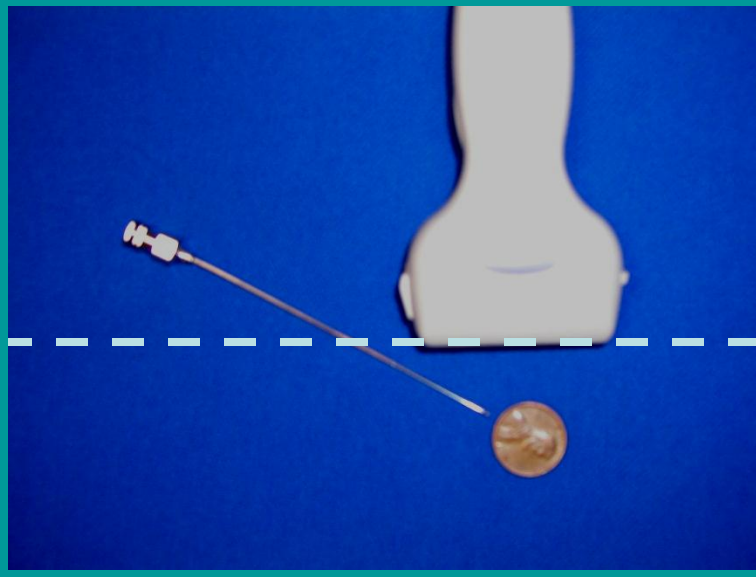
- Move tip in & out of field
- Walk-down advancement



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# USG MSK INTERVENTIONS

## Procedure – Entry Site

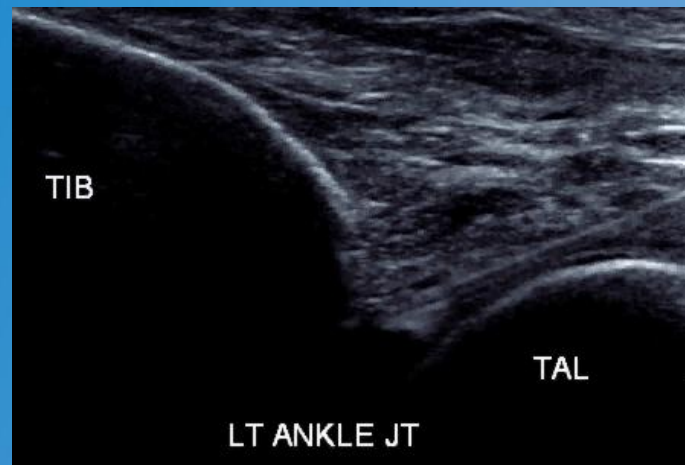


- Deeper target requires entry site farther away from transducer due to effect of obliquity on needle visualization
- Ensure adequate **needle length**

# USG MSK INTERVENTIONS

## Procedure – Technique

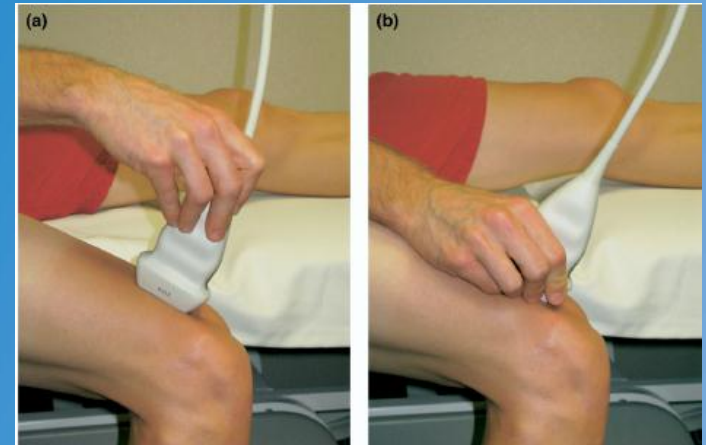
- Cold Spray
- Penetrate skin 1 cm
- Find needle
- Advance real-time
- Local anesthesia
  - Test trajectory
  - Hydrodissection



