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Boston
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June 18–June 21

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Title: Equation Predicting Change in Tibial-Tuberosity to Trochlear-Groove (TT-TG) Distance Following Tibial Supratubercle Osteotomy

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Disclosures:

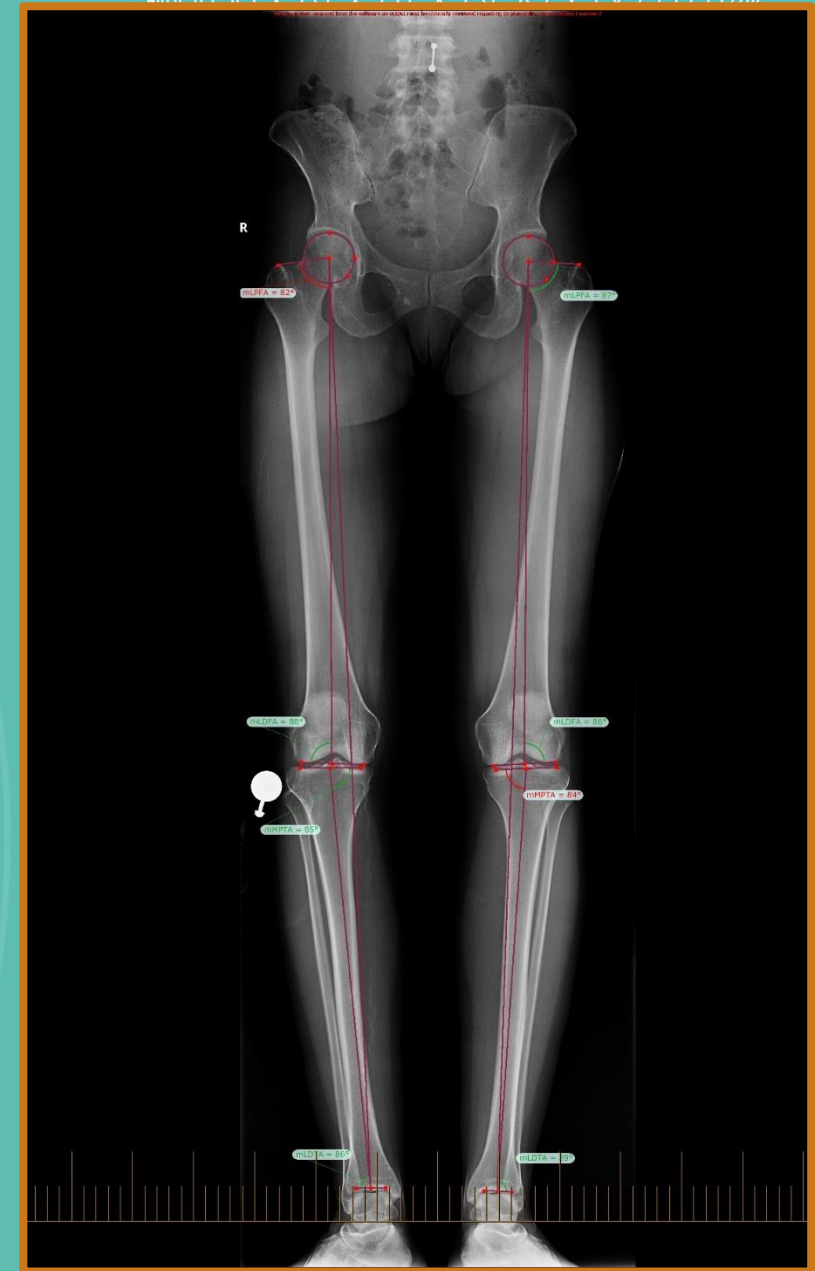
All authors have no conflicts of interest to disclose.



INTRODUCTION

- Supratubercle tibial rotational osteotomy: useful adjunct for treating patellar instability.
- Simultaneously addresses increased tibial-tuberosity to trochlear groove (TTTG) distance and excessive external tibial torsion
- Jud et al. (AJSM, 2020): 1° IR = ~ 0.68 mm decrease TTTG

Objective: Derive a novel, anatomically individualized equation to accurately predict Δ TTTG from pre-operative CT scans.



