Analyzing the Alignment Error in Tibial Tuberosity-Trochlear Groove Distance (TT-TG) in Clinical Scans Using 2D and 3D Methods

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Disclosure

My disclosure along with my co-authors is listed in the disclosure index on the ISAKOS website.

I have nothing to disclose.

Disclaimer

In the following you will see a quick overview of published in the American Journal of Sports Medicine (AJSM):

Analyzing Alignment Error in Tibial Tuberosity-Trochlear Groove Distance in Clinical Scans Using 2D and 3D Methods

by Sieberer et. al. 2024 [1]

Background

- Tibial tuberosity to trochlear groove distance (TT-TG) is used as the primary surgical decision-making metric in patellar instability.
- It has high interrater reliability, but it is prone to measurement errors caused by patient-scanner gantry alignment [3]
- The error in clinical practice has not been quantified yet.

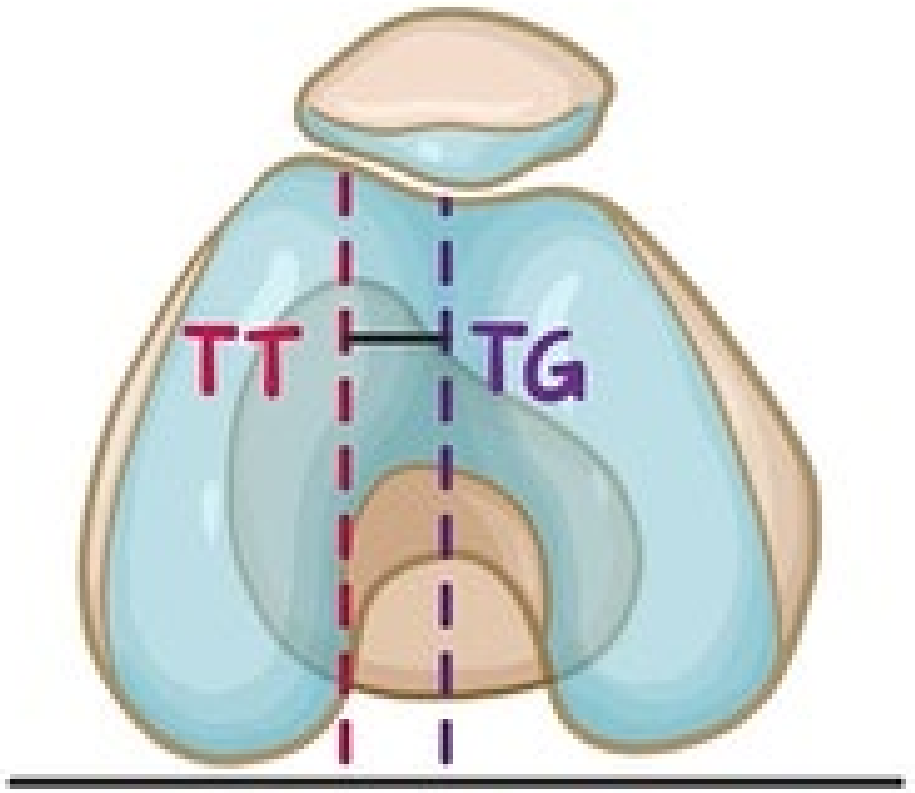
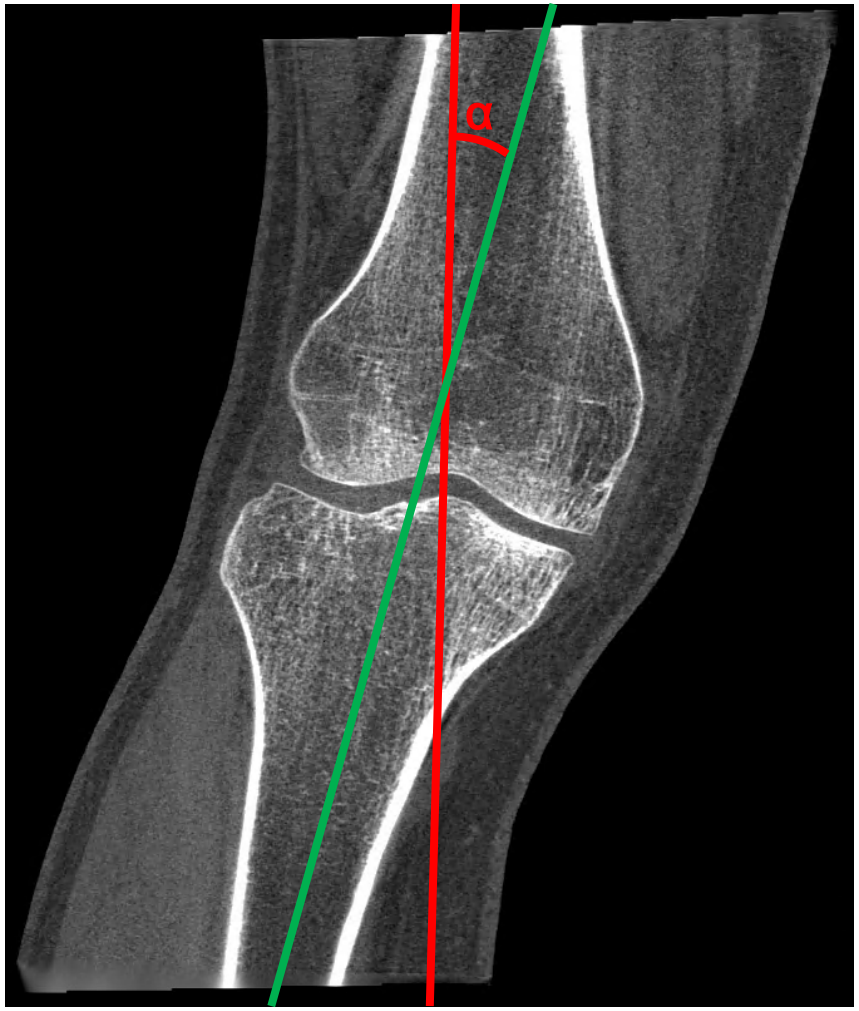


