Interventional MSK Ultrasound: Advanced Procedures

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Outline:
• Calcific tendinosis
• Tendon fenestration
• Tendon injection and PRP
• Soft tissue mass biopsy

Tendon Calcification:
• Degenerative: thin, linear deposit
• Calcific tendinosis:
  – Formative: well-defined, dense shadow
  – Resorptive:
    • Globular, amorphous
    • Variable shadow
    • Best success with aspiration

Degenerative Calcification

Calcific Tendinosis
• Hydroxyapatite deposition: metaplasia
  – Usually do not have cuff tear
• Appearance:
  – 79% hyperechoic & shadowing
  – No shadow: 7%
• Two phases:
  – Formative
  – Resorptive: painful

Farin et al. Skeletal Radiol 1996; 25:551

Calcific Tendinosis

Calcific Tendinosis: resorptive phase

Patient #1

Patient #2: Intra-osseous invasion

Calcific Tendinosis: supraspinatus

Use of Tendon Anisotropy

Long axis

Calcific Tendinosis: aspiration

• Percutaneous lavage and aspiration
  – Best: rounded amorphous calcification
  – Correlate with radiography
• 3-10 cc syringes: Lidocaine
• 20 – 22 gauge needle
• Position patient: syringe is dependent

Subscapularis: calcific tendinosis

Calcific Tendinosis: aspiration

• Inject Lidocaine, then aspirate
  – Dilute calcification
  – Syringe dependent
  – Calcification will flow into needle
  – Repeat until calcification decreases
• Inject steroids into adjacent bursa
Calcific Tendinosis: results
- Calcium decrease correlates with symptom improvement
- Improvement: 91% at 1 year*
- Calcium gone in 89%
- Transitory recurrence at 15 weeks: 44%
- Improved symptoms at 1 year
- No difference at 5, 10 years**

*del Crura, AJR 2007; 189:W128
**Serafini G, Radiology 2009; 252:157

Outline:
- Calcific tendinosis
- Tendon fenestration
- Tendon injections and PRP
**Tendon: anatomy**
- Primarily: Type 1 collagen
  - Viscoelastic
  - Minor collagens
  - Proteoglycans
  - Glycoproteins
- Tendon fibroblasts or tenocytes
  - Respond to mechanical loading
  - Modulate extracellular proteins

**Tendon: injury**
- Acute tensile overload
  - Usually underlying abnormal tendon
- Chronic overuse: repetitive excessive loading
  - Loss of normal tendon architecture
  - Change in tenocyte morphology
  - Altered collagen fibril distribution and neovascularity
  - Microtears
  - Resulting underuse may contribute

**Tendon: healing**
- Inflammatory phase
  - First week after injury
  - Fibrin clot
  - Cell migration, neovascularity
- Proliferation phase
  - 1 to 4 weeks
  - Fibroblasts synthesize collagen and extracellular proteins
- Remodeling phase

**Tendinosis or Tendinopathy**
- Terms used instead of tendinitis
- No acute inflammatory cells
  - Primarily mucoid degeneration
  - Chondroid metaplasia
- Ultrasound:
  - Hypoechoic tendon
  - Heterogeneous, ill-defined
  - Possible increased thickness

**Percutaneous Tendon Treatments**
- Corticosteroid
- Fenestration (dry needling, tenotomy)
- Hyperosmolar dextrose, prolotherapy
- Whole blood (autologous)
- Platelet-rich plasma
- Stem cells
- Other: deer antler velvet, amniotic membrane
Peritendon Steroid Injections

- Elbow: common extensor tendon
  - Pain returns worse than before injection¹
- Gluteal:
  - 72% showed improvement at 1 month²
- Hamstring:
  - 24% had symptom relief beyond 6 months³

¹Coombes BK et al. JAMA 2013; 309:461
²Labrosse JM et al. AJR 2010; 194:202
³Zissin MH et al. AJR 2010; 195:993

Steroid Injection: plantar fascia

- Into fascia:
  - 2% risk of plantar fascia rupture¹
  - Temporary pain relief: 4 weeks
  - No difference at 8, 12 weeks compared to saline²
- Deep to fascia: 1st branch of the lateral planter nerve (Baxter’s nerve)
- Superficial to fascia:
  - Risk of fat atrophy theoretical using US guidance