METHODS

4 VARIABLE EQUATION:

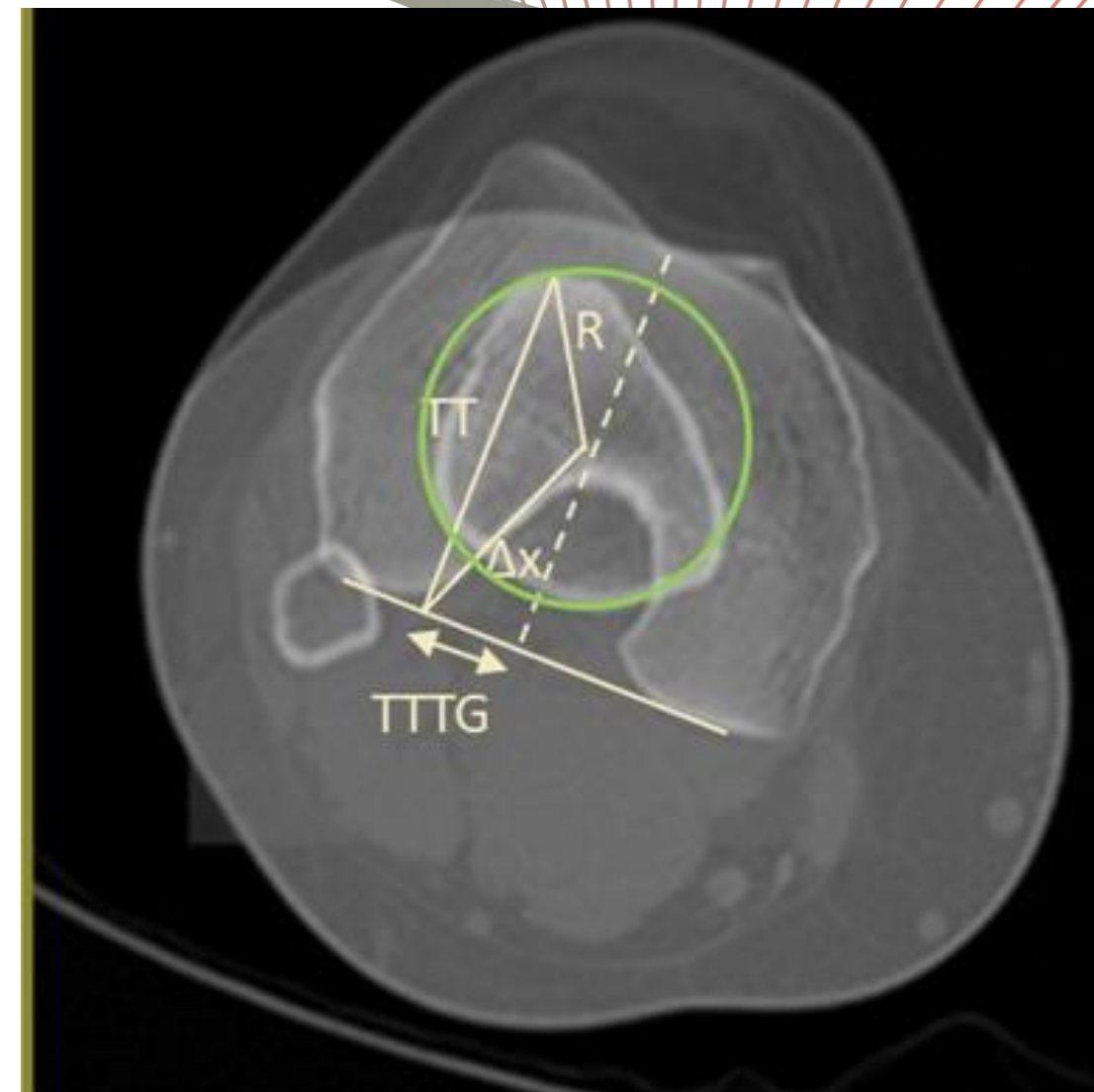
The corrected change in length of TTTG, can be more accurately estimated as:

$$\Delta TTTG' = \sqrt{2R^2(1 - \cos(\alpha))} * \cos\left(\cos^{-1}\left(\frac{R^2 + TT^2 - \Delta x^2}{2R(TT)}\right) - \frac{\alpha}{2}\right)$$

COMPARISON WITH LINEAR RELATIONSHIP AND 'TRUE' VALUE:

Compared 2 methods to compute the $\Delta TTTG$ to the 'True' change in TTTG (simulated radiographically):

