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An Anteromedial Reconstruction Mimicking the Deep Medial Collateral Ligament Stress-Shields the ACL in Anteromedial Rotatory Instability – Biomechanical Validation of Different Anteromedial Reconstruction Techniques

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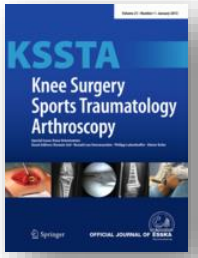
Disclosures

The authors declare no conflicts of interest related to this study

Introduction I – Incidence of MCL injuries

- MCL injuries are the most common combined injury with the ACL
- This concomitant MCL injury has been identified to increase the risk for ACL reconstruction failure

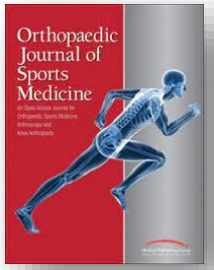


Knee Surg Sports Traumatol Arthrosc. 2019 Aug;27(8):2450-2459.
doi: 10.1007/s00167-018-5237-3. Epub 2018 Oct 29.

Increased risk of ACL revision with non-surgical treatment of a concomitant medial collateral ligament injury: a study on 19,457 patients from the Swedish National Knee Ligament Registry

Eleonor Svantesson [1], Eric Hamrin Senorski [2], Eduard Alentorn-Geli [3 4 5], Olof Westin [6 7], David Sundemo [6], Alberto Grassi [8 9], Svemir Čustović [10], Kristian Samuelsson [6 7]

n = 19,457 ACL Reco + MCL injury
MCL w/o OP → failure risk ↑ + worse KOOS
MCL repair → ns different to isolated ACL



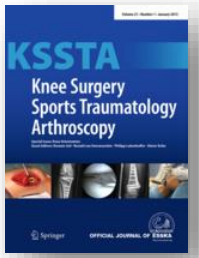
Orthop J Sports Med. 2021 Mar 15;9(3):2325967121989312. doi: 10.1177/2325967121989312.
eCollection 2021 Mar.

Lower Failure Rates and Improved Patient Outcome Due to Reconstruction of the MCL and Revision ACL Reconstruction in Chronic Medial Knee Instability

Lena Alm [1 2], Tobias Claus Drenck [1], Jannik Frings [3], Matthias Krause [3], Alexander Korthaus [3], Anna Krukenberg [3], Karl-Heinz Frosch [1 3], Ralph Akoto [1 2 4]

n = 53 ACL revisions+ 2° chronic MCL-Instability
MCL reco → 5.9 % failure
MCL repair → 36,1 % failure

- Commonly the superficial MCL (sMCL) and deep MCL (dMCL) are injured in ACL deficient knees, not the posterior oblique Ligament (POL)

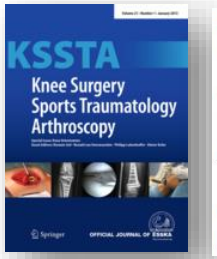


Knee Surg Sports Traumatol Arthrosc. 2022 Jan;30(1):167-175. doi: 10.1007/s00167-021-06514-x.
Epub 2021 Mar 4.

High incidence of superficial and deep medial collateral ligament injuries in 'isolated' anterior cruciate ligament ruptures: a long overlooked injury

Lukas Willinger [1 2], Ganesh Balendra [3], Vishal Pai [3], Justin Lee [3], Adam Mitchell [3], Mary Jones [3], Andy Williams [4]

n = 100
sMCL injuries in 62%, dMCL in 31%, POL in 11%



Knee Surg Sports Traumatol Arthrosc. 2024 Apr;32(4):881-888. doi: 10.1002/ksa.12137.
Epub 2024 Mar 12.

The anteromedial retinaculum in ACL-injured knees: An overlooked injury?

