



# Intra-Articular Femorotibial Rotation is Associated with Tibial Tubercle – Trochlear Groove Distance

Nicolas Pascual-Leone, BA

Amirhossein Jahandar, MS

Ryann Davie, MD

Joshua Bram, MD

Danielle E. Chipman, BS

Carl W. Imhauser, PhD

Daniel W. Green, MD, MS, FACS, FAAP

Hospital for Special Surgery,

New York, NY, USA



ISAKOS

## NO RELEVANT DISCLOSURES

- **Daniel W. Green**

Board or committee member: AAOS, NY County Medical Society, NYS Society of Orthopedic Surgeons, PatelloFemoral Foundation, POSNA, PRiSM

Paid presenter or speaker: AO Trauma International, Arthrex, Inc.

Paid consultant: Arthrex, Inc.

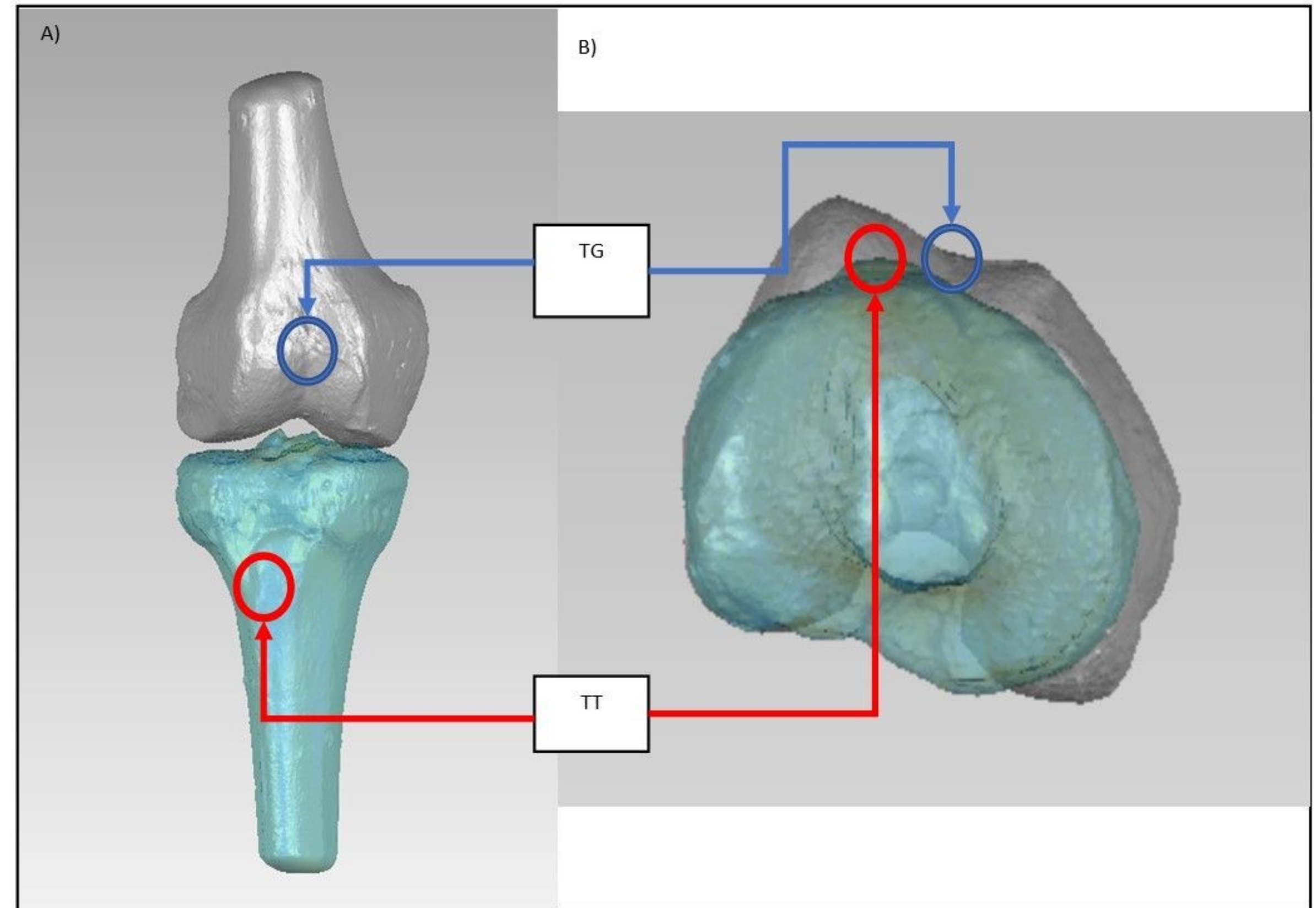
Editorial or governing board: Current Opinion in Pediatrics

