VuMedi Webinar
February 26, 2014

Anatomy of the ACL

Dr. Freddie H. Fu
Distinguished Service Professor
David Silver Professor and Chairman
Department of Orthopaedic Surgery
University of Pittsburgh
Head Team Physician
University of Pittsburgh Athletic Department

Disclosures

Freddie H. Fu, MD, DSc (Hon), DPs (Hon)

None

University of Pittsburgh Department of Orthopaedic Surgery

Royalties and Stock Options: None

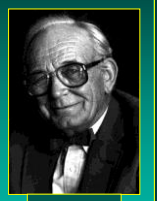
Consulting Income: None

Research and Educational Support: Smith & Nephew

Other Support: Department of Orthopaedic Surgery of the University of Pittsburgh receives funding from Arthrocare, Synthes, Stryker, Johnson & Johnson, DePuy, DonJoy, Breg, Omeros, Biomet, Mitek

Anatomy is the Basis of Orthopaedic Surgery

"Whenever you are having anatomy sessions, pay particular attention, because orthopaedics is all anatomy, plus a little bit of common sense."

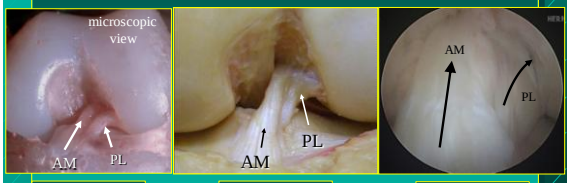


J. Hughston

Fracture

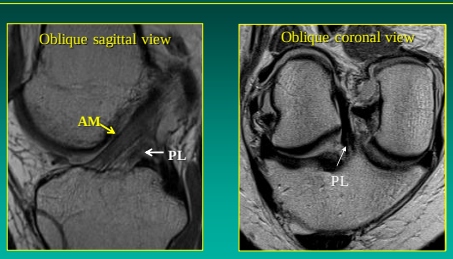
Fixation

Anatomy of the ACL



Fetus | Human | Arthroscopic

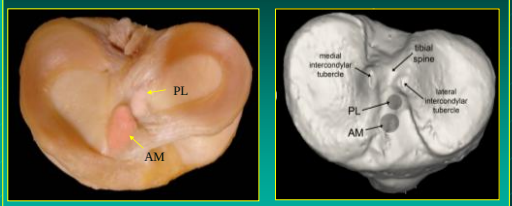
Double-Bundle Anatomy of the ACL



Special Planes – Native ACL

Casagranda, Towers, Fu, et al, Am J Roent 2009

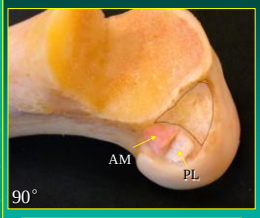
Tibial Insertion Site Anatomy

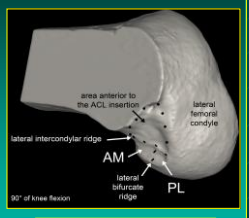


Native tibial insertion sites | 3D-CT Reconstruction

Forsythe B, Kopf S, Fu, et al. JBJS 2010

Femoral Insertion Site Anatomy



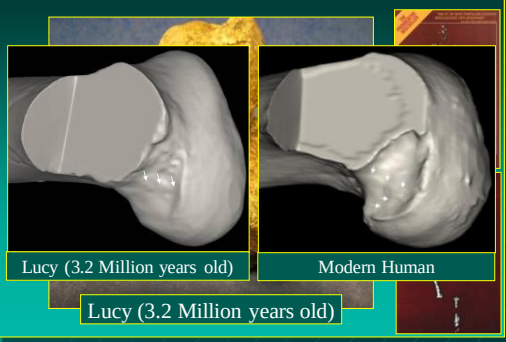


Native femoral insertion sites

3D-CT Reconstruction

Forsythe B, Kopf S, Fu, et al. JBJS 2010

Anatomy Never Changes

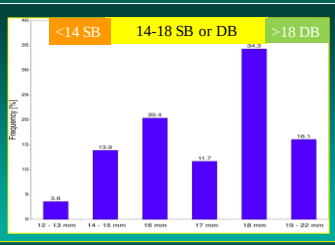


Lucy (3.2 Million years old)

Modern Human

Lucy (3.2 Million years old)

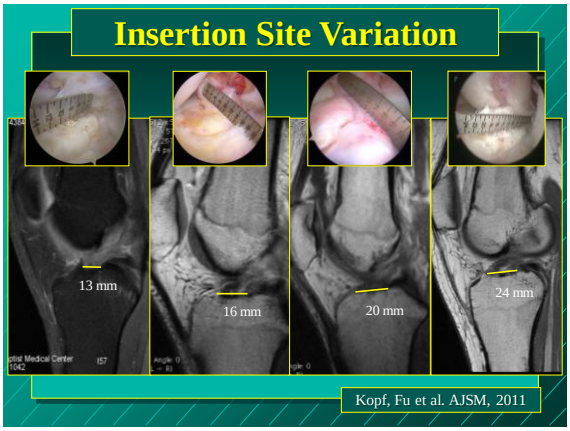
Anatomical Variation



Accountable for 100% of the Patient

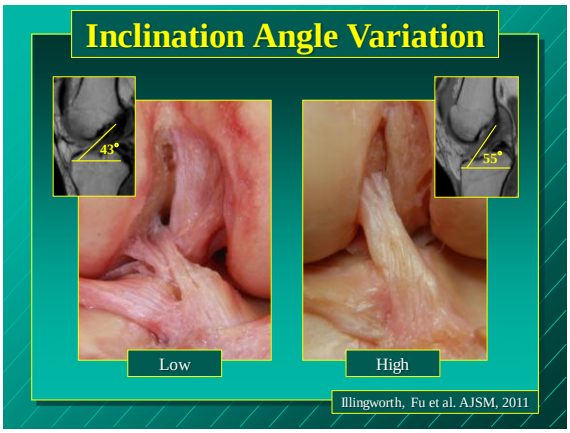
Kopf, Fu et al. AJSM, 2011

Insertion Site Variation



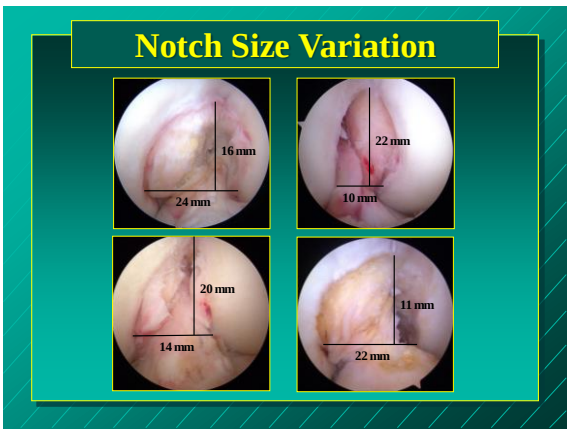
Kopf, Fu et al. AJSM, 2011

Inclination Angle Variation



Illingworth, Fu et al. AJSM, 2011

Notch Size Variation



Animal Kingdom

Lion

Tiger

Bear

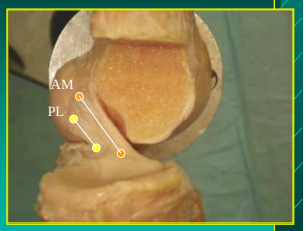
Lemur

Gorilla

Kangaroo

Collaboration with Pittsburgh Zoo, Carnegie Natural History Museum and Dr. Willem van der Merwe

The ACL Underlies the Bony Morphology of the Knee



The AM and PL Bundle Work Synergistically

Golano, Fu et al

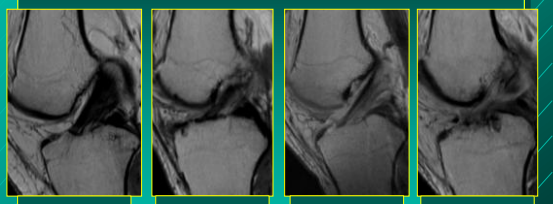
Chhabra and Fu, 2006

Does the ACL Degenerate with Age?

