Interventional MSK Ultrasound: Tendon Treatments and PRP

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Outline
• Tendon treatment overview
• Tendon fenestration / tenotomy
• Whole blood injection
• Prolotherapy
• Platelet-rich plasma

Tendon: anatomy
• Primarily: Type 1 collagen
  – Viscelastic
  – 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

Note: all images from the textbook Fundamentals of Musculoskeletal Ultrasound are copyrighted by Elsevier Inc.
**Tendinosis**
- 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**
- Shoulder: minimal transient pain relief
- Elbow: common extensor tendon
  - Pain returns worse than before injection
- Gluteal:
  - 72% showed improvement at 1 month
- Hamstring:
  - 24% had symptom relief beyond 6 months

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

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

Kim C et al. Foot Ank Spec 2010; 3:335
2 McMillan AM et al. BMJ 2012; 344:e5263

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

Fenestration: 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

Common Extensor Tendon (Elbow)

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


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.)


Gluteus Medius

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

Percutaneous Fenestration: Hamstring

Tensor Fascia Lata

Sagittal

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 tenotomy\(^1\)
  - Risk of tendon rupture

\(^1\) McShane JM et al. J Ultrasound Med 2008; 27:1137
Ultrasonic Tenotomy (Tenex)

- Ultrasound phacoemulsification
  - Debride and aspirate necrotic tendon
- Irrigation
- Safe and effective
- No comparison studies
  - Outcomes, cost-effectiveness

Williams RC et al. PM R 2018; 2015; 10:313

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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

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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

Courtes Ch of Mark Cresswell, Vancouver

Prolotherapy

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


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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


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

**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 healing\(^2\)

\(^2\)McCarrel TM et al. JBJS 2012; 94:e143

**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

\(^1\)Giusti et al. BioMed Res Internat 2014

**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**

- PRP vs fenestration: 230 subjects
  - 24 weeks: PRP higher success (84% vs 68%)
- PRP, fenestration, steroid (in tendon):
  - No significant difference
- PRP vs whole blood: no difference

- PRP vs steroid (+fenestration)
  - Metanalysis: inconclusive
- PRP is superior to steroids
  - PRP is equal to lidocaine
  - Martin GI, J Ortho Surg Res 2019; 23:14
**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\(^1\)
  - Two injections: more sustained response\(^2\)

  \(^1\)Jacobson JA et al. J Ultrasound Med 2016; 35:2413

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**PRP and Tendon Injection**

- **Gluteal Tendons: greater trochanter**
  - Randomized controlled: 80 patients
  - PRP versus steroid injection
  - Ultrasound-guided: 5 – 6 needle passes
  - Patients with > 4 months of symptoms had greater clinical improvement with PRP at 12 weeks


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**Step #1: tendon fenestration**

- Fenestration
- Post-fenestration

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**PRP: proximal patellar tendon**

- Pre-procedure
- PRP injection
PRP and Tendon Injection

- **Patellar tendon**
  - Randomized controlled: 23 patients
  - PRP + fenestration versus fenestration alone
  - PRP better at 12 weeks, no different at 26 weeks
  - PRP no better than saline


- **Achilles tendon**
  - Randomized controlled: 54 patients
  - PRP versus saline injection
  - No significant difference at 24 weeks
  - PRP + eccentric physical therapy compared with saline
  - No difference in outcomes: clinical or ultrasound findings

1. de Vos RJ et al. JAMA 2010; 303:145

- **Rotator cuff**
  - PRP not beneficial

- **Supraspinatus**
  - Interstitial tear
  - No difference between PRP and saline


- **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**

- **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


<table>
<thead>
<tr>
<th>PRP and Ligament Injection</th>
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<tbody>
<tr>
<td><strong>Ulnar collateral ligament:</strong> elbow</td>
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<tr>
<td>- Partial tear on MRI</td>
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<td>- 34 athletes: followed for 70 weeks</td>
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<td>- 88% returned to play, average 12 weeks</td>
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<td>- Joint space widening:</td>
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<td>- Decreased from 28 to 20 mm</td>
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<td>- Change in widening: 7 to 2.5 mm</td>
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**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 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

**PRP and Meniscus**

- 15 patients
- US-guided PRP injection
- Meniscal degeneration
- 67% had functional improvement
- Grade 2 degeneration improved to Grade 1

Ozyavc ON. et al. J Ortho Surg 2019; 28:1
**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?

**Take Home Points**

- Fenestration / tenotomy:
  - Proven effective at many sites
- Other tendon treatments: same
- Platelet-rich plasma
  - Tendon: not proven better than other treatments
  - Osteoarthritis: promising
  - What about cost effectiveness?

Syllabus on line and other educational material: www.jacobsonmskus.com

Twitter handle: @jacobson