IP royalties: Arthrex, Inc., Pega Medical

Publishing royalties, financial or material support: Wolters Kluwer Health - Lippincott Williams & Wilkins, Current Opinion in Pediatrics

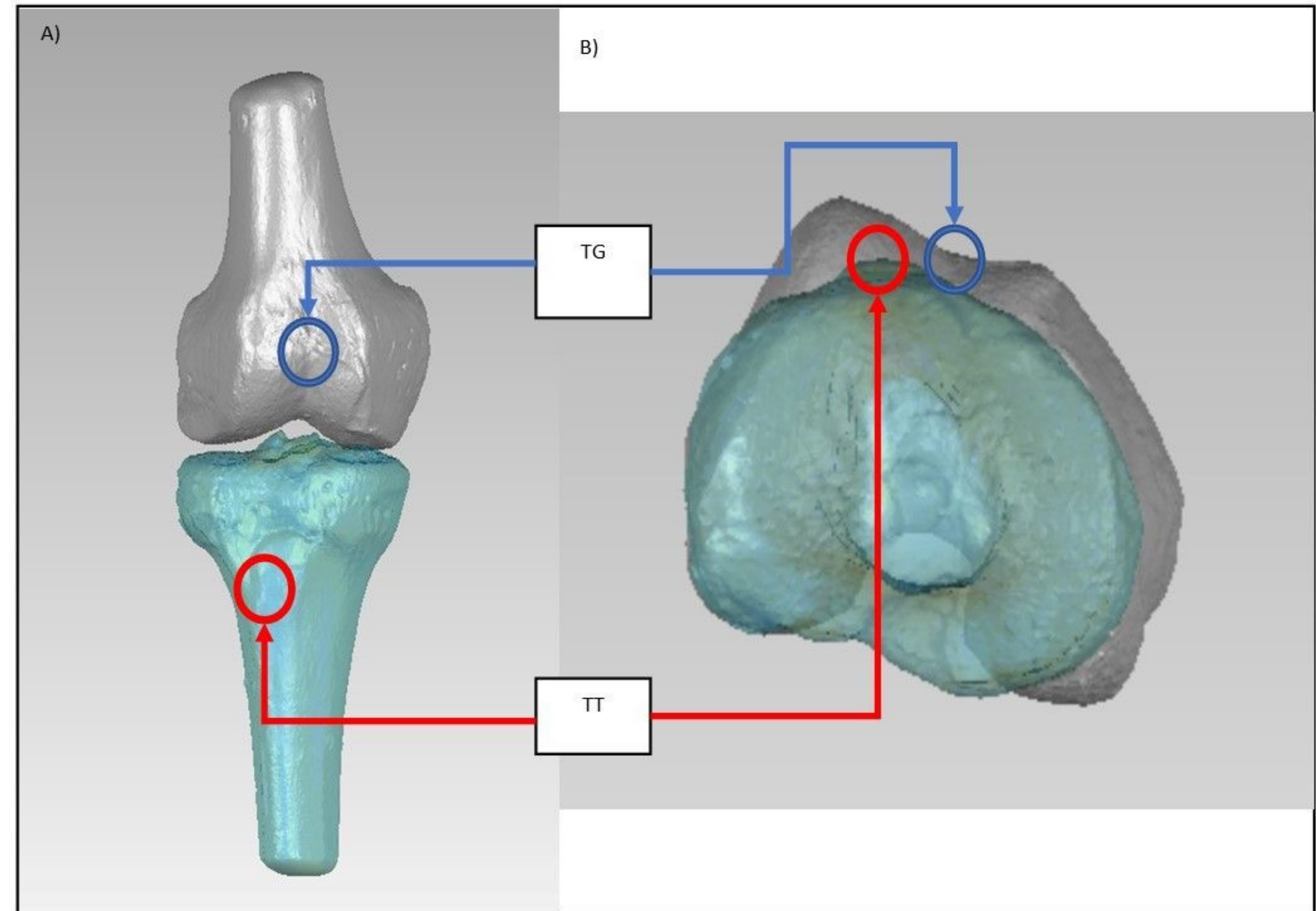
# Objectives

- A tibial tubercle-trochlear groove (TT-TG) distance of 20 mm is typically used when determining whether tibial tubercle anteromedialization (AMZ) is needed for patellar instability
- TT-TG distance, however, may depend on the internal/external (IE) rotation of the tibia in relation to the femur, which is typically not controlled for



# Objectives

- Without knowledge of the variability in an individual's TT-TG influenced by femorotibial rotation, the use of a specific TT-TG distance during pre-operative planning for patellar instability may lead to incorrect decisions on the use of tibial tubercle AMZ
- **Hypothesis:** Knee joint IE rotation is related to the TT-TG distance



- 8 independent human cadaveric knee specimens were utilized
  - Mean age =  $32 \pm 6$  years
  - 4 males, 4 females
- A robotic manipulator (ZX165U, Kawasaki Robotics, Wixom, MI, USA) instrumented with a universal force/moment sensor was used to determine knee joint internal/external (IE) rotation under applied moments of  $\pm 5$ Nm at full extension
- Two independent reviewers selected the trochlear groove and tibial tuberosity points on CT images of each specimen to define TT-TG (ICC=0.969)
- To determine the influence of knee joint IE rotation on TT-TG, 3D models generated from CT scans were registered to tibiofemoral kinematics
- Linear regression was performed to determine the relationship between knee joint IE rotation and TT-TG
- Regression coefficient and standard error of measurement ( $\alpha=0.05$ ), and coefficient of determination ( $r^2$ ) were reported

