

**ACL Treatment and Prevention Today**  
**Track 1 #101**

**Terry Malone PT, EdD, ATC, FAPTA**  
**Professor, University of Kentucky**  
[trmal01@uky.edu](mailto:trmal01@uky.edu)

**■ Learning Objectives:**

**■ Upon completion the attendee will have been:**

- 1. presented the surgical procedures of choice today**
- 2. presented the post-operative and non-operative treatment approaches today**
- 3. presented the prevention programs & their efficacy as provided in the literature and research today**

*How We have gotten to:*  
*Evidence Based (EBM)*  
*ACL Rehabilitation*

**In the last analysis, we see only what we have been taught to see, we eliminate and ignore everything that is not a part of our prejudice.**

**Jean Charcot**

**■ Be Diligent**

**Never be satisfied with one diagnosis.**

**Dr. Jack Hughston**

**■ Be Appropriate**

**In my estimation, rehabilitation accounts for 50% of a successful result following injury or surgery.**

**Dr. Jack Hughston**  
**In the Beginning !!!**

**“Genu Cruciatu”**  
**Claudius Galen**

**After 1600 years**  
**Recognition of “ACL Rupture”**

**Early History**

- “ after casting – residual disability”**

**J.Stark - 1850**

- ACL Repair**  
**Performed successfully**

**Battle - 1900**

**Early History**

■ **ACL-PCL Repair**

**Excellent result**

**Mayo Robson - 1903**

■ **After Repair or**

**Reconstruction –**

**It takes one year for return to function**

**Cubbins - 1937**

**Pulling it Together**

■ **Merger of Pathology & Clinical Outcomes were well described in:**

**“Biomechanics & Structural**

**Interactions”**

**Brantigan & Voshell – JBJS - 1941**

**“Modern Era”**

■ **Surgical Treatment of Fresh Injuries to the Major Ligaments of the Knee**

**O’Donoghue – JBJS - 1950**

**Rotatory Instability**

■ **Rotatory Instability of the Knee**

**“Role of the Capsule”**

**AMRI – Pes Transfer**

**Slocum & Larson**

**JBJS – 1968**

**Origins of “Today”**

■ **Intra-articular**

**B-PT-B Procedure**

**Jones – JBJS -1963**

**“Middle –third evolved as most appropriate- fewer problems long-term with PF joint-also more consistent graft thickness”**

**Today’s Technique**

**ACL Surgery**

■ **Arthroscopic**

**“Assisted”(???)**

**Mini-Arthrotomy**

**“Strong construct, well placed & fixated”**

**Evolution of ACL**

**Rehabilitation Concepts**

■ **Knee: Athletic Injuries – Special issue – Phys Therapy – Dec. - 1980**

- Paulos L, Noyes FR: Knee rehabilitation after ACL reconstruction & repair AJSM - 1981
- Rehabilitation of the Surgical Knee -1984
- Shelbourne KD, Nitz P: Accelerated rehabilitation after ACL reconstruction AJSM – 1990
- ACL Surgery and Rehabilitation JOSPT-1992

**ACL Injury Prevention and Performance Enhancement  
“Hows and Whys”**

**“Development & Use”**

**Realities of Today**

- It is difficult to “sell kids” on injury prevention (& even coaches)
- To make it work: emphasis is on “enhanced performance” (great news is that A begets B) & Even Coaches ...
- The focus must be on those we identify as having greatest risk or a very efficient part of the existing “Program” (Opinion)

**How to do it !**

- Identify the need (injury rates, population specific, related to ...)
- Study the mechanisms (trauma vs. non-trauma, contact vs. non-contact, Micro vs. Macro)
- Delineate possible interventions
- Do “study” to see if it works
- Present/Publish the outcome – SHARE IT

**Whys of doing it!**

- Movement Dysfunction is a large part of our “practice” definition
- It is a nice link to general community as well as Special Groups (Industry, Athletic, etc.)
- IT IS OUR RESPONSIBILITY Prevention not just after the fact

**The ACL Problem**

**Non-contact Female ACL Injured NCAA Basketball Players**

**6x more likely (16.1% vs. 2.2%)**

**Several female teams had 3 to 5 with the average being greater than 2 ACL injured participants**

*Aggregate Data*

<b>Males</b>	<b>Females</b>
<b>402</b>	<b>Participants 385</b>
<b>9</b>	<b>Documented ACL 62</b>