1. 4-Variable Equation
 2. Jud et al. Proportion: $\Delta TTTG = 0.68(\alpha)$
- 2-independent reviewers: measured with IntelViewer 4.14.1
 - Statistical analysis with SPSS (IBM, Armonk NY): 1-way ANOVA & Student's t-tests



METHODS


PATIENT SELECTION

- 37 patients known for miserable malalignment syndrome (MMS) underwent simulated de-rotations of 5, 10 and 15° for both knees
→ $N = 222$ total CT images
- Inclusion criteria:
 - Age: 12-21 years
 - Any gender
 - Bilateral pre-operative 3D-CT scans
 - Clinical diagnosis of lower limb torsional deformities
- Exclusion criteria:
 - Incomplete medical charts or imaging
 - Other MSK diagnoses (cerebral palsy, arthrogryposis)



RESULTS

PATIENT DEMOGRAPHICS

- 37 patients
 - n = 222 simulated derotations
 - ♂ – 3 Male
 - ♀ – 34 Female
- 
- Average age: 15.7 ± 1.86 years

Example Pt #17 Rt knee:

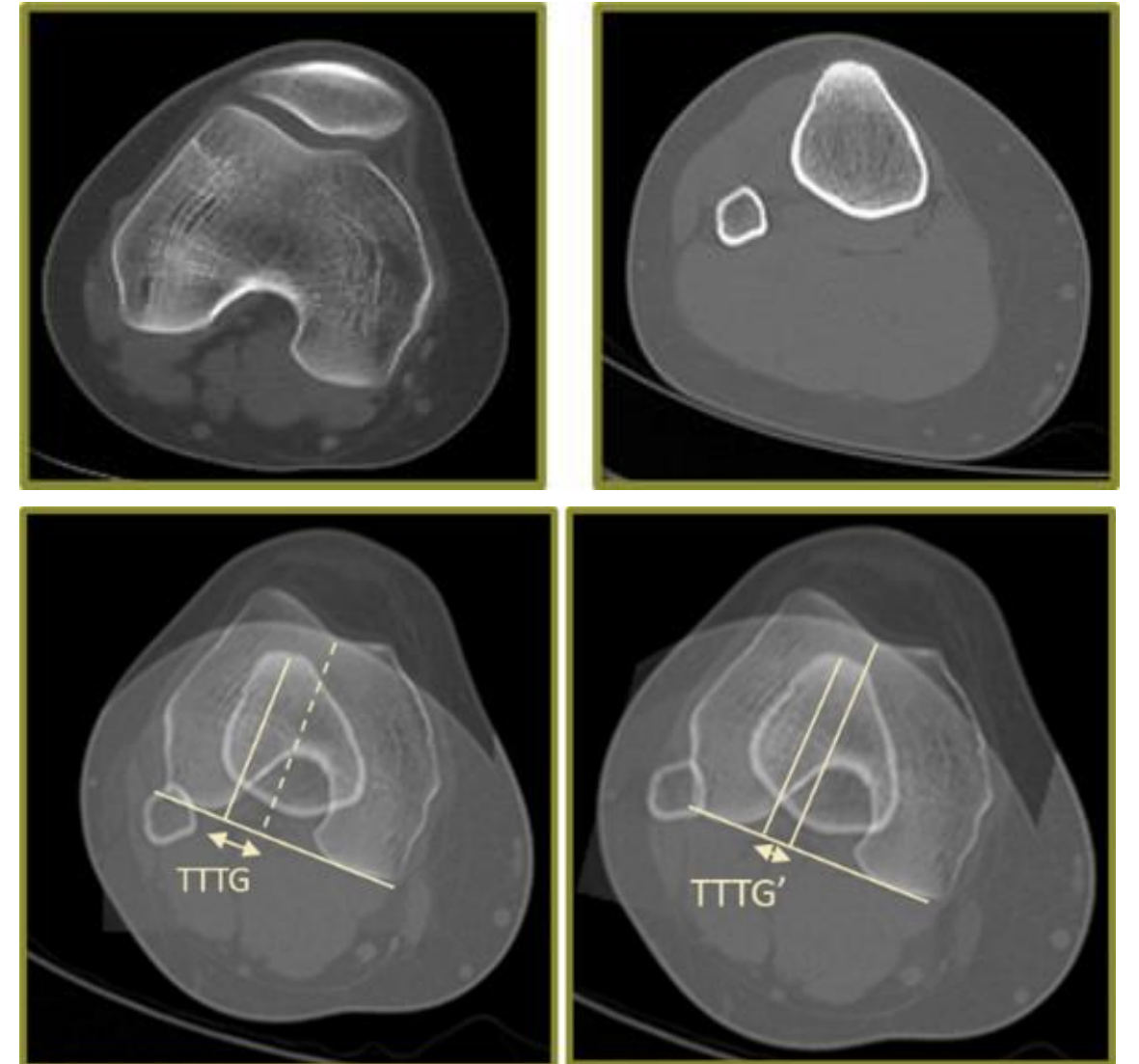
(A) Axial CT cross-section:

- Left: femur at the level of the femoral condyles
- Right: level of the tibial tuberosity

(B) TTTG measurement:

- Left: at 0° pre-correction
- Right: post-derotation of 15°

SIMULATED DEROTATION (Pt #17)



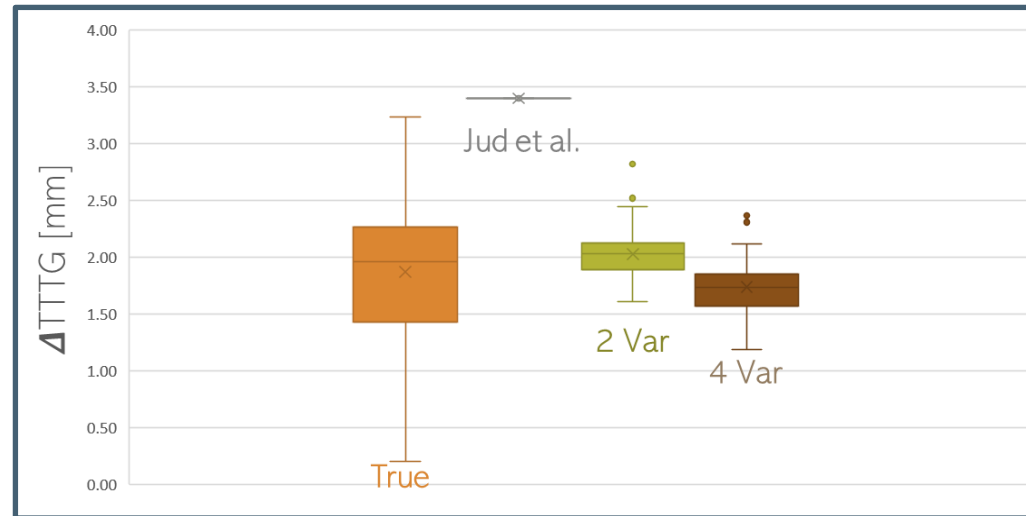
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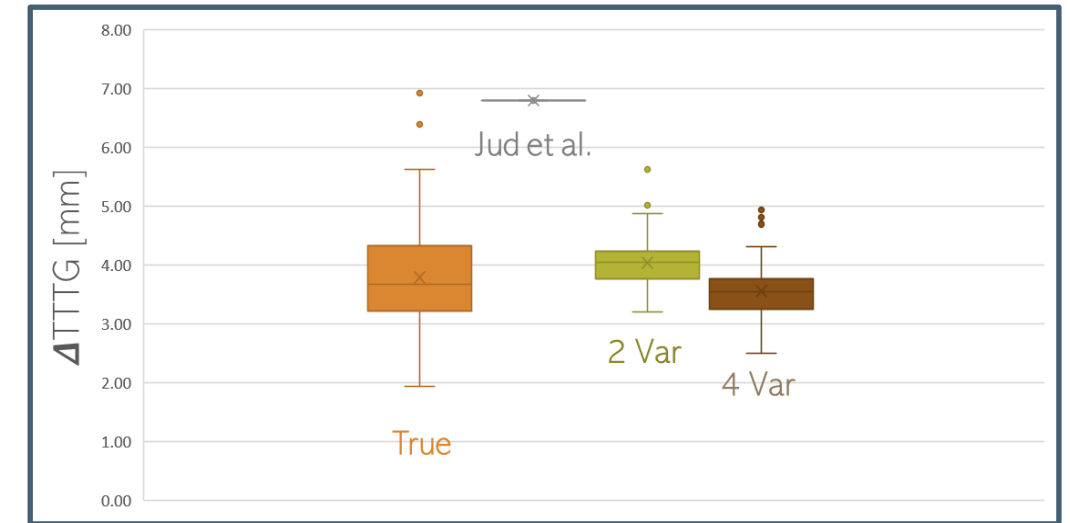
RESULTS: Δ TTG COMPARISON

