Increased Internal Tibiofemoral Rotation is Associated with Anterolateral Ligament Injury and High-grade Pivot-shift in ACL-Injured Patients

Chilan B. G. Leite[1], Alexander Bumberger[1], Andre Giardino M. da Silva[2], Gergo Merkely[1], Richard Smith[1], Paulo V. P. Helito[3], Peter Asnis[4], Camilo P. Helito[2], Christian Lattermann[1]

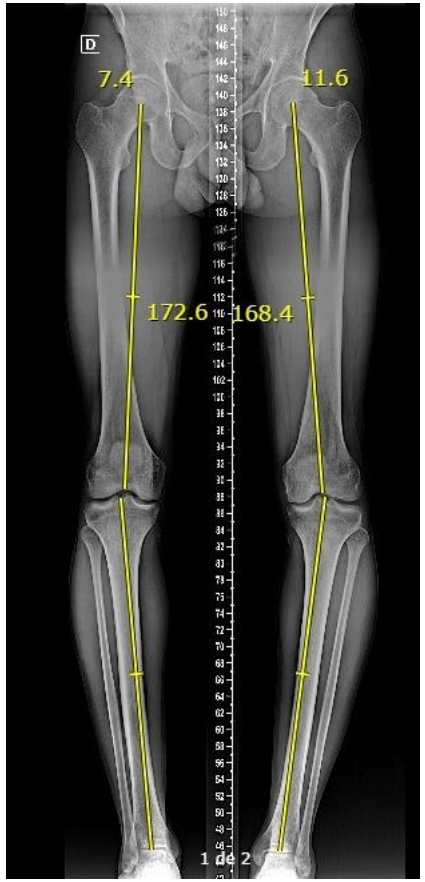
1 Department of Orthopedic Surgery, Center for Cartilage Repair and Sports Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA.
2 Instituto de Ortopedia e Traumatologia, Hospital Das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil
3 Aspetar Orthopaedic and Sports Medicine Hospital, Ad Dawhah, Doha, Qatar.
4 Department of Orthopaedic Surgery, Massachusetts General Hospital, Boston, MA, USA

DISCLOSURES

- The authors have no relevant disclosures.

BACKGROUND

Coronal and sagittal malalignment are well-known risk factors for ACL reconstruction (ACLR) failure.



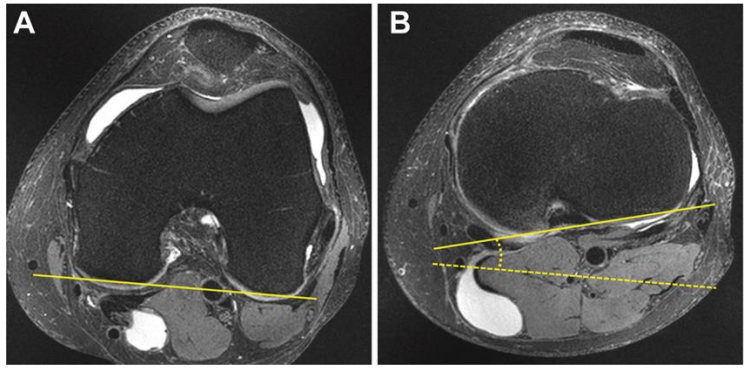
Recently, axial or rotational malalignment has been described as a possible risk factor for ACL revision.

