Anatomy

“Useless structure”

Complete meniscectomy was common and associated with poor outcomes
Osteophyte formation & joint space narrowing

Wedge Shaped

Deepen joint

Extracellular matrix

Water (72%)
Collagen (22%)


Periphery from capsular lining
Lateral and medial geniculate arteries
Peripheral vascularity: Medial (10-30%), Lateral (10-25%)
A-P horns more vascularized

Innervation

Free nerve endings greatest density in outwe 1/3 and A/P horns
Mechanoreceptors

Type I: Ruffini (pressure)
Type II: Pacinian (tension)
Type III: Golgi (terminal ROM)
  Type II = Joint Motion
  Type I & III = Joint position


“C” shaped: crescent
Covers 60% articular cartilage
Attaches to semimembranosus and deep MCL
Firmly fixed


“O” shaped: circular
Covers 80% of articular cartilage
Attached to popliteus
Very mobile


Medial (5mm)
Lateral (11mm)
NWB: Muscles move menisci
Meniscal Function

- Joint stability: femorotibial articulation
- Shock absorption: ↓ by 20% post meniscectomy
- Joint lubrication & nutrition
- Proprioception
- Load bearing: 70% lateral compartment; 50% medial compartment
- Contact area reduced by 50%-70% post meniscectomy
- Contact pressure ↑ by 200% to 300% post meniscectomy
- Maintain joint height

Maintain hoop stresses: Convert compressive force to tensile force


- Older age (>60 yo) (OR = 2.32)
- Male (OR = 2.98)
- Work related kneeling/squatting (OR = 2.69)
- Climbing >30 flights of stairs/day (OR = 2.28)
- Acute tears: Soccer (OR = 3.58) or Rugby (OR = 2.84)
- Future medial tears: Delayed ACLR (OR = 3.50)


- Medial (41%) vs Lateral (59%)
- A/P horn
- Body
- Central / Peripheral

Meniscal Pathology / Incidence

2nd Most common knee injury (12-14%) 61/100K


>40 yo rate of meniscal tears 4x higher


Concomitant with ACL (22% - 86%)


Delay in ACLR (>12 months) ↑ cartilage & medial meniscus lesions


- Traumatic Tears (Younger, Active)
  - Longitudinal or radial tears
- Degenerative Tears (Older)
  - Horizontal cleavage, flap, complex tears
Nearly ¼ of all knee injuries
High prevalence with primary & revision ACLR
↑ incidence of meniscal surgical procedures
Older Patients:
↑ rate of tears
Medial meniscal tears
Meniscectomy more likely
Younger Patients:
↓ rate of tears
Lateral meniscal tears
Repair more likely
Meniscal Pathology / Location
Vascular region
Red on red, Red on white, White on white
Mechanism of Injury / Subjective Report
Twisting injury
Delated effusion (6-24 hours post injury)
“catching” or “locking”
Pain with forced hyperextension or flexion
Exam
Joint line tenderness
Sensitivity: 76%
Medial: 83%; Lateral: 68%
Specificity: 77%
Medial: 76%; Lateral: 97%
McMurray
Sensitivity: 55%
Medial: 50%; Lateral: 21%
Specificity: 77%
Medial: 77%; Lateral: 94%
Thessaly: (Pain, locking or catching at 20° flexion)
Sensitivity
Medial meniscus: 59% - 89%
Lateral meniscus: 67% - 92%
Specificity
Medial meniscus: 83% - 97%
Lateral meniscus: 95% - 96%
A Collaborative Care Approach to Meniscal Pathology:
Surgical Management

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January 24, 2019

I. Meniscal Tears

Incidental Meniscal Tears

- MRI diagnosed meniscal tears evident in 40% asymptomatic patient older than 50 years (Englund et al., 2008)
- 56% in 70-90yrs old (Jerosch, Castro, & Assheuer, 1996)
- Arthritis
  - 63% : if knee pain, aching, stiffness most days
  - 60% without those symptoms

Why are Meniscal Tears Painful

- Peripheral meniscus has neurosensory capabilities (Dye, Vaupel, & Dye, 1998)
- Unstable fragments irritates local capsule
- Mechanical catching, locking
- Release inflammatory proteins leading to pain and swelling
- Resultant swelling, acute bleeding
- Greater force reaching bone
  - Subchondral bony changes
  - Bony edema bone
  - Changing mechanics