¹Kim C et al. Foot Ank Spec 2010; 3:335
²McMillan AM et al. BMJ 2012; 344:e3260

Prolotherapy

- Injection of an irritant
  - Hyperosmolar dextrose or morrhuate sodium
- Unknown mechanism
  - Irritant attracts inflammatory mediators
  - Stimulate release of growth factors
  - Vascular sclerosant

Distel et al. PMR 2011; 3:S78

Achilles: hyperosmolar dextrose

- 36 patients with chronic tendinosis
- Hyperosmolar dextrose every 6 weeks
- Significant reduction in pain
- Decreased vascularity in 55%


Prolotherapy

- Achilles
  - Transducer: short axis to plantar fascia
  - Needle: in plane with transducer

Steroid Injection: plantar fascia

- Transducer: short axis to plantar fascia
- Needle: in plane with transducer

Courtesy of Mark Cresswell, Vancouver
Tendon Fenestration

- Also called "dry-needling" or tenotomy
- Needle repeatedly passed through areas of tendinosis
- Disrupts area of tendinosis
- Bleeding causes release of growth factors
- Stimulates tendon healing

Fenestration: technique

- No NSAIDS x 2 weeks prior
- Ultrasound guidance: in plane
  - Long axis to tendon
- 20 or 22 gauge needle
- 20 – 30 passes until area soft
- Minimal Lidocaine: over tendon

Percutaneous Fenestration

- 20 or 22-gauge needle
- 20 to 30 needle passes
- Continued until area covered and tendon softens

Non-sterile technique for simulation only!

Fenestration: technique

- Cover entire tendon abnormality
- Contact bone if at tendon abnormality
- Pull needle out of tendon to redirect
- Also redirect medial to lateral
  - Pivoting at needle entrance
  - Cone-shaped area

Fenestration: technique

- Contraindications:
  - Not delineated in literature
  - Prior steroid injection < 3 months ago
  - Bleeding disorders
  - Infection
  - Tendon tear > 50% thickness?

Post-procedure:

- No ice
- Rest for 2 weeks
  - Daily activities okay
  - Gradual return to activities
- Follow-up:
  - Referring physician, physical therapy
- No NSAIDS: 2 weeks
Phases of Tissue Healing

Post-procedure:
• Patellar tendon:
  – Knee brace (locked) x 2 weeks
  – First week non-weight bearing with crutches
  – Nothing?
• Achilles tendon:
  – Walking boot x 2 weeks

Tendons
• Common extensor tendon: elbow
• Patellar tendon
• Gluteal tendons: great trochanter
• Achilles
• Other

Tendon Fenestration
• 14 tendons
• VAS score improved: 4, 12 weeks
• Patellar (5), Achilles (4)
• 1 each: gluteus medius, iliotibial tract, rectus femoris, hamstring, common extensor tendon

Patellar Tendon

- 45 tendons
- 76% improved at 4 weeks, 24% no change
- Improved outcome at 4 weeks if:
  - Less pain prior to procedure
  - Well-defined area of tendinosis at US
  - No correlation with other ultrasound findings (color, size, location, etc.)


Fenestration: pelvis

- 22 tendons in 21 patients
- Gluteus medius (11), hamstring (8),
gluteus minimus (2), tensor fascia lata (1)
- Marked or some improvement: 82%


Gluteus Medius

PRP: Gluteus Minimus
Percutaneous Fenestration: Hamstring

Tensor Fascia Lata

Ilium

Achilles tendon

Discussion: tendon fenestration
• Studies are relatively limited to date
• Most common site:
  – Common extensor tendon (elbow)
  – Other sites have been attempted
• All studies show improvement
• Procedure well-tolerated
  – Potential risk of tendon tear

Discussion: other treatments
• Fenestration is often combined with other treatments:
  – Platelet-rich plasma or whole blood injection
  – Hyperosmolar dextrose or prolotherapy
• Common extensor tendon (elbow):
  – There is no benefit of injecting steroids during tenotomy1
  – Risk of tendon rupture

Discussion: questions
- Do some tendons respond better?
- Young versus old patients?
- What timing (acute versus chronic)?
- Tendinosis versus partial tear?
- Timing of physical therapy?
- Hyperemia on color Doppler?