Age-Related Degeneration of the ACL

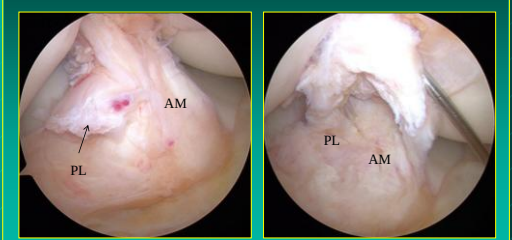
Fetus | 30 years old | 60 years old

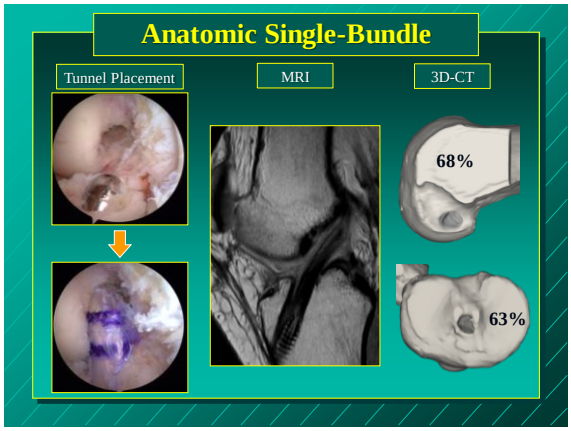
Age-Related Degeneration of the ACL

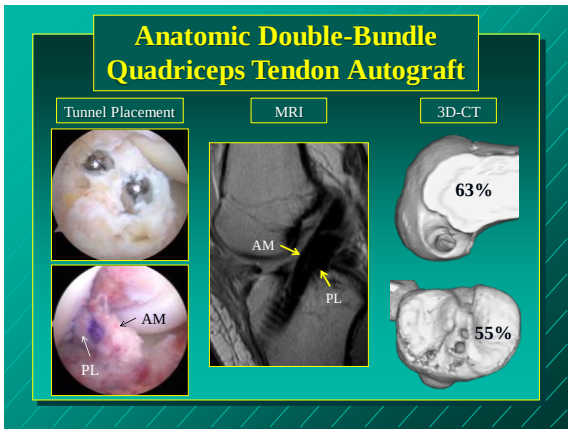


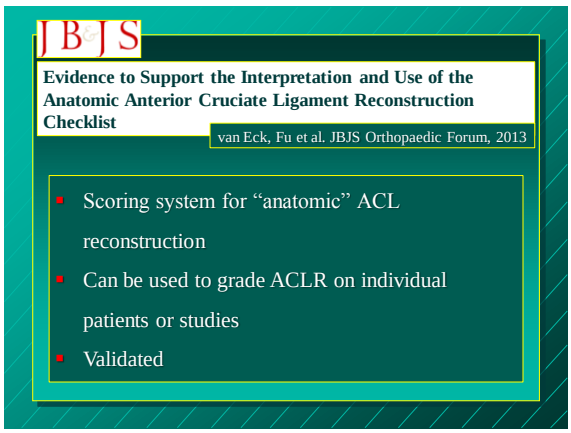
20 years old | 40 years old | 60 years old | 80 years old

Intra-Operative Evaluation of the ACL
Young Patient




Anatomic Single-Bundle
Tunnel Placement
MRI
3D-CT
68%
63%


Anatomic Double-Bundle
Quadriceps Tendon Autograft
Tunnel Placement
MRI
3D-CT
AM
PL
AM
PL
63%
55%


JBJS
Evidence to Support the Interpretation and Use of the Anatomic Anterior Cruciate Ligament Reconstruction Checklist
van Eck, Fu et al. JBJS Orthopaedic Forum, 2013
Scoring system for "anatomic" ACL reconstruction
Can be used to grade ACLR on individual patients or studies
Validated

2013 Hughston Award

The American Journal of Sports Medicine

Prospective randomized Clinical Evaluation of Conventional Single-Bundle, Anatomic Single-Bundle, and Anatomic Double-Bundle Anterior Cruciate Ligament Reconstruction

Hussein, Fu et al. AJSM 2012

Level I

- 85% follow-up at 3-5 years
- Anatomic DB > Anatomic SB > Conventional SB

The American Journal of Sports Medicine

Individualized Anterior Cruciate Ligament Surgery: A Prospective Study Comparing Anatomic Single- and Double-Bundle Reconstruction.

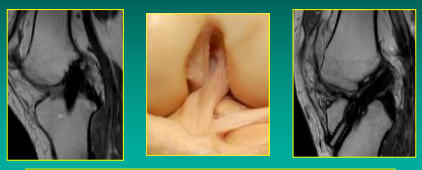
Hussein, Fu et al. AJSM 2012

Level II

- Individualized surgery
  - < 16 mm = SB
  - ≥ 16 mm = DB
- No clinical differences

In Situ Force Higher in Anatomic Graft

Vertical Graft | Native | Anatomical Graft



Higher Re-rupture?

Yagi, Fu, Woo et al AJSM 1997

Araujo, Fu, et al, AAOS and ISAKOS 2013

JBJS

Transtibial ACL Femoral Tunnel Preparation Increases Odds of Repeat Ipsilateral Knee Surgery

Duffee, MOON Group, Kaeding et al JBJS 2013

Repeat Ipsilateral Knee Surgery

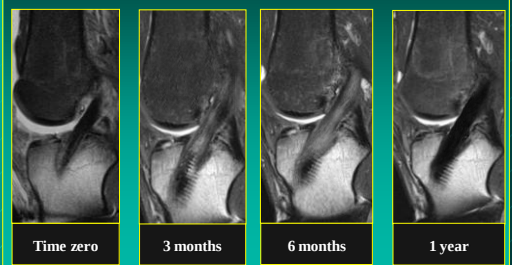
2.5x higher with TT drilling than AM drilling

Anatomic ACL Reconstruction

Rehabilitation Should Be Modified Accordingly

Return to Sports

Functional Testing **Healing?**



See the Big Picture!

Anatomy

Biology

Biomechanics

Kinematics

Proprioception

Rehabilitation

Thank You!

University of Pittsburgh
Cathedral of Learning

This speaker receives royalties from Smith and Nephew

Medial Portal For ACL Reconstruction

William G. Clancy, Jr., MD, PhD (Hon)

Medial Portal

Very distinct advantages over a lateral portal

Medial Portal

Why?

Medial Portal

1. More obliquity of the approach angle to the LFC
2. Less flexion needed
3. Better visualization of the Bifuricate Ridge and posterior edge of the LFC
4. Seldom need to perform a notchplasty
5. More accurate tibial tunnel

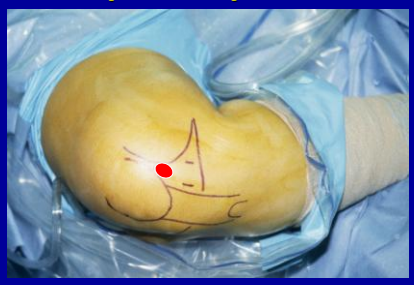
Medial Portal

To achieve these benefits
need to create
a superior medial portal
for
arthroscopic visualization

Superior Medial Portal
(Portal of Patel)

This Portal is created just below the confluence of the inferior medial portion of the patella and the medial femoral condyle with the knee flexed to approximately 60°

The superior medial portal of Patel

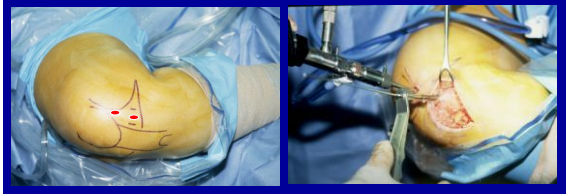


The drill guide is placed in a mid medial portal

Medial Portal

Placed vertically or horizontally halfway between the medial edge of the patellar tendon and the anterior edge of the confluence of the MFC and the medial tibial plateau

The scope is placed in a high medial portal at the confluence of the edge of the patella and Medial Femoral Condyle

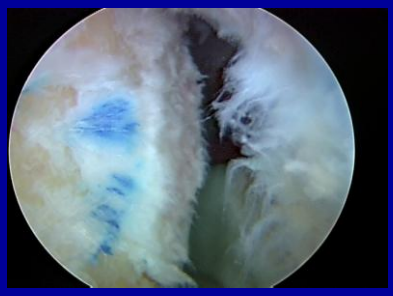


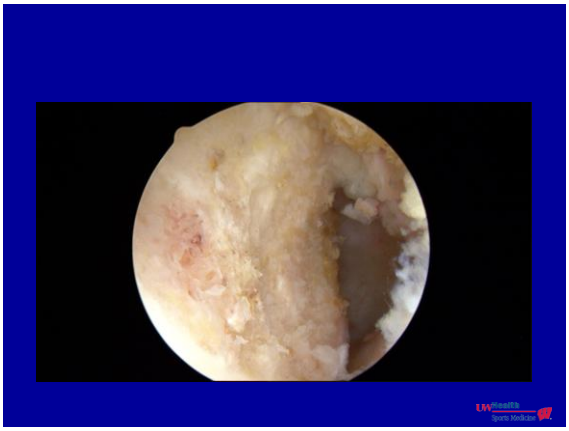
The drill guide is placed in a mid medial portal