Meniscus Biomechanics

- Meniscus works via “hoop stress”
  - Distributes the load of the tibiofemoral joint throughout the meniscus
  - (Walker & Erkman, 1975)
    - Lateral Meniscus decreases compartment loads by 70%
    - Medial Meniscus decreases compartment loads by 50%
  - (Pengas et al., 2012)
    - 40 yr follow up of adolescents, total meniscectomy
  - (FAIRBANK, 1948)

- Function
  - Shock Absorber
    - Loss inner 1/3 medial meniscus decreased contact area 10%
      increased stress 65%;
    - Total meniscectomy = 235% increase (Baratz, Fu, & Mengato, 1986)
  - Cartilage and Bone Health
    - Alters fluid mechanics of articular cartilage correlated to size of meniscal resection (Kazemi, Li, Buschmann, & Savard, 2012)
- Remodeling subchondral bone plate (Anetzberger et al., 2014)
  - Stability/Biomechanics
  - >46% removal posterior horn medial meniscus causes posterior shift of medial femoral condyle (Arno et al., 2013)

- Vascularity
  - Entire meniscus is vascular at birth,
  - Decreased vascularity with time
    - inner 1/3 avascular by nine months
  - Adults: outer 10-30% is vascular (Arnoczky & Warren, 1982)

- Classification
  - Zones of vascularity
    - Red, red-white, white
  - Zone of position on tibia by thirds:
    - Anterior, Mid, Posterior
  - Quality of tissue
  - Size of tear
  - Associated cyst
  - Pattern
    - Vertical vs. Horizontal
    - Radial
    - Flap
    - Horizontal
    - Complex
    - Special

<table>
<thead>
<tr>
<th>Degenerative</th>
<th>Traumatic/Non-degenerative</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Degenerative tears: “complex, horizontal cleavage, shredded”</td>
<td></td>
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<tr>
<td>- Associated older age and more degenerative change</td>
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</table>

![Images showing different types of meniscal tears](image1.jpg)
II. When to operate on a meniscus

(Moseley et al., 2002)
- 178 patients: Arthroscopic debridement 58 Pts, Arthroscopic lavage 61 pts, Placebo 60
- At no point did either intervention group report less pain or better function than placebo
- Limitations:
  - Selection Bias: Veterans
  - 44% opted out of study
  - No measurement of severity of DJD

Arthroscopy in Osteoarthritis
- Ineffective pain / arthritis alone
- Does not alter the natural history of osteoarthritis
- Negative prognostic signs
  - Correlation of symptoms to pathology
  - Severity of cartilage loss and bone marrow edema in the same compartment of meniscal tear (Kijowski et al., 2011)
  - Severity of meniscal extrusion (Spahn, Mückley, Kahl, & Hofmann, 2006)
  - Meniscal root tear
  - Age > 70 (Uzun et al., 2017; Wai, Kreder, & Williams, 2002)
  - Alignment (Spahn et al., 2006)
- Best for Loose bodies, Mechanical symptoms (Chang et al., 1993; Wai et al., 2002)

(Katz et al., 2013)
- Multicenter, randomized controlled, symptomatic patient 45 yo or older
- 251 pts randomized to surgery and PT or PT
- Mean improvement in WOMAC
  - 20.9 pts surgery, 18.5 pts PT only
  - No significant difference
- Limitations:
  - 35% of patients assigned to PT underwent surgery (Cross-over)
  - Intent to treat analysis:
  - 70% Surg versus 40% PT

(Raine Sihvonen et al., 2013)
- 146 patients between 35 and 65 years of age –
  - "No evidence of arthritis"
- assigned to meniscectomy versus sham surgery (lavage)
- “In this trial involving patients without knee osteoarthritis but with a degenerative medial meniscal tear, the outcomes of partial meniscectomy were no better than those after a sham surgical procedure”
- Limitations:
  - Lavage as Sham Surgery?
  - Both procedures were effective
  - Satisfied: 89% meniscus 83% lavage
  - Willing repeat: 93% meniscus 96% lavage
  - 67% of patients meniscectomy had arthritis at time of surgery
Inherent bias? (Rossi, D'Agostino, Provencher, & Lubowitz, 2014)