Ole Grunenberg [1], Mirjam Gerwing [2], Simon Oeckenpöhler [1], Christian Peez [1], Thorben Briese [1], Johannes Glasbrenner [1], Luise M Hägerich [1], Michael J Raschke [1], Christoph Kittl [1], Elmar Herbst [1]

n = 120
sMCL injuries in 50%, dMCL in 77.5%, POL in 31.6% (Grad III 5.8%)

Introduction II – Anteromedial reconstructions and hypothesis

- Single bundle MCL complex reconstructions are not capable of restoring native kinematics in a sMCL and dMCL deficient knee.

The Control of Anteromedial Rotatory Instability Is Improved With Combined Flat sMCL and Anteromedial Reconstruction

Peter Behrendt, Priv-Doz Dr med [*,†,‡], Elmar Herbst, Priv-Doz Dr med, PhD [‡], James R. Robinson, FRCS (Orth), MS [§], Leslie von Negenborn, cand. med. [†], Michael J. Raschke, Univ-Prof. Dr med [‡], Jens Wermers, MSc [‡], Johannes Glasbrenner, Dr med [‡], Christian Fink, AO Univ-Prof. Dr med [‖], Mirco Herbort, Prof. Dr med [¶], and Christoph Kittl, Dr med MD(res) [‡,#]

Optimizing the control of Anteromedial Rotatory Knee Instability – a biomechanical validation of different anteromedial reconstruction techniques

Florian Gellhaus, James R. Robinson, Martin Lind, Adrian Deichsel, Matthias Klimek, Nina Backheuer, Michael J. Raschke, Andreas Seekamp, Peter Behrendt, Christoph Kittl

Accepted for publication, 2025

A Flat Reconstruction of the Medial Collateral Ligament and Anteromedial Structures Restores Native Knee Kinematics: A Biomechanical Robotic Investigation

Adrian Deichsel, MD [†,*], Christian Peez, MD [†], Michael J. Raschke, MD, Prof. [†], Alina Albert, MSc [†], Mirco Herbort, MD, Prof. [‡], Christoph Kittl, MD [†], Christian Fink, MD, Prof. [§], and Elmar Herbst, MD, PhD [†]

→ An additional anteromedial limb of the MCL reconstruction is needed to control the instability pattern caused by a sMCL and dMCL injury.

- However, the effects of these reconstructions on the resulting ACL load (and therefore potential failure source) remain underexplored
- Therefore, this study aimed to investigate the effects of an sMCL + dMCL deficiency on the resulting ACL load and it was hypothesized that combined sMCL + anteromedial reconstructions are more powerful to reduce ACL load than single – bundle sMCL reconstructions.

Materials and Methods I – testing setup

- 9 unpaired fresh-frozen knees were tested in a custom-made kinematic rig (Fig. 1)
- The ACL was sharply dissected from its tibial attachment and transosseously refixed into a custom made tensioning device (Fig. B). Force in the ACL was measured in Newtons (N).
- Testing was done in 0°, 30°, 60° and 90° of flexion, in the intact, sMCL + dMCL deficient and reconstructed state
- ACL load was taken during the following conducted tests:
  - Neutral rotation
  - Anterior tibial translation 89N
  - External / Internal Rotation 5 Nm
  - Anteromedial drawer as anterior tibial translation in external rotation