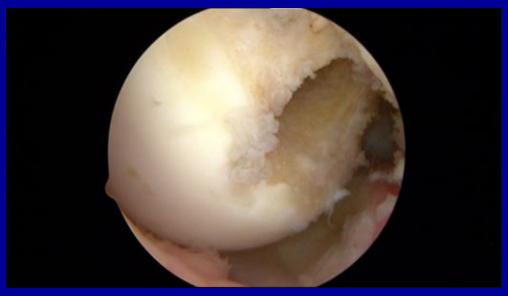
Superior Medial Portal

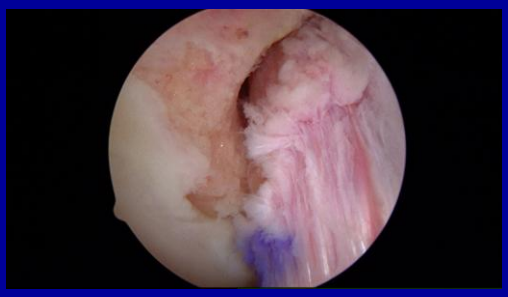
Provides the best possible visualization for drilling of the ACL tunnel on the femur and also for drilling the correct site on the tibia

Resident's Ridge/ACL Ridge









Superior Medial Portal

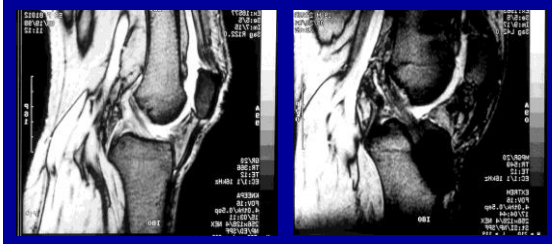
The distance between the arthroscope placed through a lateral or medial portal for visualizing tibial k-wire placement is extremely short making it difficult for accurate k-wire placement

Superior Medial Portal

Evaluating many x-rays and MRI on ACL reconstructions, I find that in greater than 75% of these the tibial tunnel is placed too far posterior

Normal ACL

Transtibial ACL

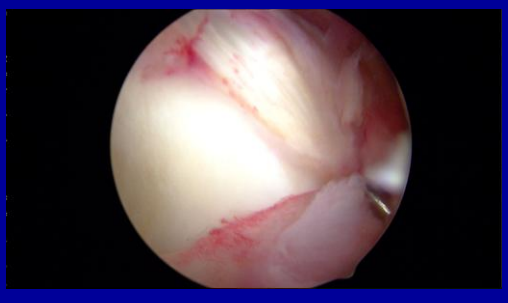


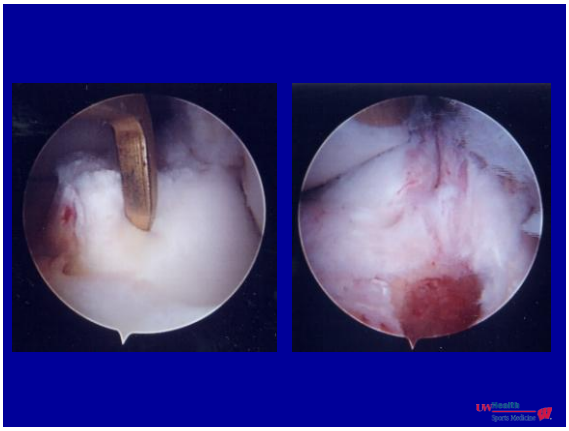
Superior Medial Portal

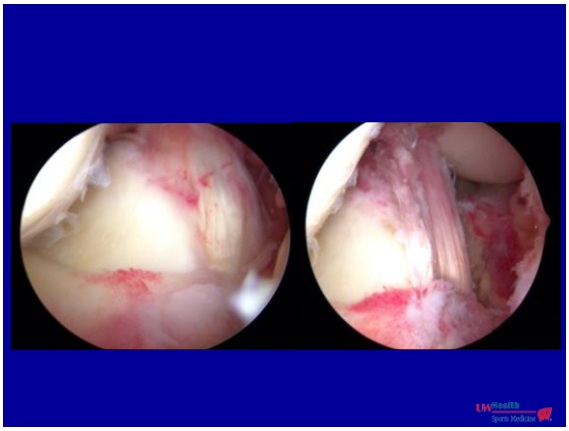
The posterior wall of the tibial tunnel should abut the base of the tibial spine and should not enter it

Superior Medial Portal

This portal allows for an axial or downward view of the tibial spine and both the medial and lateral tubercles and allows for a more correct tibial tunnel

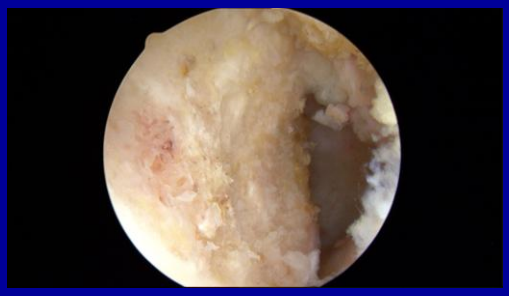






Medial and Superior Medial Portals

1. Better visualization of the lateral wall with the bony landmarks:
   - *Resident Ridge*
   - *Bifuricate Ridge*
   - *Posterior Edge of the LFC*



Medial and Superior Medial Portals

2. Placing the knee in a figure 4 position produces increased varus opening of the intercondylar space so less flexion is needed for drilling and visualization

The scope is placed in a high medial portal at the confluence of the edge of the patella and Medial Femoral Condyle

The drill guide is placed in a mid medial portal

Medial and Superior Medial Portals

2a. A medial portal drilling along with varus allows for a more oblique drilling angle

Medial and Superior Medial Portals

2b. Combining this portal placement and varus with a curved drill guide and a flexible reamer allows for a much smaller oval entrance tunnel


Medial and Superior Medial Portals

3. A straight reamer especially if placed through a lateral portal can create a very large entrance diameter oval which can lead to a too anterior graft fixation site

Medial and Superior Medial Portals

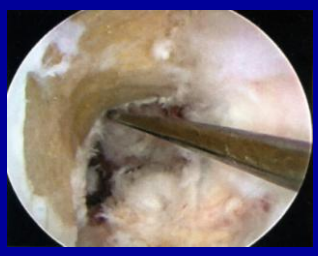
4. Seldom a need for a lateral notchplasty

Lateral Wall Notchplasty

If too much bone is taken away from the LFC then containment for side to side sheer is lost

Lateral Wall Notchplasty

Lateral to medial sheer has been shown to increase poly wear in total knees and the loss of containment by a large notchplasty could lead to increased cartilage surface wear



Notchplasty

Too much notchplasty at the femoral insertional area will place the graft too lateral

Small Intercondylar Notch

One technique does not fit all!

Even a flexible reamer system in a narrowed notch or small knee cannot always achieve correct tunnel placement.

A rear entry system should be utilized for correct placement.

University of Wisconsin

Can flexible Reamers Improve Access to the Femoral Insertion Site

ACL Imaging & Reconstruction Webinar

2014

Mark E. Steiner, MD

New England Baptist Hospital

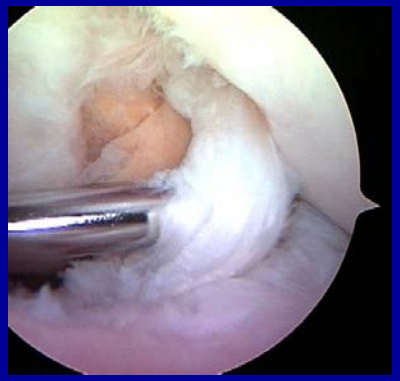
Boston

Disclosures

• Consulting and Royalties	Stryker
• Fellowship Support	Arthrex Don Joy Mitek Smith & Nephew Con Med
• Research Support	Don Joy Stryker

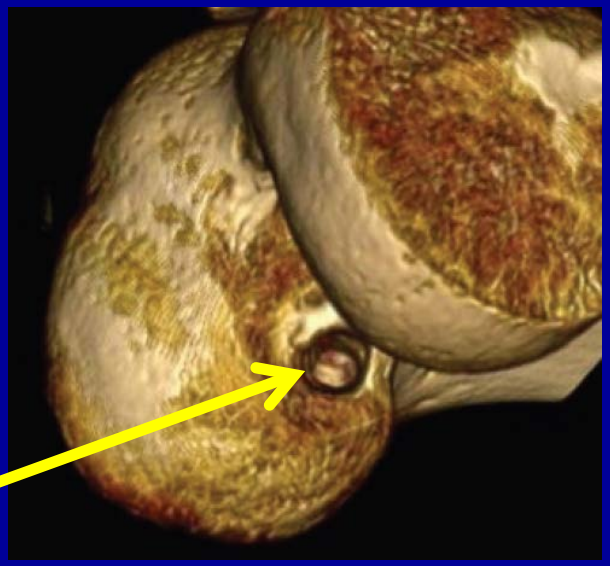
Failures of ACL Reconstruction

- "Failure" up to 25%
- Technical error in tunnel Placement - very common



One vs Two Bundle ACL
SB = DB with AM Drilling (not with TT Drilling)

