The axial rotation between the femoral neck and ankle joint influences the kinematics in normal knees.

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Background

✓ Several studies have evaluated the kinematics in normal knees (1-5) and determined that the femur externally rotates with a medial pivot followed by a bicondylar rollback during squatting (2, 5).

✓ Femoral and tibial torsions have been reported in healthy individuals (6-9).

Femoral torsion

- Decreased femoral neck anteversion associated with increased medial pressure (10, 11).
- Small femoral anteversion is a risk factor for non-contact anterior cruciate ligament (ACL) injuries (12).
- Femoral anteversion is lower in patients with varus osteoarthritic knees than in patients with healthy knees (8).

Tibial torsion

- Tibial torsion is associated with joint loading (10, 13, 14).
- Distal tibial internal torsion is higher in patients with knee osteoarthritis (OA) than in healthy knees (7, 15).

Femoral and tibial torsion

- The algebraic sum of the femoral and tibial torsions is associated with medial femorotibial OA (6).
- Femoral and tibial torsions are correlated with varus inclination of the proximal tibia in patients with medial knee OA (16).

The evaluation of femoral and tibial torsions is important to monitor the progression to OA.

However, the relationship between knee kinematics and the lower extremity torsions remains unknown.

Objective

To clarify the effects of axial rotation between the femoral neck and ankle joint on the kinematics.

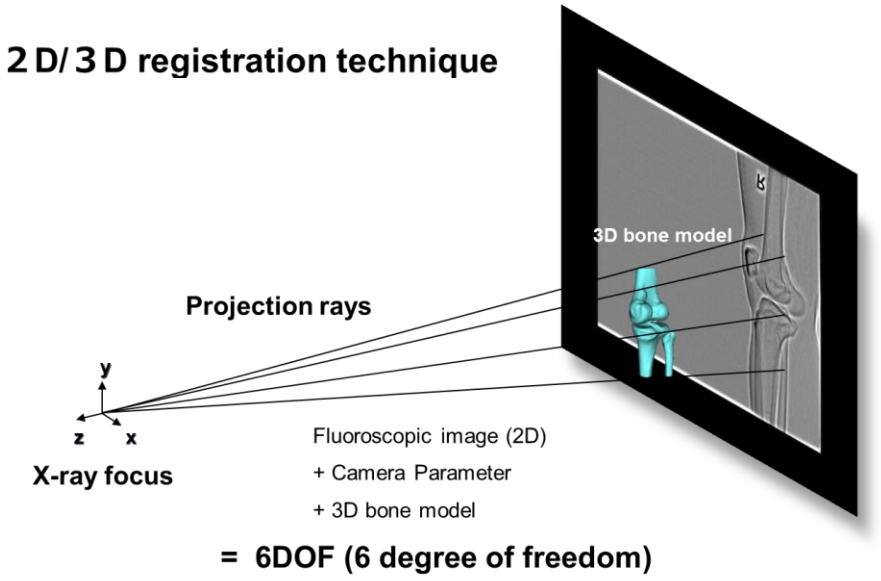
Methods

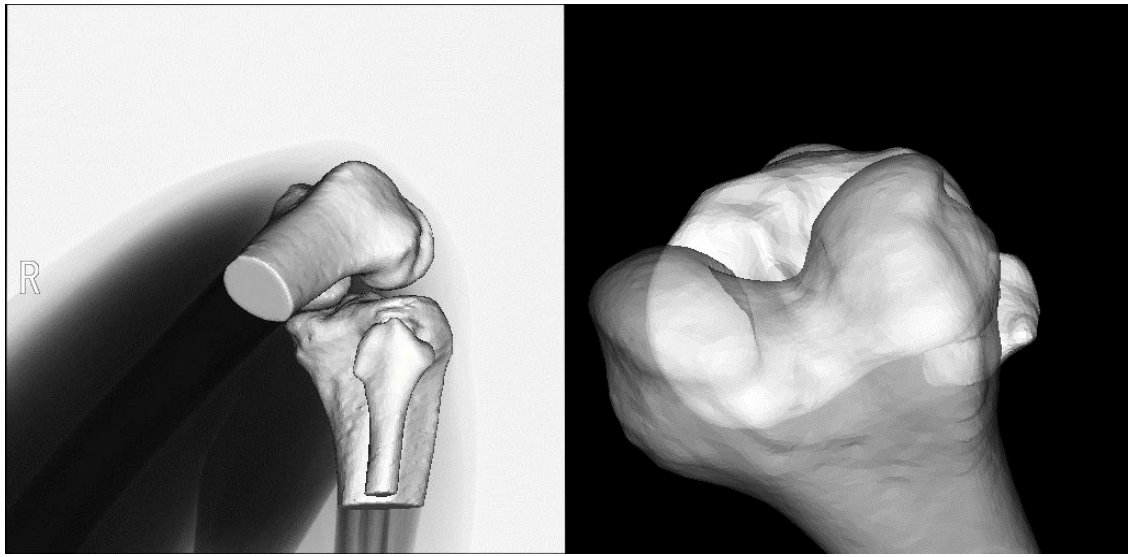
- Japanese healthy males (38 knees)
- Age: 35.7 ± 4.9 years ¶
- Body height: 173.0 ± 6.3 cm ¶
- Body weight: 68.7 ± 8.5 kg ¶