Whole Blood Injection
- Autologous whole venous blood
- Injected into abnormal tendon during fenestration
- Release of growth factors that will promote healing
- Refractory tendinopathy may be helped
  - Additional studies are needed
  
  Kampa RJ et al. Int J Clinical Practice 2010; 64:1813

Outline:
- Calcific tendinosis
- Tendon fenestration
- Tendon injections and PRP

Platelet-Rich Plasma
- Autologous venous blood
- Centrifuged
- Concentrated platelet sample
- Platelets degranulate:
  - Alpha granules: contain 95% of growth factors
  - Secrete additional growth factors (7 days)
  - Bind to cell membrane receptors: healing

Platelets: growth factors
- PDGF: platelet-derived growth factor
- VEGF: vascular endothelial growth factor
- TGF: transforming growth factor b-1
- IGF: insulin-like growth factor
- EGF: epidermal growth factor
- FGF: fibroblast growth factor
- TNF: tumor necrosis factor
- TGIF: thank gosh it’s Friday

Platelet-Rich Plasma: uses
- Historically:
  - Used in maxilla-fascial surgery: 1990’s
- Other surgeries:
  - Fracture, non-union, bone fusion
- Cosmetics:
  - Alopecia, scars, wrinkles
- Tendon and ligament injuries
- Osteoarthritis

Platelet-Rich Plasma: who cares?
- Many high-profile athletes claim effectiveness
- Patients are requesting this treatment
- Everyone is doing it
- It works, but may not be best treatment

PRP: what’s in the mix
- Platelet count:
  - 500K ideal (in vitro)¹
  - Tenocyte proliferation, migrations, collagen type I production
  - Less effectiveness if higher, even cell death
- White blood cells:
  - Leukocyte poor or rich concentrations
  - Poor: less catabolic cytokines, more healing²

PRP: Arthrex
- One of many available systems
- Double syringe system
- Leukocyte poor
- No anticoagulant needed
- Venous draw: 15 ml
- Place directly in centrifuge: 5 min
- 2 - 5 ml PRP
- Platelet concentration: 200 – 500K

PRP: safety
- Pain: up to several days
- Risks:
  - Infection: PRP has antibacterial effects
  - Tumor:
    - Insulin-like growth factor (IGF) linked to cancer
    - IGF is not elevated in PRP preparations

²McCarrel TM et al. JBJS 2012; 94:e143

**PRP: injections**

- Tendon
- Muscle
- Ligament
- Osteoarthritis
- Cartilage

**Common Extensor Tendon: PRP**

- 22-gauge needle
- In plane with transducer and long axis to tendon
- Fenestrate prior to or during PRP injection
- Most common: one treatment

**Common Extensor Tendon: elbow**

- 58 patients
  - Outcome: average 28 months
    - Pain level and difficulties with related activities
      - 64% excellent, 16% good, 7% fair, 13% poor
      - No adverse effects
    - Follow-up study: 57 patients
      - 93% excellent or good results
      - Corticosteroid injection not needed

1 McShane JM et al. J Ultrasound Med 2006; 25:1281

**Common Extensor Tendon: elbow**

- Randomized controlled: 230 patients
  - PRP + fenestration versus fenestration alone
  - No difference in outcomes at 12 weeks
  - Significant difference in pain scores at 24 weeks: PRP group had less pain


**Common Extensor Tendon: elbow**

- Randomized controlled: 28 patients
  - PRP + fenestration versus fenestration alone
  - Trend for greater clinical improvement in PRP subjects at 2 months
  - No difference in clinical outcome at 6 months

Stenhouse G et al. Skeletal Radiol 2013; 42:1515

**Common Extensor Tendon**

- PRP (72%) vs fenestration (56%)
  - Both improved
- PRP, fenestration, steroid (in tendon):
  - No significant difference
- PRP vs whole blood: no difference
Common Extensor Tendon:
- PRP vs steroid (+fenestration)
  - PRP significantly better at 2 years
- Metanalysis: inconclusive

PRP and Tendon Injection
- Gluteal Tendons: greater trochanter
  - Randomized controlled: 30 patients
  - PRP versus fenestration alone
  - Significant improvement at weeks 1 and 2
  - Approximately 80% had long term improvement: up to 1 year follow-up
  - No difference between treatment groups

