Mass General Brigham

Measurements of Malalignment on Magnetic Resonance Imaging (MRI): Incorporating sex and patient height

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Background

- Malalignment is a known risk factor for patellar instability.[1]
- It can be assessed using metrics such as tibial tubercle-trochlear groove (TTTG) distance and tibial tubercle to posterior cruciate ligament (TT-PCL) distance[2]
- There is substantial variability in thresholds for abnormal values based on imaging modality and patient size[3,4]

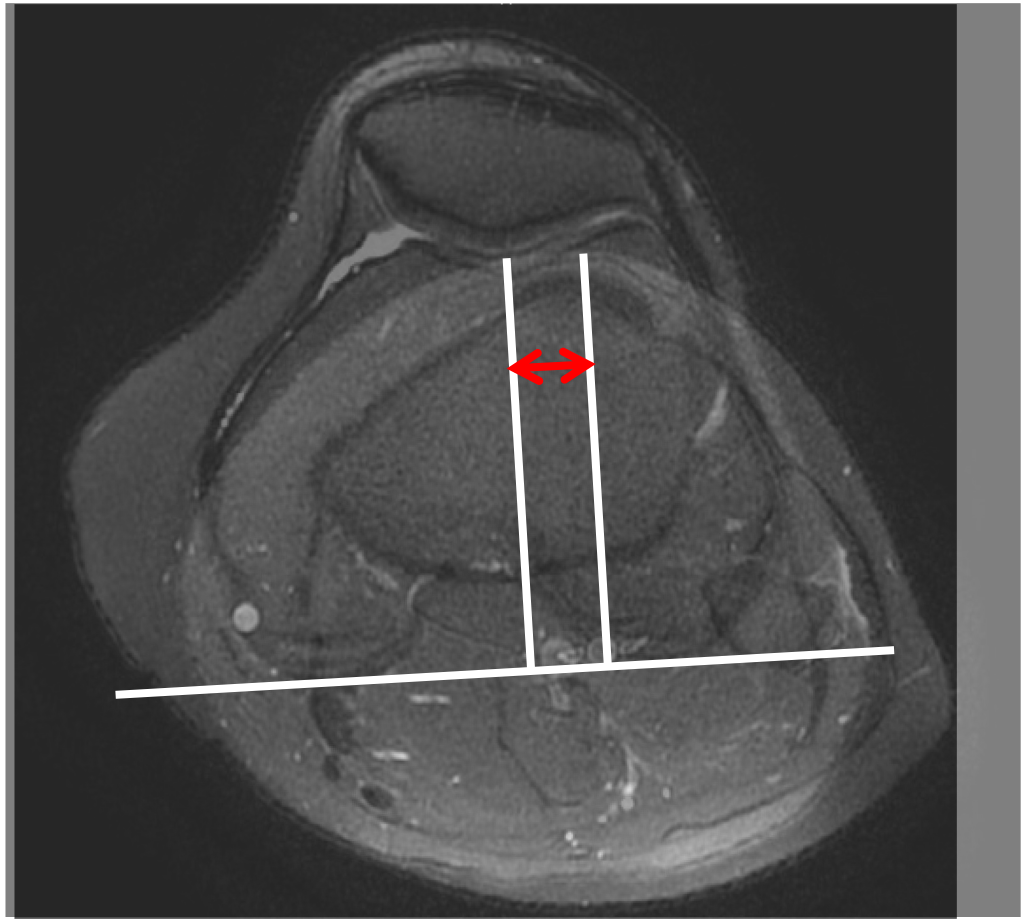
Objectives

- Identify MRI-based thresholds for measurements of malalignment and the accuracy of these measurements in identifying patellar instability
- Determine the impact of patient sex and height on thresholds for instability

Methods

- 120 knees with symptomatic patellar instability were compared with 120 gender-matched knees.
- On axial images, tibial tubercle-trochlear groove (TTTG) distance and tibial tubercle to posterior cruciate ligament (TT-PCL) distance were measured
- Statistics
  - Receiver Operating Characteristic (ROC) curve analysis was performed to determine the area under the curve (AUC) and confidence intervals, with AUC >0.7 indicating a good diagnostic test.
  - Youden's J statistic was used to establish diagnostic thresholds
  - Subgroup analysis was performed based on sex and height