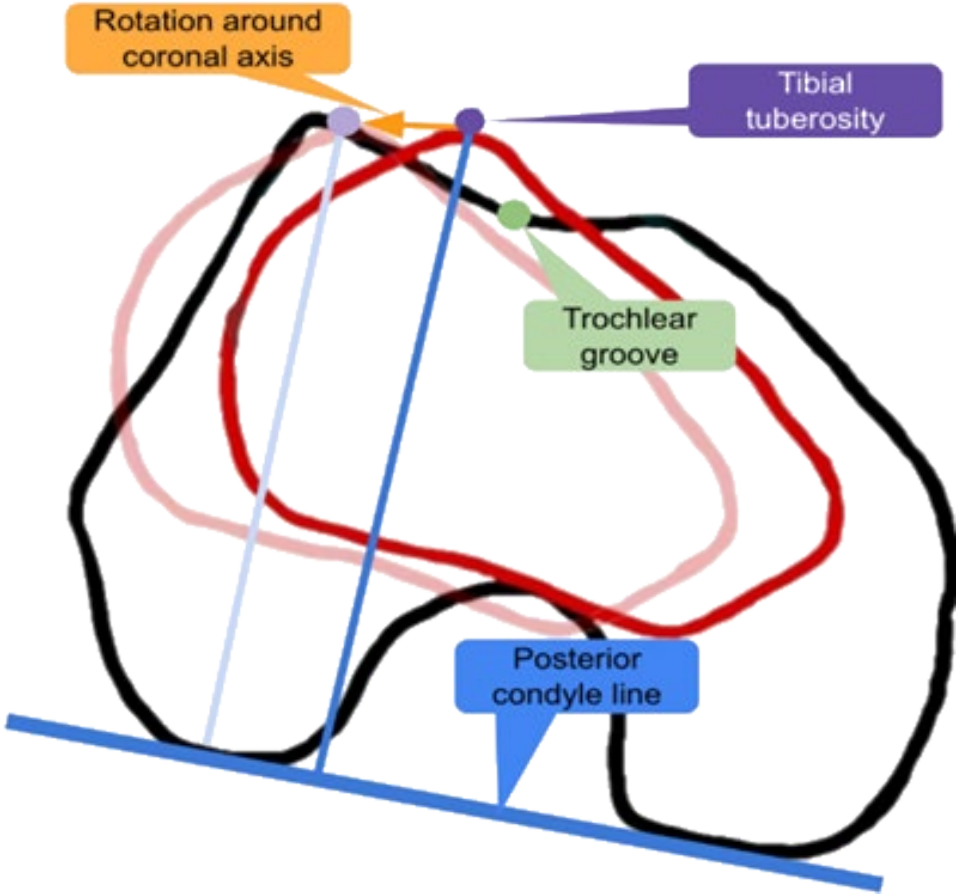
Image Source: [2]