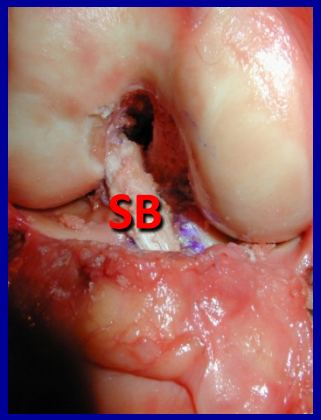
- **SB = DB**
  10% reinjury in both groups
  Ahlden AJSM 2013 Sweden
- **SB = DB**
  32 SB (if footprint ≤ 16 mm) vs 69 DB
  Hussein AJSM 2012 Pittsburgh
- **SB = DB**
  52DB vs 60 SB
  Song AJSM 2013 South Korea

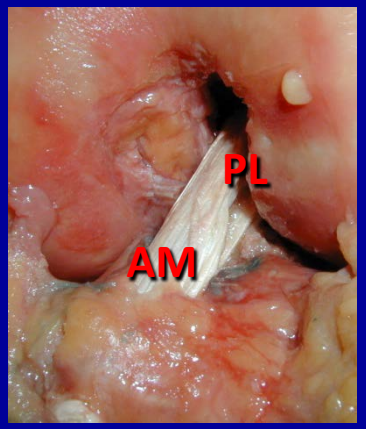


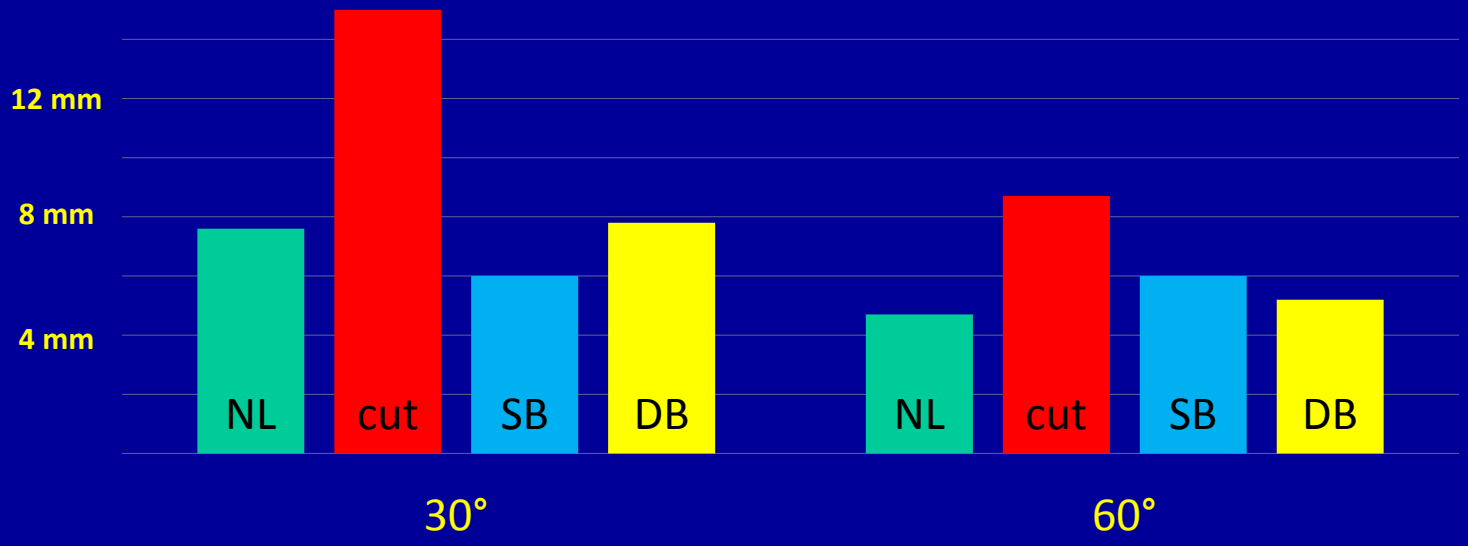
Anatomic Femoral Tunnel

Biomechanics of Anatomic SB vs DB

– Ho, Arthroscopy '09

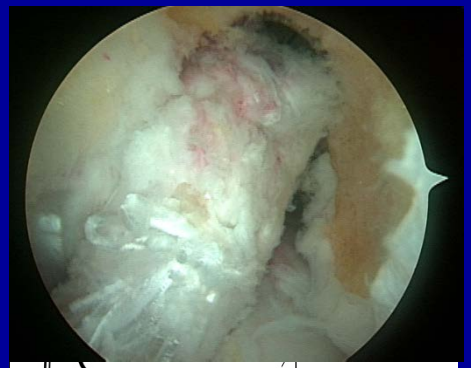


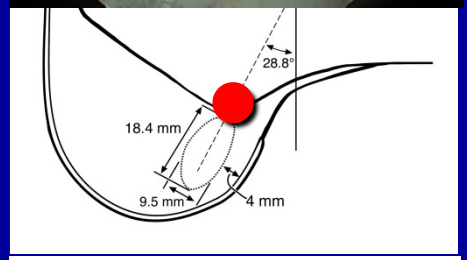


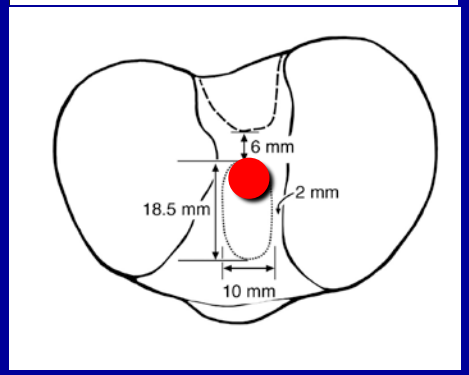


SB Centered (Anatomic) in ACL Footprint = DB

NO

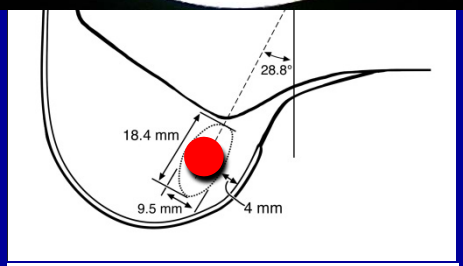


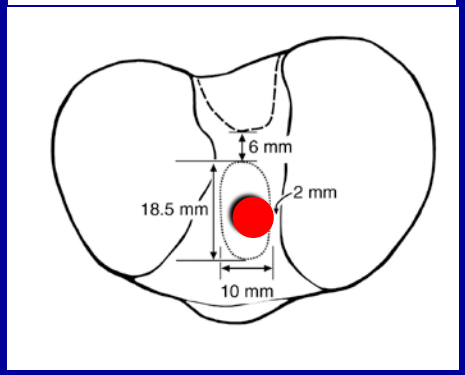




Transtibial ACL
Increased Translation

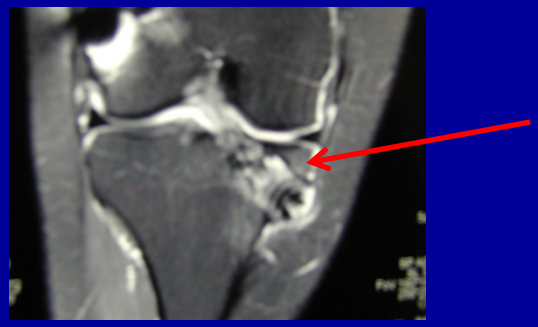
YES



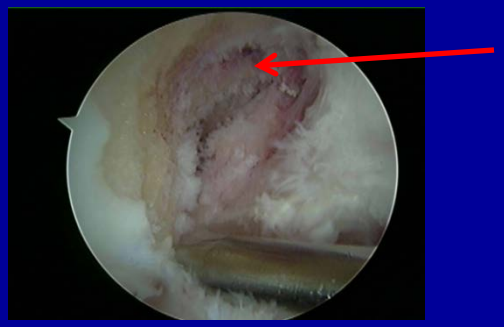


Anatomic ACL
Normal Translation

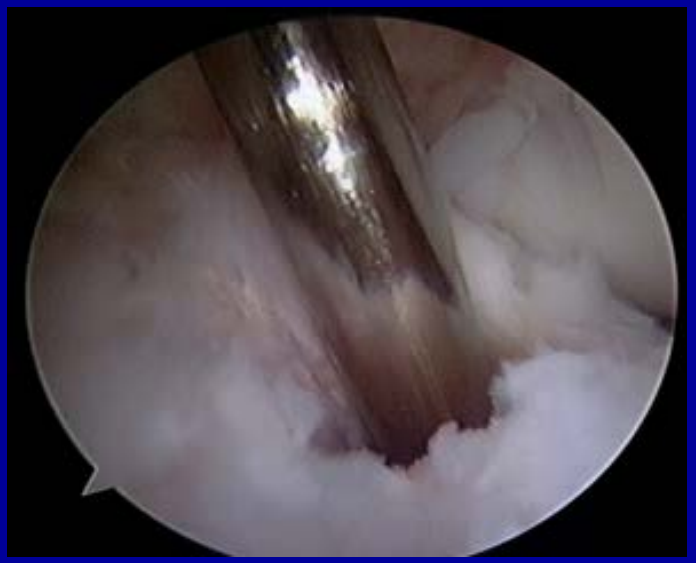
Anatomic Transtibial Drilling
Tibial or Femoral Tunnels have to be compromised



Drilling under Tibial Plateau



Failed Vertical Tunnel



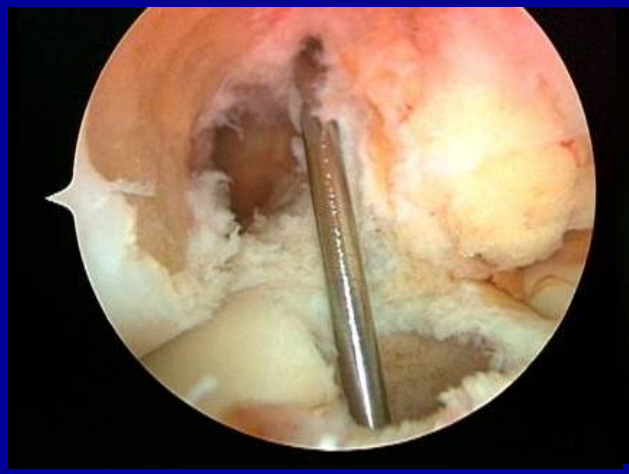