Gluteus Medius

Gluteus Maximus and Minimus
- Randomized controlled: 30 patients
- PRP versus fenestration alone
- Significant improvement at weeks 1 and 2
- Approximately 80% had long term improvement: up to 1 year follow-up
- No difference between treatment groups

PRP and Tendon Injection
- Patellar tendon
  - Randomized controlled: 23 patients
  - PRP + fenestration versus fenestration alone
  - PRP outcomes better at 12 weeks
  - No significant difference in outcomes when greater than 26 weeks
PRP and Tendon Injection

- **Achilles tendon**
  - Randomized controlled: 54 patients
  - PRP versus saline injection
  - No significant difference at 24 weeks\(^1\) and 1 year\(^2\)
- **Metaanalysis**
  - PRP + eccentric physical therapy compared with saline
  - No difference in outcomes: clinical or ultrasound findings\(^3\)

\(^1\)de Vos RJ et al. JAMA 2010; 303:145
\(^3\)Zhang YJ. Clin Orthop Relat Res 2018; 39:1623

PRP and Tendon Injection

- **Plantar fascia**
  - PRP versus corticosteroid (40 patients)
  - PRP more effective and durable

Monto et al. Foot Ankle Int 2014; 35:313

PRP and Muscle Injection

- **Proximal hamstring**
  - PRP versus rehabilitation only
  - Randomized controlled: 28 patients
  - PRP group: full recovery earlier
    - 27 days versus 42 days (average)


Adductor Tear: PRP

- Target: tendon tear
- Efficacy uncertain
PRP and Muscle Injection

- Gastrocnemius: rat model
- PRP versus saline injection: 46 rats
- Followed to 14 days
- Outcome: strength and histologic analysis
- No significant difference between groups


PRP and Muscle Injection

- Hamstring
- PRP versus rehabilitation alone
- 10 National Football League players
- Median time: return to play
  - PRP = 20 days vs. rehabilitation =17 days
- No significant difference between groups


PRP and Ligament Injection

- Ulnar collateral ligament: elbow
  - Partial tear on MRI
  - 34 athletes: followed for 70 weeks
  - 88% returned to play, average 12 weeks
  - Joint space widening:
    - Decreased from 28 to 20 mm
    - Change in widening: 7 to 2.5 mm


PRP and Knee Osteoarthritis

- Several studies evaluating PRP and knee OA
- Most studies show superior results with leukocyte-poor PRP compared with saline or hyaluronic acid
- Mild OA responds better
- No anatomic information
- One study showed same results with 1 or 2 injections

Wang D. et al. JBJS Reviews 2017; 5:1

PRP and Knee Osteoarthritis

- Several studies evaluating PRP, knee OA
- PRP may be slightly better than hyaluronic acid
- Benefits may decrease after 1 year
- Mild OA responds better
- No anatomic information
- Leukocyte-poor preparation is best

PRP and Cartilage

- Meta-analysis: 21 papers
- Increased chondrocyte and mesenchymal stem cell proliferation
- Proteoglycan and Type II collagen deposition
- Increase chondrocyte viability
- Migration of stem cells
- Hyaline vs. fibrocartilage?

Labrum: PRP

- Platelet-rich plasma injection
- Inject into labral tear (yellow arrow)
- Efficacy unknown

White arrowheads = needle

PRP: issues

- Different PRP systems
  - Variable platelet concentrations
  - Leukocyte poor versus rich
- Studies:
  - Variable controls, often unblinded
  - Often not compared to other treatments
  - Variable follow-up time points
  - How many injections?
  - Acute versus chronic conditions?
  - Which tendon?

PRP: where are we today?

- Promotes healing, does not cause harm
- Need: randomized controlled trials
- Meta-analysis:
  - No conclusive evidence to support PRP use
  - Supports ultrasound-guided leukocyte-rich PRP for tendinopathy
  - Supports use for knee osteoarthritis
- Accuracy? What about cost effectiveness

2. Fitzpatrick J. et al. AJSM 2017;  45:226
3. Wang D. et al. JBJS Reviews 2017;  5:1

Take Home Points

- Calcific tendinosis:
  - Inject before aspiration
- Tenotomy:
  - Proven effective at many sites
  - Integral part of other tendon treatments
- Platelet-rich plasma
  - What about cost effectiveness compared to tenotomy?

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