Influence of knee malposition on radiographic measurements of patella alta

Miho J. Tanaka, MD, PhD
Chance Bowman
Patrick T. Howard,
Maria V. Velasquez Hammerle, MD,
F. Joseph Simeone, MD,
Fang Liu, PhD

HARVARD MEDICAL SCHOOL

MGH 1811 MASSACHUSETTS GENERAL HOSPITAL
ORTHOPAEDICS

Disclosures

Tanaka

- Consultant for DePuy/Mitek
- Consultant for VeryWell Health
- Consultant for Healthy Sleep
- CMO, Core2U
- Research funding from AANA
- Research funding from FujiFilm
- NIH 1R01AR079442
- NIH 1R01AR081344

Liu

- NIH 1R01AR079442
- NIH 1R01AR081344

Background

- Patella alta is a known risk factor for patellar instability[1-3]
- Patella alta can be addressed with distalizing osteotomy in the setting of patellar stabilization surgery, but this carries increased risks when compared to other types of tuberosity osteotomies[4-6]
- Accurate assessment of patellar height is critical in determining indications for distalization
- Knee rotation on radiographs has been shown to influence accuracy of anatomic measurements[7]

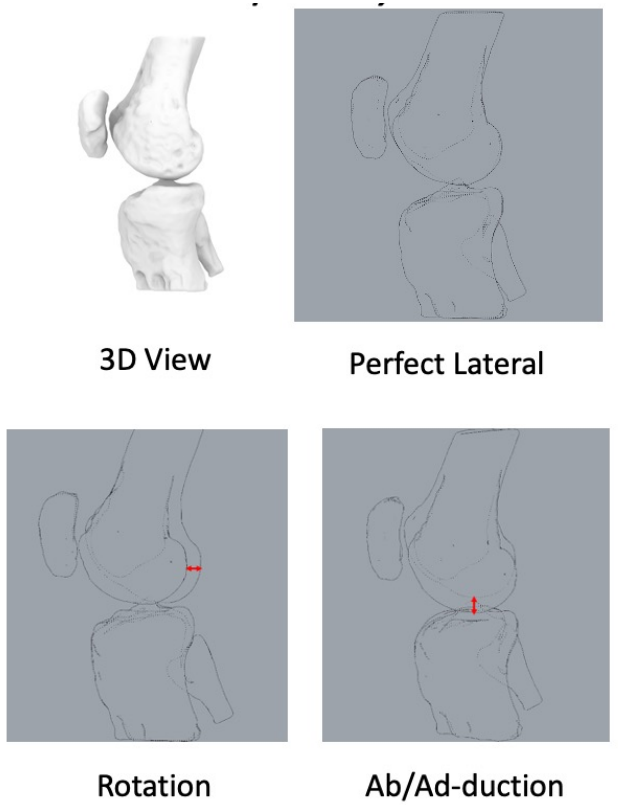
Objective

- The purpose of this study was to identify the role of knee malposition on radiographic measurements of patella alta

Methods

- 3D models derived from CT scans of patients with unilateral patellar instability were included in this study
- Models with knee flexion angles between 20 and 30° were projected onto 2D radiographs to create a perfect lateral radiograph [Figure 1]
- Measurements of patella alta were compared after adding 5° increments of internal/external rotation (IR, ER), 5° increments of ad/abduction, and the addition of combined errors
- Corresponding measurements of posterior and distal condylar overlap were measured in each condition.

Figure 1. 2D figures were created based on repositioning 3D models of knees derived from CT scans of patients with patellar instability. *Condylar distance is indicated in red.*