Anatomic Tibial Tunnel Places a Vertical Femoral Tunnel

Does it Matter if the Tibial or Femoral tunnel is Compromised

- Sometimes good results with TT drilling
- Some compromise is probably OK
- Patellar tendon grafts may particularly forgiving

Bone plug rotated

ACL Footprint



Transtibial Drilling

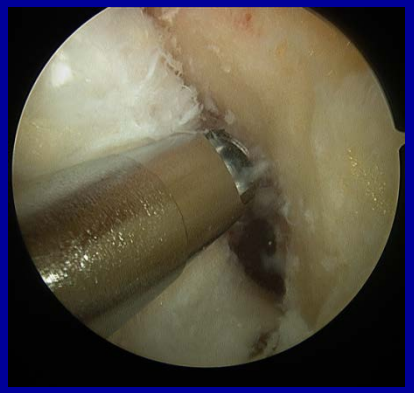
Vertical Graft

Trying to Find an Anatomic ACL
View of the Notch Varies

- Best view at 55°
- Changes with flexion
- Posterior “closes” with flexion
- Portal changes perspective

55°

90°

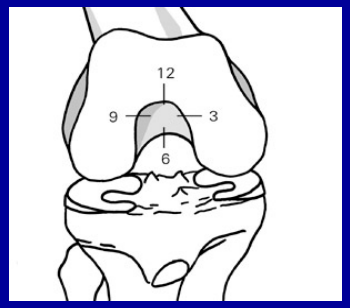


110°

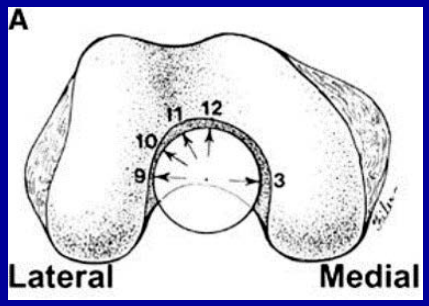
125°

Problem with Clock Face
Too much variability

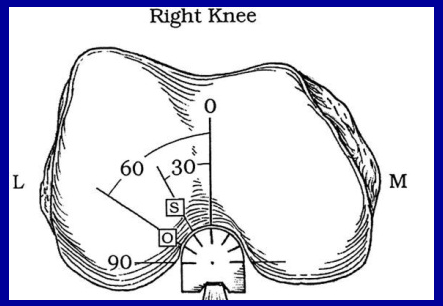
IKDC



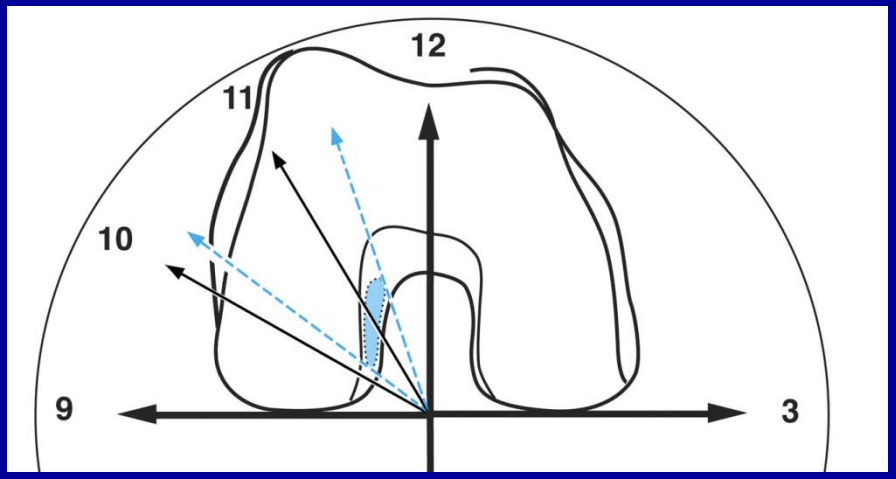
Pittsburgh



Duke



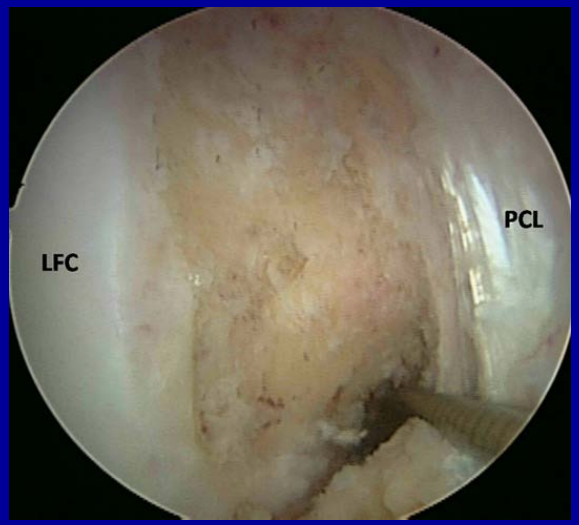
- Knee flexion ?
- Horizontal axis ?
- Perspective ?

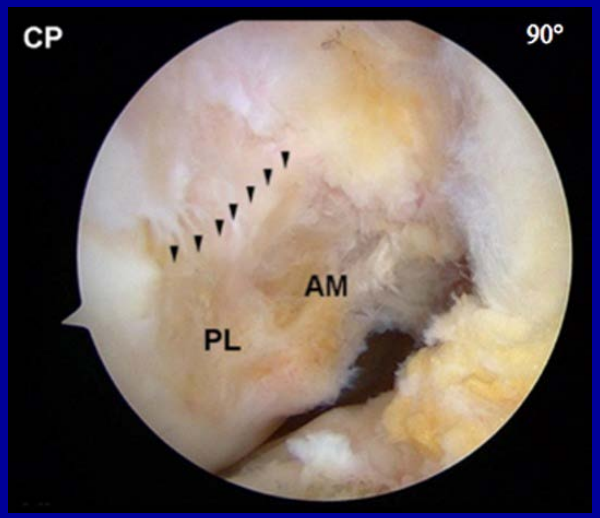


Heming AJSM 2007

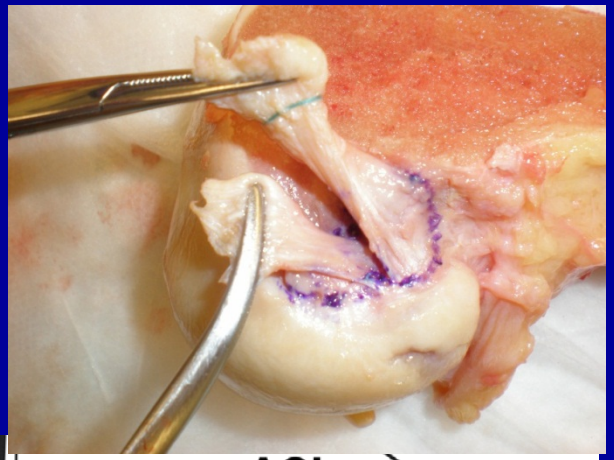
Finding the ACL Footprint
Intercondylar and bifurcate Ridges