5° Derotation



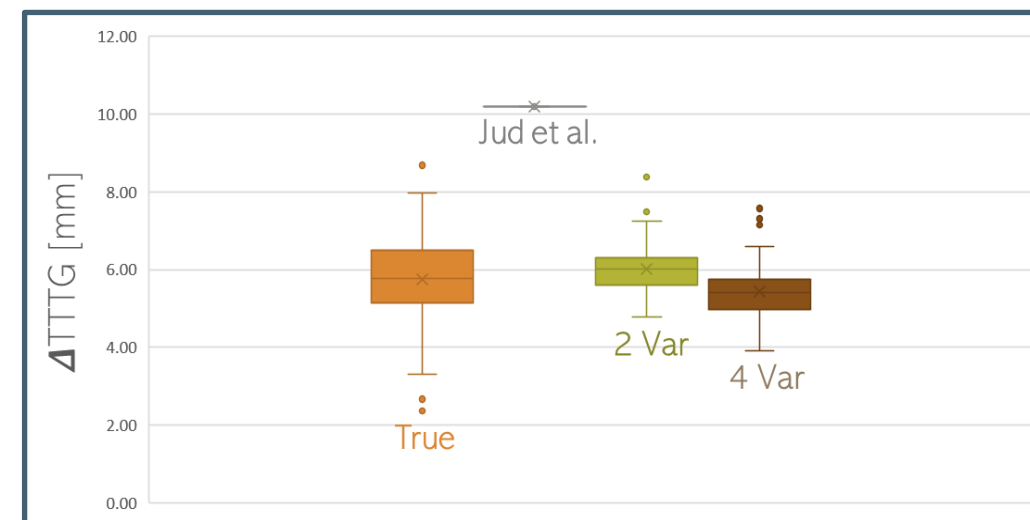
Student t-test	p-value
True v. Jud	<0.00001
True v. 2 Var	0.0515
True v. 4 Var	0.1032

10° Derotation



Student t-test	p-value
True v. Jud	<0.00001
True v. 2 Var	0.0515
True v. 4 Var	0.1032