Mechanical symptoms as an indication for surgery?
- (Gauffin, Tagesson, Meunier, Magnusson, & Kvist, 2014)
  - At 3 years: no significant benefit
  - Both groups improved
  - Surgery may be more beneficial for patients without mechanical symptoms
- (R. Sihvonen, Englund, Turkiewicz, & Järvinen, 2016)

Modern meniscal Surgery
- Arthroscopy does not improve outcome of osteoarthritis
- Degenerative meniscal tears are one of earliest sign of arthritis
- Consider negative prognostic signs:
  - Lack of correlation of symptoms to pathology
  - Severity of cartilage loss and bone marrow edema in the same compartment of meniscal tear
  - Severity of meniscal extrusion
  - Chronic meniscal root tear
  - Age > 70
  - Poor alignment
- Arthroscopy reserved for failure of conservative treatment
  - Meniscus surgery can best remove source of catching and locking only if the meniscus is the source of the mechanical symptoms
  - Mechanical symptoms are difficult to identify
  - Results from meniscectomy in large trials are no better than “lavage”
    - Individual results – likely improvement
- Best indication is “potentially repairable” tear

III. Surgery: Meniscectomy and Meniscal Repair

Partial meniscectomy
- Leave as much good meniscus as possible
  - Leave smooth contoured border to avoid catching or re-tearing – Some remodeling can occur (Jeong, Lee, & Ko, 2012)
  - Preserve peripheral meniscus whenever possible
    - Maintains circumferential fibers protects hoop stresses

Meniscal repair
- Meniscal repair should be undertaken whenever possible
  - Create a stable-well-fixed meniscus (method independent)
  - Often both – partial meniscectomy and repair
- Considerations
  - Age (Cost-benefit- risk ratio changes)
  - Location
  - Type of tear / Cartilage status
  - Athletes: Level of Play
— Special: Radial tears
  - Neurovascular risks
  - Large differences in rehab, meniscectomy versus rehab

Factors influencing a successful repair
  - Repair technique
  - Repair method
  - Number of sutures
  - Repair pattern
  - Tear pattern
  - Traumatic versus degenerative
  - Patient age, smoking (Uzun et al., 2017)
  - Rehab (Stability over immobilization)
  - Environment: Intact ACL, alignment Simultaneous repairs, growth factors, clot

Right tool for the right job
  - Perform repair with surgical technique surgeon is most comfortable using
  - Recognizing size, pattern, location of tear
  - Stability of the construct matters

IV. Special Tears:

Bucket-Handled Tears
  - All-inside posteriorly
  - Inside out- body of tear
  - Outside-in anteriorly

Horizontal Tears
  - All-inside repair

Radial Tears
— An all-inside repair may be biomechanically stronger (Zhang, Miller, Coughlin, Lotz, & Feeley, 2015)

Root Tears
— Complete radial tears and root tears are equivalent to total meniscectomy
— Classification: (C. M. LaPrade et al., 2015)
— Technique: Transtibial
— Medial
  ▪ A degenerative process?
  ▪ Single event of painful popping (specificity 99.5%) (Bae et al., 2013)
  ▪ Extent of meniscal extrusion may define chronicity (Furumatsu et al., 2017)
— Lateral
  ▪ More traumatic
  ▪ Stabilizer for IR at higher flexion angles (Frank et al., 2017)
  ▪ One factor in higher pivot shift (Song et al., 2017)
  ▪ Lack of repair may increase loads on ACL (Frank et al., 2017)

Ramp Lesions
▪ tear or disruption of the peripheral meniscocapsular attachments of the posterior horn of the medial meniscus”
  — Common in ACL injuries (DePhillipo et al., 2017)
  — Not always seen on MRI
  — Will not find unless surgeon probes the meniscus

Meniscopopliteal Fascicle Tears
▪ Pain in figure 4 position
▪ Inside out repair with multiple sutures (Noyes)
▪ Open repair on both sides LCL (LaPrade)(R. F. LaPrade & Konowalchuk, 2005)

