Improved control of knee laxity after ‘dynamic’ augmentation of ACL suture repair

Biomechanical comparison of three ACL suture repair techniques in the human cadaveric knee

Roy A.G. Hoogeslag MD
Reinoud W. Brouwer, MD, PhD
Rianne Huis in ‘t Veld, PhD
Joanna M. Stephen, Ph
Andrew A. Amis, FREng, DSc(Eng)

1Centre for Orthopaedic Surgery OCON, Hengelo, the Netherlands
2Department of Orthopaedic Surgery, Martini Hospital, Groningen, the Netherlands
3Biomechanics Group, Mechanical Engineering Department, Imperial College London, London, UK
4Fortius Clinic, Fitzhardinge Street, London, UK
5Musculoskeletal Surgery Lab, Department of Surgery & Cancer, Imperial College London School of Medicine, London, UK
DISCLOSURE

NO CONFLICTS OF INTEREST
Although augmented suture repair of the ruptured ACL regained interest in the last decade, there is lack of objective evidence investigating how contemporary techniques affects anterior tibial translation across the full arc of flexion, and after cyclic loading of the knee.

A biomechanical study was conducted on human knee cadavers to compare results after non-, static- and dynamic-augmented ACL suture repair across the arc of flexion, and after cyclic loading.

Hypotheses
1. Non-augmented suture repair and
2. Static joint bridging augmentation do not restore anterior tibial translation (ATT) compared to ACL-intact values across the arc of flexion of the knee, after cyclic loading.
3. Dynamic joint bridging augmentation restores ATT compared to ACL-intact values and significantly reduces ATT compared to ACL-deficient values across the arc of flexion of the knee, and maintains these values after cyclic loading.
ACL suture repair techniques

Classic ACL suture repair technique as described by Marshall et al.: the tibial stump of the ruptured ACL is sutured and the suture wires are knotted over the femoral cortex after the suture are led through two femoral tunnels (in PL en AM attachment).

Contemporary ACL suture repair technique as described by Mackay et al.: the sutured ACL is stabilized with a static joint bridging augmentation (Internal Brace; Arthrex); a thread through the ACL, a tibial and a femoral tunnel is fixed to the femoral cortex with a button and to the tibial cortex with an interference screw; the thread can be tightened by means of a variable loop length cortical suspension device (TightRope; Arthrex).

Contemporary ACL suture repair technique as described by Eggli et al.: the sutured ACL is stabilized with a dynamic joint bridging augmentation (Ligamys; Mathys); a thread through the ACL, a tibial and a femoral tunnel is fixed to the femoral cortex with a button and to the tibial cortex with an spring-in-screw mechanism; the thread is pretensioned before fixation in the dynamic tibial screw.
METHODS

Twelve human cadaveric knees were mounted in a test rig, and knee kinematics from 0° to 90° of flexion were recorded by use of an optical tracking system. Measurements were recorded without load and with 89-N anterior force.

The knees were tested in the following states:
• ACL-intact
• ACL-deficient
• non-augmented suture repair (Marshall) after 10, 150 and 300 loading cycles
• static joint bridging augmentation (Internal Brace™) after 10, 150 and 300 loading cycles, and
• dynamic joint bridging augmentation (Ligamys™) after 10, 150 and 300 loading cycles.

Statistical analysis used mixed-model analysis comparing the effects of states for ATT across the arc of flexion. Post hoc SIDAK tests were applied in order to investigate differences across conditions while controlling for multiple comparisons. Level of significance was set at p<0.05.
Non-Augmented ACL Suture Repair (Marshall) after 10, 150 and 300 cycles

ACL-deficient state
Compared to the ACL-deficient state, across the arc of flexion, non-augmented ACL suture repair (Marshall) did not result in significant decrease of ATT directly postoperative (p=0.642) and after cyclic loading with 150 (p=1.000) and 300 (p=1.000) cycles of flexion and extension.

