Algorithm Based ACL Rehabilitation

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Introduction

- Common contact and non-contact injury in athletes
- 100,000 new cases annually (Bach, Boonos)
- Previously meant season ending, if not career ending injury
- Athletes are returning to pre injury levels, at times within the same season
- Outcomes are accomplished through a post operative program focusing on functional rehabilitation and neuromuscular control activities
**Anatomy & Biomechanics**

- **ACL**
  - 2 bands: anteromedial & posterolateral
  - **Functions**
    - Primary restraint to anterior tibial translation
    - Significant restraint to hyperextension
    - Limits tibial internal rotation
    - Secondary restraint to varus/valgus stresses
Anatomy & Biomechanics

**PCL**
- 3 bundles: Anteriolateral, Intermediate & Posterioomedial
- Functions
  - Primary restraint to posterior tibial translation
  - Secondary restraint to hyperextension & varus /valgus stress

**MCL**
- 2 Layers: superficial and deep
- Functions
  - Primary restraint to valgus stress
  - 57% at 0°
  - 78% at 25°

**LCL**
- Functions
  - Restraint to varus stress
  - 55% at 0°
  - 69% at 30°
Medial Meniscus
- Semi lunar or C shaped
- Extensive capsular attachment

Lateral Meniscus
- Circular shape
- Minimal capsular attachment

Meniscal functions
- Shock absorption
- Joint lubrication and nutrition
- Joint stability
Surgical Considerations

- **Procedure**
  - “Mini-open” vs all arthroscopic

- **Graft type**
  - Autograft vs allograft

- **Fixation**
  - Boney vs soft tissue

- **Graft properties**
  - Tensile strength
  - Stiffness

- **Graft “Ligamentization”**
# Graft Properties

<table>
<thead>
<tr>
<th></th>
<th>Ultimate Strength (N)</th>
<th>Stiffness (N/mm)</th>
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</thead>
<tbody>
<tr>
<td>Intact ACL</td>
<td>2160</td>
<td>242</td>
</tr>
<tr>
<td>Bone Patella Bone</td>
<td>2376</td>
<td>812</td>
</tr>
<tr>
<td>Quadruple Hamstring</td>
<td>4108</td>
<td>776</td>
</tr>
<tr>
<td>Quadriceps Tendon</td>
<td>2352</td>
<td>463</td>
</tr>
<tr>
<td>Posterior Tibialis Tendon</td>
<td>3391</td>
<td>302</td>
</tr>
</tbody>
</table>

*From presentation by Arthur Bartolozzi MD*
## Fixation Properties

**Ultimate Tensile Load (N)**

### Direct Soft Tissue

<table>
<thead>
<tr>
<th>Fixation Method</th>
<th>Ultimate Tensile Load (N)</th>
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<tbody>
<tr>
<td>Metal Interference Screw (7mm)</td>
<td>242 +/- 90</td>
</tr>
<tr>
<td>Bioabsorbable Screw (7mm)</td>
<td>341 +/- 163</td>
</tr>
<tr>
<td>Bone Mulch Screw</td>
<td>1126</td>
</tr>
<tr>
<td>Tandem Soft Tissue Washers</td>
<td>768</td>
</tr>
<tr>
<td>Cross-pin Technique</td>
<td>725-1600</td>
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</table>

### Direct Bone

<table>
<thead>
<tr>
<th>Fixation Method</th>
<th>Ultimate Tensile Load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Interference Screw (7mm)</td>
<td>640 +/- 201</td>
</tr>
<tr>
<td>Metal Interference Screw (9mm)</td>
<td>276 +/- 436</td>
</tr>
<tr>
<td>Metal Interference Screw (11mm)</td>
<td>302</td>
</tr>
<tr>
<td>Metal Interference Screw (13mm)</td>
<td>328</td>
</tr>
<tr>
<td>Metal Interference Screw (15mm)</td>
<td>330-418</td>
</tr>
<tr>
<td>Bioabsorbable Screw (7mm)</td>
<td>330-418</td>
</tr>
<tr>
<td>Bioabsorbable Screw (9mm)</td>
<td>565</td>
</tr>
<tr>
<td>Staples</td>
<td>588</td>
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</tbody>
</table>

From presentation by Arthur Bartolozzi MD
Post Op Evaluation

- ROM
- Strength
- Girth
- Patella mobility
- Observation
- Swelling/joint effusion
- Lachman’s
- Gait
- Other special tests
Protocol vs Algorithm Based Rehab