V. Surgical Factors influencing Rehabilitation

▪ Initial indications
  — Degenerative tear
  — Presence of arthritic change
  — Meniscal extrusion
  — Presence of bony edema
  — Patient age
▪ All inside techniques
  — Number of stitches (sign of stability)
  — Vertical vs Horizontal Sutures (not as important)
  — All inside suture passers (manual knots)
▪ Healing environment (ACL)
▪ Tear Configurations
  — Vertical Peripheral tear (stable?)
— Horizontal tear
— Complexity of tearing
— Radial tears
— Meniscal Root Tears
VI. Outcomes from Meniscal Repair

(Eberbach et al., 2018)

Sports specific outcomes after isolated meniscal repair: A systematic review
- Sport-specific outcomes after “isolated meniscus repair”
- 28 studies (664 patients)
- Pooled failure: 21%
- Professional athlete vs mixed level athlete failure rates: 9% vs 22%
- RTP: 4.3-6.5 months
- Preinjury RTP level: 89%
- Meniscal repair rates of success 75-80%

(Everhart, Higgins, Poland, Abouljoud, & Flanigan, 2018)
- Meniscal repair rates in patients over 40 are comparable to rates of younger patients
- Repair outcomes for 148 patients in 11 studies
- Overall failure 10%
- Most tears peripheral with avascular extension
- Complex horizontal tears “: 23%
- Concomitant ACL 5%

Failures up to 2 years out (Saltzman et al., 2018)

VII. Post-Meniscectomy Syndrome

Pain without Chondrosis
- Consider Unloader Brace Younger = surgery
- Medial Meniscal : HTO, Meniscal transplant
- Lateral Meniscal: DFO, meniscal transplant

Focal chondral defect
- Osteotomy, meniscal transplant, cartilage restorative procedure

Advanced arthritis
- Osteotomy versus arthroplasty

VIII. Conclusions

- Arthroscopy/Meniscectomy does not improve outcomes in osteoarthritis
- Optimal indications for meniscectomy continue to be refined.
  - Often decision making individualized
    - Activity level, quality of life, Professional status
    - Partial meniscectomy leads to DJD
- Indications (importance) for meniscal repair expanding
  - Repairing heals 75-80%
- Surgical options/techniques continue to be developed and will require different rehabilitative approaches
Works Cited


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**A Kheterpal**

**Combined Sections Meeting 2019**

**Imaging of the Meniscus**

I. **Imaging Modalities**
   
   a. X-rays and CT scan – Excellent spatial resolution, good for osseous structures, alignment, degenerative changes
   
   b. MRI – Excellent contrast resolution, good for evaluation of menisci, cartilage, ligaments, tendons, bone marrow

II. **MRI Basics**

   a. **Pulse Sequences**
      
      i. Focus on the *fluid-sensitive* (T2-weighted sequences) where fluid signal will be bright. Joint fluid will be bright on this sequence.
      
      ii. We can employ *fat-saturation* with these sequences which makes the fat dark.

   b. **Signal of Normal Structures on fluid-sensitive sequences:**
      
      i. Articular cartilage (Hyaline cartilage) – Intermediate (gray)
      
      ii. Menisci (Fibrocartilage) – Low signal (black)
      
      iii. Muscles – Intermediate signal (gray)
      
      iv. Tendons – Low signal (black)

III. **Normal MRI Appearance of the Meniscus**
i. Morphology – Triangular appearance on cross-section
ii. Signal – Low signal (black)

IV. MRI Appearance of Meniscal Tears
   a. Direct Signs:
      i. Surfacing signal abnormality
      ii. Abnormal morphology
      iii. Missing or displaced meniscal tissue without prior surgery
      iv. Meniscocapsular injury or disruption
      v. Intrameniscal fluid on T2-weighted imaging

V. Associated MRI findings
   i. Peripheral Extrusion
   ii. Bone marrow and soft tissue edema
   iii. Parameniscal cyst

VI. MRI Appearance of the Postoperative Meniscus
   i. Partial meniscectomy – normal blunting/truncation
   ii. Meniscal repair – surfacing signal abnormality may remain
   iii. Persistent or Recurrent Knee Pain
      1. Persistent tear or re-tear of the meniscus
      2. Articular cartilage defect
      3. Subchondral insufficiency fracture
      4. Osteoarthritis, loose bodies

