Current Concepts in the Operative Treatment of ACL Injuries

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Outline
• Introduction
• Associated Injuries
  • Meniscus
• Graft Choices
  • Allograft
  • Quadriceps tendon
• Orthobiologics and ACL
• Return to Play Criteria

Introduction
• Approximately 200,000/year
• Risk factors:
  • Cutting sports
  • Downhill skiing
  • Females: 2-4 x increased risk
  • Familial predisposition
  • ? (hormones, laxity, neuromuscular, tibial slope, notch width, limb alignment)

Rule of 70
• 70% ACL tears non-contact
• 70% ACL tears sports related
• 70% acute hemarthroses are ACL tears
• 70% ACL tears feel “pop”

Mechanisms of Injury
• Non-contact (majority)
  • Quad contraction with decreased relative hamstring strength
  • Knee valgus with internal tibial rotation
• Contact (25%)
  • Direct blow to knee or leg
  • Concurrent injuries frequent

Disclosures
• I have nothing to disclose relevant to this presentation
Associated Injuries

- Meniscus*
  - 40% ACL injuries
  - Acute: Lateral > Medial
  - Chronic: Medial > Lateral
- Ligament tears
  - MCL
  - Posterolateral corner
- Articular cartilage

Medial Meniscus

- Less mobility than lateral meniscus
- PHMM = most important secondary restraint to anterior tibial translation
  - Injects in the medial meniscus are doubled in the ACL deficient knee ACL graft force increases 15-50% with meniscectomy of the posterior horn
- Meniscal Root Avulsion
  - Loss of hoop stresses
  - Meniscal extrusion
  - Increased peak contact pressure
  - Decreased contact area
- Posteromedial meniscocapsular junction separation ("Ramp lesions")
  - Often overlooked
  - Results in increased ACL strain
- Meniscal Healing
  - 90% (62-96%) in conjunction with ACL reconstruction
  - 70% (50-75%) if isolated repair
  - 40% (17-62%) in setting of ACL deficiency

Posteromedial Meniscocapsular Junction Separations (Ramp Lesions)

- 15.4-16.8% may be missed
- 13.1% incidence in association with ACL tear
Posteromedial Meniscocapsular Junction Separations (Ramp lesions)

Meniscal Root Tears

- Avulsion injury of the meniscus attachment or a radial tear within 1 cm of the insertion
- Disruption of meniscal circumferential fibers
- Loss of hoop stress generation
- Biomechanical effects approaching total meniscectomy

Autograft Choices

- Patellar tendon
  - Pros: Ease of harvest, rigid fixation, bone-to-bone healing, favorable clinical outcomes
  - Cons: Donor site morbidity (kneeling pain, anterior knee pain), patella fracture
- Hamstring tendons
  - Pros: Excellent stiffness & tensile load properties, reduced harvest morbidity
  - Cons: Higher degree of reported laxity and lower return to preinjury activity levels, terminal hamstring weakness
- Quadriceps tendon
  - Pros: Less donor site morbidity, favorable clinical outcomes
  - Cons: Least studied

Graft Choice

- Ideal Graft Choice
  - Structural properties similar to native ACL
  - Minimal donor site morbidity
  - Low cost
  - Enables stable initial fixation
  - Permit rapid biologic incorporation
- Common Graft Choices
  - Hamstring
  - Bone patellar tendon
  - Quadriceps
  - Allograft

Take Home Point

- Biomechanical and clinical studies support preservation of the medial and lateral meniscus
- Arthritis
- ACL strain
- Laxity
- Increased awareness of ramp lesions and meniscal root lesions important to optimize ACL healing environment
- SAVE the Meniscus!
Allografts

- Advantages:
  - No harvest morbidity
  - Shorter OR time
  - Faster early recovery
  - Repeat availability

- Disadvantages:
  - Risk of disease transmission (HIV/Hepatitis – 1/1.6 million)
  - 3 mrad needed to kill HIV, but weakens graft
  - Higher re-tear rate in young active patients
  - Longer time to bio-incorporate
  - More expensive
  - Low grade immune response

Allograft vs. Autograft

- MOON Cohort
  - Allograft ACLR
    - 6.9% retear rate
    - 5.2X greater odds of graft retear vs. autograft
    - Most clinically relevant in younger, active patients
    - No clinically significant difference by the mid-30's

Single vs. Double Bundle

- Basic science studies:
  - Increased rotational control
  - More closely replicates normal knee kinetics