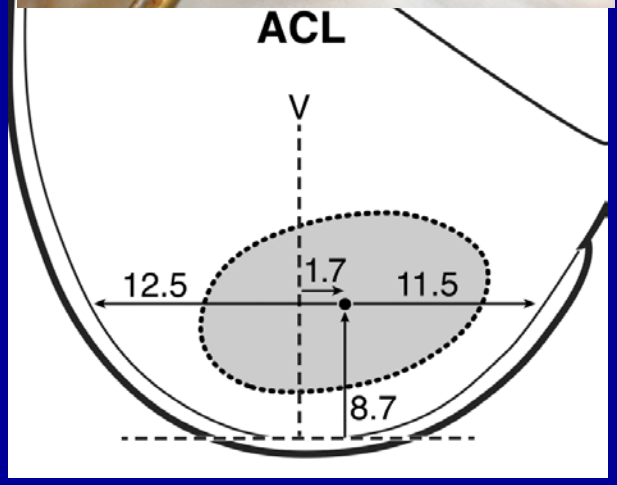
- Can be difficult
- May be unreliable

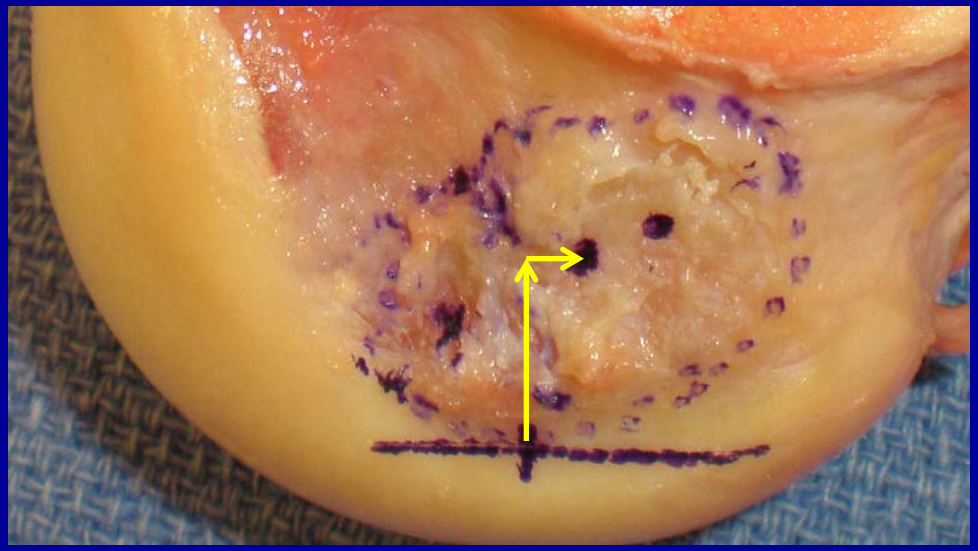




Measurements to the ACL Center at 90° flexion





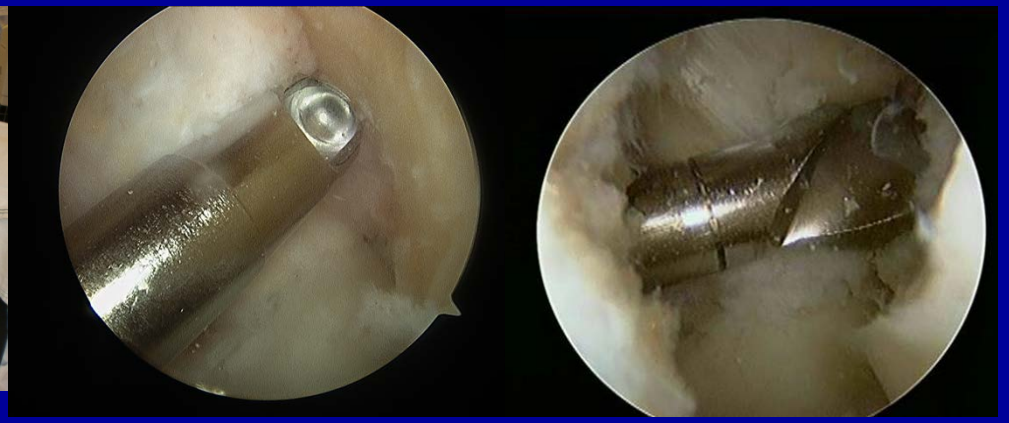


- 8.5 mm up lateral wall
- 1.5 mm deep to a vertical line from low point

Flexible Reamers = Reconstruction in 90° Flexion

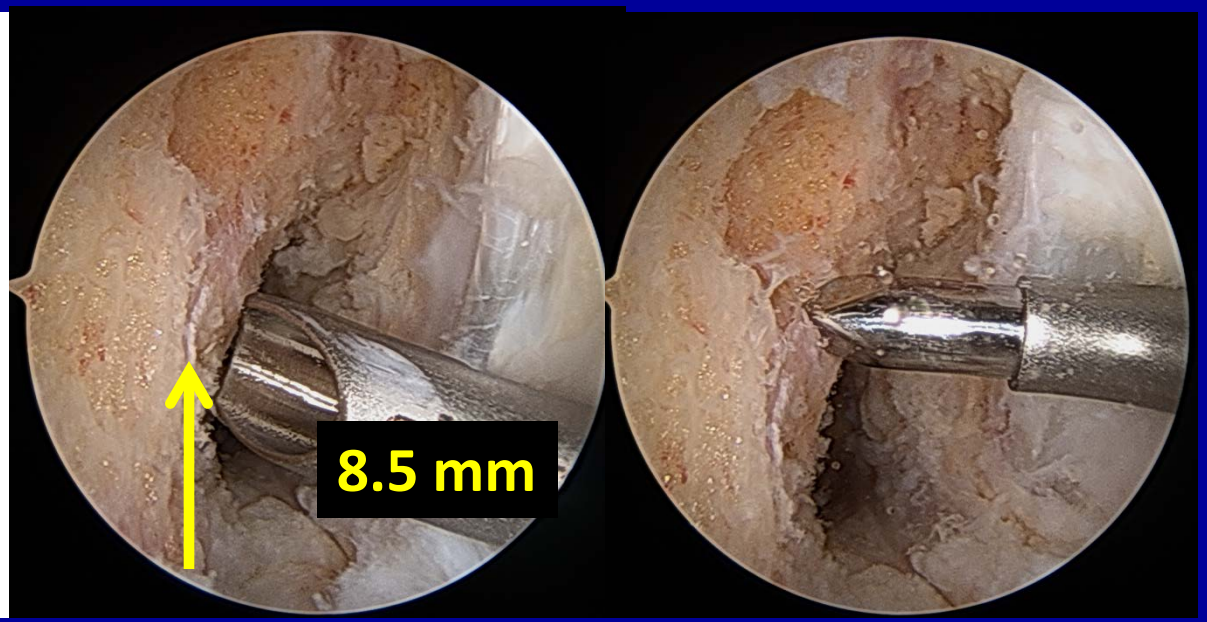
90°

125°

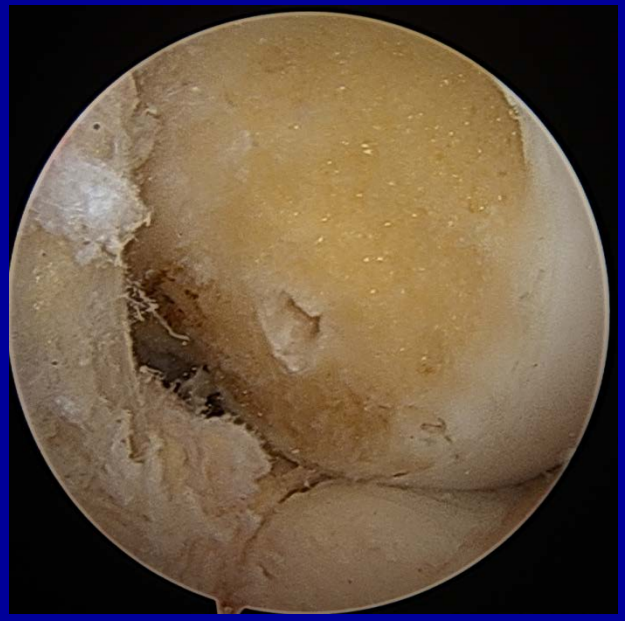


AM Aimer at Height of ACL
→ Point just deep to ACL

- **Height:** 8.5 mm
- **Depth:** aimer places slight deep to ACL



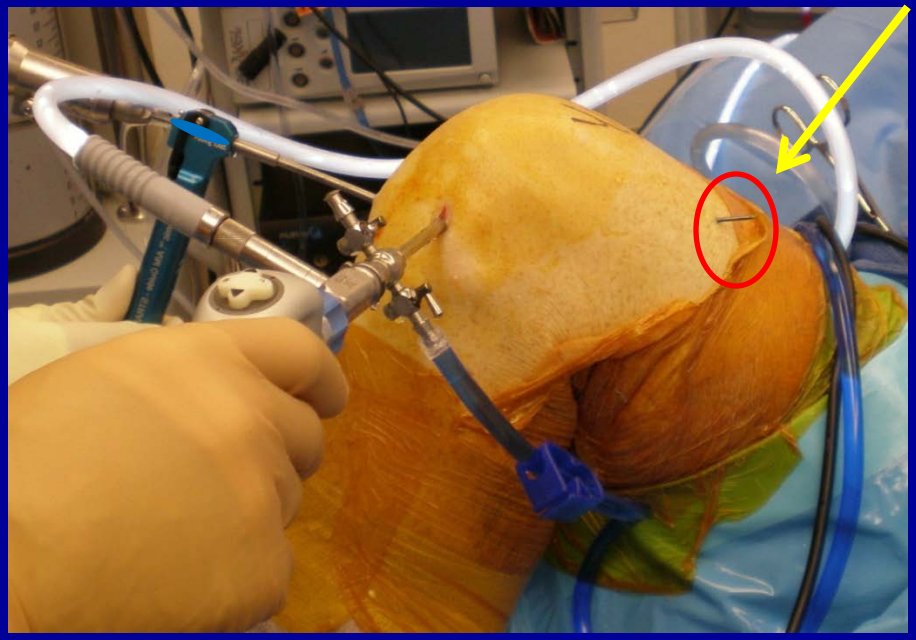
Enlarge Pilot Hole with the Awl



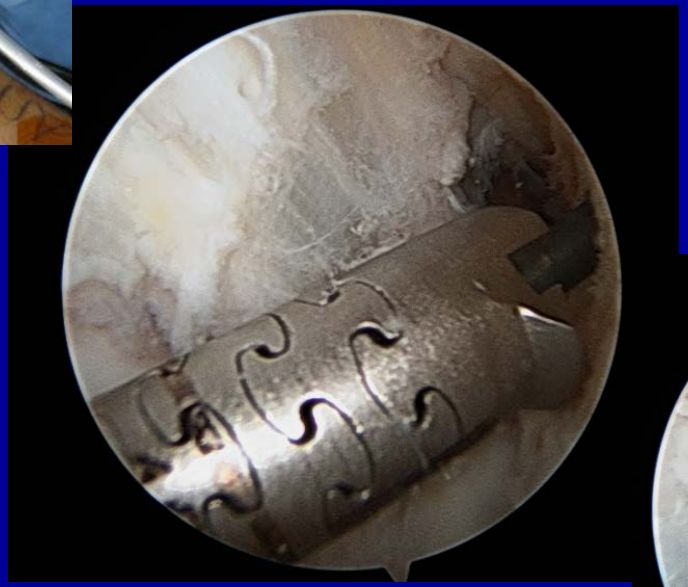
Aimer Placed Through AM Portal
Pin Positioned in Starter Hole