**2.2 % ACL Prevalence 16.1 %**

*Basic Analyses*

**Gender – ACL**

**Odds Ratio**

**8.38**

**95 % Confidence Intervals**

**6.34 to 10.42**

**NCAA “Frequency”**

**1989 & 1990**

**Initial attempt – incomplete data**

**But using available data:**

**Odds Ratio**

**of injury during season:**

**Women were 6.19 times**

**more likely to have ACL injury**

**during respective season**

*Other Descriptive Data*

**Vast Majority : Mechanism was ... (single leg)**

**“Weight bearing with a twist”**

**“Most often near extension”**

**“Off balance – rotation”**

**“Felt or heard a POP”**

**“Swelled quickly”**

**Prevention Theories**

**ACL Prevalence/Incidence**

**4-6 x greater in Female Basketball compared to**

**male counterparts**

**Hypotheses: Level of Competition, Lower Extremity Strength, Hamstring Strength, Playing Posture, Fatigue Level, Q-Angle, Hamstring Flexibility/Stiffness, Training**

**Factors to Consider**

■ **Strength - (Hamstring “Ratio”)**

■ **Training - (Single vs. Cross)**

**Neuromuscular Patterns**

■ **Posture - (Flexion !!!)**

■ **Stiffness - (McNair - Inherent Hamstring Tissue) - Male/Female**

■ **Hamstring Flexibility**

**NCAA “Trial” (1988)**

**13 Female Basketball Players**

**“4 ACL Reconstructed Participants”**

**Backward Running (Dry & H2O)**

**Agility Hops - Jump Training**

**“Plyometric Patterns”**

**Jump Stop Patterns - Increased Flexion (Knee & Hip)**

**Hewett et al AJSM 1996**

**Plyometric Training in Females**

**Results: Female Volleyball players enhanced performance while decreasing landing impacts, approaching the untrained male values in several parameters**

*Baker, et al – (MS Thesis) Controlled Landing Forces*

Stepping off a 16 inch box  
Flexion angles > : impact max <  
Keep flexed:  
Hip, Knee and “Ankle”  
Absorb & Dissipate

*Bolgla, et al (PhD Dissertation – UK – 2005)*

■ Significant hip “weakness” with patello-femoral pain subjects – Consistent with our theory of proximal issues with both ACL and PF (hip/knee positions)

*Hewett – 2005 & 2006*

■ Landing positions demonstrate significant valgus & “IR” in those at greatest risk

■ Identification of those at greatest risk may be possible and thus permit greater focus on intervention (bang for the \$)

Prevention: Is it possible ?

Early results appear to support  
the use of training, neuromuscular activities and strengthening  
to decrease the incidence of non-contact ACL injuries

Personal Preferred approach

■ Pre-season – identification of those at greatest risk (knee collapse – knee approximation) – During off-season do three things: 1) provide feedback – visual and auditory/verbal; 2) neuromuscular adaptations; 3) strengthening (integrated with plyometrics) as well as strict Q/HS/core approach – 3X weekly 6-8 weeks – then integrated into in-season

Results of intervention

■ Better playing posture – positions

■ Enhanced stability in landings – minimize single leg impacts – decrease quadriceps dependence

■ “more” male like neuromuscular patterns

■ Increased strength – Decreased fatigue

■ Enhanced jumping heights - injuries

Playing Posture

“Flexion is the WORD !”

Knees & Hips

Keep over the foot

Avoid Extension & Valgus

Care when fatigued

(Stay Down – see above !)

Playing Postures

Men versus Women

Flexion is

Strength is

Fatigue is

**Playing Postures “Solutions”**

**Motor Programs**

**“Keep the knees bent – stay down”**

**Ready Position**

**Functional changes –**

**“Coaching and preparation”**

**“Altered Landings”**

**Careful when fatigued !!!**

**Exercises to accomplish this**

**■Begin with knowledge of present practice (IR/ADD/Valgus - approximation of knees during landing) “Listen for impact” I like a riser – instant feedback**