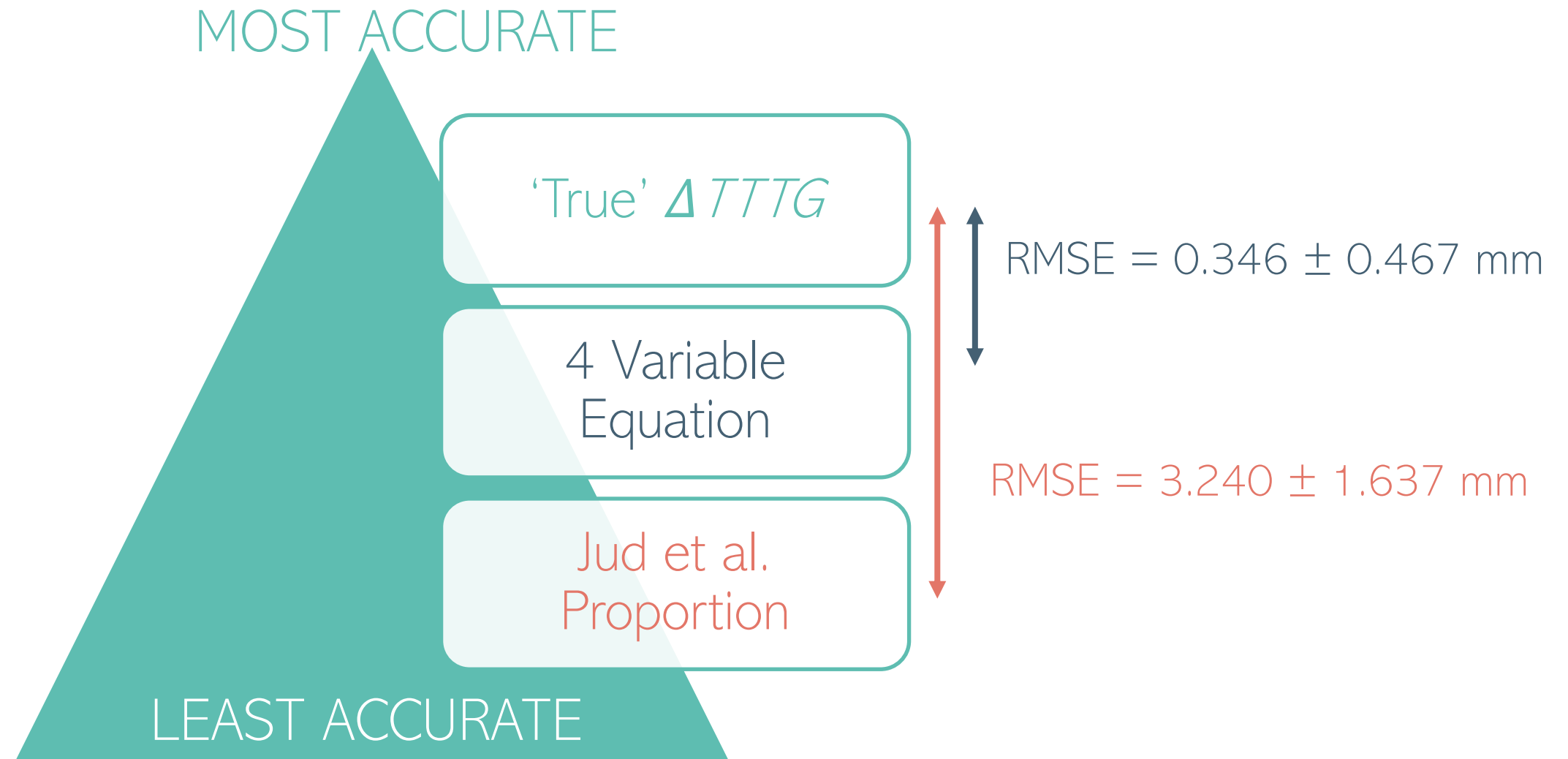
15° Derotation



Student t-test	p-value
True v. Jud	<0.00001
True v. 2 Var	0.0948
True v. 4 Var	0.0588

RESULTS

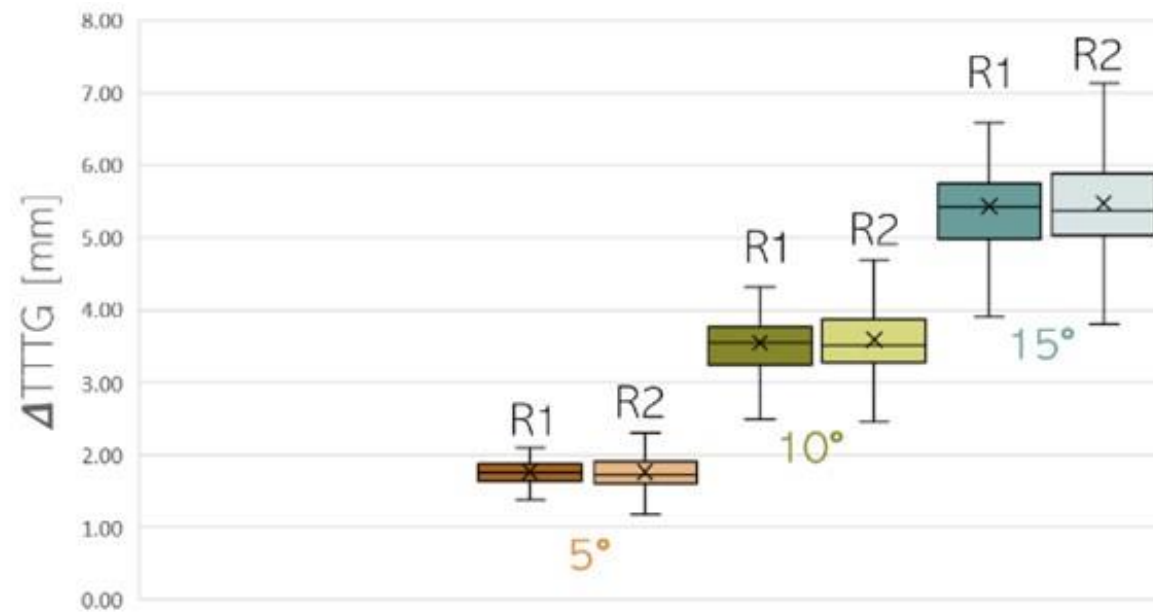
COMPARISON OF 4-VARIABLE, LINEAR RELATIONSHIP & “TRUE” RADIOGRAPHIC MEASUREMENTS