Figure 2

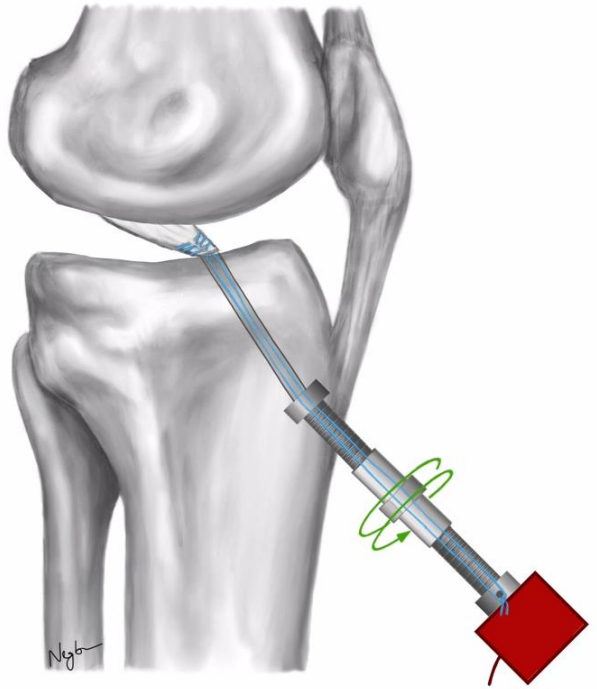
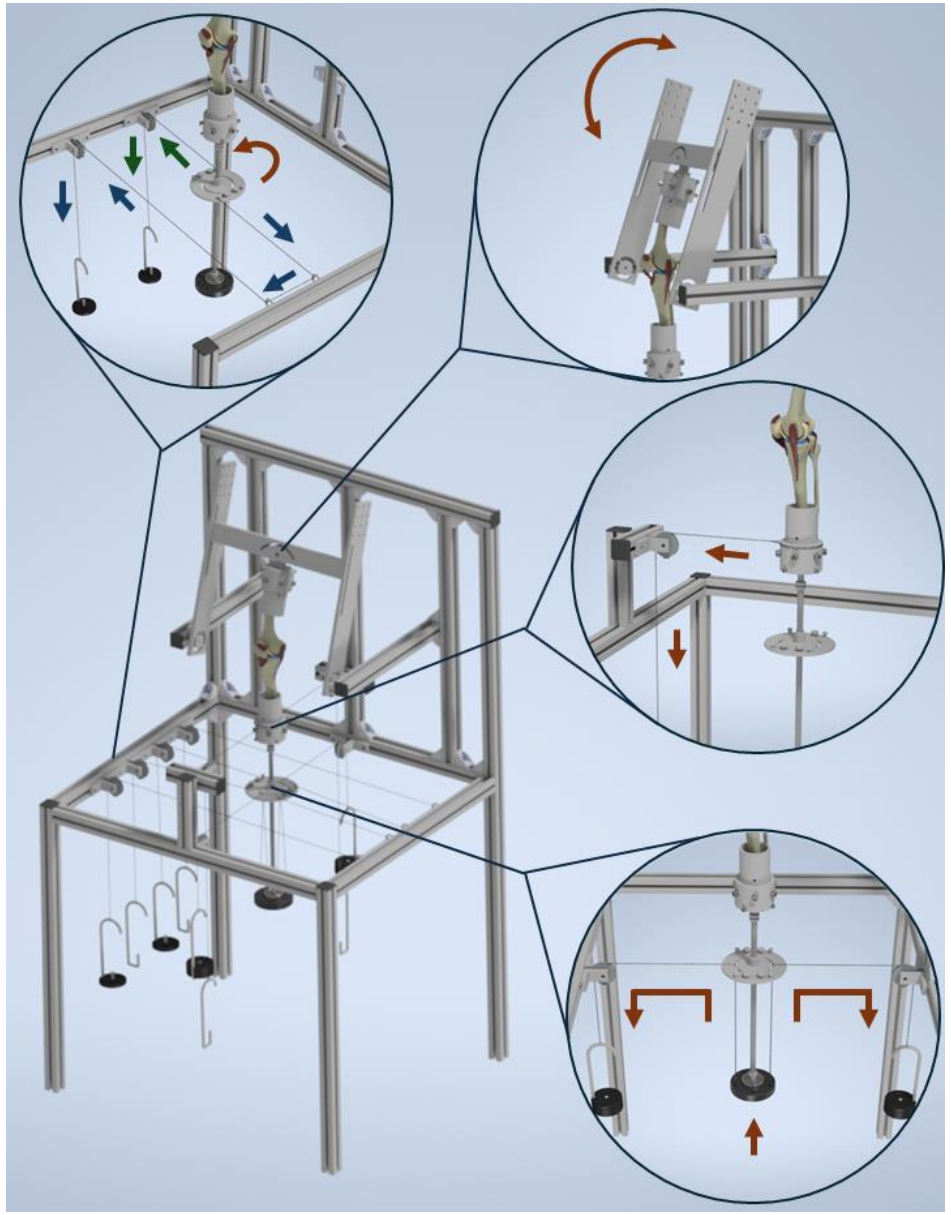