**Table 1.** Inter-class Correlation on the Calculated TT-TG for Each Specimen.

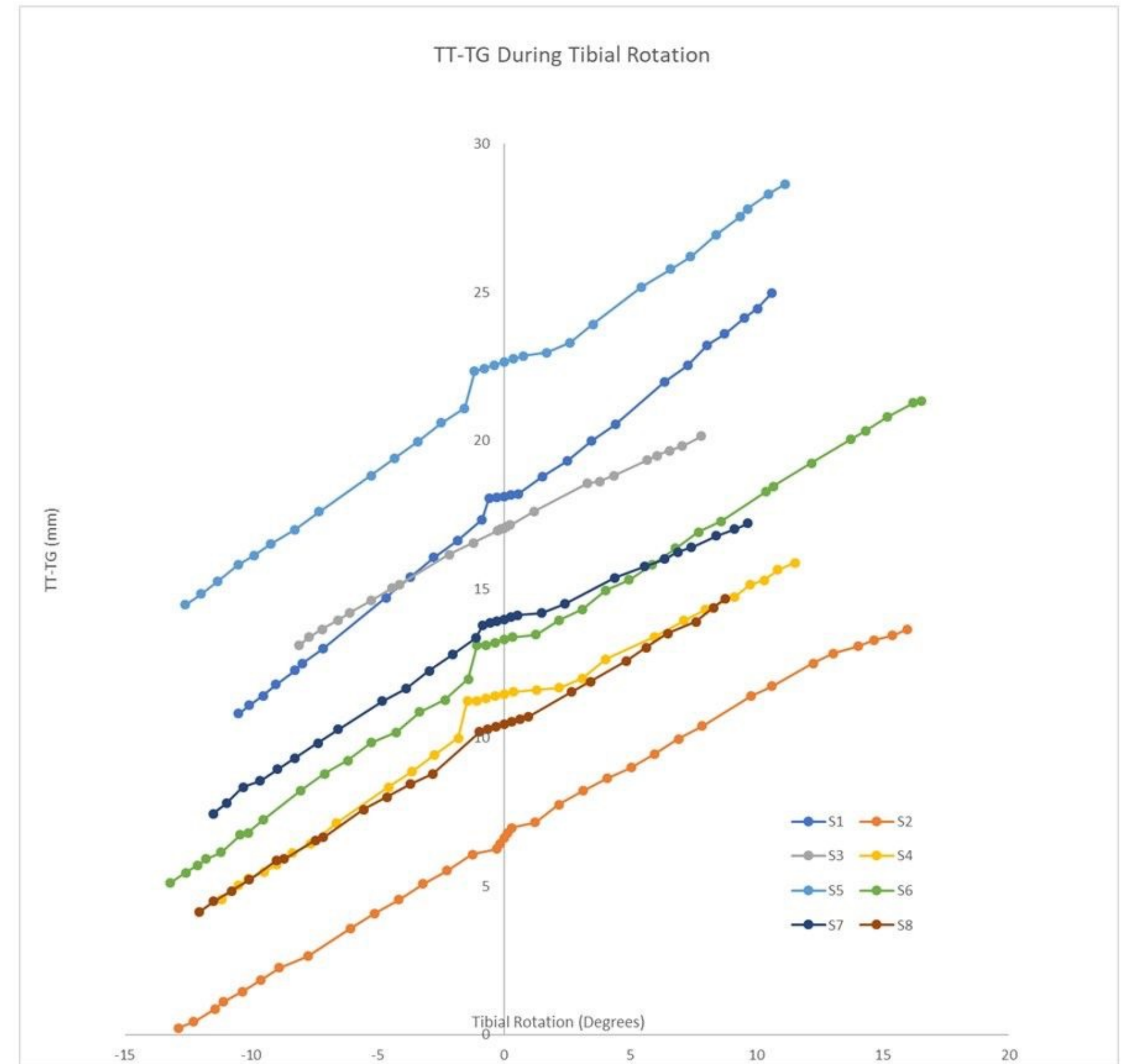
Specimen	TT-TG ICC
1	0.842
2	0.995
3	0.503
4	0.748
5	0.982
6	0.996
7	0.632
8	0.955

**Table 2.** Rotation data for each specimen demonstrating TT-TG, rotation, and change in TT-TG per degree of rotation.

Specimen	Average Range of TT-TG (mm)	Range of Rotation (°)	Average Slope (mm/°)	Alpha (mm)	
1	14.1	21.1	0.66	17.9	
2	13.4	28.9	0.48	6.5	
3	7.0	15.9	0.44	16.9	
4	11.3	22.7	0.50	10.7	
5	14.2	23.8	0.59	22.1	
6	16.2	29.8	0.55	12.7	
7	9.9	21.2	0.46	13.4	
8	10.6	20.9	0.49	10.3	
All Specimens	Mean $\pm$ SD	12.1 $\pm$ 28	23.0 $\pm$ 4.2	0.52 $\pm$ 0.07	13.8 $\pm$ 4.6