- Clinical studies:
  - May have better pivot shift results
  - No difference in patient reported outcomes

Quadiceps Tendon

- Gaining popularity
- Least studied, least used autograft –
- 1% orthopaedic surgeons
- Pros:
  - Predictable graft size
  - Less donor site morbidity than BTB autograft
  - Biomechanics: superior to BTB autograft in terms of load to failure, strain at failure, and Young’s modulus of elasticity
  - Greater cross sectional area
  - Mean percentage volume of residual QT greater than after patellar tendon graft harvest
  - Versatility in skeletally immature

Take Home Point

- Autograft superior to Allograft in young, active patient population
- Bone patellar tendon bone autograft still considered the gold standard by most surgeons for young athletes
- Single bundle favored over double bundle ACLR
- Quadiceps tendon grafts are gaining popularity and have shown favorable clinical results

Orthobiologics and ACL Surgery

- Potential benefits:
  - Enhancement of graft incorporation & strength, gene activation, trophic induction, and microenvironment facilitation and signaling with cells or bioactive factors to optimize, delay, or prevent premature progression of osteoarthritis
  - Potential positive growth factors: TGF-B1, FGF-2, Insulinlike GF, epidermal GF, PDGF, VEGF
  - Positive effects on cell proliferation, cell migration, angiogenesis, and extracellular matrix in vivo and in vitro models
  - Fibroblasts = primary cell in the ACL
    - Receptors for PDGF, TGF-B, FGF
- Products
  - Platelet-rich plasma
  - Stem Cells
  - Bone marrow aspirate concentrate (BMAC)
  - Hyaluronic acid

Orthobiologics

- Platelet-rich plasma (PRP)
- Hyaluronic acid
- Bone marrow aspirate concentrate (BMAC)
- Stem Cells

Partial anterior cruciate ligament tears treated with intraligamentary plasma rich in growth factors

- 19 professional soccer players with partial ACL tears
- PDGF injected into remaining intact bundle
- 18/19 able to return to prior level of play at mean 16.2 weeks
- 81.75% (16/19) returned to pre-injury level of sport activity
- KT-1000 values normalized in all cases

Comparison of Magnetic Resonance Imaging Findings in Anterior Cruciate Ligament Grafts With and Without Autologous Platelet-Derived Growth Factors

Fernando Radice, M.D., Roberto Vásquez, M.D., Vicente Gutiérrez, M.D., Julio Rossales, M.D., Miquel Pinedo, M.D., and Sebastián Coda, M.D.

- Case-control study
- 50 ACL reconstructions
- Platelet-rich plasma gel vs. no gel
- MRI 3-9 months (Group A) vs 3-12 months (Group B)
- Graft homogeneity time 177 days (A) vs 369 days (B)
- PRPG group needed only 48% of the time group B required to achieve the same MRI image

The effect of platelet-derived growth factors on knee stability after anterior cruciate ligament reconstruction: a prospective randomized clinical study

Matjaž Vogrinčič, Miha Rupnik, Anton Crgaj, Dejan Dimovski, Ziva Krkapin, Gregor Redžičk

- Platelet-leukocyte gel
- RCT Hamstring autograft ACL
  - 25 with platelet-leukocyte gel
  - 25 without gel
- KT-2000: Gel group better AP knee stability at 6 months post-op

Has Platelet-Rich Plasma Any Role in Anterior Cruciate Ligament Allograft Healing?

Juan Ramón Valentín Nin, M.D., Ph.D., Gonzalo Mora Gasque, M.D., Ph.D., Andrés Valenti Ariztia, M.D., Jesús Dámaso Aguirre Beza, M.D., Ph.D., and Milagros Hernandez Gonzalez, M.D., Ph.D.

- Level 1, RCT
- 100 ACLR with BTB allograft
- Platelet-enriched gel (50), no gel (50)
- Results:
  - Inflammatory markers – no difference
  - MRI appearance – no difference
  - Clinical scores (VAS, IKDC, KT-100) – no difference
Biological Augmentation of ACL Refixation in Partial Lesions in a Group of Athletes: Results at the 5-Year Follow-up

Alberto Gobbi, MD; Georgios Karatzilias, MD; Salvo L. Sambirano, MD; and Massimo Paterna, MD

- 50 athletes with partial ACL tears treated with primary repair + bone marrow stimulation + PRP gel
- 5-year follow-up
- 78% returned to pre-injury sports activities
- Significant decrease in the side-to-side difference in anterior translation, post-op Tegner score, SANE scores
- 4 retears, 1 residual laxity
- Survival rate 90% at 5-year follow-up

Ligamentization of Tendon Grafts Treated With an Endogenous Preparation Rich in Growth Factors: Gross Morphology and Histology

Mikel Sánchez, M.D.; Eduardo Anitua, M.D.; Juan Arozti, M.D.; Roberto Prado, Ph.D.; Francisco Munzarabal, Ph.D.; and Isabel Andía, Ph.D.