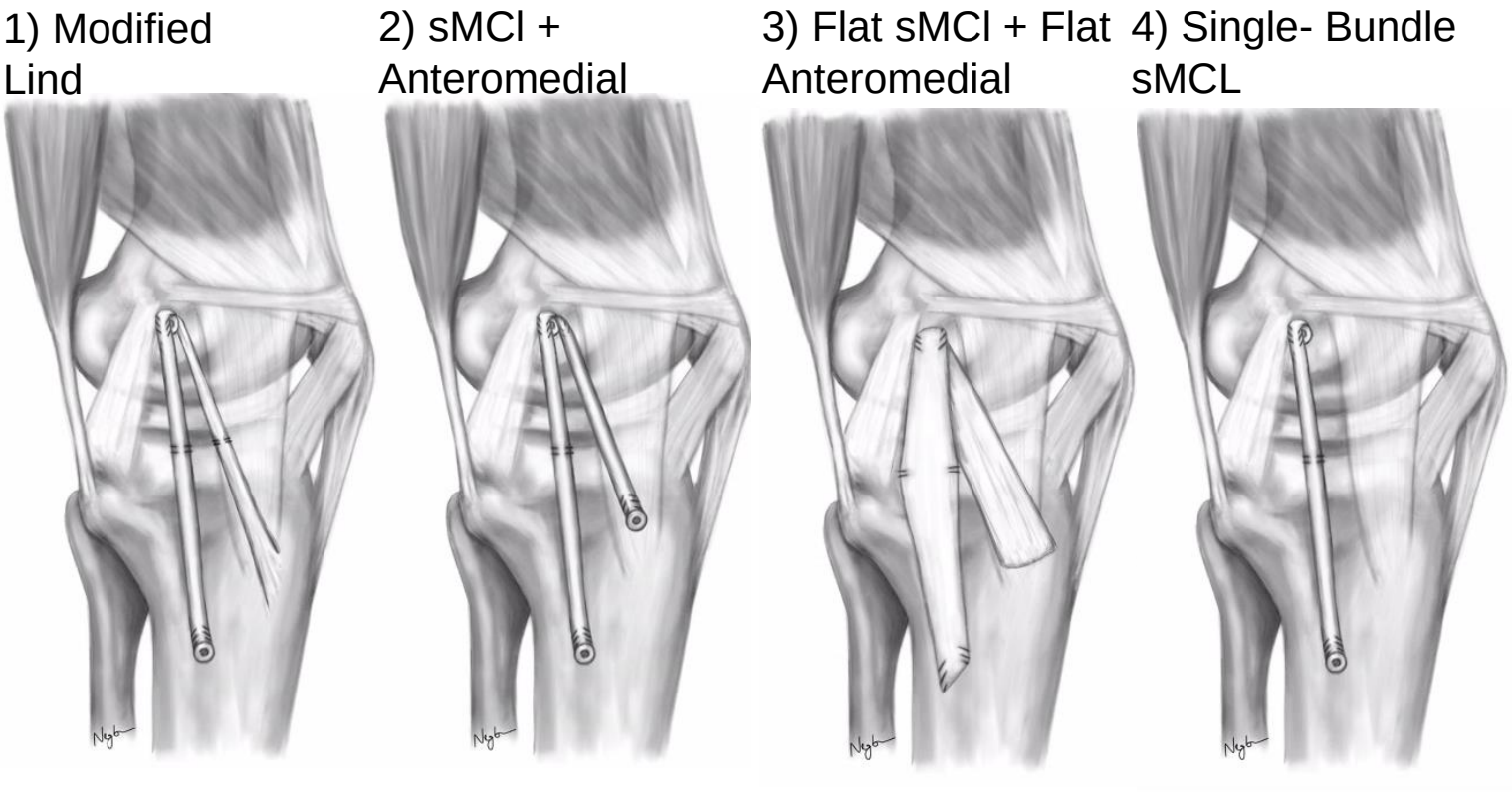
Figure 1



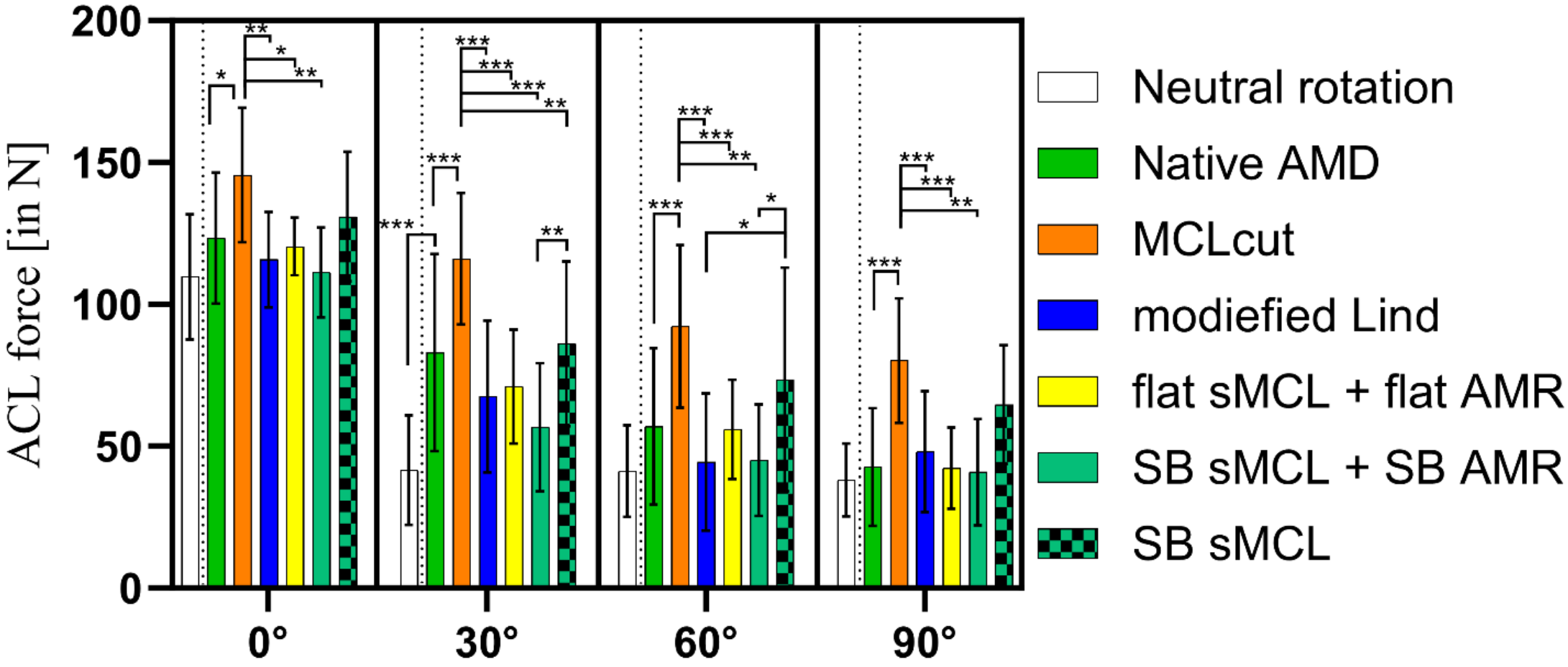
Materials and Methods II – assessed reconstructions