¶ Mean ± Standard deviation

✓ Each volunteer performed a squat under fluoroscopic surveillance in the sagittal plane.

✓ To estimate spatial position and orientation of the knee, a two-dimensional/three-dimensional (2D/3D) registration technique was used (2).



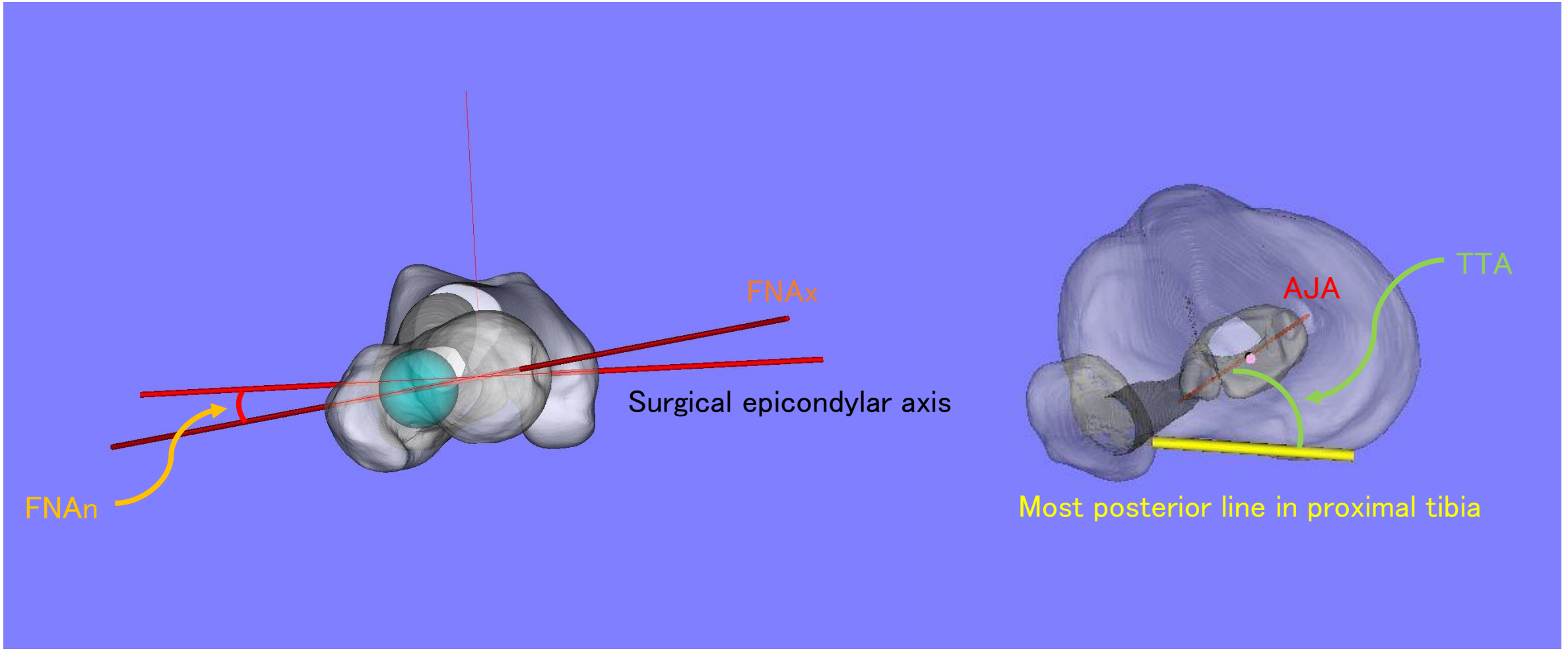


Femoral neck axis (FNAx): The line between the center of the head of the femur and the centroid of the best fitted circle of the most distal part of the femur neck (17)