# USG MSK INTERVENTIONS

## Procedure – Pitfalls & Pearls

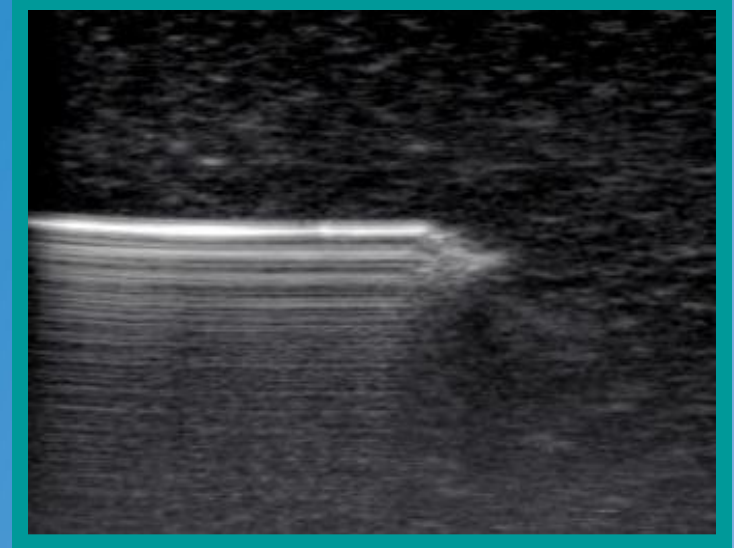
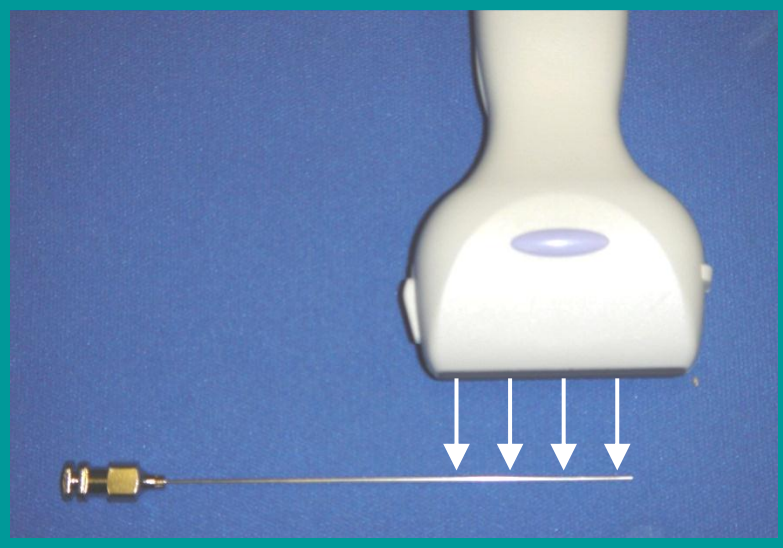
1. Anchor transducer!!!
2. Can't see tip → don't advance
3. Don't move needle & transducer at the same time
4. Know when to withdrawal and redirect



# USG MSK INTERVENTIONS

## Needle Visualization – In Plane

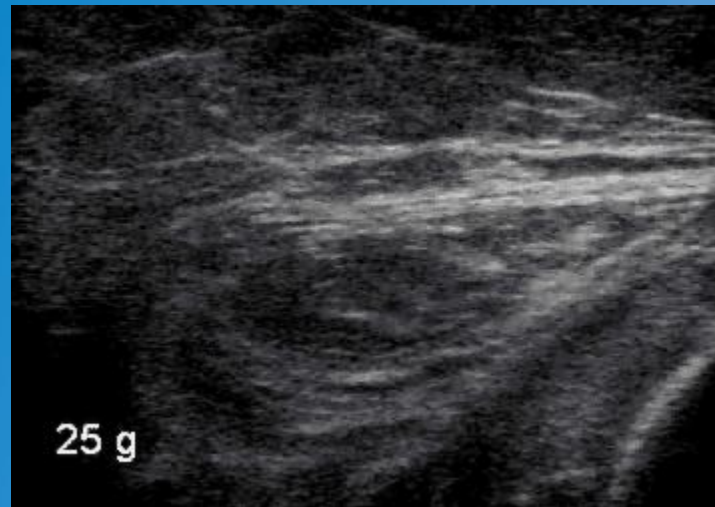
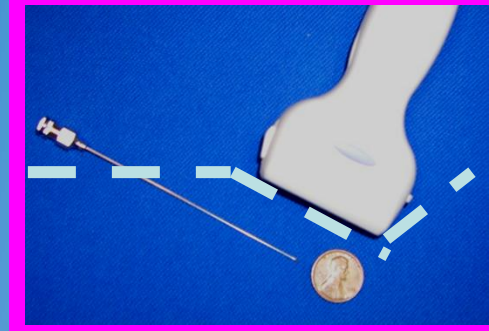
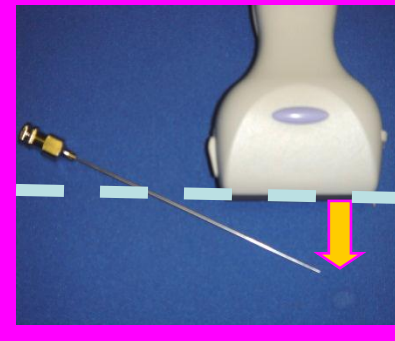
- Strive for parallel



