Response of Tibial Tunnel and Tibial Inlay Posterior Cruciate Ligament Graft Reconstructions to Cyclic Loading

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Introduction

- The clinical outcome of PCL surgery is less predictable than that of ACL surgery
- Residual posterior laxity is common

  Lipscomb, et al, *AJSM*, 1993

  Noyes, et al, *Arthroscopy*, 1994
- Why?

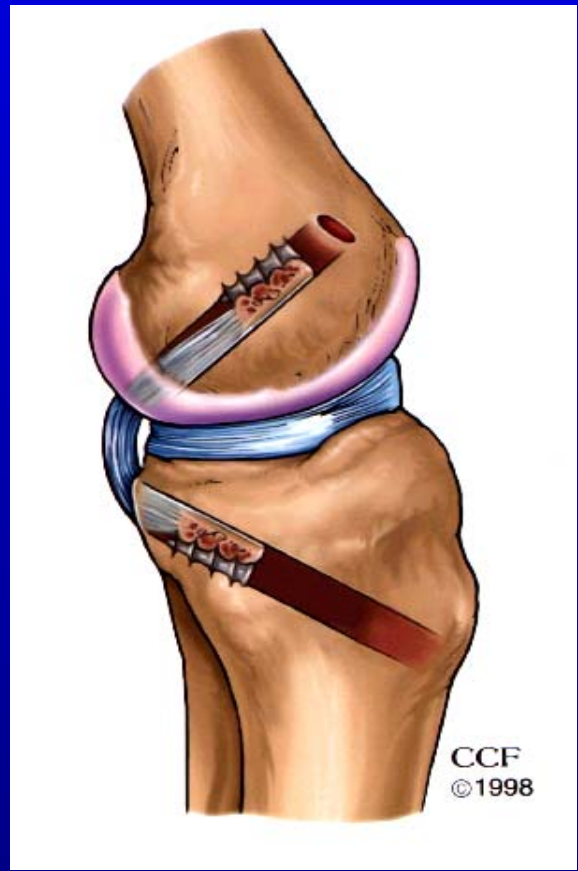
Possible Explanations

- Graft placement?
- Graft tensioning?
- Mechanical changes in graft tissue due to in vivo mechanical loading?

Reconstruction Techniques

Tibial tunnel

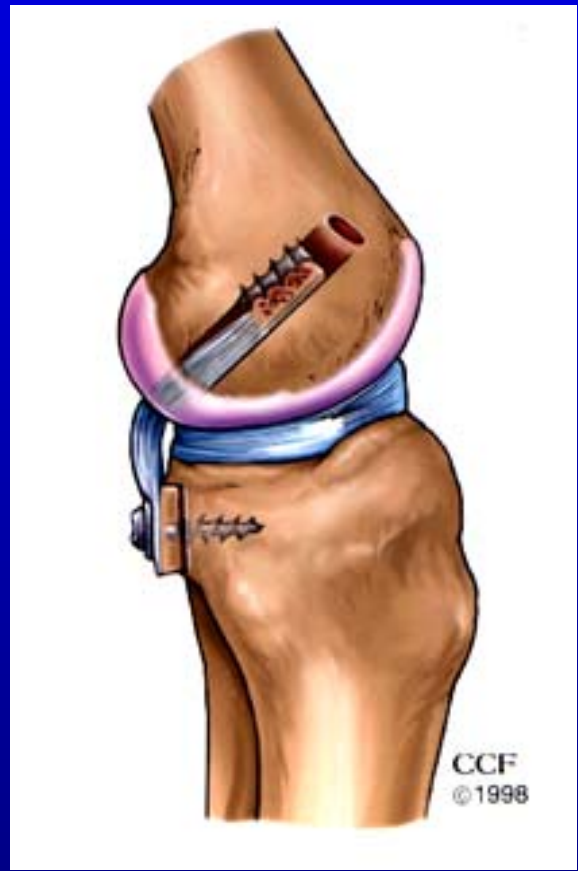
- Most commonly used
- Tunnel drilled from anterior-medial tibia to exit at PCL insertion
- Graft makes acute angle turn behind tibia