- Protocols
  - Rehab programs that are usually time based
  - Often times separated into accelerated and non-accelerated programs

- Algorithms
  - Allow all patients to follow the same rehabilitation guidelines progressing according to specific goals irrespective of time frames
  - “Phases” of algorithm based rehab
Protocol vs Algorithm Based Rehab

- **Protocol**
  - Were developed according to biological healing times
  - Based on time frames

- **Algorithm**
  - Goal based rehab
  - Based on objective and functional goals

- Algorithm allows for a more appropriate progression for each individual patient
Initial Post Op Phase

Goals to be achieved
- PROM 0°-110°
- Full active extension
- Minimal joint effusion
- Normal gait
- Good quad control/tone
- Normal patella mobility
**Gait**

- **Focus on normal heel to toe pattern**
- **Start with bilateral crutches and brace open to available AROM**
- **Progress out of brace before off crutches**
Proprioception & Neuromuscular Control

- Three inputs: visual, tactile, vestibular
  - Try to challenge all three
- Unilateral standing activities: slight knee flexion to eliminate stability from boney congruence and screw home mechanism
- Look to progress to activity/sport specific balance exercises
- “Toys”: Dyandisc, wobble board, foam pad, physioball, BOSU, balance beam
Strengthening and Muscle Re-Education

- **Quad tone/control**
  - Russian/neuromuscular electric stimulation with quad set during supine extension stretch

- **Strengthening**
  - Initiate exercises focusing on single plane/single muscle group
  - Progress to multiple plane/multiple muscle group exercises
  - Include proprioceptive/ neuromuscular control component
  - Look to include activity/sport specific exercises
Strengthening Progression

- Mini Squats → Leg Press → Unilateral Leg Press → Leg Press on Disc/Foam Roll/Ball
- Leg Raises → Hip Machine → Walking/Stepping with Theraband
- Prone Hamstring Curls → Standing Curls → Resisted Curls → Bilateral Curls on Physioball → Unilateral Curls on Physioball
Joint Effusion

- Some benefit with modalities initially
- Sign of healing within the joint
- Warmth sign of acute inflammation
- Monitor changes in joint effusion to assess tolerance with rehab program
Controlled Activity Phase

Goals to be achieved

- Full strength with manual muscle testing
- No joint effusion
- PROM 0°-125° +
- Passing isokinetic test at 85%
- Passing functional hop test at 85%
- Running initiated in this phase
Proprioception & Neuromuscular Control

- Progress sport specific activities
- Initiate speed ladder for agility and foot work
- Initiate weight acceptance/attenuation activities
- Must develop limb confidence
Neuromuscular Control

- Replicate demands place on lower extremity
- Include activity specific input
- Be creative and think activity/sport/position specific!
Strengthening

- Incorporate neuromuscular control component
- Work on both muscle power and endurance
- Isokinetic exercises
Criteria to Initiate Running Program

- Isokinetic test at least 75% of uninvolved
- No patellofemoral symptoms
- No joint effusion
- Start on treadmill; progress to outside due to running mechanics
Return to Sport/Activity Phase

- Slow progression into practices
  - Simple straight plane drills
  - Progress to multidirectional drills
  - Non-contact progressing to contact drills

- Follow up isokinetic testing as indicated
Advanced Training

- Initiated during Return to Sport/Activity Phase of post operative rehabilitation
- Remember training should include both rehabilitation and integration into practice
Advanced Training

Goals are to return the athlete to pre injury levels

- Neuromuscular control
- Strength
- Endurance
- Power
- Limb confidence
- Sport specific skills
Lower Extremity Strength and Conditioning

- Must return to pre injury levels of strength, power, and endurance
- Must be sport specific as well as position specific
- Many athletes return to sport activities prior to reaching pre injury levels
- Should be based on principals of periodization
Periodization

- **Strength and conditioning program based on cyclic program of work and recovery/rest phases**
- **Is systematic, sequential, and progressive**
- **Must integrate individual’s rehabilitation program into team’s/coach’s seasonal program**
Lower Extremity Strength

- **Strength**: the ability to exert maximum force
- Can be assessed manually, isokinetically or in weight room
- **SAID principle**
- Continuation of rehabilitation exercises
- Should incorporate dynamic exercises
Endurance: ability to maintain optimal levels of strength, power, and neuromuscular control

Needs to be sport, position, and level of play specific

Both aerobic and anaerobic
Lower Extremity Endurance

- Can be measured isokinetically (?)
- Aerobic vs Anaerobic conditioning
- Must be sport, position, and level specific
- Needs to be performed within the context of the sport
Lower Extremity Power

