Current Concepts for ACL Reconstruction

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Disclosure

- Member of Medical Board of Trustees and Consultant to MTF
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Demographics

- 250,000 ACL reconstructions per year performed in United States
- Annual incidence of ACL tears in the US is 1 in 3000 Americans
- Average age: 26
- 70% occur from sports participation
- 70% are non-contact, 30% occur as result of direct contact
- Annual Cost is > 2 Billion dollars
Demographics

- Complication rates range from 10-25%
- Graft failure rate is ~8%
- 4200 to 8000 recurrent instability per year
Goals of ACL Reconstruction

- Provide stable joint
- Avoid meniscal injury
- Return to full ROM
- Return to sport, work, daily activities
- Prevent osteoarthritis???
Success

- Functional stability
- Relief of symptoms
- Return to pre-injury level of activity

Objective outcomes:

- Lachman, anterior drawer, pivot shift tests, KT 1000
- Kocher et al. AJSM 2004
  - Pivot shift is the only test shown to correlate with subjective satisfaction
Normal Anatomy

Courtesy of Pau Golano, MD
Recent Trends in ACL Reconstruction: “Anatomic” ACL Reconstruction

- Lower Femoral tunnel position
- Transtibial vs. AM portal creation of femoral tunnel
- Double Bundle ACL reconstruction
- Use of allografts for ACL reconstruction
ACL Reconstruction Facts

- Tunnel position is important
- Fixation is important
- Rehabilitation following surgery is important
- Little difference between graft types (i.e. B-PT-B vs. Hamstring autograft)
Is Lower Femoral Tunnel Position Better?

- A number of surgeons have recently advocated a lower femoral tunnel position as more “anatomic”

- However, is lower necessarily more “anatomic”?
Is Lower Femoral Tunnel Position Better?

- Evaluated femoral tunnel location in 14 cadaver knees
- Varying placement of the femoral tunnel 1 hour clockwise or counterclockwise from the 11/10'clock position did not significantly affect any biomechanical parameters.
  - Markolf et. al. JOR 2002
Does placing the femoral tunnel at a more oblique orientation at approximately 9:30 to 10 o'clock in the notch provide the graft with a better mechanical advantage for controlling tibial rotation and eliminating the pivot shift?

In a study of 17 cadaver knee, moving the femoral tunnel from the standard 11:00 location to a more oblique position (9:30 to 10 o'clock) in the notch did not significantly alter pivot-shift kinematics.

The rationale for placing the femoral tunnel at an oblique position in the notch to reduce the pivot shift is questioned.

- Markolf et. al. AJSM 2010
Is Lower Femoral Tunnel Position Better?

- Recent Clinical Study
- Report of the Danish ACL registry that the revision rate for failed reconstruction for the anteromedial portal technique was two times greater than that for the transtibial technique
  - Wagner et. al. KSSTA 2012
Transtibial vs. Anteromedial Reaming of Femoral Tunnel

- There are multiple studies with conflicting results
- However, many of the studies are biased in favor of anteromedial reaming
  - Bowers et al, Arthroscopy, 2011
  - Bedi et al, Arthroscopy, 2011
  - Gadikota, AJSM 2012
Transtibial vs. Anteromedial Reaming of Femoral Tunnel

- Tibial and femoral tunnels can be positioned in a highly anatomic manner using a transtibial technique but require careful choice of the tibial starting position.
- A transtibial single-bundle technique can accomplish a highly anatomic reconstruction
  - Piasecki et al, AJSM, 2011
“Anatomic” ACLR Double or Single Bundle?

Questions?

1. Is DB more “anatomic” than SB ACL reconstruction?”

2. “Is it all about maximizing the filling of the tibia and femoral footprints (attachments) to reproduce the anatomy?”