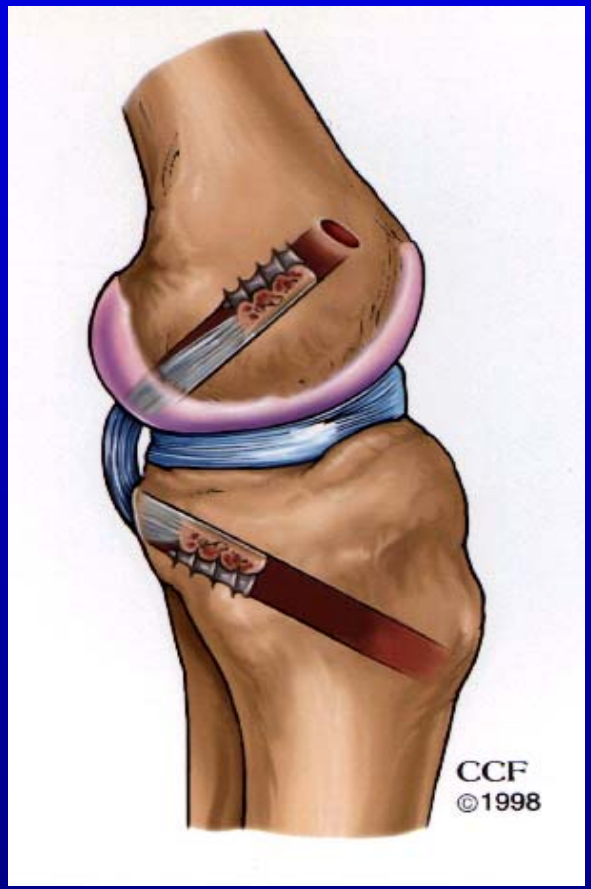
Reconstruction Techniques

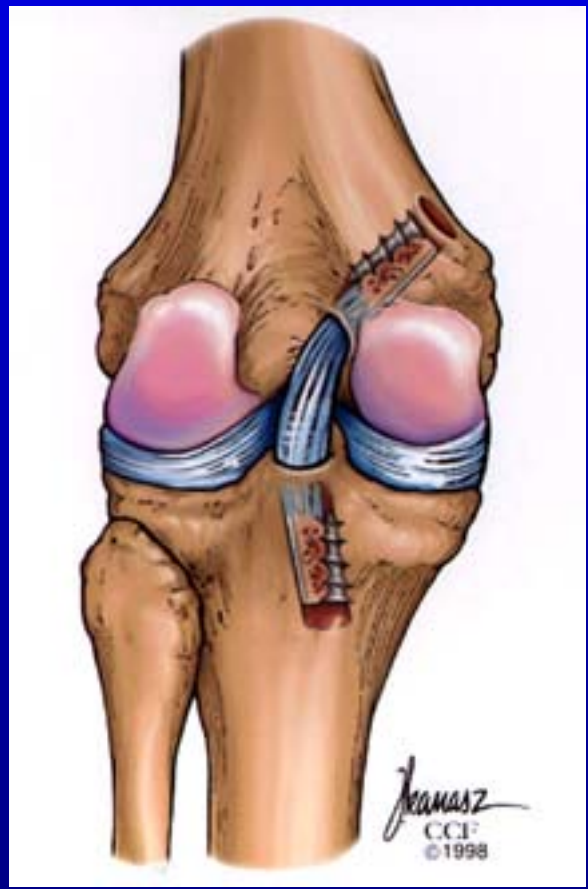
Inlay technique

- Posterior arthrotomy
- Bone block secured to bony recess in back of tibia near site of native PCL origin
- Fibers of graft make less of acute angle turn