Effect of Tibiofemoral Rotation Angle on Graft Failure After Anterior Cruciate Ligament Reconstruction

The American Journal of Sports Medicine

	Revision ACLR	Primary ACLR
	N=151	N=151
(p<.001)	Mean TFA: **5.8° ± 4.5°**	Mean TFA: **3.0° ± 3.3°**

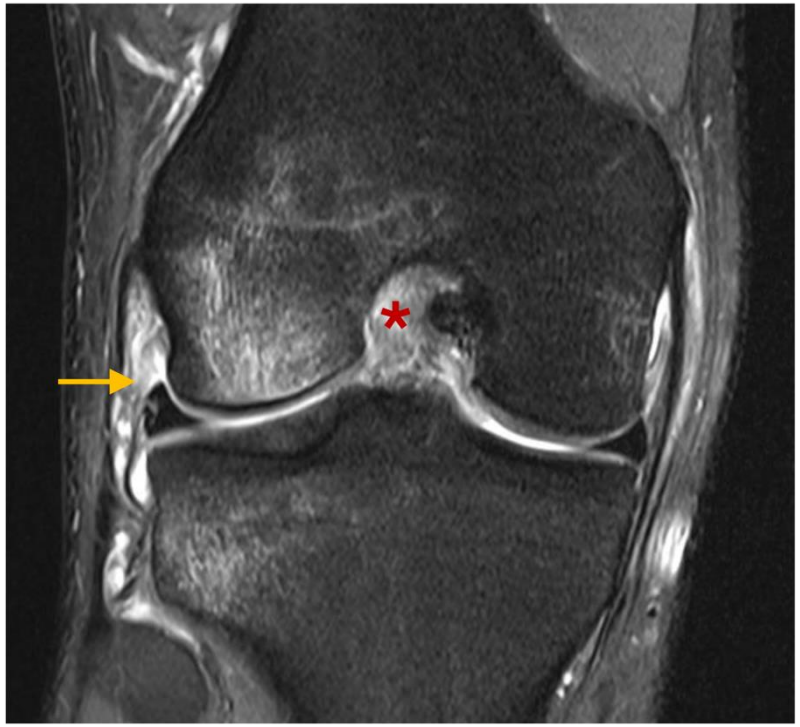
TFA ≥ 4.5° = 6.6x higher chance of ACLR revision (p<.001)



TFA = tibiofemoral rotation angle

BACKGROUND

The anterolateral ligament plays an important role in rotational control of the knee in patients with ACL injury.



ALL injury

Effect of Preoperative Anterolateral Ligament Injury on Outcomes After Isolated Acute ACL Reconstruction With Hamstring Graft

