Injectables, Percutaneous, Fenestration and Tenotomy

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Outline
- Anesthetic agents
- Corticosteroids
- Fenestration or tenotomy
- Autologous blood products
- Miscellaneous

Anesthetic Agents: types
- Diagnostic or therapeutic joint injection
- All agents harm tissues
  - Dependent on exposure time and dose
  - Use of epinephrine

<table>
<thead>
<tr>
<th>Genomic Name</th>
<th>Trade Name</th>
<th>Relative Potency</th>
<th>Dose</th>
<th>Duration of Action (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mepivacaine</td>
<td>Marcaine</td>
<td>1</td>
<td>Moderate</td>
<td>30–60</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>Xylocaine</td>
<td>2</td>
<td>Rapid</td>
<td>30–120</td>
</tr>
<tr>
<td>Bupivacaine</td>
<td>Marcaine</td>
<td>8</td>
<td>Longed</td>
<td>100–300</td>
</tr>
<tr>
<td>Ropivacaine</td>
<td>Marcaine</td>
<td>6</td>
<td>Moderate</td>
<td>120–240</td>
</tr>
</tbody>
</table>

MacMahon PJ et al Radiology 2009; 252:647

Anesthetic Agents: harm
- Human chondrocytes and synovial cells
  - 0.5% Bupivacaine + 1:1000 epinephrine: 60% cell death
  - 1% Lidocaine: induced most apoptosis (programmed cell death)
  - Epinephrine: very cytotoxic
  - 0.5% Ropivacaine: most protective
Rao AJ et al. AJSM 2014; 42:50

Anesthetic Agents: joint injection
- Aim for joint recess
- Determine pain generator
  - Labrum: significance of imaging findings
  - Midfoot and hindfoot: prior to fusion
- Often combined with steroids
- Mepivacaine (Carbocaine)
  - Rapid onset, short duration
  - Did not reduce arthrography-related pain
1Choo HJ et al AJR 2013; 200:860
Joint injection

- Anterior recess
- In plane
- Transducer:
  - Parallel to femoral neck
  - Consider curvilinear
- Needle: distal to proximal
- 97% accuracy

Anesthetic Agents: harm

- Tenoblasts
  - Cell death: related to exposure time and concentration
  - All agents were toxic
  - 0.2% Ropivacaine: least toxic
  - Lidocaine: most toxic regardless of concentration

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Corticosteroids: types and doses

<table>
<thead>
<tr>
<th>Steroid</th>
<th>Commercial Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylprednisolone acetate</td>
<td>Depo-Medrol, Medrol, Deltason, Medrolone</td>
</tr>
<tr>
<td>Triamcinolone acetate</td>
<td>Kenalog</td>
</tr>
<tr>
<td>Betamethasone acetate</td>
<td>Solurot</td>
</tr>
<tr>
<td>Betamethasone sodium phosphate</td>
<td>Celestone</td>
</tr>
<tr>
<td>Dexamethasone sodium phosphate</td>
<td>Decadron Phosphate, Decadron, Decadject</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Joint Size</th>
<th>Methylprednisolone (mg)</th>
<th>Triamcinolone (mg)</th>
<th>Betamethasone (mg)</th>
<th>Dexamethasone Sodium Phosphate (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large*</td>
<td>20-30</td>
<td>10-15</td>
<td>1-2</td>
<td>2-4</td>
</tr>
<tr>
<td>Medium†</td>
<td>10-40</td>
<td>5-10</td>
<td>0.5-1.0</td>
<td>0-3</td>
</tr>
<tr>
<td>Small‡</td>
<td>4-10</td>
<td>2.5-5</td>
<td>0.25-0.5</td>
<td>0.8-1</td>
</tr>
</tbody>
</table>

MacMahon PJ et al Radiology 2009; 252:647

Corticosteroids: types

- Particulate:
  - Methylprednisolone and triamcinolone
  - Prepared with esters, insoluble in water
  - Forms microcrystalline suspension
  - Slower onset, longer duration
  - Depigmentation, fat atrophy: more common
- Non-particulate:
  - Betamethasone and dexamethasone