# USG MSK INTERVENTIONS

## Needle Visualization – In Plane

- If can't get parallel, try:
  - Heel-toe



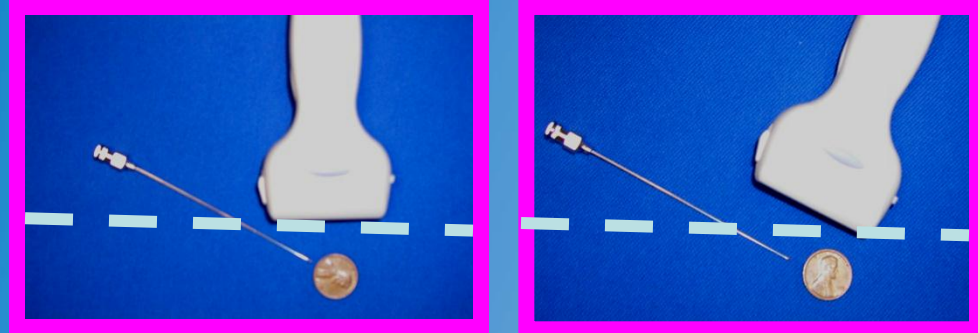
v

# USG MSK INTERVENTIONS

## Needle Visualization – In Plane

• Or:

- Oblique stand-off

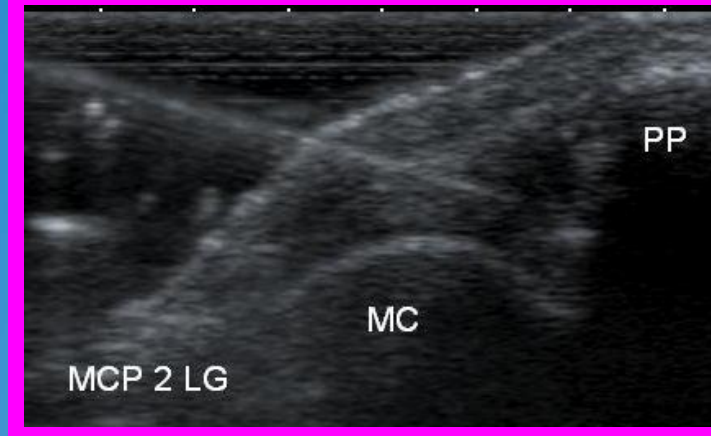
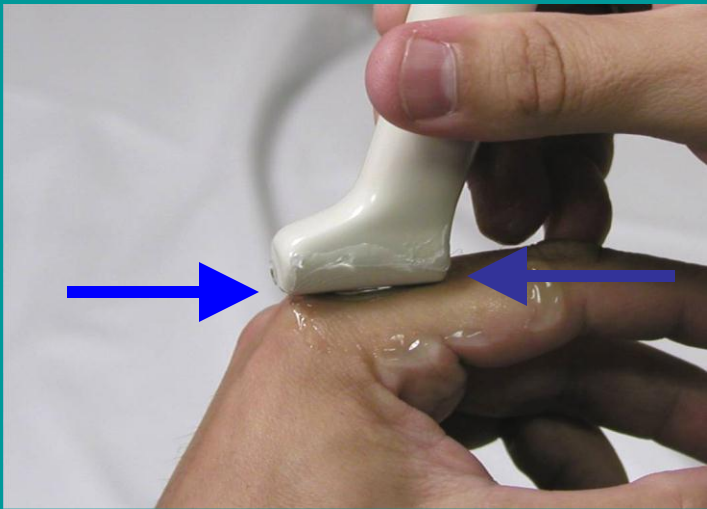


1. Lift one end of Tx
2. Anchor other
3. Fill gap with gel



# USG MSK INTERVENTIONS

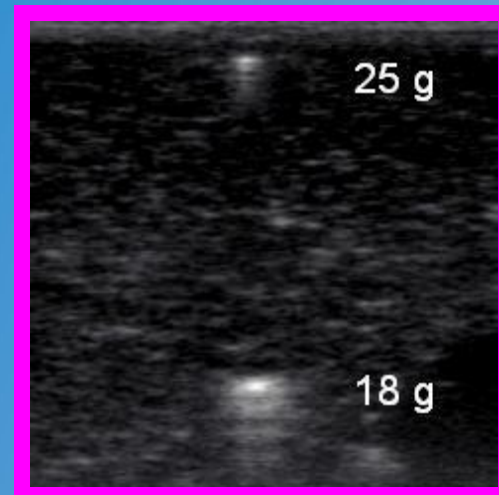
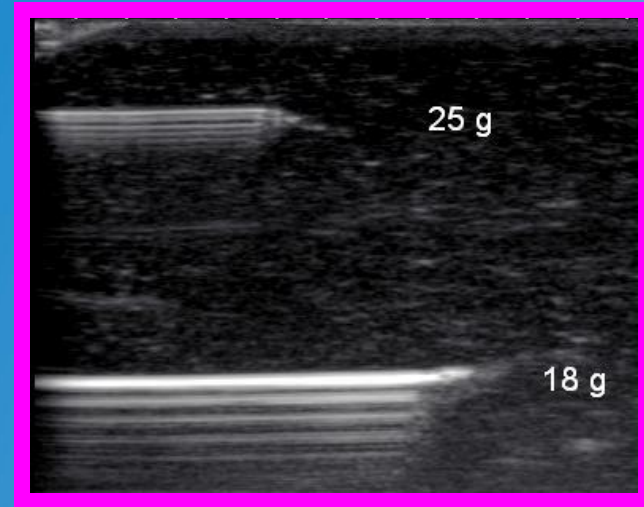
## Oblique Stand-off: OOP → IP