A Prospective Study With Minimum 5-Year Follow-up

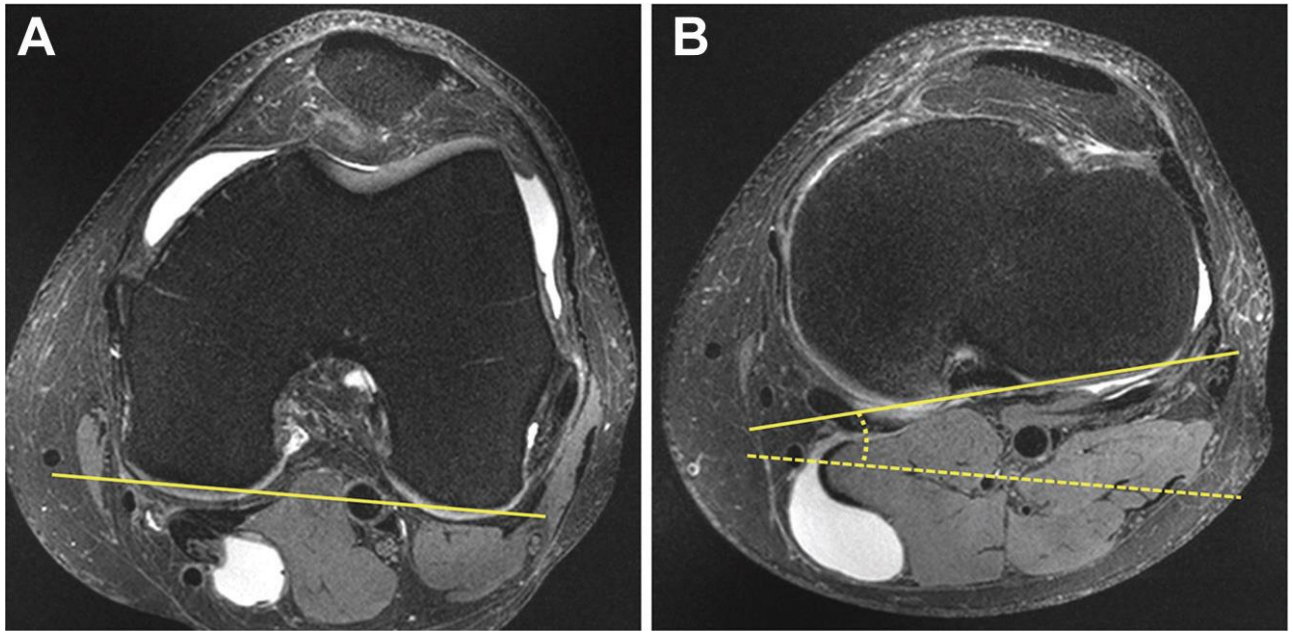
The American Journal of Sports Medicine

Preoperative MRI-detected ALL injury is associated with a higher risk of failure after isolated ACLR

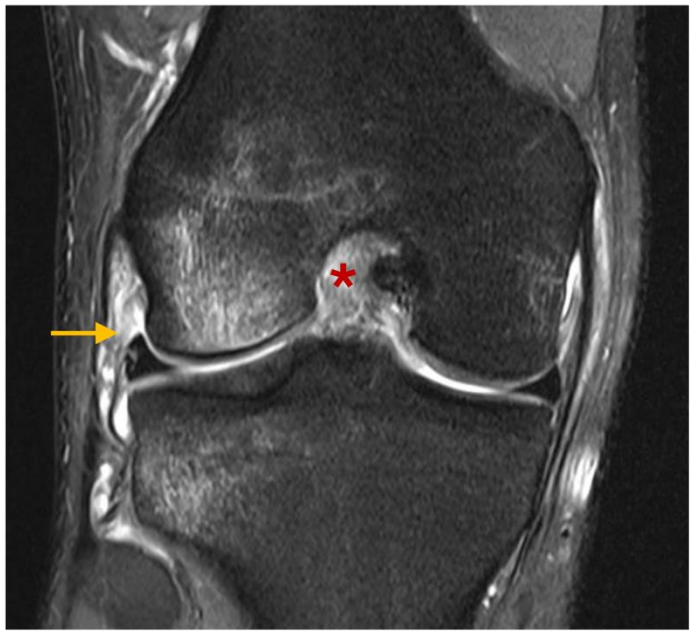
Patients with isolated ACLR		
ALL injury on preop MRI	**No ALL injury on preop MRI**	p=0.049
Failure = **14.3%**	Failure = **4.6%**	

AIM

To evaluate whether an increased TFA is related to ALL injury and a higher degree of pivot shift in patients with ACL injury.