Four different AMR were assessed: (1) Modified Lind reconstruction with the semitendinosus tendon pulled up from its origin, flipped over at the medial femoral epicondyle and then flipped down to an sMCL reconstruction; (2) sMCL + anteromedial limb combination; (3) flat sMCL + flat anteromedial reconstruction; and (4) Single-bundle sMCL reconstruction serving as a control.

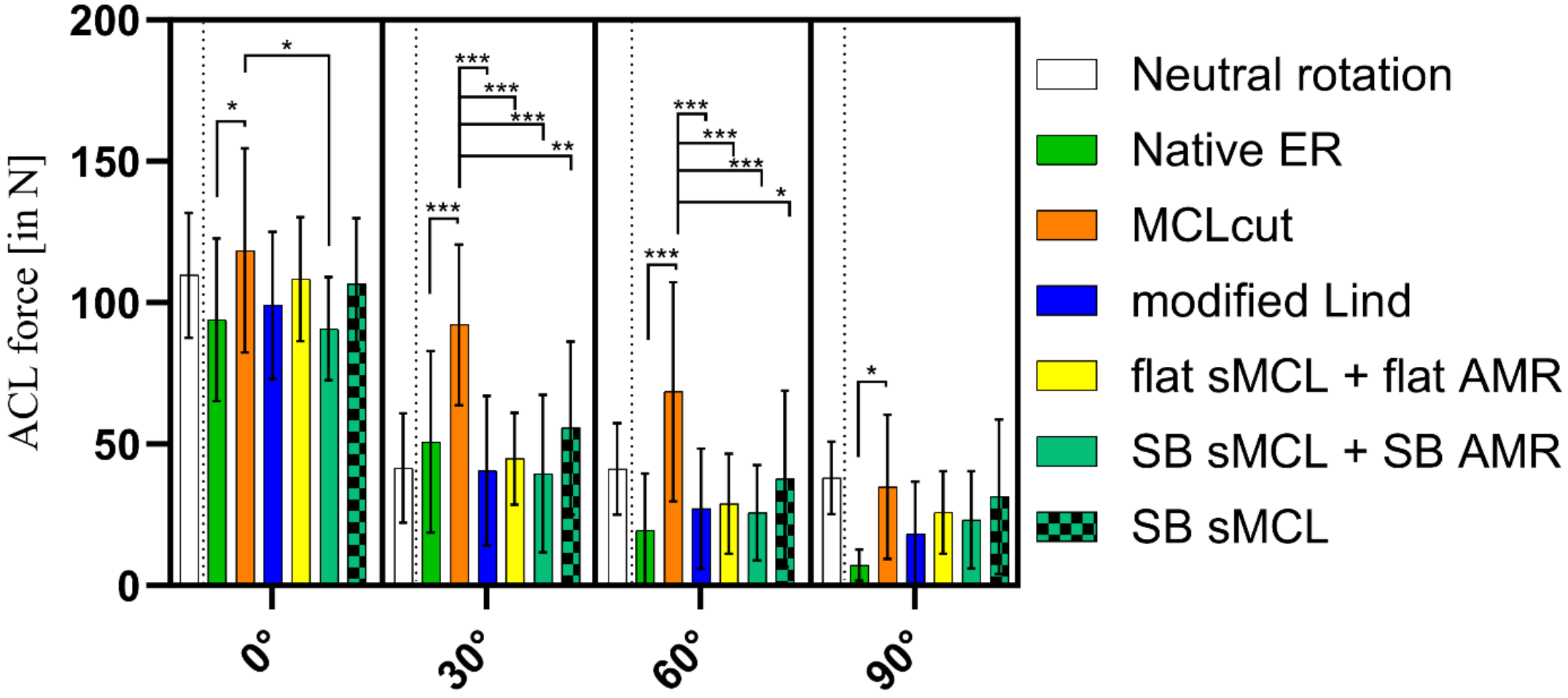
For all reconstructions, a single fused point at the medial femoral epicondyle was selected. This point was placed slightly posterior to the epicondyle to ensure firm tension in extension and a slight slackening during flexion[8, 9].