<table>
<thead>
<tr>
<th>Normal MR Appearance of the Meniscus</th>
<th>Fibrocartilage, low signal on MRI</th>
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<tbody>
<tr>
<td>MRI Appearance of Meniscal Tears</td>
<td>Best evaluated on T2-weighted sequences, look for high surfacing signal, abnormal morphology, missing meniscal tissue</td>
</tr>
<tr>
<td>Associated MRI Findings</td>
<td>Reactive edema, peripheral extrusion, cysts</td>
</tr>
<tr>
<td>The Postoperative Meniscus</td>
<td>Look for reasons for continued or recurrent pain</td>
</tr>
</tbody>
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K Fleming
Combined Sections Meeting 2019
Rehab and Return to Sport Following Meniscus Repair

   a. Descriptive epidemiology study
   b. Database representing 9% of the US population under the age of 65
c. Data were stratified to create groups undergoing (1) isolated meniscus repair, (2) isolated meniscectomy, (3) isolated meniscus repair followed by meniscectomy, (4) concomitant meniscus repair and ACL reconstruction, and (5) concomitant meniscus repair and ACL reconstruction followed by meniscectomy.
   i. from 2005-2011, there were a total of 387,833 menisectomies, 23,640 repairs, and 84,927 ACL reconstructions
   ii. there was a significant increase in the total number of isolated meniscus repairs performed and a doubling of the incidence of repairs from 2005-2011
d. There was an increased number of isolated meniscus repairs performed between 2005-2011 without a concomitant increase in meniscectomies over the same time frame. This would suggest that meniscus repairs are preferentially being performed over meniscectomies.

II. Meniscal root tears
   a. Defined as a radial tear within 1 cm of the root insertion, or an avulsion
   b. The meniscus translates axial load into hoop stress; this function is compromised without the root attachment (radial force created by axial loading can result in meniscal extrusion)
   c. Posterior lateral root tears are often associated with ACL injury
   d. Posterior medial root tears are often degenerative
   e. A close anatomical relationship exists between the posterior meniscal roots and the PCL
   f. Meniscal root tears and avulsions perform functionally equivalent to a total meniscectomy

III. ROM precautions following meniscal repair
      i. 14 knees examined with dynamic MRI through 0-90 degrees open- and closed-chain knee flexion
ii. Most movement occurred in the anterior horn of the lateral meniscus, but significant movement noted throughout

IV. Rehabilitation following meniscal repair

a. Early post-operative phase (weeks 0-6)

i. Goals
   1. protection of the repaired tissue
   2. restore extension ROM and normalize patellar mobility
      a. maintain anterior interval space availability
   3. effusion management
   4. minimize muscular atrophy/restore quadriceps control

ii. 0-2 weeks
   1. Peripheral longitudinal/vertical tears: PWB
   2. Central/complex tears: TTWB
   3. ROM: 0-90 degrees

iii. 2-6 weeks
   1. Peripheral/longitudinal tears: WBAT
   2. Central/complex tears: PWB
   3. ROM: 0-120 degrees

iv. Brace locked in full extension with all weight-bearing

v. Depending on location/complexity of tear, hamstring strengthening may be restricted x 4-6 weeks

b. Intermediate post-operative phase (weeks 6-12)

i. Goals
   1. Normalize gait
   2. Progress to full, pain-free ROM
   3. Gradually introduce load
      a. Progress CKC strengthening
      b. Progress static → dynamic loads
      c. Progress stable → unstable surfaces
   4. Develop muscular control/endurance
      a. High repetition/low load
      b. Heavy focus on form
   5. Initiate hamstring strengthening, as appropriate
6. Enhance balance/proprioception
c. Late post-operative phase (weeks 12+)
   i. Goals
      1. Muscular hypertrophy (higher loads, lower repetition)
      2. Progress balance/proprioception
      3. Introduce plyometrics (>60-70% quad symmetry, ~12-16 weeks)
         a. Shuttle/gravity-eliminated → over-ground
         b. 2 legs → 1 leg
         c. Stationary → broad jumps → box jumps → depth jumps
   4. Introduce interval jogging progression (~16 weeks)
      a. Full knee ROM
      b. Normal, pain-free gait x 30 minutes
      c. Trace or less knee effusion
      d. >80% quadriceps strength symmetry