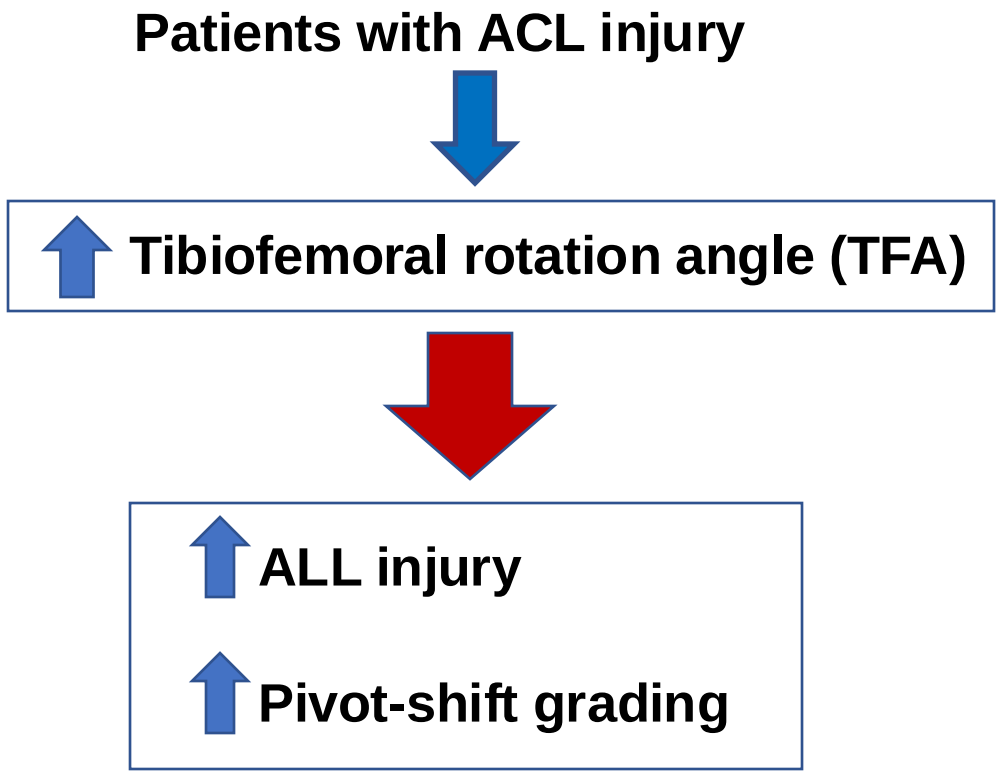
TFA = tibiofemoral rotation angle



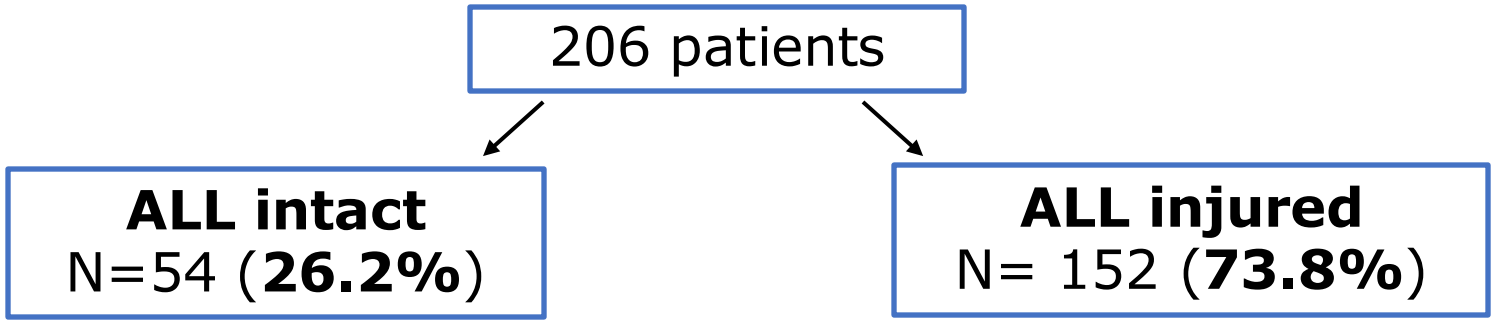
ALL injury

METHODS

- Multicenter cross-sectional study
- Medical records and MRI scans of patients with unilateral primary ACL injury were reviewed
- Demographics and pivot-shift grading were collected.
- Anterolateral ligament was identified on MRI coronal images and classified as intact or injured.
- TFA was measured on axial MRI.
- Optimal TFA cutoff associated with ALL injury was identified by a receiver operating characteristic (ROC) curve.