- Power: the ability to exert maximal force in the shortest time
- Ability to convert strength to movement
- Functional/sport specific progression of strengthening exercises
- Includes plyometric training
Plyometric Training

- Training of stretch shortening cycle of muscle action
- Goals of Plyometrics
  - Improve explosive power
  - Tolerate greater stretch loads
  - Attenuate ground reaction forces
- Isn’t a conditioning activity
Advanced Training Program Components

- Flexibility program
- Dynamic Stabilization exercises
- Strength program
- Core Program
- Speed and Agility exercises
- Anaerobic Conditioning
- Aerobic Conditioning
Flexibility Program

- Should include both static and dynamic stretches
- Lower extremity should focus on
  - Hamstrings
  - Quads
  - Gastroc/soleus
  - Hip flexor
  - Hip rotators
  - Illiotibial band
Dynamic Stabilization Exercises

- Proprioceptive/neuromuscular control exercises for the lower extremity
- Should include
  - Balance exercises (balance boards, disc, etc)
  - Manual rhythmic stabilization and PNF exercises
  - Partner balance exercises (ball toss, manual perturbations)
Strength Program

- Should include both bilateral and unilateral exercises
- Think sport and position specific
- Emphasize quad and hamstring exercises
Core Training

- Core: Lumbar-pelvic-hip complex
- All movement begins with the core
- Accelerates, decelerates and dynamically stabilizes the body
- Allows the body to work as an integrated unit
- Can improve performance and prevent injury
Core Program

- Need to teach draw in maneuver
- Incorporate stabilization with all rehabilitation exercises
- Not just “ab” work
- Examples
  - Bridging progression
  - Plank exercises
  - Reverse curl ups
  - Leg raises
  - Physioball exercises
Speed and Agility Exercises

- **Straight Ahead Speed**
  - Includes acceleration, top speed, speed endurance, deceleration

- **Lateral Speed and Agility**
  - Includes acceleration, change of direction, deceleration

- **Speed and agility exercises**
  - Speed ladder
  - Resisted running
  - Assisted running
  - Change of direction drills
Anaerobic Conditioning

- Interval training
- Needs to be sport, position, and level of play specific
  - Frequency
  - Duration
  - Intensity
  - Distance
Aerobic Conditioning

- General Fitness Base
- Recovery activity
- Needs to be sport, position, and level of play specific
Return to Practice

- Initiated in advanced training phase
- Systematic return to full sport activates
- Non-contact drills
- Full contact drills
- Scrimmages
- Full practice
Non-Contact Practice

- Start with straight line drills
- Add sport specific input
- Progress to change of direction drills
- Add sport specific input
- No symptoms and equal quality of movement and neuromuscular control side to side before progressing to non-contact scrimmages
Contact Practice

- Must pass return to sport criteria before initiating contact drills
- No symptoms and equal quality of movement and neuromuscular control side to side before progressing to full practice
- Need coaches input to determine if the player is “back to where they were pre-injury”
Return to Sport Criteria

- Functional testing at 85% of uninvolved
- Isokinetic testing at 85% of uninvolved
- Satisfactory performance with sport specific testing
- Minimal symptoms with testing and no joint effusion
Return to Full Game Status

- Will already be participating in contact practice
- Equal quality of movement and neuromuscular control side to side
- Minimal symptoms and no joint effusion
- Should pass all team fitness criteria
- Should have at least 2 full weeks of contact practice before playing
Other Considerations

- **Meniscal Repair**
  - Avoid flexion past 90° in weight bearing for first 6 weeks
  - Avoid pivoting/twisting with flexion in weight bearing
  - Weight bearing as tolerated in full extension for 3-4 weeks
  - Continue brace for first 6 weeks; limited to 90° of flexion with ambulation
  - Look to initiate running in 3-4 months
Other Considerations

- **Bone Bruise**
  - Limit weight bearing early on
  - Good candidate for aquatic rehab

- **Chondral Lesion**
  - Need to know what procedure if any was performed
  - If micro fracture procedure or osteochondral grafting done, will be a restriction in their weight bearing status early on
  - Need to limit shear forces
Conclusion

- Rehab based on objective findings and measurable goals versus time frames
- Make rehab sport/activity specific
- Consider biological healing times of concomitant procedures
References

- McFarland, E: ACL Update: The Biology of Anterior Cruciate Ligament Reconstructions. Orthopedics 1993 April;16(4)
References