**■Land softly, like a feather, piston approach - knee over foot – no longer knee collapse or COG outside**

**Strength Differences**

**Hamstrings in women**

**Women are “Quad” Dominant**

**Women have greater**

**“Mechanical Delay”**

**Strength Solutions**

**Hamstring emphases: OKC & CCK**

**“Isolated and Functional Patterns”**

**Strength and Endurance**

**Watch Patterns – Russian HS**

**Work CORE – HIPS !!!**

**“Flexion is the WORD”**

**“Types” of Training**

**Major Concern:**

**Women don’t get the**

**“Variety & Quality”**

**of “motor” activities to best**

**prepare for the long-term.**

**Often single or similar events.**

**“ Training Types - Solutions”**

**Participate in a great variety of:**

**Strengthening Activities (O/CKC)**

**Motor Patterns**

**Sports**

**“Training drills”**

**(Landing Patterns, cross-over, etc.,  
Proper feedback- Skill acquisition)**

**MT-Unit Stiffness**

**“Flexibility”**

**Women have HS Flexibility  
and  
Stiffness**

**Remember: You can only do  
so much !**

**MT “Solutions”**

**Recommendation: HS**

**Stretch as preparation for events**

**NOT to flexibility !**

**3-4 reps – 10-15 counts after W/U**

**Do many eccentrics (All Forms !)**

**Isotonic Lowering, Isokinetics if able**

**CPM & Active Modes**

**MT – “Solutions”**

**Functional Eccentrics**

**Stretch-Shortening Cycle – “Plyometrics”**

**Keys: Quality/intensity not #'s**

**Resistance/load before Speed**

**Tuck jumps-bounds-lunges-High Intensity – Technique Focus**

**Inherent Differences**

**Menstruation – Hormonal Changes**

**Biomechanics – “Hips”**

**Fat Stores – Weight Distribution**

**Tissue Differences ?**

**Selection of Motor Patterns ?**

**Things to Consider**

**Intrinsic**

**Alignment**

**Hyperextension**

**General Laxity (Men/Women)**

**ACL Size/Volume/Notch**

**Hormonal/Skill Set**

**Pick Your Parents Wisely !!!**

**Inherent “Ideas”**

**As in religion:**

**Grant us the wisdom to accept ...**

Unfortunately we don't know how many of those that we can change - we dramatically impact on those - that we can not –

But ...

**Things to Consider**

**Extrinsics**

**Strength**

**Level of Training – Preparedness**

**Shoe Surface Interface**

**Variety of Actions**

**Level of Competition**

**“Change is Possible”**

**What has worked**

**Hewett et al – Female volleyball players through training (land softly, “like a feather”, “Keep the knees & Hips bent”, structured strengthening O/CKC.) (Now called DNA Program)**

**Resulted in their landing impacts approaching that of the normal males.**

**What has worked**

**Sportsmetrics – Cincinnati**

**Caraffa et al – Italian Soccer**

**Ettlinger et al – Skiing**

**Mandelbaum – US Soccer - PEP**

**“Trained females approach the rate of untrained males”**

**Realities**

**Numerous folks have had success with interventional programs using the concepts presented –**

**Personal experience: Knee flexion and Hip flexion working with motor patterns does work !!!**

**ACL: Prevention**

**Can we prevent these injuries?**

**(i.e. -What can we change !)**

**THE KEY(s) IS/are:**

**POSITION & ACTIVATION**

**Neuromuscular Phenomenon**

**From the literature**

**■6 well defined peer reviewed studies exist – Using Meta-Analyses : Results indicate that plyometric training coupled with biomechanical analyses and feedback were present in all successful Programs; strength training was also a component in “most” of others that were successful**

**Remember not just Prevention- Enhancement**

**■Important to sell the changes that accompany the reduction in injury- They jump higher and react more efficiently – thus enhanced athletic performance**

■ **Reality: ACL Injury is rare so year to year changes can be “erratic”**

**Easy Website for PEP. etc.**

■ **aclprevent.com** (Santa Monica Orthopaedics) This website along with all the University based units provides protocols and helpful approaches - PEP, Sportsmetrics, Cincinnati Childrens Hospital, etc. - Neuromuscular factors (what we can change) & Strength (what we can change) !!!

**So Now What?**

■ **Take the past information and integrate into what is now expected**

■ **Evidence Based Decision Making**

*EBM Emergence*

■ **Use of the current best evidence in making decisions... integrating individual clinical expertise with best available external clinical evidence from systematic research ...**

**D. Sackett 1996**

■ **Key words precede: Conscientious, explicit and judicious use ...**

*General Rules for Us*

■ **Best if several studies find same result Often best presented via Meta Analysis or Systematic Review**

■ **If limited # of studies – care with use**

■ **Don’t ignore your “Clinical expertise” but recognize your own bias (We remember the extremes too well ...)**