3. Don’t forget about biomechanics!
Double Bundle ACL Reconstruction

- Recently, double bundle ACL reconstructions of the ACL have been performed with the hope of producing a better clinical results

- Perhaps this may be more effective in controlling rotational stability than a single bundle reconstruction
Double vs. Single Bundle ACL Reconstruction

- What are the contributions of the Native PL bundle of the ACL?
  - Laxity
  - ACL Force

- Methods
  - 14 cadaver knees instrumented with load cell
  - AP laxity testing at 100 N of applied tibial force
  - Tested before and after cutting native PL bundle
    - Markolf et al, Arthroscopy 2008
Double vs. Single Bundle ACL Reconstruction

- Small increase (about 1mm) in AP laxity after cutting of the PL bundle at 0° and 10°
- Small decrease in resultant force of the ACL after cutting of the PL bundle near full extension
- Suggests that the PL bundle plays a somewhat minor role in providing AP stability
Double vs. Single Bundle ACL Reconstruction

- What are the abilities of anatomic single-bundle and double-bundle reconstructions to restore?
  - Laxity
  - Kinematics
  - Graft Force

- The single-bundle reconstruction produced graft forces, knee laxities, and rotations that were closest to normal.

- Adding a posterolateral graft to an anteromedial graft tended to reduce laxities and tibial rotations, but with markedly higher forces in the posterolateral graft near 0 that occasionally caused it to fail.

Double vs. Single Bundle ACL Reconstruction

- The relatively small improvements in laxity from adding a PL graft may not be worth the high graft forces necessary to achieve them.
- The high forces in the PL graft cause for concern and may help to explain the posterolateral graft ruptures that have been reported clinically.
- The need for a double-bundle reconstruction is questioned.

Courtesy of Freddie Fu, MD
What about elimination of the pivot shift?

- A conventional single bundle reconstruction was sufficient to restore intact knee kinematics during a simulated pivot shift event.
- Therefore the need for a more technically complex and time consuming double bundle reconstruction to restore a normal pivot shift sign is questioned.
Double Bundle Clinical Studies

- No difference in subjective results
- DB has better objective results (about 1mm)
  - Yasuda et al., Arthroscopy 2006: Level II
  - Aglietti et al., CORR 2007: Level II
  - Kurosaka, CORR 2007: Level II
  - Muneta, Arthroscopy 2007: Level I
Comparison of Rotatory Stability after ACL Reconstruction between Single and Double Bundle Techniques

- Level 3, cohort
- 23 patients SB; 25 DB
- Less AP laxity in DB (about 1 mm)
- No difference in pivot grades
- No difference in subjective outcome scores

Izawa, et al, AJSM 2011
Outcome of Arthroscopic Single and Double Bundle reconstruction of the ACL: A Preliminary 2-year Prospective Study

- Level 2, prospective
- 50 patients SB; 63 DB
- No difference in AP laxity
- No difference in pivot grades
- No difference in subjective outcome scores

Park, et al, Arthroscopy 2010
Double Bundle Meta-analysis

- First: Level 1 (4 RCTs)
- Second: Level 1, 2, 3 (5 additional)
- No difference between DB and SB ACLR
  - KT 1000 .52 mm closer to nl in DB
  - Pivot Shift-no difference
- Lubowitz et al, AJSM 2008
Clinical Failure (early) of PL Bundle

- 3% in Kondo et al, Arthroscopy, 2007
- 7% Asagumo et al, Arthroscopy, 2007
- 11% Otsubo et al, KSSTA, 2007

This means that some of these patients are left with a single bundle (usually 2-ply) hamstring reconstruction
Is this Better?
Single bundle ACL reconstruction is a good operation

Let’s be careful about changing a “successful” operation

Placing the graft anatomically is not new

Even if it is better, is DB generalizable to the average community orthopaedic surgeon?

Revision of DB is more difficult
Use of Allograft in Young Athletes

- A prospective study at the United States Military Academy on incoming cadets
- A total of 120 cadets underwent 122 ACL reconstructions before matriculation:
  - 30 female and 90 male cadets.
  - 61 BTB
  - 45 hamstring
  - 16 allograft
- A total of 20 failures occurred among this cohort. Of the failures requiring revision, 11% were BTB, 44% were allograft, and 13% were hamstring.
- Cadets with an allograft were 6.7 times more likely to experience a subsequent graft failure during the follow-up period when compared with the autograft group.
  - Palis et al, AJSM 2012
Use of Allograft in Young Athletes