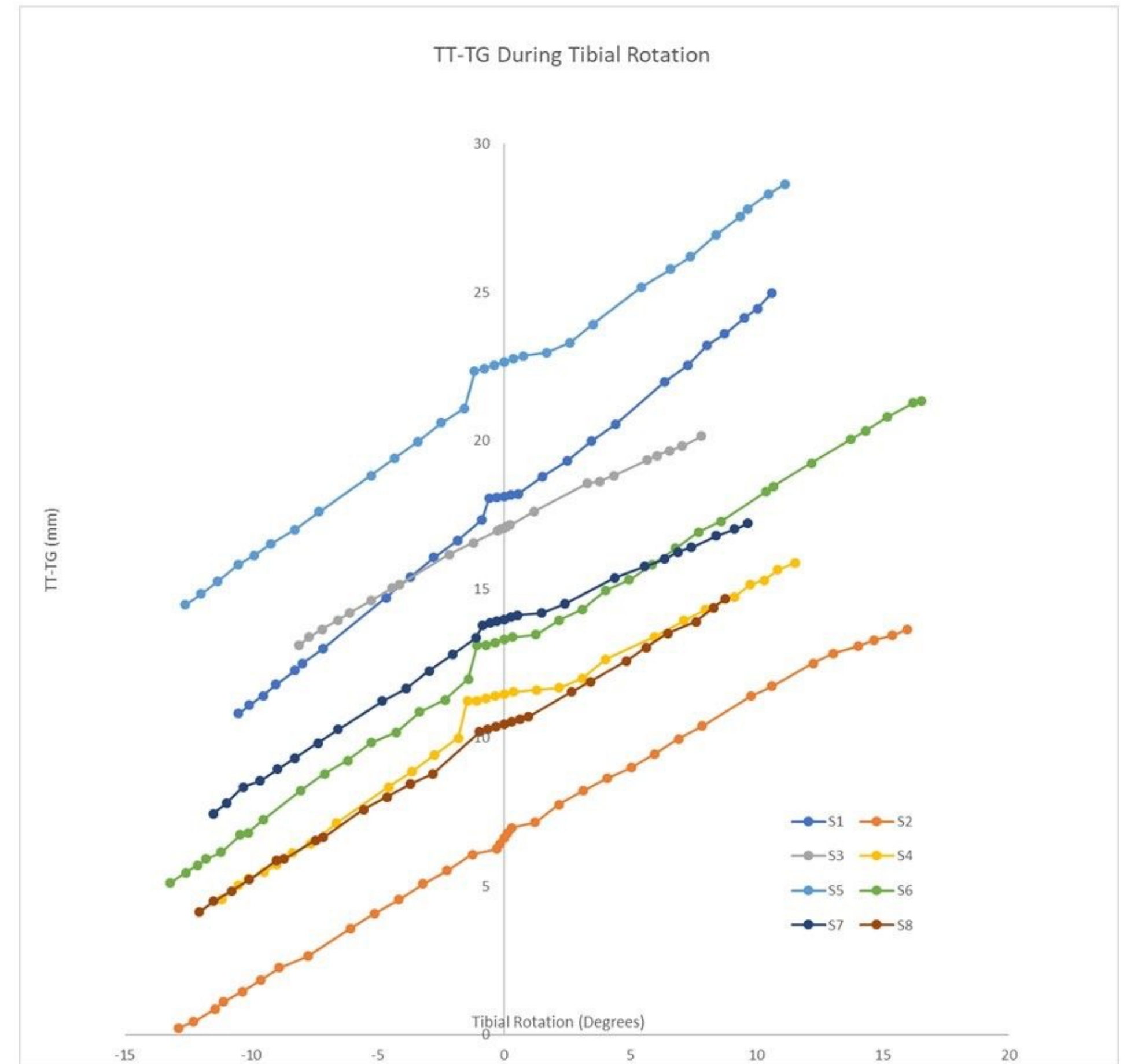
# Results

- Knee joint IE rotation averaged  $23.0 \pm 4.2^\circ$
- TT-TG changed by  $12.1 \pm 2.8$  mm over this range
- For every degree of knee joint IE rotation, TT-TG changed by  $0.52 \pm 0.07$  mm ( $p < 0.001$  and  $r^2 > 0.987$ )
- At neutral rotation, the TT-TG averaged  $14.21 \pm 5.0$  mm