V. Meniscal root repairs
   a. Key differences with rehabilitation following meniscal root repair
      i. Strictly NWB x 6 weeks
      ii. Avoid passive hyperextension x 6 weeks
      iii. No isolated hamstring activation x 6 weeks
      iv. 0-90 ROM restrictions x 2 weeks
      v. Progressive loading into CKC flexion
   b. Kim 2011 Arthroscopy
      i. 14 patients, immediate PWB allowed
      ii. Second-look arthroscopy revealed “loose fixation” in 3 knees, loss of fixation in 2 knees
   c. Lee 2009 Arthroscopy
      i. 21 meniscal root repairs, remained NWB x 6 weeks
      ii. Only 1 re-tear occurred

Return to Sport Decision-Making
   a. Systematic review of 69 articles (7556 patients)
   b. Average follow-up: 3.5 years
      i. 81% of patients returned to sport
      ii. 65% returned to pre-injury level
      iii. 55% returned to competitive sport
   c. Factors that favored returning to pre-injury level: male gender, young age, symmetrical hopping performance, playing at an elite level, and a positive psychological response
   a. Systematic review of 19 articles
   b. Overall ACL re-injury: 15%
      i. Ipsilateral graft failure: 7%
      ii. Contralateral primary ACL injury: 8%
   c. Of patients who returned to sport: 20% re-injured
   d. Of patients under 25 y/o: 21%
   e. Patients who are <25 y/o and are returning to sport: pooled 23% re-injury rate

   a. 354 patients who underwent ACLR before age 20
   b. 5-year follow-up
   c. Ipsilateral graft rupture: 18% at an average 1.8 yrs post-op
      i. 47% of graft ruptures occurred within the first year
      ii. 28.3% re-injury in males younger than 18 y/o
      iii. 12.9% re-injury in females younger than 18 y/o
      iv. 13.8% graft rupture in males 18-19 y/o
   d. Contralateral ACL rupture: 17.7%
   e. Combined instance of either ipsilateral or contralateral ACL injury in patients who undergo an ACLR before age 20: 35%

IX. Barber-Westin SD, Noyes FR. Factors used to determine return to unrestricted sports activities after ACLR. *Arthroscopy.* 2011;27(2):1697-1705.
   a. Systematic review, 264 studies included
      i. Inclusion criteria: English language, published within 10 years, clinical trial, all adult patients, primary ACLR, original research investigation, minimum 12 mo follow-up
   b. 40% failed to provide any criteria for RTS
   c. 32% only provided time from surgery as a RTS criteria (6 months)
   d. 15% provided time from surgery and one subjective criteria
   e. 13% (35 studies) provided time from surgery and one objective criteria
      i. thigh circumference – 28 studies
      ii. general knee exam (knee effusion, ROM, stability) – 15 studies
      iii. single-leg hop testing – 10 studies (4%)

   a. 106 patients; prospective 2-year cohort study
i. inclusion criteria: 13-60 y/o, participation in level 1 or level 2 sports at least twice weekly
ii. meniscus injury and ACL rupture classified as “re-injury”

b. Level 1 vs Level 2 sports
i. Level 1 sports: 29.7% (26 patients) re-injured by 2 years
ii. Level 2 sports: 7.7% (2 patients) re-injured by 2 years
iii. Patients returning to Level 1 sports had a 4.32x higher risk of re-injury than those who participated in Level 2 sports
c. Time
i. Up to 9 months, for each one month delay in RTS clearance, injury risk was reduced by 51%
   1. No correlation between time and re-injury after 9 months
ii. 4 patients returned to sport at or before 5 months post-op; all 4 patients (100%) suffered ipsilateral graft failure
d. Quadriceps Strength
i. For every 1% increase in quadriceps strength symmetry, injury risk was decreased by 3%
ii. Most significant RTS variable associated with re-injury
e. RTS Criteria
i. 7 criteria:
   1. isokinetic quadriceps strength testing
   2. 4 hop tests (single-leg hop for distance, triple hop for distance, crossover hop for distance, 6-meter timed hop)
   3. 2 self-reported outcome measures (KOS-ADLS and Global Rating Scale of perceived function)
ii. Passing scores defined as 90% limb symmetry with isokinetic strength and hop testing and 90% on both subjective measures
iii. 55 patients did not pass RTS criteria: 38.2% suffered re-injury
iv. 18 patients passed RTS criteria: 5.6% suffered re-injury