RESULTS

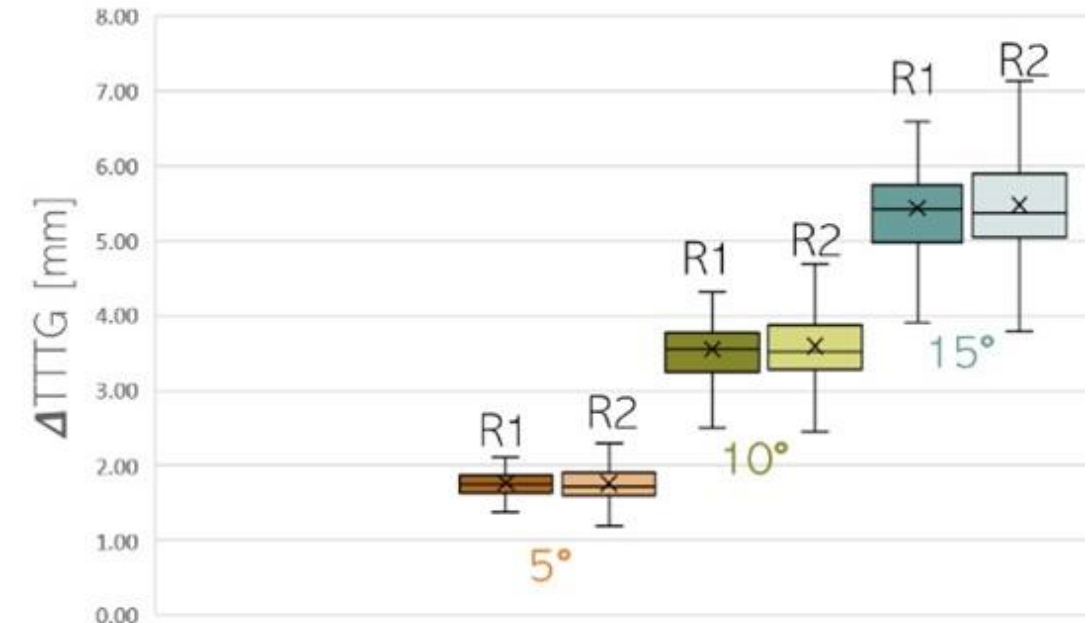
RATER VALIDATION FOR 4-VARIABLE EQUATION

INTER-RATER VARIABILITY



Student t-test	p-value
5°	0.952
10°	0.979
15°	0.908

INTRA-RATER VARIABILITY



Student t-test	p-value
5°	0.496
10°	0.600
15°	0.716

No statistically significant difference for inter- and intra-rater variability!



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CONCLUSIONS

OUTCOMES

1. 4-variable equation had the lowest RMSE for $\Delta TTTG$
2. “True” and 4-variable: no statistically significant difference for 5, 10 & 15° derotations
3. “True” values were statistically significant different from Jud et al. values for all derotation angles ($p < 0.001$)
4. Intra- and inter- rater analyses: no statistically significant difference for 4-variable equation

LIMITATIONS:

1. Radiographic proof of concept study
2. Soft tissue factors not considered
3. Assumptions may not hold true in real world settings given lack of clinical post-operative assessments

ULTIMATE GOALS:

Improve surgical planning and patient outcomes by:

- Using an accurate and precise formula to predict $\Delta TTTG$
- Account for unique differences in patient anatomy in predicting post-operative correction



