Automated Three-Dimensional Analysis Improves Trochlear Dysplasia Characterization

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Introduction: There is variable inter-rater reliability for components of trochlear dysplasia reported in the orthopaedic literature. Standardly, surgeons make their grading decisions based on perfect lateral radiographs. However, these images may not provide clear delineation of the anatomic contours of the distal femur. The purpose of this study was to compare inter-rater agreement of trochlear dysplasia grading amongst sports orthopaedic surgeons using perfect lateral radiographs versus a novel method using pseudo-perfect lateral three-dimensional (3D) models with surface topography lines superimposed.

Methods: Seven sports orthopaedic surgeons with over 10 years in practice and five sports orthopaedic fellows were recruited to complete a REDCap survey consisting of twelve patellar instability patients with varying degrees of trochlear dysplasia. A perfect lateral x-ray for each patient was presented with associated questions asking the responder to determine a Dejour dysplasia grade, the presence or absence of a crossing sign, the presence of a double contour sign, and the presence of a supratrochlear spur. All twelve patients had a pseudo-perfect lateral image created using 3D-segmented models with lines along the surface landmarks ("3D Line Model"; **Figure 1**). Surgeons were presented these 3D representations in a randomized order with the preceding questions repeated. Kappa coefficients were calculated to determine inter-rater agreement between all responders, as well as subgroup analyses for attending surgeons and fellows **(Table 1**).

Results: The assessment of qualities such as Dejour dysplasia grade and the presence of a crossing sign demonstrated inconsistent interrater agreement with inability to reject the null hypothesis that all grades were assigned randomly ($p>0.05$) whether on x-ray or 3D line model. However, the 3D line method did improve surgeon agreement on the presence of a double contour sign ($k = 0.210$, $p<0.0001$) and detection of supratrochlear spurs ($k = 0.664$, $p<0.0001$) compared to perfect-lateral radiographs ($k = -0.197$ and $k = 0.038$, respectively).

Discussion: Our novel 3D line projection method results in fair-to-substantial agreement in the detection of trochlear dysplasia components, with marked improvement compared to the traditional method of using perfect lateral radiographs. However, Dejour Dysplasia grading continues to have poor inter-rater agreement whether on x-ray or 3D line model.

Clinical Relevance: The adaptation of 3D imaging can improve agreement among surgeons on the classification of pathological trochlear morphology.

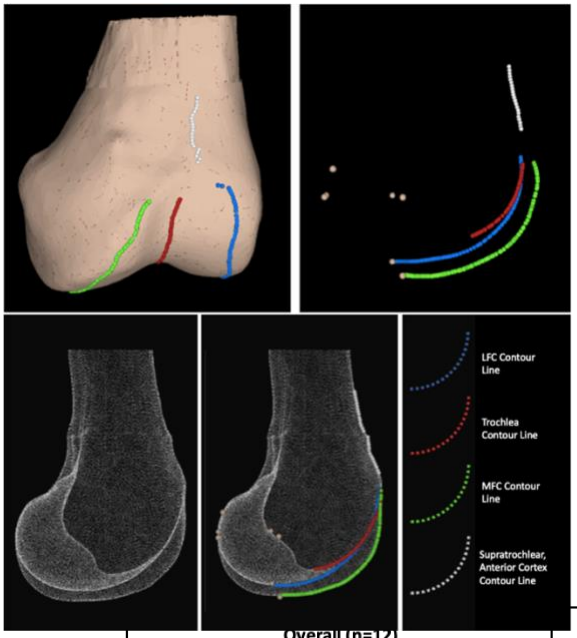

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Figure 1. Psuedo-perfect lateral three-dimensional model with superimposed surface contour lines. The brown 8 points in the figure correspond to the most distal, posterior, and central points of medial and lateral condyles (6 points), and the most posterior points at 30° of femur flexion (2 points; overlapped).

	Overall (n=12)		Attendings (n=7)		Fellows (n=5)	
Grading Category	**Perfect Lateral X-ray**	**3D Line Model**	**Perfect Lateral X-ray**	**3D Line Model**	**Perfect Lateral X-ray**	**3D Line Model**
Dejour Dysplasia Grade	k=0.280 (p=0.994)	k=0.257 (p=0.995)	k=0.351 (p=0.313)	k=0.327 (p=0.420)	k=0.212 (p=0.301)	k=0.252 (p=0.148)
Crossing Sign	k = 0.314 (p=1.00)	k = 0.030 (p=0.403)	k = 0.409 (p=1.00)	k = 0.0902 (p=0.152)	k = 0.331 (p=0.989)	k = -0.156 (p=0.088)
Double Contour	k = -0.197 (p=0.844)	**k = 0.21 (p<0.0001)**	k = -0.016 (p=0.794)	**k = 0.254 (p<0.0001)**	**k = -0.199 (p=0.030)**	k = 0.097 (p=0.287)
Supratrochlear Spur	k = 0.038 (p=0.281)	**k = 0.664 (p<0.0001)**	k = 0.103 (p=0.102)	**k = 0.761 (p<0.0001)**	k = -0.136 (p=0.138)	**k = 0.632 (p<0.0001)**

Table 1. Inter-rater agreement for responses to survey components based on perfect lateral x-rays or pseudo-perfect lateral 3D representations with novel line method superimposed. Kappa coefficients are presented with associated p-values. Yellow highlight signifies statistically significant agreement.