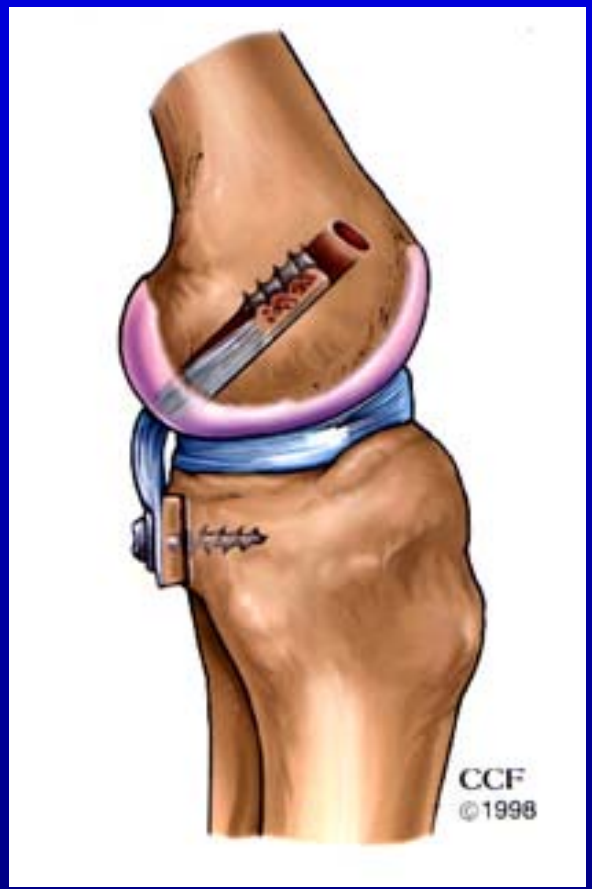


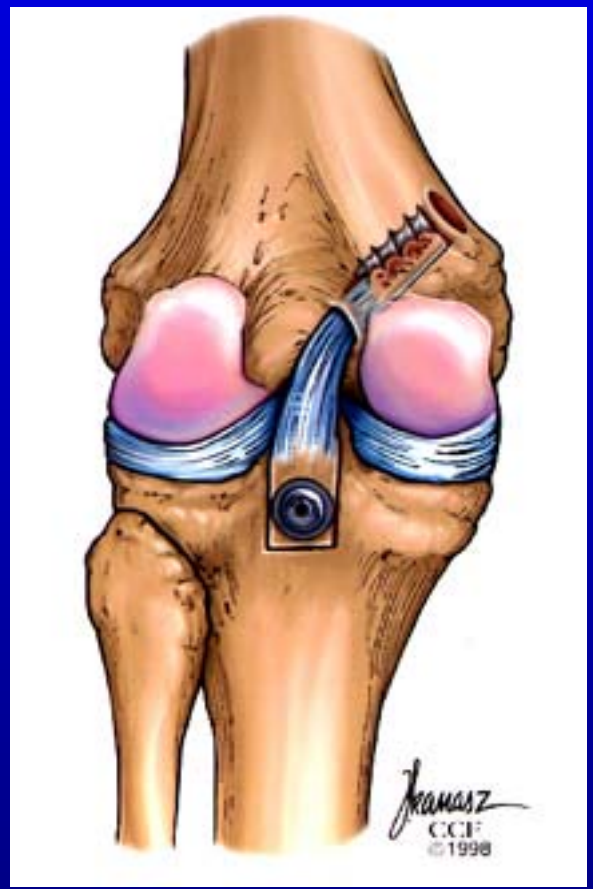
Tunnel Reconstruction



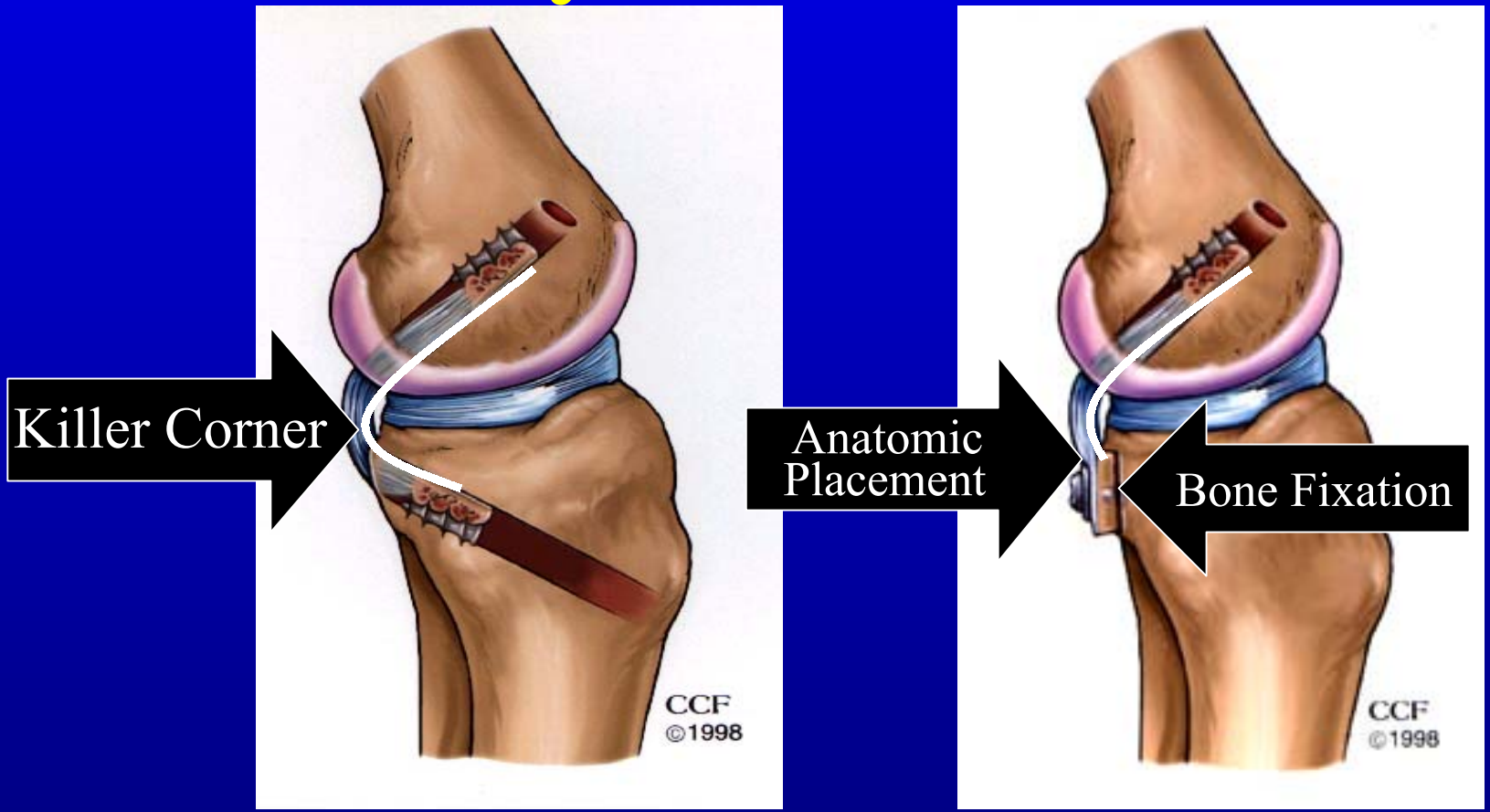


Inlay Reconstruction





Theoretical Advantages of Inlay Reconstruction



Tunnel Reconstruction

Inlay Reconstruction