RESULTS

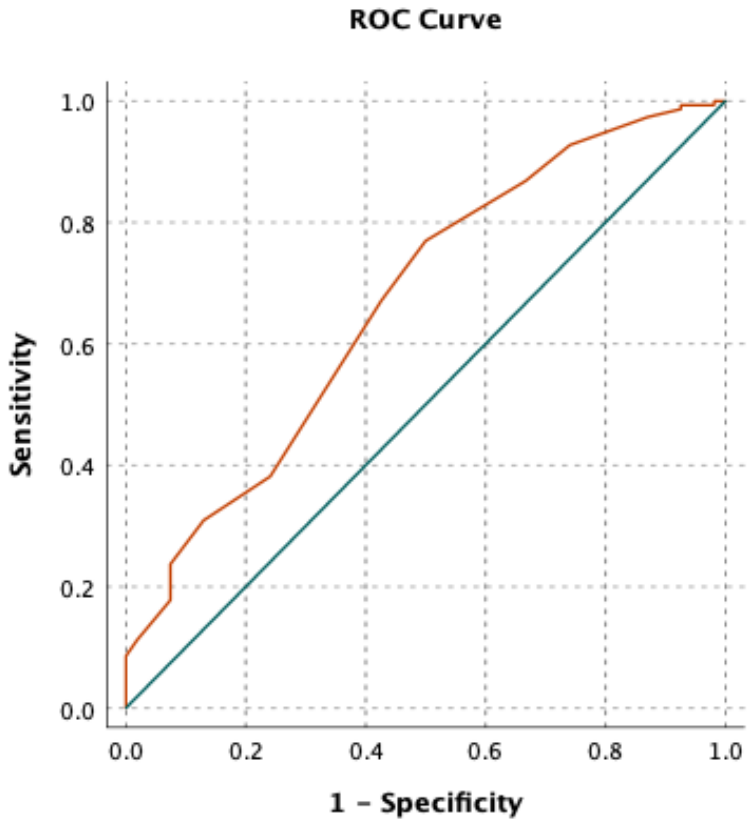


	Total (N = 206)	ALL injured (N = 152)	ALL intact (N = 54)	P value
Age, y	28.3 ± 11.3 (14 to 64)	28.6 ± 11.6 (15 to 64)	27.4 ± 10.5 (14 to 56)	0.599
Sex				**0.024**
Male	120 (58.3)	96 (63.2)	24 (44.4)	
Female	86 (41.7)	56 (36.8)	30 (55.6)	
Side				
Left/Right	107/99	83/69	24/30	0.209
Meniscal injury				0.106
Isolated lateral	43 (20.9)	36 (23.7)	7 (13.0)	
Isolated medial	38 (18.4)	25 (16.4)	13 (24.1)	
Lateral and medial	31 (15.0)	26 (17.1)	5 (9.3)	
Pivot-shift test				**<0.001**
Grade 1	34 (16.5)	4 (2.6)	30 (55.6)	
Grade 2	147 (71.4)	123 (80.9)	24 (44.4)	
Grade 3	25 (12.1)	25 (16.4)	0	
TFA	4.5 ± 3.8 (-7 to 16)	5.2 ± 3.6 (-2 to 16)	2.7 ± 3.5 (-7 to 10)	**<0.001**

Pivot-shift grade	Mean TFA
1	3.0 ± 4.1
2	4.7 ± 3.6
3	5.8 ± 3.8

p = 0.003

RESULTS



The optimal cutoff point of the TFA to predict ALL injury was 2.5° (sensitivity 77% / specificity 55%).

TFA ≥ **2.5°** (**OR** **3.34**, $p < 0.001$)

TFA ≥ **2.5° +** pivot shift **2 or 3** (**OR** **13.68**, $p < 0.001$)

CONCLUSION

- An increased tibiofemoral rotation angle (TFA) is associated with a higher prevalence of anterolateral ligament (ALL) injuries and a greater degree of pivot shift in patients with ACL injury.

- Patients with an TFA ≥ 2.5° were three times more likely to have an associated ALL injury, and this risk increases further when associated with a higher grade of pivot shift.