Blaichman JI et al Radiographics 2020

Corticosteroids: contraindications

- Absolute:
  - Septic joint
  - Bacteremia
  - Intra-articular fracture
  - Joint instability

MacMahon PJ et al Radiology 2009; 252:647
Corticosteroids: contraindications

- Relative:
  - Severe juxta-articular osteoporosis
  - Coagulopathy
  - Greater than 3 injections per year or within 6 weeks

MacMahon PJ et al Radiology 2009; 252:647

Corticosteroids: adverse effects

- Septic arthritis: 0.01 – 0.03%
- Post-injection "flare": 2 – 25%
  - Within hours: if more than 24 hours- aspirate
- Local tissue depigmentation, atrophy
- Facial flushing: 15%, histamine mediated
- Increased glucose level

MacMahon PJ et al Radiology 2009; 252:647

Corticosteroids: adverse effects

- Cartilage thinning:
  - Debated in the literature
  - Knee study:
    - 8 injections 40 mg Triamcinolone
    - Over 2 years
    - Compared to saline
    - Greater cartilage loss (seen on MRI)
    - No difference in pain relief

McAlindon TE et al JAMA 2017; 317:1967

Corticosteroids: synovial spaces

- Joints, bursae, tendon sheaths
- Decrease inflammation
- Caveats:
  - Many bursae: distended and not inflamed
  - Some tendon sheaths communicate: joints
  - Biceps brachii and glenohumeral joint

1Nwawka OK et al AJR 2016; 206:373

Hip: intra-articular steroid injection

- 44% showed osteoarthritis progression compared with 24% of controls
- 17% showed new collapse compared with 1%
  - Occult insufficiency fracture?
- In spite of anecdotal discussions, no proven link with intra-articular steroids and osteonecrosis

Simeone FJ et al. Skeletal Radiology 2019; 48: 1417
Kompel A et al. Radiology 2019; 293

Corticosteroids: synovial spaces

- Midfoot and hindfoot
- In-plane: joint recess
- Out-of-plane: joint space
- Midfoot steroid injection:
  - Improvement at 4 months
  - Less improvement if obese

1Protheroe D et al Foot Ankle Int 2018; 39:101
Subacromial-subdeltoid: injection

Iliopsoas Bursa
- Oblique-axial plane:
  - Superior to femoral head
  - Lateral to medial
  - Inject between tendon and ilium
- Pain relief = successful iliopsoas surgical release

Blankenbaker DG. Skeletal Radiol 2006; 35: 565

Baker Cyst
- Aspiration
  - Inferior to superior
  - Medial to lateral
- Aspirate joint effusion first if present
- Steroid injection
  - Baker cyst injection works better than intra-articular injection1


De Quervain’s Tenosynovitis
- Inject short axis: dorsal
- Between EPB & radius
- Possible septation
- Inject around both tendons
- Avoid superficial branch of radial nerve

Corticosteroids: other sites
- Ganglion and paralabral cysts: unproven
- Morton neuromas: pain relief 3 months
- Carpal tunnel: pain relief up to 6 months
- Plantar fasciosis: equal to saline

1Ruiz A et al. Rev Esp Anestesiol Reanim 2013
2Tannam TF J Anesth 2013

Ganglion Cyst (elbow): aspiration

18-gauge needle
Lavage
Post-aspiration
Morton Neuroma
• Steroid injection\(^1\)
  – 3 month: pain relief
• Alcohol injection\(^2\)
  – Symptoms return at 5 yrs
• Radiofrequency ablation\(^3\)
  – 85% effective at 6 months

1Thomson CE JBJS 2014; 96A:334
2Gurdezi S Foot Ank Int 2013; 34:1064
3Chuter GSJ Skeletal Radiol 2013; 42:107