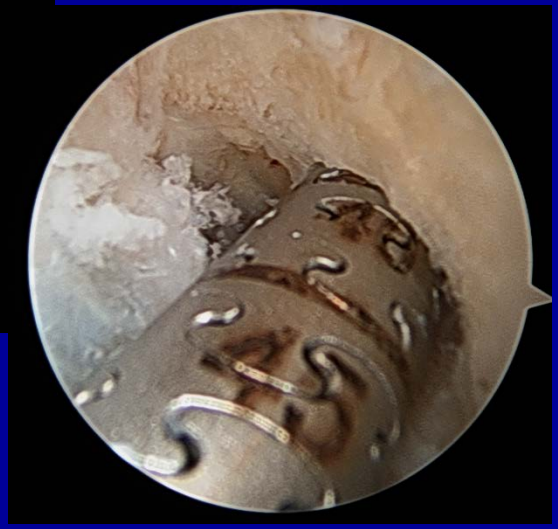
Guidepin Placement

- Pin Exits in safe zone on lateral thigh



Advance Flexible Reamer Over Pin

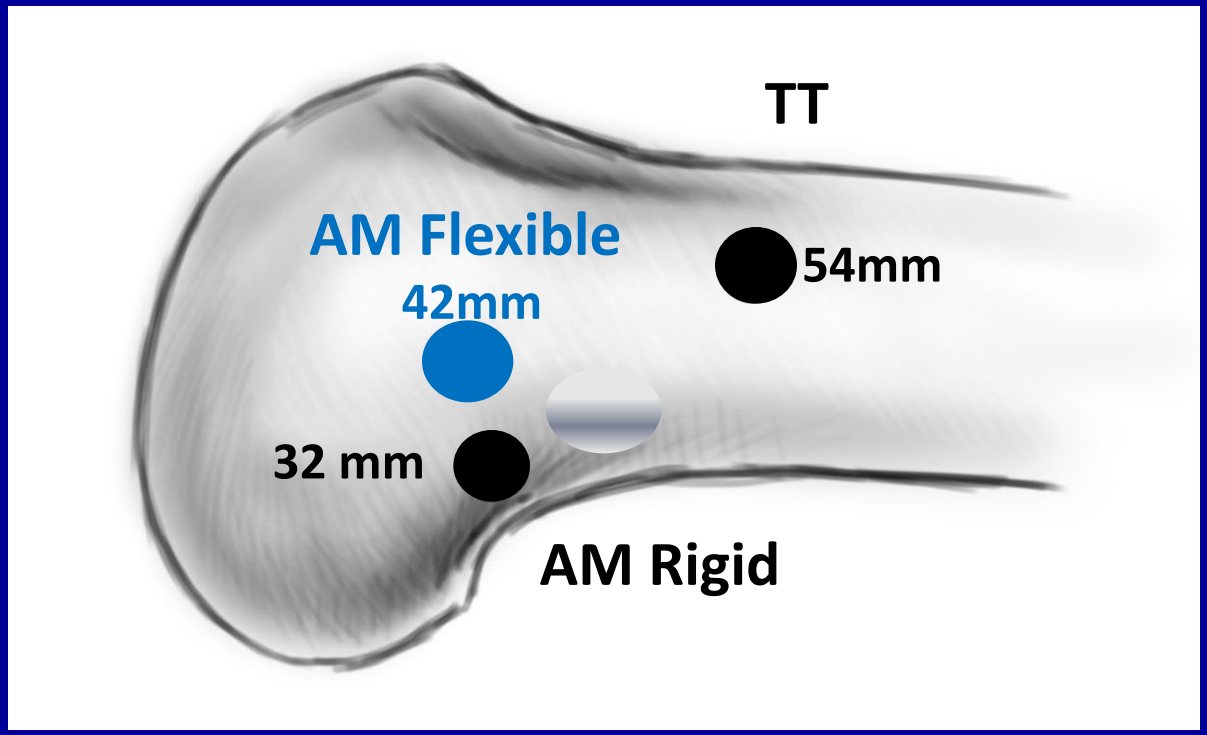




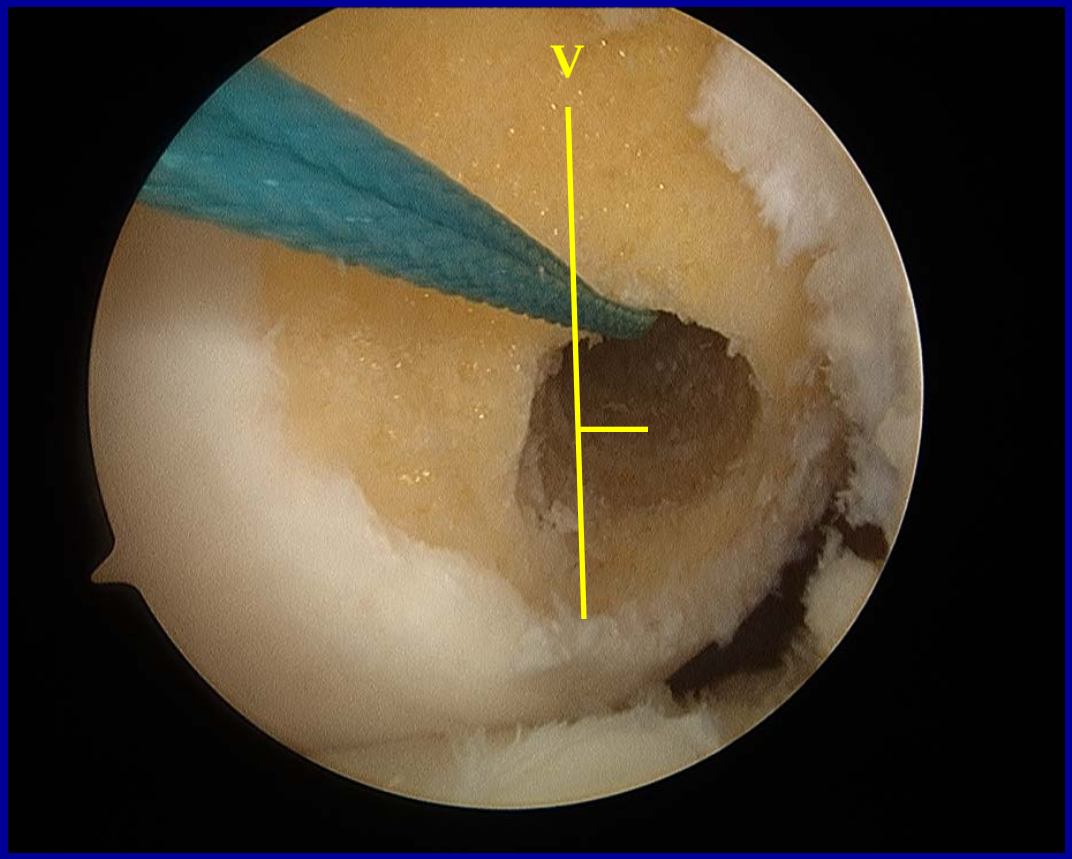
Tunnels ≈ 40 mm Length

- No violation of posterior cortex
- No injury to medial condyle

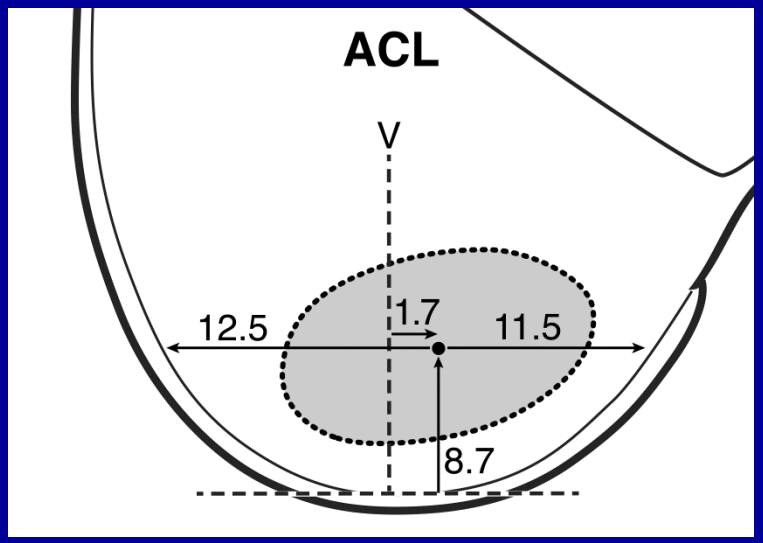
Arthroscopy ‘12



Tunnel low at 90° = Tunnel posterior at 20°



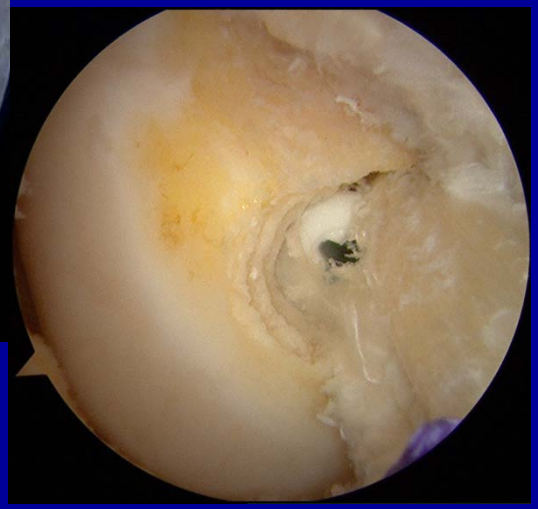
90°