XI. Risk Factors
a. Non-modifiable: bony morphology (tibial slope, intercondylar notch size, femoral ante/retroversion), gender, joint laxity, hormonal changes, etc
b. Modifiable: strength, neuromuscular control, fatigue/fitness
   i. Modifiable risk factors are both testable and trainable

XII. Clearance to perform functional testing
a. Full, pain-free ROM
b. Trace or less knee effusion
c. Stable (0-1) knee pain
d. Ability to achieve active hyperextension with superior patellar glide (in long-sitting, able to keep knee on table and pop heel off table with quad contraction)
XIII. Testing Algorithm

a. Strength Testing via handheld dynamometry


1. Absence of external stabilization decreases validity
2. “The handheld dynamometer can be used with confidence as an instrument for assessing muscle performance (strength) and/or monitoring changes due to rehabilitation interventions.”

ii. Luggage scale has also been established as a “reliable, valid, and cost-efficient clinical tool...”

1. Demonstrated similarly high inter- and intra-rater reliability to HHD when measuring gluteal strength (BJ Lehecka)
2. Moderate correlation found between luggage scale and HHD to hip extension, and high correlation for hip abduction

iii. Quadriceps (in sitting) in 60 degrees knee flexion

1. 60 degrees of knee flexion is the “quad-neutral” position where no anterior drawer is exerted on the knee

iv. Hamstrings (in prone or sitting) in 60 deg knee flexion

1. Keep in mind that quad:hamstring ratio cannot be calculated if measured in prone

v. Hip Abduction (in sidelying with hip in neutral, lifting into abduction/extension)

vi. *90-95% strength symmetry required for return to sport clearance*

b. Motor Control

i. Timed lateral step-down

1. Step height: set to achieve 60-deg knee flexion when heel touches ground
2. Metronome set to 80 bpm
3. Form deviations: hands come off of hips, loss of balance, dynamic knee valgus, placing weight on NWB limb, contralateral pelvic drop, inability to keep up with metronome

ii. Lateral leap and catch

1. Distance between lines: set to 60% of patient height
2. Metronome set to 60 bpm
3. Form deviations: dynamic knee valgus, asymmetrical knee flexion (poor load attenuation/eccentric control), hands come off of hips, feet do not reach lines, inability to keep up with metronome

c. Hop Testing

i. Single-leg hop for distance

ii. Triple hop for distance

iii. Crossover hop for distance (line width: 10 cm)
iv. 6-meter timed hop
v. 90-95% hop symmetry required for clearance
d. Y-balance Test
   i. Composite score reached by calculating sum of 3 reach scores and dividing by (3 x leg length) in centimeters
   ii. Composite injury cutoff: 94, or 5cm reach asymmetry in any direction
e. Calculated single-leg 1 repetition maximum
   i. Patient performs as many repetitions as possible (to failure) with each leg
   ii. Weight should be appropriate such that the patient is able to perform between 5-10 repetitions
   iii. Widely available algorithm online to derive “calculated 1 repetition maximum”
   iv. Captures picture of global total leg strength, allometrically scaled
   v. Patient should be able to press roughly 150% of their own body weight with each limb
f. Agility Testing
   i. T-Test
   ii. Square Hop Test
   iii. LEFT
   iv. Evaluate as appropriate for athletic demands of each patient
g. Psychological Readiness
      1. Psychological readiness was the factor most strongly associated with returning to pre-injury activity, when compared to age, sex, and pre-injury activity level
      2. Psychological Readiness for Return to Sport (PRRS): 6-point questionnaire evaluating patients confidence in the knee to handle the demands of sport
      1. ACL-Return to Sport after Injury Scale (ACL-RSI)
      2. 12-point scale with “acceptable reliability” – patients who had given up sport scored significantly lower on the scale than those who had returned or were planning to return to sport

References


5. Barber-Westin SD, Noyes FR. Factors used to determine return to unrestricted sports activities after ACLR. *Arthroscopy.* 2011;27(2):1697-1705.