Purpose

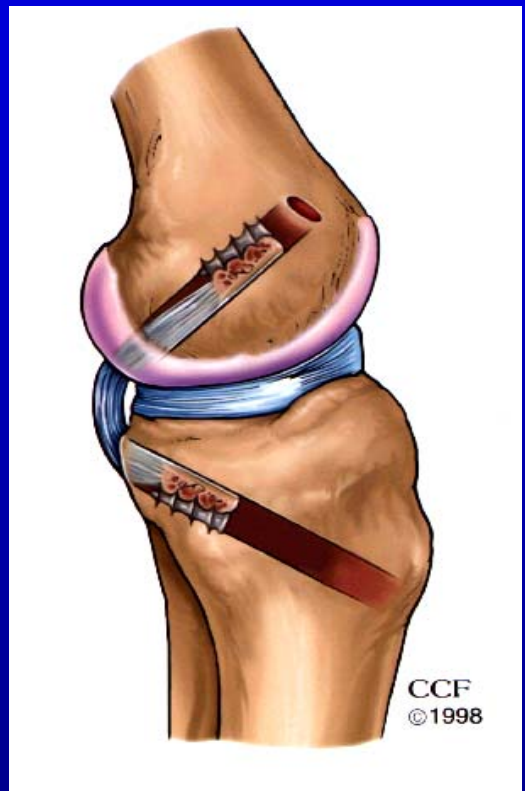
- Evaluate cyclic loading of PCL reconstruction using tibial tunnel and tibial inlay techniques
- Evaluate graft for changes in:
  - Graft thickness
  - Graft elongation during loading cycle
  - Graft elongation over 2000 cycles