- Evaluated patients with allograft and autograft PT ACL reconstruction.
- Autograft scored higher than allograft on a visual analog scale and scored significantly higher on the postoperative Tegner activity scale.
- The active allograft group was 2.6 to 4.2 times more likely to fail compared with low-activity allografts and low- and high-activity autografts.
- Concluded that fresh-frozen BPTB allografts should not be used in young patients who have a high Tegner activity score because of their higher risk of failure.
  - Barrett et al, Arthroscopy, 2010
Use of Allograft in Young Athletes

- Evaluated patients who had ACL reconstruction with allograft and autograft bone-patellar tendon-bone.
- Allograft (29.2%) resulted in significantly higher failure rates than bone-patellar tendon-bone grafts (11.8%) in the age group of patients 25 years and younger.
- These data suggest that autografts may be a better graft source for young, active individuals.
  - Barrett et al, AJSM 2011
Use of Allograft in Young Athletes

- Twenty-one patients with ACL graft failure were identified over a 2-year period. Forty-two age- and sex-matched controls were identified over the same period.
- Higher odds of ACL graft failure for those with high activity level compared with low activity level and for allografts compared with autografts.
- Higher activity level after reconstruction and allograft use for reconstruction are risk factors for ACL graft failure.
  - Borchers et al, AJSM 2009
Surgical Technique

- Most avoidable cause of graft failure

- Technical Errors:
  - Non-anatomic tunnel placement
  - Inadequate notchplasty
  - Inadequate graft fixation
  - Improper graft tensioning
  - Improper graft selection
  - Failure to address secondary stabilizers
Surgical Technique

- The most common cause of graft failure following ACL reconstruction is a combination of:
  - Re-injury
  - Loss of fixation
  - Tunnels place improperly
  - Graft fails to incorporate
Anatomic Tunnel Placement

- Many ACL graft failures are caused by tunnel malposition

- Aberrant tunnel placement can lead to:
  - Graft impingement
  - Stretch-out and Laxity
  - Loss of knee ROM
Femoral Tunnel Placement

- As posterior in the notch as possible without violation of the posterior cortical wall

- 1-2 o’clock or 10-11 o’clock position
  - Tunnel that is too vertical has good AP control but poor rotational stability?

- Beware resident’s ridge
Femoral Tunnel Placement
Femoral Tunnel Placement

- Too Anterior
  - Most common error
  - Tight in flexion
  - Lax in extension
  - Loss of Flexion or stretch-out of graft
Tibial Tunnel Placement

- 7 mm anterior to PCL
- Adjacent to anterior horn of lateral meniscus
- Native ACL footprint
- In between the tibial spines
Tibial Tunnel Placement

- Parallel and posterior to Blumensaat’s line with knee in full extension
Aberrent Tibial Tunnel Placement

- Too Anterior
  - Notch impingement

- Too Posterior
  - PCL impingement
Inadequate Notchplasty

- ACL graft often larger than native ACL
- Need clearance between graft and roof of notch
- Notch large enough to accommodate full ROM
- Inadequate notchplasty
  - Impingement in extension
  - Loss of extension
  - Can lead to graft attrition
  - Formation of “cyclops” lesion
- Overly aggressive notchplasty
  - Can affect patellofemoral mechanics
  - Can proximalize the femoral fixation point
  - Can lateralize the femoral attachment
Graft Fixation

- Direct fixation:
  - interference screws, staples
- Indirect fixation:
  - endobutton, cross-pin
- Aperture fixation (Near):
  - interference screw, press fit fixation
- Suspensorry fixation
  - Endobutton, screw post
Graft Fixation

- Tibial fixation is weak point
  - Less bone density
    - Dual Photon Absorptometry (DEXA) of the tibial metaphysis less bone density than femoral metaphysis.
  - Angle of force
    - Line of force on graft directly in line with tibial tunnel
    - Line of force on graft oblique to femoral tunnel during most weight bearing activities
Recent Trends in ACL Reconstruction:

“Anatomic” ACL Reconstruction

- Lower Femoral tunnel position
  - Don’t go too low

- Transtibial vs. AM portal creation of femoral tunnel
  - Do whatever is necessary to get to the correct position

- Double Bundle ACL reconstruction
  - No evidence that this is better

- Use of allografts for ACL reconstruction
  - Avoid in young athletes
Thank You