TTTG Distance Measurement



Results:
Table 1: Measurement Means

Characteristic	N	Control, N = 120[1]	Symptomatic, N = 120[1]	p-value[2]
TTTG Distance (mm)	240	12.23 (4.50)	16.69 (6.00)	<0.001
TT-PCL Distance (mm)	240	23.93 (4.76)	23.79 (5.40)	0.8

[1]Mean (SD), [2]Welch Two Sample t-test

Table 2: AUCs and cutoff values for TTTG and TT-PCL

Measurement	Sex	Height	AUC	Cutoff Value	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
TTTG								
	All		**0.75 (0.69, 0.81)**	>14.9	0.65	0.72	0.7	0.67
		< 170.2 cm	**0.79 (0.7, 0.88)**	>14.4	0.7	0.69	0.7	0.69
		> 170.2 cm	0.68 (0.58, 0.77)	>16.3	0.59	0.74	0.71	0.62
	Male		**0.7 (0.57, 0.82)**	>16.4	0.62	0.78	0.72	0.69
		< 177.8 cm	**0.79 (0.61, 0.94)**	>16.1	0.54	0.86	0.7	0.76
		> 177.8 cm	0.56 (0.39, 0.72)	>20.1	0.3	0.81	0.73	0.41
	Female		**0.78 (0.7, 0.85)**	>14.1	0.68	0.67	0.68	0.67
		< 165.1 cm	**0.77 (0.64, 0.88)**	>13.7	0.77	0.55	0.65	0.7
		> 165.1 cm	**0.76 (0.64, 0.86)**	>14.7	0.68	0.76	0.76	0.68
TT-PCL								
	All		0.5 (0.43, 0.57)	<19.3	0.15	0.83	0.47	0.5
		< 170.2 cm	0.5 (0.39, 0.59)	>29	0.04	0.92	0.33	0.48
		> 170.2 cm	0.52 (0.41, 0.63)	<20.8	0.22	0.81	0.57	0.49
	Male		0.53 (0.4, 0.66)	<20.7	0.29	0.87	0.67	0.57
		< 177.8 cm	0.5 (0.29, 0.72)	>30.2	0.15	0.95	0.67	0.66
		> 177.8 cm	0.59 (0.41, 0.76)	<23.2	0.44	0.88	0.86	0.48
	Female		0.54 (0.45, 0.63)	>20.7	0.77	0.32	0.54	0.57
		< 165.1 cm	0.56 (0.42, 0.71)	<22.7	0.58	0.52	0.56	0.54
		> 165.1 cm	0.62 (0.48, 0.75)	>21.5	0.86	0.35	0.59	0.71

Results

- The overall AUC and 95% confidence interval for TTTG distance was 0.75 (0.69, 0.81), while TT-PCL yielded values below 0.7 for all subgroups.
- The study cohort had a median height of 170.2 cm (177.8 cm in males and 165.1 cm in females).
- The identified cutoff values for TTTG distance were 13.7 mm for “short” females, 14.7 mm for “tall” females, 16.1 mm for “short” males, and 20.1 mm for “tall” males.
- The AUC for TTTG distance was 0.79 (0.7, 0.88) for patients below the overall median height and 0.68 (0.57, 0.77) for those above.
- AUC for TTTG distance was good in both females and males, at 0.78 (0.7, 0.85) and 0.7 (0.57, 0.82), respectively.
- TTTG distance in males had greater predictive ability in males below the median male height (0.79 (0.61, 0.94)) versus males above the median height (0.56 (0.39, 0.72)).
- Among women, the TTTG cutoff had a similar efficacy among those with heights below and above the female median (AUC = 0.77 (0.64, 0.88) and 0.76 (0.64, 0.86), respectively).

Conclusion

- TTTG distance on MRI is an effective measurement for detecting malalignment related to patellar instability, while TT-PCL thresholds demonstrated low efficacy. In all cases, the cutoff value was below the reported value of 20mm.
- We identified varying thresholds for TTTG distance based on sex and height, with the lowest diagnostic value among patients with above median heights, particularly in male patients.
- Notably, calculated cutoff values varied between male and female subgroups.
- These findings highlight a need for incorporating patient specific factors when using these thresholds in clinical practice.

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Thank you!