- Level III, Case-control study
- 37 patients c/s either conventional (n=15) or PRGF ACLR with hamstring autograft
- Second-look arthroscopy
- Arthroscopic appearance of graft: PGRF (37.1% excellent) vs. Conventional (33.3% excellent)
- Newly formed connective tissue envelope around graft 77.3% vs 40% controls

Orthobiologics & ACL Surgery

- Currently, the literature is inconsistent in providing definite conclusions on outcomes and usage of biologics for the treatment of musculoskeletal injuries; but laboratory, animal, and some clinical studies have provided promising results for the future direction of orthopedic treatment protocols and rehabilitation.

ACL Repair

- Not as high as previous thought
- Risk of re-injury
  - Ipsilateral ACL graft
  - Contra lateral ACL
  - Other knee structures
    - Meniscus
    - Knee
- Young patients at highest risk

Return to Play After ACLR

- 48 studies, 5770 patients
- Results:
  - ~90% normal or nearly normal knee function (laxity, strength)
  - 85% normal or nearly normal IKDC
  - BUT....
  - Only 63% returned to preinjury level of participation
  - Only 44% returned to competitive sport at final follow-up

- Total second ACL reinjury rate = 15%
- Ipsilateral reinjury rate = 7%
- Contralateral injury rate = 8%
- Secondary ACL injury rate (ipsilateral + contralateral)
  - < 25 y/o = 21%
  - Athletes who return to a sport = 20%
  - < 25 y/o + return to a sport = 23%

Return To Play

- Criteria for return to play after ACL reconstruction
  - NO CONSENSUS!
- 2017 Herodocus Society Meeting (~ 100 team physicians > 10 years experience)
  - ~ 50% - 5-6 months
  - Rest – 6-12 months (with 1/3 > 9 months)
- Literature – all over the place

Biologic Healing of the ACL

- Graft in tunnels
  - BTB – 6 weeks
  - Hamstring – 6-12 weeks
  - Allografts – longer
- Ligamentization
- Cellular necrosis
- Repopulation
- Maturation
- Most data on ACL biologic healing from animal models – may not be able to extrapolate to humans

Traditional RTP Criteria

- Biomechanical
- Biological (healing)
- Functional (i.e. performance/neuromuscular)
- Other
  - Psychological (fear of re-injury)
  - Lifestyle (moving, school, work, etc)

Return to play

- What does the evidence show?
  - Autografts heals better and faster than allograft
  - Healing times in humans definitely > 6 months (9-12 months preferred)
  - Younger athletes who RTP early to high risk sports – 25-35% higher rate of second ACL injury
- Need to develop improved, accurate, cost efficient ways to assess graft healing that will help clinician develop safe RTP timelines
  - PET scan
  - UTE MRI
Traditional Return to Play Criteria

- Classic
  - Cybex testing
  - Hop testing
- Time
  - “Clinical judgement”
  - Formalized/comprehensive functional testing

Time

- 6 months – most widely accepted
- But … Persistent Deficits
  - Impaired knee function & movement asymmetry persist at 12 & 24 months
  - Single limb balance deficits at one year
  - Hip ankle coordination deficits in reinjured athletes
  - Avg strength deficit 23% at 6 months, 14% at one year
  - Gait disturbance at 1 year

Nawasreh et al, AJSM, 2017 Apr;45(3):1037-48
Hutton et al, J Foot Ankle Surg, 2017 Feb;56(2):192-9

“Clinical Judgement”

- Insufficient
  - Typical exam criteria insufficient to distinguish those with functional deficits

Return to Play – Functional Criteria

- 2014 AAOS Guidelines
  - “Limited strength evidence does not support waiting a specific time from surgery/injury, or achieving a specific functional goal prior to return to sports participation after ACL injury or reconstruction”
- Traditional Guidelines
  - Hamstring-to-quadriceps strength ratio of at least 85% baseline
  - 90% symmetry of untreated leg for time and distance for single-legged, crossover, and triple hops for distance and 6-m timed hop test