Nitinol Pin Creates a Straight Tunnel

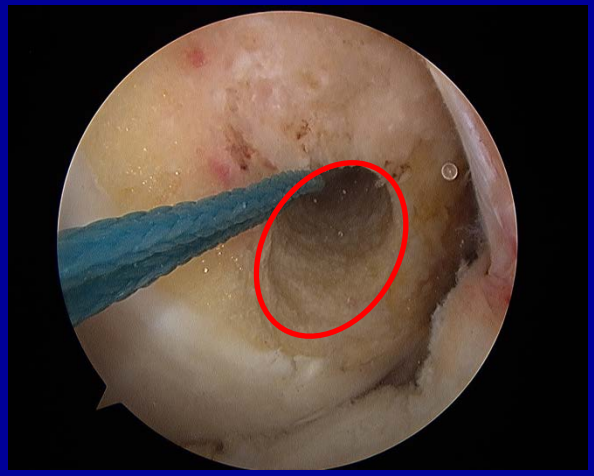
Interference Screw Fixation with Flexible Screwdriver at 90°

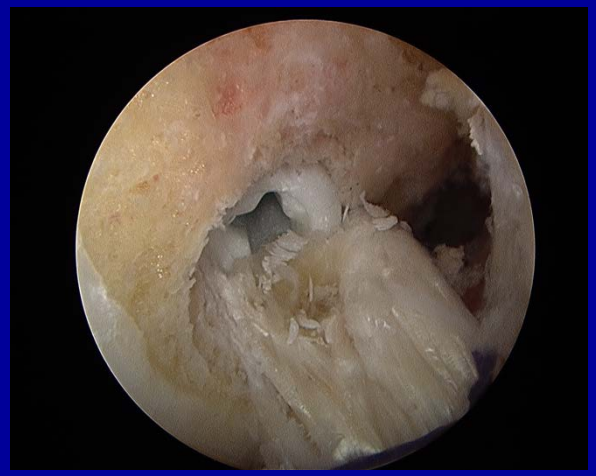
sheath to protect soft tissue grafts



Biomechanics of Aperture vs Suspensory Fixation

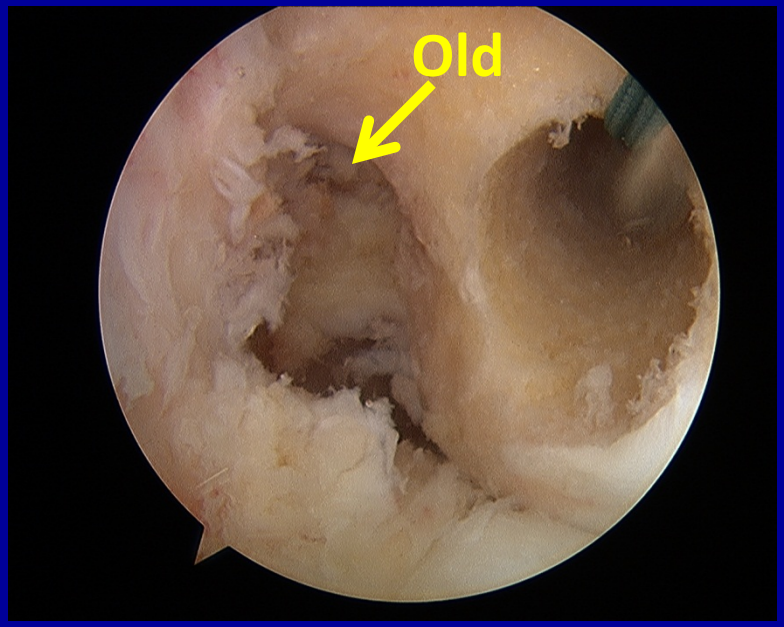
- Femoral socket drilled at an acute angle creates an elliptical femoral tunnel
- May change the mechanics of the graft





Anatomic Nonimpinging Graft

Keep It Anatomic



Thank you