Three-dimensional imaging informs the understanding and treatment of recurrent patella dislocation

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INTRODUCTION: Three-dimensional (3D) imaging provides a more comprehensive understanding of complex dysplastic anatomy and has potential to improve diagnostic understanding and decision-making for treatment of recurrent patella dislocation. To date, two-dimensional imaging-based measurements and classification schemes guide clinical decision-making for patients with recurrent patella dislocation.

METHODS:

3D prints were generated from 17 patients with recurrent patella dislocation (15 female, 2 male) seen and treated by the senior author between January 2020 and November 2021and compared to 20 age matched knees with no known history of patella dislocation from the New Mexico Decedent Image Database. All CT scans were performed in a 128 slice multidetector CT scanner with 0.625 mm slice thickness, 120 kVp tube voltage, a 0.5 spiral pitch ratio, and tube current values of 100-150 mA. Contrast material was not administered. DICOM image files were loaded onto a medical visualization application (Simpleware ScanIP) and segmentation of the distal femurs was performed via thresholding, edge detection, and manual segmentation. The entirety of the distal femoral metaphysis and femoral condyles were included. Stereolithography files were generated for formatting and printing 100% to scale in polylactic acid or draft resin using a high-resolution dual-extrusion printer (Ultimaker S5 or Form 3BL, respectively). All printing supports were removed, leaving only the bony region of interest. 3D-printed models were visually assessed as they lay on their posterior femoral condyles to devise and evaluate novel 3D trochlear measurement methods. Two-way, unpaired student's t-tests were performed between the control and recurrent patella dislocation cohorts. A value of $p<0.05$ was considered significant.

RESULTS:

The average age of the recurrent dislocation cohort was 19.2 years (range 15-43 years). The average age of controls was 19.7 years (range 15-25 years). Visual assessment led to two novel measurements focused on the morphology of the proximal trochlea. The area of a scalene triangle (Figure 1) formed between the entry point (EP) (defined as the midpoint of the flattened region of the proximal trochlea that first engages with the patella in early knee flexion and the midpoint of the intercondylar notch region) and a transition point (defined as the point along the trochlear groove at which the direction of patella tracking changes course from an oblique orientation proximally to more vertical towards the intercondylar notch distally) varied significantly between the recurrent dislocation and control cohorts, $p<0.0001$ (Table 1). The angle between the EP and midpoint of the distance between the medial and lateral femoral condyles, as defined using the surgical transcondylar axis (Figure 2), was termed the entry point-trochlear groove (EP-TG) angle and differed significantly between cohorts, $p<0.0001$ (Table 1).

DISCUSSION AND CONCLUSION:

This study describes measurements based on 3D morphology of the femoral trochlea that differ significantly between patients with a history of recurrent patella dislocation and those without. The morphology of the proximal trochlea is crucial to patellofemoral joint stability, particularly in the first 30°of knee flexion. The measurements described herein reflect a lateralized course of patella tracking and engagement with the trochlea that cannot be seen, measured, or understood well using conventional 2D imaging modalities. These measures capture lateralized trochlear engagement more proximally and accurately than on conventional CT or MRI tomographic slices. 3D enables visual understanding of trochlear tracking paths which, together with the measures noted herein, will likely improve accuracy of planning for osteotomy surgery including tibial tubercle transfer, trochleoplasty, and femoral derotation.

Figure 1. Proximal trochlea triangle area measurement illustration

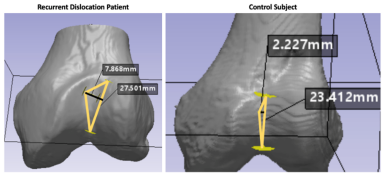

Figure 2. Entry point-trochlear groove (EP-TG) angle illustration

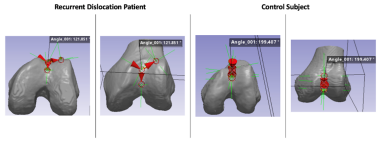

Table 1. 3D proximal trochlear measurements

	Mean Triangle Area (cm^2)	Standard Deviation	P-value	Mean EP-TG Angle	Standard Deviation	P-value
Recurrent Dislocators	0.8	0.6	p<0.0001	33.2°	19.3°	p<0.0001
Controls	0.1	0.6		8.2°	12.1°	