Alignment Error



$$iment$$

$$sin(\beta) * sin(\gamma))$$



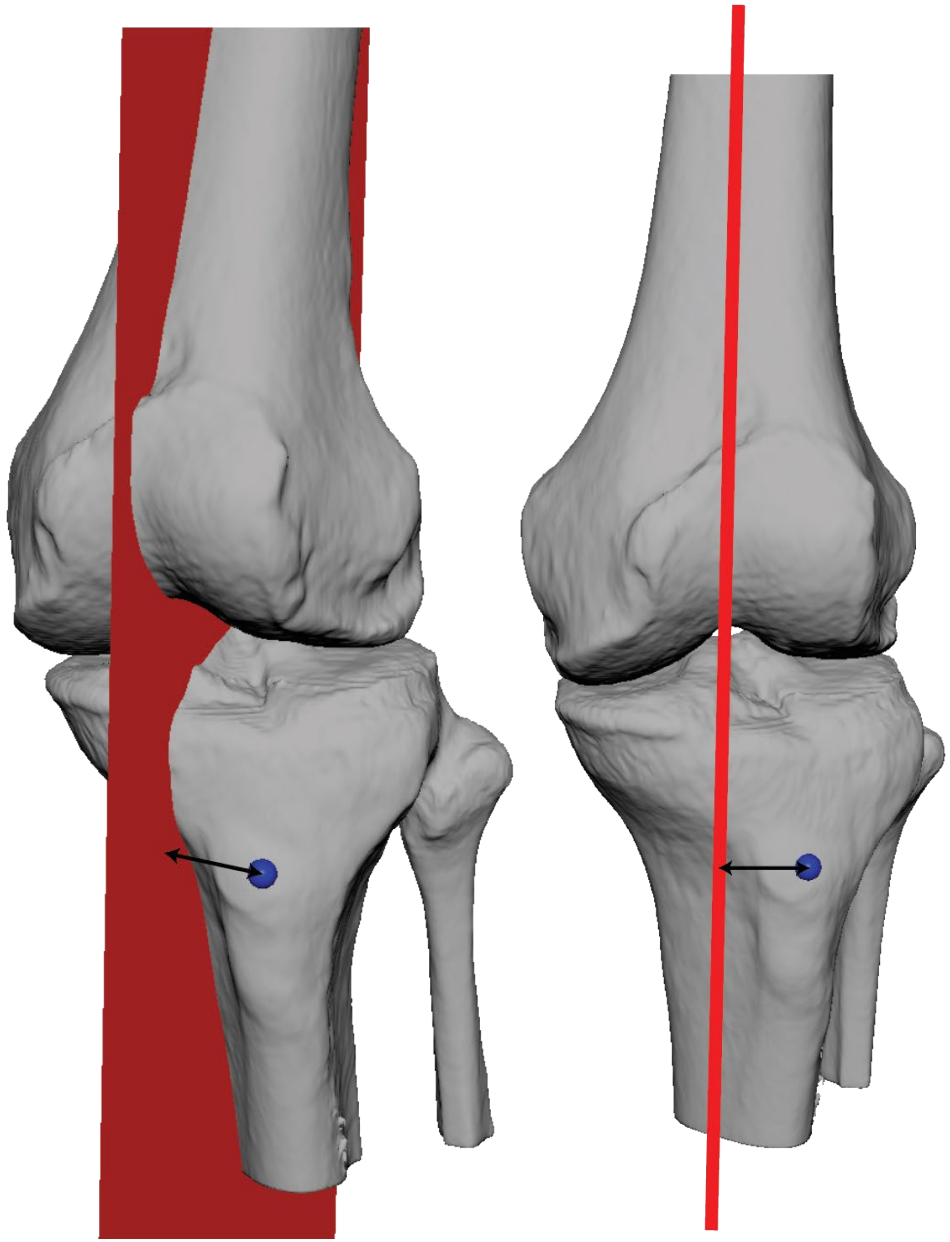
$$Difference\ due\ to\ alignment$$
$$\approx d * (\mathbf{sin(\alpha)} * cos(\gamma) + sin(\beta) * sin(\gamma))$$
$$\alpha, \beta, \gamma \ldots Coronal, sagittal, and$$
$$posterior\ condyle\ line\ (PCL)\ rotation$$

Aim

Development of a 3D method to measure TT-TG independent of patient alignment and quantify the error in clinical scans