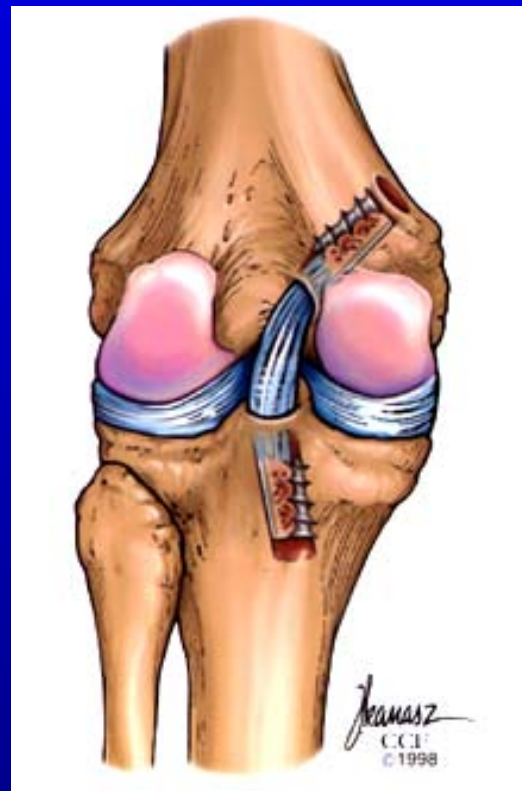
Materials and Methods

- 16 matched pairs of cadaveric bone - patellar tendon - bone grafts
- Patellae divided into med/lat grafts
- Ave age = 51.2 yrs (23-64 y.o.)
- 4 cadaveric tibias prepared for reconstruction - 2 inlay, 2 tunnel
- Age 53 and 64

Tibial Tunnel

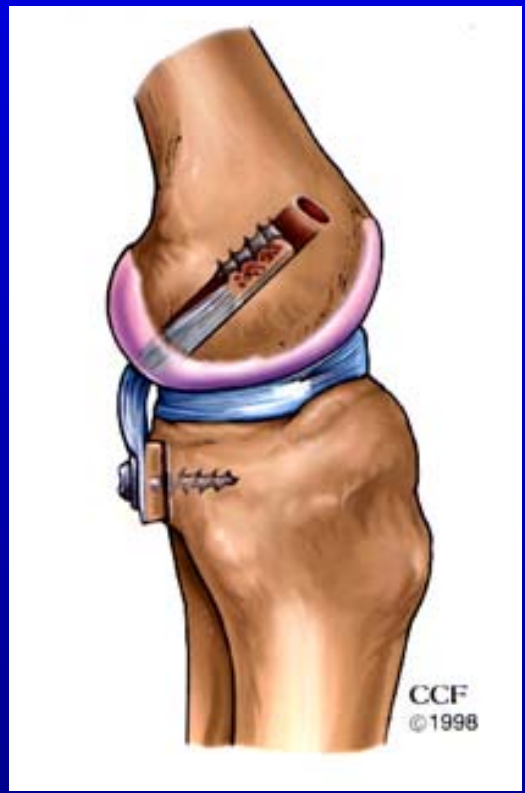
- 60^{o} tunnel angle, exiting at posterior tibial PCL attachment
- 11mm tunnel
- Posterior lip of tunnel smoothed with rasp

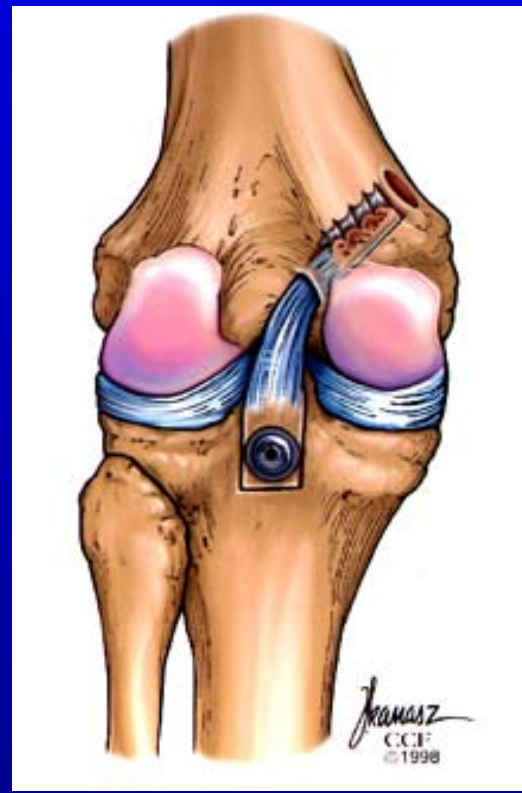




Tibial Inlay

- Trough in posterior cortex at PCL origin
- Bone block fastened to tibia using 4.5 mm cancellous screw and washer