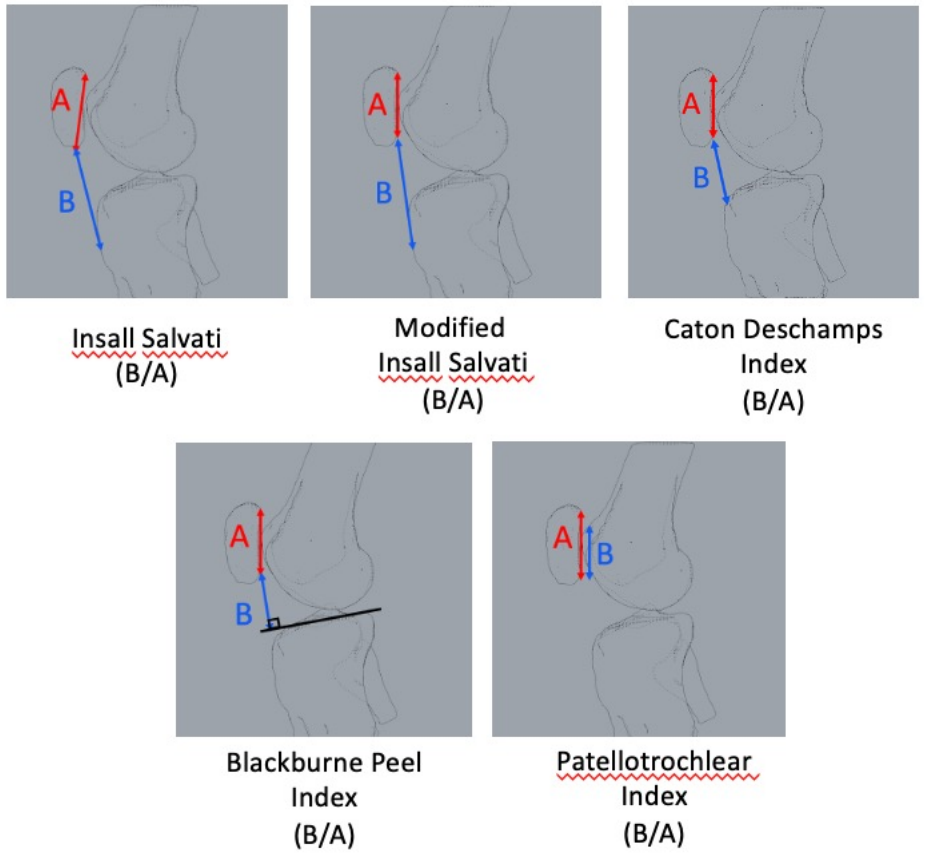


Methods

In each condition, measurements of patella alta included the following [Figure 2]:

- Insall Salvati (IS)
- Modified Insall Salvati (m-IS)
- Blackburne Peele Index (BPI)
- Caton Deschamps Index (CDI)
- Patellotrochlear index (PTI)

Figure 2. Measurements of patella alta were performed as shown below



Methods

- Measurements were compared in each condition, and 0.05 change in the calculated index was considered to be clinically significant
- Linear regression analysis was performed to identify the relationship between knee malpositioning and changes in patellar height measurements
- Subgroup analysis of symptomatic vs asymptomatic knees was performed to identify the role of variations in morphology and patellar position on measurements of patella alta

Results

- 40 knees from 20 patients were included in this study
- On radiographic views, for every 5° of aberrant rotation, the overlap between the posterior condyles increased by 4mm ($p<0.001$)
- For every 5° of ab/adduction, the overlap between the distal condyles increased by 4mm ($p<0.001$)
- Insall Salvati measurements showed no significant changes throughout conditions but was noted to have a strong correlation with ER in symptomatic knees ($R=0.97$, $R2= 0.94$, $p<0.001$) and abduction in asymptomatic knees ($R=0.87$, $R2=0.77$, $p=0.05$)

Results

- Errors were noted in modified Insall Salvati measurements with >5° abduction ($p<0.001$)
- Errors in BPI and CDI were found with rotation >10° and 15° ($p=0.005$, $p<0.001$), respectively
- Errors in PTI occurred with 10° adduction ($p<0.001$) as well as with 5° adduction combined with 5° IR ($p<0.001$)
- Stepwise regression analysis demonstrated an independent relationship with trochlear dysplasia in sensitivity to rotational errors for BPI and CDI, and TTTG distance for abduction errors in m-IS

Measurement values for asymptomatic knees based on knee position

Position	ER (degrees)	Adduction (degrees)	Posterior Condylar Gap (mm)	Inferior Condylar Gap (mm)	Gap total (mm)	Insall Salvati	m-IS	BPI	CDI	PTI
3D	0	0				1.52	2.00	1.08	1.15	1.11
2D	0	0	0.00	0.00	0.00	1.43	1.96	1.12	1.16	0.89
	5	0	4.05	0.00	4.05	1.42	1.95	1.12	1.15	0.90
	10	0	7.96	0.00	7.96	1.42	1.94	1.10	1.12	0.91
	15	0	11.65	0.00	11.65	1.42	1.95	1.06	1.07	0.92
	-5	0	4.24	0.00	4.24	1.43	1.96	1.12	1.16	0.88
	-10	0	8.35	0.00	8.35	1.43	1.95	1.11	1.15	0.87
	-15	0	12.66	0.00	12.66	1.43	1.94	1.11	1.14	0.86
	0	5	0.00	4.70	4.70	1.44	2.00	1.14	1.17	0.85
	0	10	0.00	9.05	9.05	1.43	2.02	1.09	1.13	0.81
	5	5	4.11	5.31	9.41	1.43	1.98	1.08	1.11	0.88
	-5	5	4.08	4.55	8.64	1.44	2.00	1.15	1.18	0.84
	0	-5	0.00	4.38	4.38	1.42	1.89	1.12	1.15	0.91
	0	-10	0.00	8.83	8.83	1.40	1.83	1.09	1.12	0.93
	5	-5	4.22	5.03	9.25	1.42	1.90	1.10	1.13	0.91
	-5	-5	4.30	4.55	8.85	1.41	1.88	1.12	1.14	0.91