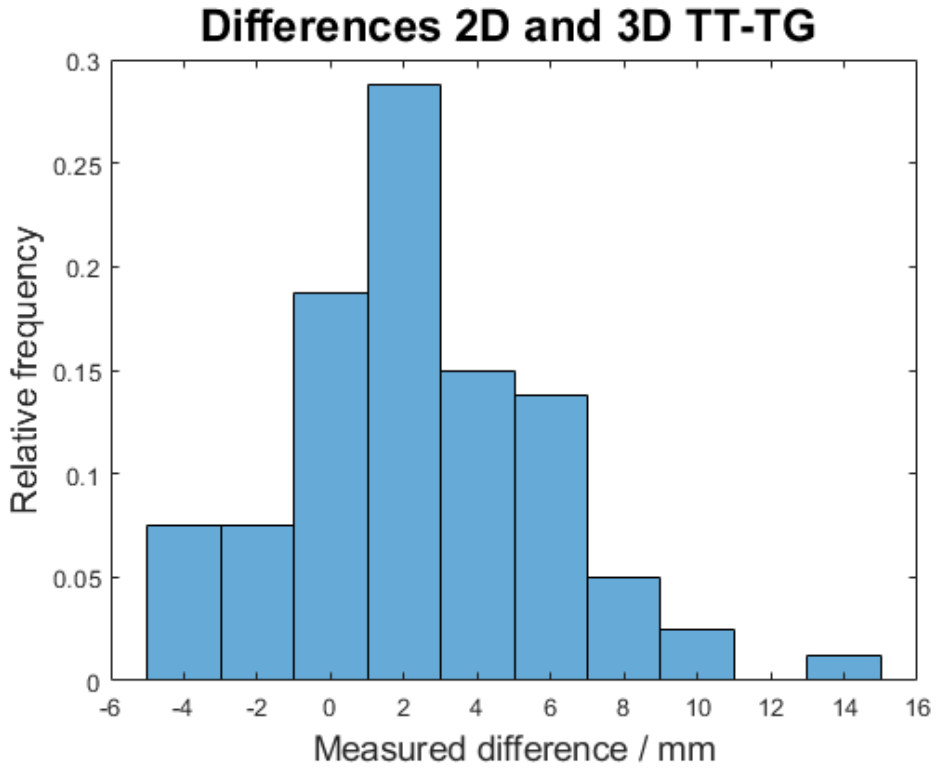
Methods

- Creation of 80 landmark sets from patient and control CT scans.
- Calculation of TT-TG based on the tibial longitudinal axis (3D) instead of the scanner's axis utilizing landmarks placed on 3D models.
- Comparison to traditional TT-TG (2D) based on the scanner's axis
- Calculation of interrater reliability (ICC)



Results – TT-TG

- 2D TT-TG significantly higher than 3D TT-TG -> caused by a mean coronal leg rotation of 2.4 degrees
- Variance in 3D TT-TG was significantly lower -> fewer outliers and reduction of range
- Differences reached from -4.8 to 14.7 mm (negative defined as corrected TT-TG is higher)
- The interrater reliability (ICC) was 0.92 (95% CI: 0.81 to 0.97) defined as good to excellent



Group	TT-TG Range / mm 2D	3D
Patients	7.2 - 41.0	10.2 - 28.3
Controls	5.2 - 22.1	6.8 - 20.4

Discussion

- Standard TT-TG is susceptible to errors caused by patient alignment in the scanner gantry.

- 3D TT-TG could mitigate or reduce this error, but widespread implementation seems unlikely.

- Physicians should be aware of the inaccuracy of TT-TG and work with their radiologists to improve measurement accuracy and base their decisions on a holistic approach, relying less on TT-TG.

- Reformatting of CT scans is a potential solution. Due to the large error caused by slight angle changes, it should be approached with caution.

Limitations

- Both methods (2D and 3D) depend on accurate landmark placement. The 3D method needs more and is, therefore, more susceptible to placement errors.

- Depending on landmark definition, TT-TG can vary; further studies are needed to define landmarks, so they provide the best insight regarding biomechanics.

Conclusion

The current method of measuring TT-TG is susceptible to errors caused by patient placement. Physicians need to be aware and act accordingly.

References:

[1] Sieberer JM, Park N, Rancu AL, et al. Analyzing Alignment Error in Tibial Tuberosity-Trochlear Groove Distance in Clinical Scans Using 2D and 3D Methods. *Am J Sports Med*. 2024;52(12):2996-3003. doi:10.1177/03635465241279852

[2] THE PATELLOFEMORAL FOUNDATION MASTERS COURSE https://elearning.patellofemoral.org

[3] Yao L, Gai N, Boutin RD. Axial scan orientation and the tibial tubercle–trochlear groove distance: error analysis and correction. AJR Am J Roentgenol. 2014;202(6):1291-1296.

Thank you!

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