Grafts

- 11 mm width
- Length of tendon measured
- Thickness of tendon measured using area micrometer

Butler, *J. Biomech.*, 1984

Grafts

- Patellar bone block - drill holes/1.2 mm stainless cable to attach to MTS
- Tibial bone block-
  - Attached to tibia
  - High-test Dacron line to attach to split clamp which anchored position in tunnel

Cyclic Loading

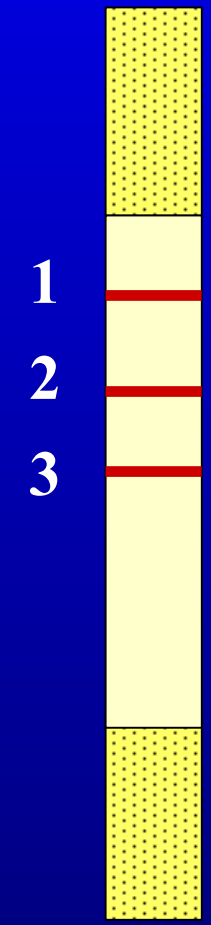
- Tibia mounted in PMMA
- PMMA secured onto MTS model 812 servohydraulic materials test machine
- Tibia adjusted so angle of pull was 45^{o} to tibial plateau

Cyclic Loading

- 2000 cycles
- 0.5 Hz
- Tensile load 50-300 N
- Grafts moistened with 0.9% NaCl
- Force v. elongation curves monitored

Measurements

- Graft thickness at 3 locations before and after cyclic loading
- Graft elongation for individual cycles
- Overall graft elongation through 2000 cycles



Statistical Analysis

- Two-way RANOVA was used to to determine significance
- Level of significance was $p < 0.05$

Results

- 31 pairs of grafts
- 10/31 tunnel grafts failed at “killer corner” prior to completion of 2000 test cycles
- 31/31 inlay grafts survived testing
- No significant differences between any measured parameter between inlay grafts whose tunnel pair survived vs. inlay grafts whose tunnel pair failed

Results

- In inlay grafts there was no difference between medial grafts and lateral grafts
- Therefore, medial and lateral graft halves were combined for subsequent analysis

Effects of Cyclic Loading on Graft Thickness

Inlay Graft Thickness (mm)

	Site 1	Site 2	Site 3
Before	3.37	3.41	3.47
2000 Cycles	2.94	3.13	3.26
% Change	**-12.46**	**-7.59**	**-6.32**

Effects of Cyclic Loading on Graft Thickness

Tunnel Graft Thickness (mm)

	Site 1	Site 2	Site 3
Before	3.57	3.62	3.71
2000 Cycles	2.11	2.66	3.13
% Change	**-40.56***	**-26.31***	**-15.39***

Increase in Graft Length After Cyclic Loading

	Inlay Graft Length Increase (mm)	Tunnel Graft Length Increase (mm)
Cycle 6 - Cycle 1	2.24	3.72*
Cycle 2000– Cycle 6	3.67	6.10*
Cycle 2000- Cycle 1	5.91	9.82*

Discussion

- Previous studies have evaluated laxity and pretension. There are only small differences in laxity between tunnel and inlay reconstructions with slightly lower graft pretensions required in inlay when compared with tunnel reconstructions.

McAllister, et al, in print, *AJSM*

Discussion

- Significant increase in graft thinning seen at “killer corner” with tunnel grafts when compared with inlay grafts

  Bergfeld, et al, *AJSM*, 2001

Discussion

- Total graft elongation could be reduced if the graft were cyclically preconditioned in its in situ configuration before final pretensioning and fixation.

Conclusions

- Tibial inlay reconstruction causes less graft thinning and fewer graft failures than tibial tunnel PCL reconstruction
- Tibial inlay reconstruction causes less overall graft elongation
- Cyclic loading leads to stiffer (less extensible) grafts
  - Preconditioning of grafts may decrease elongation seen with cyclic loading

Conclusions

- Differences in response to cyclic loading may represent the principal difference between tunnel and inlay PCL reconstruction techniques

Thank You