Measurement values for symptomatic knees based on knee position

Position	ER (degrees)	Adduction (degrees)	Posterior Condylar Gap (mm)	Inferior Condylar Gap (mm)	Gap total (mm)	Insall Salvati	m-IS	BPI	CDI	PTI
3D	0	0				1.47	1.87	1.01	1.08	1.09
2D	0	0	0.00	0.00	0.00	1.40	1.93	1.10	1.14	0.89
	5	0	3.76	0.00	3.76	1.40	1.93	1.10	1.13	0.89
	10	0	7.57	0.00	7.57	1.40	1.92	1.06	1.09	0.90
	15	0	11.29	0.00	11.29	1.39	1.89	1.01	1.04	0.89
	-5	0	4.16	0.00	4.16	1.41	1.92	1.10	1.13	0.87
	-10	0	8.18	0.00	8.18	1.41	1.91	1.09	1.12	0.86
	-15	0	12.42	0.00	12.42	1.42	1.94	1.13	1.14	0.86
	0	5	0.00	4.67	4.67	1.40	1.99	1.13	1.16	0.87
	0	10	0.00	8.90	8.90	1.40	2.01	1.11	1.14	0.83
	5	5	4.17	5.51	9.68	1.40	1.98	1.11	1.13	0.88
	-5	5	4.04	4.44	8.48	1.41	1.98	1.16	1.19	0.85
	0	-5	0.00	4.41	4.41	1.40	1.87	1.10	1.14	0.89
	0	-10	0.00	8.89	8.89	1.38	1.79	1.06	1.09	0.89
	5	-5	3.80	4.92	8.72	1.40	1.87	1.12	1.14	0.91
	-5	-5	4.47	4.73	9.20	1.39	1.84	1.08	1.11	0.89

Conclusions

- Measurements of patella alta on radiographs were found to vary significantly based on malpositioning of the knee with regard to rotation or ad/abduction
- >4mm of distal condylar overlap was associated with erroneous IS and PTI measurements
- >4mm posterior condylar overlap influenced BPI and CDI
- Surgeons should be aware that measurements of patellar height can be influenced by knee position at the time of radiographs when assessing patella alta during the management of patellar instability

References

1. Drapeau-Zgoralski V, Swift B, Caines A, Kerrigan A, Carsen S, Pickell M. Current Concepts Review, Lateral Patellar Instability. J Bone Joint Surg Am. 2023 Jan 19.
2. Arendt EA, England K, Agel J, Tompkins MA. An analysis of knee anatomic imaging factors associated with primary lateral patellar dislocations. Knee Surg Sports Traumatol Arthrosc. 2017 Oct;25(10):3099-3107.
3. Jaquith BP, Parikh SN. Predictors of Recurrent Patellar Instability in Children and Adolescents After First-time Dislocation. J Pediatr Orthop. 2017 Oct/Nov;37(7):484-490.
4. Tanaka, M.J. and A.J. Cosgarea, *Measuring Malalignment on Imaging in the Treatment of Patellofemoral Instability.* Am J Orthop (Belle Mead NJ), 2017. 46(3): p. 148-151.
5. Johnson AA, Wolfe EL, Mintz DN, Demehri S, Shubin Stein BE, Cosgarea AJ. Complications After Tibial Tuberosity Osteotomy: Association With Screw Size and Concomitant Distalization. Orthop J Sports Med. 2018 Oct 19;6(10):2325967118803614.
6. Lundeen A, Macalena J, Agel J, Arendt E. High incidence of complication following tibial tubercle surgery. J ISAKOS. 2022 Nov 24:S2059-7754(22)00105-5.
7. Huddleston HP, Redondo ML, Cregar WM, Christian DR, Hannon CP, Yanke AB. The Effect of Aberrant Rotation on Radiographic Patellar Height Measurement Using Canton-Deschamps Index: A Cadaveric Analysis. J Knee Surg. 2023 Feb;36(3):254-260.

Thank you

HARVARD MEDICAL SCHOOL

MASSACHUSETTS GENERAL HOSPITAL ORTHOPAEDICS