REFERENCES

1. Balcarek P, Radebold T, Schulz X, Vogel D. Geometry of Torsional Malalignment Syndrome: Trochlear Dysplasia but Not Torsion Predicts Lateral Patellar Instability. *Orthop J Sport Med.* 2019;7.
2. Bruce WD, Stevens PM. Surgical correction of miserable malalignment syndrome. *J Pediatr Orthop.* 2004;24:392-396.
3. Cameron JC, Saha S. External Tibial Torsion. *Clin Orthop Relat Res.* 1996;177-184.
4. Christensen TC, Sanders TL, Pareek A, Mohan R, Dahm DL, Krych AJ. Risk Factors and Time to Recurrent Ipsilateral and Contralateral Patellar Dislocations. *Am J Sports Med.* 2017;45:2105-2110.
5. Dickschas J, Tassika A, Lutter C, Harrer J, Strecker W. Torsional osteotomies of the tibia in patellofemoral dysbalance. *Arch Orthop Trauma Surg.* 2017;137:179-185.
6. Drexler M, Dwyer T, Dolkart O, Goldstein Y, Steinberg EL, Chakraverty R, Cameron JC. Tibial rotational osteotomy and distal tuberosity transfer for patella subluxation secondary to excessive external tibial torsion: surgical technique and clinical outcome. *Knee Surgery, Sport Traumatol Arthrosc.* 2014;22:2682-2689.
7. Fan C, Yang D, Niu Y, Xu Y, Li M, Feng X, Wang F. Clinical Outcomes in Soft Tissue Repair Surgery With and Without Femoral Derotation Osteotomy for Patellar Dislocation : A Retrospective Study. *Res Sq.* 2020:1-20.
8. Gulati A, McElrath C, Wadhwa V, Shah JP, Chhabra A. Current clinical, radiological and treatment perspectives of patellofemoral pain syndrome. *Br J Radiol.* 2018;91.
9. Haj Zargarbashi R, Nasiri Bonaki H, Zadegan SA, Nabian MH, Abdi R, Vafaei A. Comparison of Pediatric and General Orthopedic Surgeons' Approaches in Management of Blount's Disease and Torsional Malalignment Syndrome. *Shafa Orthop J.* 2017;4.
10. Hiemstra LA, Kerslake S, Loewen M, Lafave M. Effect of trochlear dysplasia on outcomes after isolated soft tissue stabilization for patellar instability. *Am J Sports Med.* 2016;44:1515-1523.
11. Jud L, Singh S, Tondelli T, Fürnstahl P, Fucentese SF, Vlachopoulos L. Combined Correction of Tibial Torsion and Tibial Tuberosity–Trochlear Groove Distance by Supratuberositary Torsional Osteotomy of the Tibia. *Am J Sports Med.* 2020;48:2260-2267.
12. Lin KM, James EW, Aitchison AH, Schlichte LM, Wang G, Green DW. Increased tibiofemoral rotation on MRI with increasing clinical severity of patellar instability. *Knee Surgery, Sport Traumatol Arthrosc.* 2021.
13. Nakamura S, Shima K, Kuriyama S, Nishitani K, Ito H, Matsuda S. Tibial Tubercle-Trochlear Groove Distance Influences Patellar Tilt After Total Knee Arthroplasty. *J Arthroplasty.* 2019;34:3080-3087.
14. Parikh S, Noyes FR. Patellofemoral disorders: Role of computed tomography and magnetic resonance imaging in defining abnormal rotational lower limb alignment. *Sports Health.* 2011;3:158-169.
15. Prakash J, Seon JK, Ahn HW, Cho KJ, Im CJ, Song EK. Factors affecting tibial tuberosity-trochlear groove distance in recurrent patellar dislocation. *CiOS Clin Orthop Surg.* 2018;10:420-426.
16. Purohit N, Hancock N, Saifuddin A. Surgical management of patellofemoral instability. I. Imaging considerations. *Skeletal Radiol.* 2019;48:859-869.
17. Strecker W, Dickschas J. Torsional osteotomy: Operative treatment of patellofemoral maltracking [German]. *Oper Orthop Traumatol.* 2015;27:505-524.
18. Tanaka MJ, D'Amore T, Elias JJ, Thawait G, Demehri S, Cosgarea AJ. Anteroposterior distance between the tibial tuberosity and trochlear groove in patients with patellar instability. *Knee.* 2019;26:1278-1285.
19. Teitge RA. The power of transverse plane limb mal-alignment in the genesis of anterior knee pain—clinical relevance. *Ann Jt.* 2018;3:70-70.
20. Xu Z, Zhang H, Chen J, Mohamed SI, Zhou A. Femoral Anteversion Is Related to Tibial Tubercle-Trochlear Groove Distance in Patients with Patellar Dislocation. *Arthrosc - J Arthrosc Relat Surg.* 2020;36:1114-1120.