# USG MSK INTERVENTIONS

## Needle Visualization – In Plane

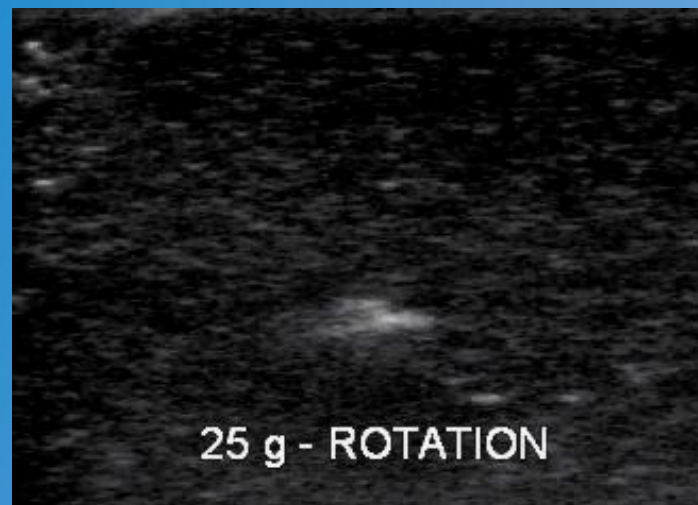
- Needle choice
  - Length
  - Size (gauge) matters
    - but not that much
  - Echogenic



# USG MSK INTERVENTIONS

## Needle Visualization – In Plane

- Having difficulty finding your needle tip?
  - Jiggle
  - Rotate bevel
  - Stylet



# USG MSK INTERVENTIONS

## Once You are in the Target

- Take a picture with the needle in the target
- Aspirate
- Inject under direct US visualization
- Re-scan area to ensure correct location of injectate
- Consider picture to document location of injectate

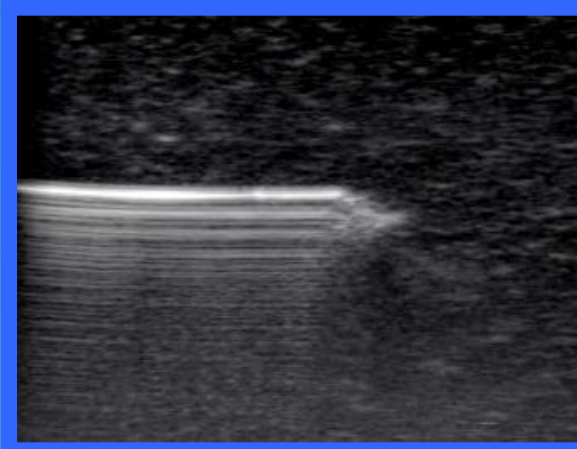


V

# USG MSK INTERVENTIONS

## Conclusions

- US is a powerful tool for guided interventions in the MSK system
- More accurate and likely more efficacious and cost effective than palpation guided injections
- Visualization of the needle is crucial
  - In plane approach with minimal obliquity is the goal



# USG MSK INTERVENTIONS

## Conclusions

- Planning for safe and efficient procedures requires:
  - Appreciation of basic US physics
  - Choosing right equipment for the job
  - Knowledge of anatomy
  - Skills to find, track, & advance needle
  - Recognizing limits
- This is harder than it looks
  - Practice is key!!!

# Thank you



# USG MSK INTERVENTIONS

## References

- Bianchi S, Martinoli C. Ultrasound of the Musculoskeletal System. Springer, New York, pp. 889-918, 2007.
- McNally E. Practical Musculoskeletal Ultrasound. Elsevier, Philadelphia, pp. 283-308, 2005.
- Anatomic images were obtained from: Schuenke et al. THIEME Atlas of Anatomy – General Anatomy and Musculoskeletal System. All rights reserved. THIEME 2007, [www.thieme.com](http://www.thieme.com)