- The evaluation of the TFA in patients with ACL injury can guide the decision to include or exclude an extra-articular reinforcement in surgery.

REFERENCES

1. Ariel de Lima D, Helito CP, Lacerda de Lima L, de Castro Silva D, Costa Cavalcante ML, Dias Leite JA. Anatomy of the anterolateral ligament of the knee: a systematic review. Arthroscopy. 2019;35(2):670–81.
2. Bosco F, Giustra F, Masoni V, Capella M, Sciannameo V, Camarda L, et al. Combining an anterolateral complex procedure with anterior cruciate ligament reconstruction reduces the graft reinjury rate and improves clinical outcomes: a systematic review and meta-analysis of randomized controlled trials. Am J Sports Med. 2024;52:2129–47.
3. Caterine S, Litchfield R, Johnson M, Chronik B, Getgood A. A cadaveric study of the anterolateral ligament: re-introducing the lateral capsular ligament. Knee Surg Sports Traumatol Arthrosc. 2015;23(11):3186–95.
4. Claes S, Bartholomeeusen S, Bellemans J. High prevalence of anterolateral ligament abnormalities in magnetic resonance images of anterior cruciate ligament-injured knees. Acta Orthop Belg. 2014;80(1):45–9.
5. Ferretti A, Monaco E, Redler A, Argento G, De Carli A, Saithna A, et al. High prevalence of anterolateral ligament abnormalities on MRI in knees with acute anterior cruciate ligament injuries: a case-control series from the SANTI study group. Orthop J Sports Med. 2019;7(6):2325967119852916.
6. Helito CP, Demange MK, Helito PVP, Costa HP, Bonadio MB, Pecora JR, et al. Avaliação do ligamento anterolateral do joelho por meio de exame de ressonância magnética. Rev Bras Ortop. 2015;50(2):214–9.
7. Helito CP, Helito PVP, Bonadio MB, Pécora JR, Bordalo-Rodrigues M, Camanho GL, et al. Correlation of magnetic resonance imaging with knee anterolateral ligament anatomy: a cadaveric study. Orthop J Sports Med. 2015;3(12):2325967115621024.
8. Helito CP, Helito PVP, Costa HP, Demange MK, Bordalo-Rodrigues M. Assessment of the anterolateral ligament of the knee by magnetic resonance imaging in acute injuries of the anterior cruciate ligament. Arthroscopy. 2017;33(1):140–6.
9. Helito PVP, Helito CP, Rodrigues MB. Anterolateral ligament MRI of the knee in ACL injuries: MRI abnormalities association with instability. Eur Radiol. 2023;33(2):1456–64.
10. Leite CBG, Merkely G, Farina EM, Smith R, Görtz S, Hazzard S, et al. Effect of tibiofemoral rotation angle on graft failure after anterior cruciate ligament reconstruction. Am J Sports Med. 2023;51(9):2291–9.
11. Sobrado MF, Giglio PN, Bonadio MB, Helito PVP, Guimarães TM, Pécora JR, et al. Outcomes after isolated acute anterior cruciate ligament rupture treatment versus combined ACL and lateral tenodesis. Orthop J Sports Med. 2021;9(10):23259671211040227.
12. Sonnery-Cottet B, Cavaignac E, Nogier A, Lucas A, Lefevre N, Saffarini M, et al. Anterolateral ligament reconstruction for chronic ACL deficiency: a systematic review and meta-analysis of 10 studies with 716 patients. Orthop J Sports Med. 2021;9(10):2325967121102452.
13. Weber AE, Salim-Salah A, Manzoli L, Ferrari L, Alezi N, Rogge T, et al. Combined anterior cruciate ligament and anterolateral ligament reconstruction yields better outcomes than isolated anterior cruciate ligament reconstruction: a meta-analysis of 25 studies with 1,100 patients. Knee Surg Sports Traumatol Arthrosc. 2021;29(5):1599–608