ACL-intact state
Compared to the ACL-intact state, across the arc of flexion, non-augmented ACL suture repair (Marshall) resulted in a significant increase (#) of ATT after cyclic loading with 150 (p=0.003) and 300 (p=0.000) cycles of flexion and extension; however, the increase of ATT directly postoperative, was not significant, although it did approach significant values (p=0.068).
Static Joint Bridging Augmentation (Internal Brace) after 10, 150 and 300 cycles

* = significant compared to ACL def
# = significant compared to ACL intact

**ACL-deficient state**
Compared to the ACL-deficient state, across the arc of flexion, static joint bridging augmentation (Internal Brace) resulted in a significant decrease (*) of ATT directly postoperative (p=0.011); however, the decrease in ATT did not reach significant values after cyclic loading with 150 (p=0.075) and 300 (p=0.223) cycles of flexion and extension.

**ACL-intact state**
Compared to the ACL-intact state, across the arc of flexion, static joint bridging augmentation (Internal Brace) decreased ATT to normal values directly postoperative (p=0.982) and after cyclic loading with 150 (p=0.774) and 300 (p=0.364) cycles of flexion and extension.
Dynamic Joint Bridging Augmentation (Ligamys 80-N) after 10, 150 and 300 cycles

* = significant compared to ACL def
# = significant compared to ACL intact

ACL-deficient state
Compared to the ACL-deficient state, across the arc of flexion, dynamic joint bridging augmentation (Ligamys) with 80-N pretensioning resulted in a significant decrease (*) of ATT directly postoperative (p=0.000) and after cyclic loading with 150 (p=0.000) and 300 (p=0.000) cycles of flexion and extension.

ACL-intact state
Compared to the ACL-intact state, across the arc of flexion, dynamic joint bridging augmentation (Ligamys) with 80-N pretensioning decreased ATT to normal values directly postoperative (p=1.000) and after cyclic loading with 150 (p=1.000) and 300 (p=1.000) cycles of flexion and extension.
Dynamic Joint Bridging Augmentation (Ligamys 60-N) after 10, 150 and 300 cycles

* = significant compared to ACL def
# = significant compared to ACL intact

ACL-deficient state
Compared to the ACL-deficient state, across the arc of flexion, dynamic joint bridging augmentation (Ligamys) with 60-N pretensioning resulted in a significant decrease (*) of ATT directly postoperative (p=0.000) and after cyclic loading with 150 (p=0.000) and 300 (p=0.000) cycles of flexion and extension.

ACL-intact state
Compared to the ACL-intact state, across the arc of flexion, dynamic joint bridging augmentation (Ligamys) with 60-N pretensioning decreased ATT to normal values directly postoperative (p=1.000) and after cyclic loading with 150 (p=1.000) and 300 (p=1.000) cycles of flexion and extension.
Non-augmented, static augmented and dynamic augmented joint bridging augmentation after 300 loading cycles

* = significant compared to ACL def
# = significant compared to ACL intact

**ACL-deficient state**
Compared to the ACL-deficient state, across the arc of flexion, dynamic joint bridging augmentation (Ligamys) with 80-N and 60-N pretensioning resulted in a significant decrease (*) of ATT after cyclic loading with 300 (p=0.000) cycles of flexion and extension.

**ACL-intact state**
Compared to the ACL-intact state, across the arc of flexion, non-augmented ACL suture repair (Marshall) resulted in a significant increase (#) of ATT after cyclic loading with 300 (p=0.000) cycles of flexion and extension.
CONCLUSION

In contrast to non-augmented ACL suture repair and static joint bridging augmentation, dynamic joint bridging augmentation resulted in restoration of normal ATT values when compared to the ACL-intact knee, and significantly decreased ATT values when compared to the ACL-deficient knee, after cyclic loading of the knee, across the full arc of flexion.

Clinical Relevance

This study suggests that dynamic joint bridging augmentation can approximate the ruptured ends of the ACL directly postoperative and can maintain this after cyclic loading, which is an important condition to promote healing of the ruptured ACL.