# Conclusion

- TT-TG was highly dependent on knee joint IE rotation changing by 0.52 mm for every degree of knee joint IE rotation
- An offset in IE rotation of 10° would lead to a change in TT-TG of 5.2 mm, enough to alter surgical decision making for or against tibial tubercle AMZ
- Physicians should pay close attention to knee joint IE rotation when measuring TT-TG in their patients, specifically in patients found to have a TT-TG near 20 mm, a key indication for surgical treatment of patellar instability





# Thank you!



**Contact Information:** Daniel W. Green, [greendw@hss.edu](mailto:greendw@hss.edu)



**ISAKOS**



# References

- Camathias C, Pagenstert G, Stutz U, Barg A, Müller-Gerbl M, Nowakowski AM. The effect of knee flexion and rotation on the tibial tuberosity–trochlear groove distance. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2016;24(9):2811-2817. doi:10.1007/s00167-015-3508-9
- Worden A, Kaar S, Owen J, Cutuk A. Radiographic and Anatomic Evaluation of Tibial Tubercle to Trochlear Groove Distance. *J Knee Surg*. 2015;29(07):589-593. doi:10.1055/s-0035-1569478
- Smith B, Millar E, Jones K, Elias J. Variations in Tibial Tuberosity to Trochlear Groove and Posterior Cruciate Ligament Distances due to Tibial External and Valgus Rotations. *J Knee Surg*. 2018;31(06):557-561. doi:10.1055/s-0037-1604444
- Imhauser C, Mauro C, Choi D, et al. Abnormal Tibiofemoral Contact Stress and Its Association With Altered Kinematics After Center-Center Anterior Cruciate Ligament Reconstruction. *Am J Sports Med*. 2013;41(4):815-825. doi:10.1177/0363546512475205
- Viidik A. Functional Properties of Collagenous Tissues. In: ; 1973:127-215. doi:10.1016/B978-0-12-363706-2.50010-6
- Marom N, Jahandar H, Fraychineaud TJ, et al. Lateral Extra-articular Tenodesis Alters Lateral Compartment Contact Mechanics under Simulated Pivoting Maneuvers: An In Vitro Study. *Am J Sports Med*. 2021;49(11):2898-2907. doi:10.1177/03635465211028255
- Camp CL, Jahandar H, Sinatro AM, Imhauser CW, Altchek DW, Dines JS. Quantitative Anatomic Analysis of the Medial Ulnar Collateral Ligament Complex of the Elbow. *Orthop J Sports Med*. 2018;6(3):232596711876275. doi:10.1177/2325967118762751
- Grood ES, Suntay WJ. A Joint Coordinate System for the Clinical Description of Three-Dimensional Motions: Application to the Knee. *J Biomech Eng*. 1983;105(2):136-144. doi:10.1115/1.3138397
- Mohammadinejad P, Shekarchi B. Value of CT scan-assessed tibial tuberosity–trochlear groove distance in identification of patellar instability. *Radiol Med*. 2016;121(9):729-734. doi:10.1007/s11547-016-0647-0
- Tanaka MJ, Elias JJ, Williams AA, Carrino JA, Cosgarea AJ. Correlation Between Changes in Tibial Tuberosity–Trochlear Groove Distance and Patellar Position During Active Knee Extension on Dynamic Kinematic Computed Tomographic Imaging. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*. 2015;31(9):1748-1755. doi:10.1016/j.arthro.2015.03.015
- Song EK, Seon JK, Kim MC, Seol YJ, Lee SH. Radiologic Measurement of Tibial Tuberosity-Trochlear Groove (TT-TG) Distance by Lower Extremity Rotational Profile Computed Tomography in Koreans. *Clin Orthop Surg*. 2016;8(1):45. doi:10.4055/cios.2016.8.1.45