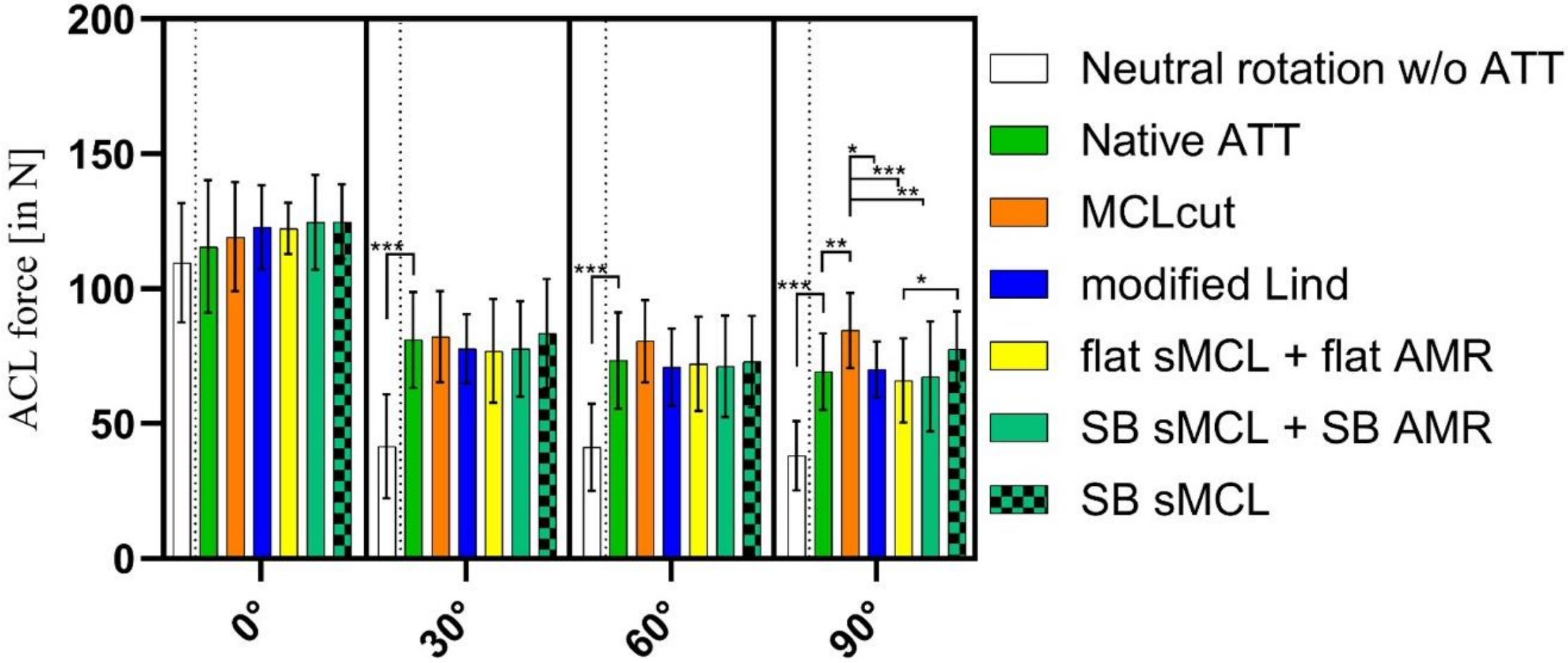
Results I: Anteromedial drawer test



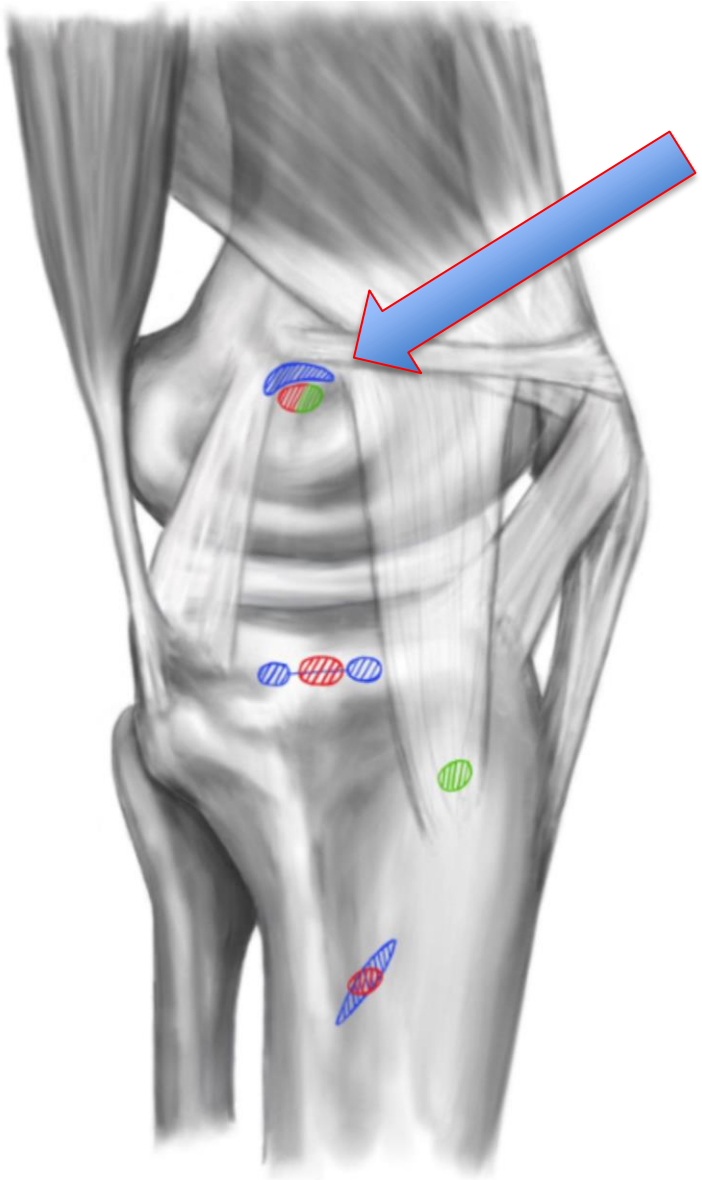
Results II: External rotation



Results III: Anterior tibial translation



Limitations



- Compromised fused insertion point (sMCL/dMCL)
- Intact POL, which is rarely part of the MCL complex injuries in ACL injuries[3, 4]
- ACL was left intact and transosseously refixed, assuming a “perfect ACL reconstruction”
- No dynamic muscle forces were analysed

Summary and Discussion

- A combined sMCL + dMCL injury significantly increases the load on an ACL reconstruction
- A Single-Bundle sMCL reconstruction was the least potent to reduce these forces
- An additional Anteromedial Reconstruction reduces the forces acting on the ACL compared to Single-Bundle sMCL reconstructions
- Biomechanically, there were no differences between the double-limbed tested reconstructions (modified Lind, double bundle sMCL + anteromedial reconstruction, flat sMCL + flat anteromedial reconstruction)

Conclusion

In a combined injury pattern of the sMCL and dMCL, adding an additional anteromedial limb to the MCL reconstruction “stress shields” an ACL reconstruction - potentially leading to reduced reconstruction failure rates.

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