Carpal Tunnel Injection
• Axial plane
• Ulnar to radial
• Begin over ulnar nerve and stay superficial
• Inject adjacent to median nerve
• Cross-sectional area may decrease within 1 week after steroid injection\(^7\)

1Carter AL et al. Muscle Nerve 2015; 51:1489

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


Peritendon Steroid Injections
• Temporary pain relief
  – Stabilizes neural membranes
• Shoulder: minimal transient pain relief\(^1\)
• Elbow: common extensor tendon
  – Pain returns worse than before injection\(^2\)
• Gluteal: 72% showed improvement at 1 month\(^3\)
• Hamstring: 24% symptom relief beyond 6 months\(^4\)

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

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Steroid Injection: plantar fascia
• Into fascia:
  – 2% risk of plantar fascia rupture\(^1\)
  – Temporary pain relief: 4 weeks
  – No difference at 6, 12 weeks compared to saline\(^2\)
• 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
**Tendinosis**
- Terms used instead of tendinitis
- No acute inflammatory cells
  - Primarily mucoid degeneration
  - Chondroid metaplasia
- Ultrasound:
  - Hypoechoic tendon
  - Heterogeneous, ill-defined
  - Possible anechoic interstitial tears

**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

**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

**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

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

\[1\text{McShane JM et al. J Ultrasound Med 2006; 25:1281}\]
\[2\text{McShane JM et al. J Ultrasound Med 2008; 27:1137}\]

Common Extensor Tendon: elbow

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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!
**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**
- Needle
- Greater Trochanter
- Normal

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


**Achilles tendon**
- Sagittal

**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; 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

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


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\(^2\)
  - Poor: less catabolic cytokines, more healing\(^2\)

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

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
- WTF: what’s that factor?

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: injections

- Tendon
- Muscle
- Ligament
- Osteoarthritis
- Cartilage

PRP: proximal patellar tendon

Pre-procedure

PRP injection

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: 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


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


Gluteus Minimus and Medius

- 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
  - Two injections: more sustained response

**Achilles Tendon**
- Randomized controlled: 54 patients
- PRP versus saline injection
- No significant difference in outcomes
  - At 24 weeks\(^1\)
  - At 1 year\(^2\)
- *Both groups: eccentric physical therapy*

\(^1\)de Vos RJ et al. JAMA 2010; 303:145

**Labrum: PRP**
- Platelet-rich plasma injection
- Inject into labral tear (yellow arrow)
- Efficacy unknown

**PRP: where are we today?**
- Promotes healing, does not cause harm
- Need: randomized controlled trials
- Meta-analysis:
  - No conclusive evidence to support PRP use\(^1\)
  - PRP may help knee osteoarthritis\(^2\)
  - Supports ultrasound-guided leukocyte-rich PRP for tendinopathy\(^3\)
- What about cost effectiveness?

\(^1\)Sheth U. et al. JBJS 2012; 94:298
\(^2\)Wang D et al. JBJS Reviews 2017; 5:e7
\(^3\)Fitzpatrick J. et al. AJSM 2017; 45:226

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**Miscellaneous Injections**
- Mesenchymal stem cells: marrow, fat, tendons
- Sclerotherapy: target neovascularity
- Prolotherapy: hyperosmolar dextrose
- High volume injection: nerves, paratenon
- Hyaluronic acid: tendon sheaths
- Human amniotic membrane
- Deer antler velvet

**Hyaluronic Acid**
- Intra-articular injection
- Treatment of osteoarthritis (knee)
- American Academy of Orthopaedic Surgeons: evidence for use “inconclusive”
- American College of Rheumatology: supportive
- Meta-analysis: no difference over placebo

Weick JW et al. JBJS 2016; 98:1429
Jevsevar D et al. JBJS 2015; 97:2047
Take Home Points

• Anesthetic agents:
  – All harm cartilage: ropivacaine is best
• Corticosteroids
  – Effective: synovial spaces
  – Other sites, peritenon: question utility
• Autologous blood products:
  – Not sure if any better than fenestration
• Miscellaneous: many unproven

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