■ **Appreciate our past – integrate with ...**

*Ranking of Evidence*

*What Meta/SR Analyses do we have?*

■ **Graft Choice – Spindler – AJSM 2004**

■ **Prevention Programs – Hewett – AJSM 2006**

■ **Muscle Activation with Functional Activities – BrJSM -Ford 2008**

■ **Systematic Review ACL Reconstruction Rehabilitation Part I- J Knee Surg Wright et al 2008**

■ **Systematic Review ACL Reconstruction Rehabilitation Part II- J Knee Surg Wright et al 2008**

*Graft Choice – Spindler –*

*AJSM 2004*

■ **Does it (graft choice) really matter? – When we really look objectively: 9 RCT comparing autograft BPTB to Quad HS Objective measures show no differences**  
■ **Increased kneeling pain is related to BPTB use and 3 of the 6 studies that reported HS strength had with HS use**

*AOSSM – 2008 – Annual*

*Meeting Presentations*

■ **Multi-Center Study – MOON /MARS Prospective Study Groups: enabling significant #'s – (power) – ACL Reconstructions in young (& female!) appear to have UNACCEPTABLY high failure rates with use of Allograft (Meta in some ways!)**

**Emerging Question**

- Is a two bundle ACL Reconstruction required for optimal outcome ???
- Noyes (Sports Health – 2009) and Meredick (AJSM-2008) “No differences are discerned in available outcome measures”
- Opinion- we use it in failed ACL reconstructions and believe it may be appropriate in some cases

**Prevention Programs**  
Hewett -AJSM 2006

- Examined six published prevention programs “targeted toward females”
- Quantitatively combine the results of the six – to draw conclusions
- 4 of 6 knee and 3 of 6 ACL Injuries
- Significant effect of neuromuscular work
- In those that worked: NMT, Plyometrics, Feedback (Technique), Strength – Not balance alone – may be “additive”
- Muscle Activation with Functional Activities – BrJSM -Ford 2008

- Age and Skill level RE to muscle co-activation during functional activities (systematic review)
- Six published studies met inclusion criteria
- Does Co-contraction level vary between ages
- Low skilled- higher levels, older use more HS pre-impact 4 of 6 studies, No gender differences were seen

**Systematic Review ACL Reconstruction Rehabilitation Part I- J Knee Surg Wright et al 2008**

- Evaluated CPM, Early Weight Bearing, Postoperative Bracing, & Home Based Rehab
- CPM -6 RCTs- Can not be justified
- EWB-small #- Appears supported
- P/op Bracing-11 studies-Not required
- Home based-4 RCTs-May be used with equivalent results – BUT selected patients

**Systematic Review ACL Reconstruction Rehabilitation Part II- J Knee Surg Wright et al 2008**

- Open vs Closed, Electrical-stimulation, Accelerated Rehab, & Miscellaneous Topics
- O/C Chain- 5 RCTs-Early p/o work CC appears better (Quad response enhanced by OC)
- E-Stim- 14 RCTs-Must be high intensity-early in p/o phase (But not a requirement for success)
- Accelerated Rehab-2 RCTs/many – 5/6 month OK – earlier story not written
- 50 RCT’s – many ?’s remain (restricted BF?)

*ACL-Gender Bias – Research Retreats*

*2001-2003-2006-2008*

- Neuromuscular & Biomechanical Factors: Females more upright, hips influence and maturation & fatigue worse for women

■ **Anatomical & Structural Factors:** Female ACL is smaller, shorter, less cs area, less stiff, less collagen, more laxity, and lower failure load when normalized vs. males

*ACL-Gender Bias – Research Retreats*

*2001-2003-2006-2008*

■ **Risk Factor Screening and Prevention :Training Programs** alter injury rates- these include plyometrics, education, feedback/technique, strength, and elements of balance (BUT not balance alone!) The alterations may be somewhat transient

■ **Hormonal Factors:** Preovulatory greater risk (last report published in JAT – October 2008)

*SO: where we are Today*

■ **EB ACL Surg & Rehab** includes/supports:

✦ **Strong construct** –correctly placed & fixated

✦ **Early motion and early weight bearing**

✦ **CC early-OC** for quads later

✦ **If E-stim** – early & High Intensity

✦ **Neuromuscular, feedback, and strength** are preventative (balance as part not isolated) & thus part of post op program as well

■ **Next Time you're in over your head !**

*Thank You for your attention*

■ **Terry Malone**

[trmalol1@uky.edu](mailto:trmalol1@uky.edu)

**“Never mess with his dog or his pickup”**