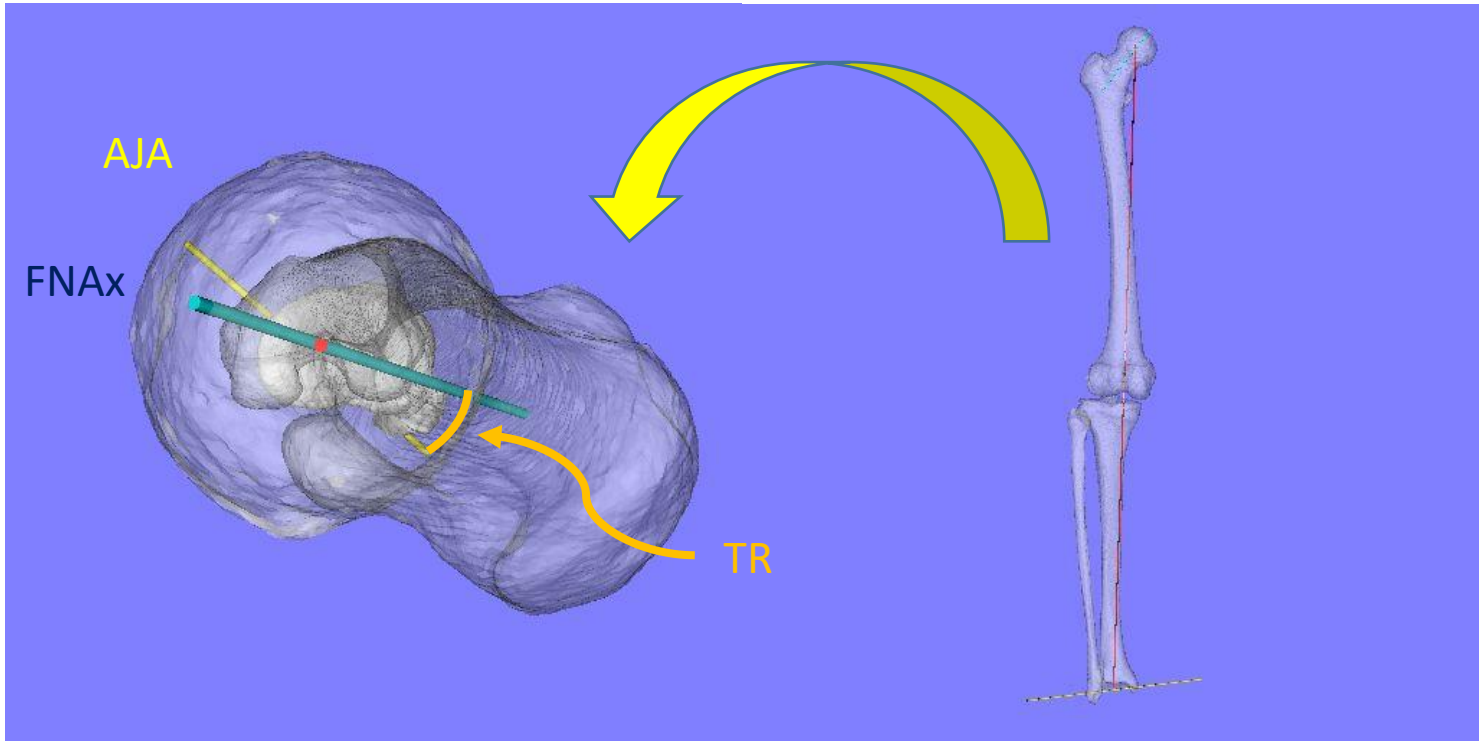
Femoral neck angle (FNAn): The angle between the FNAx and the surgical epicondylar axis (18)

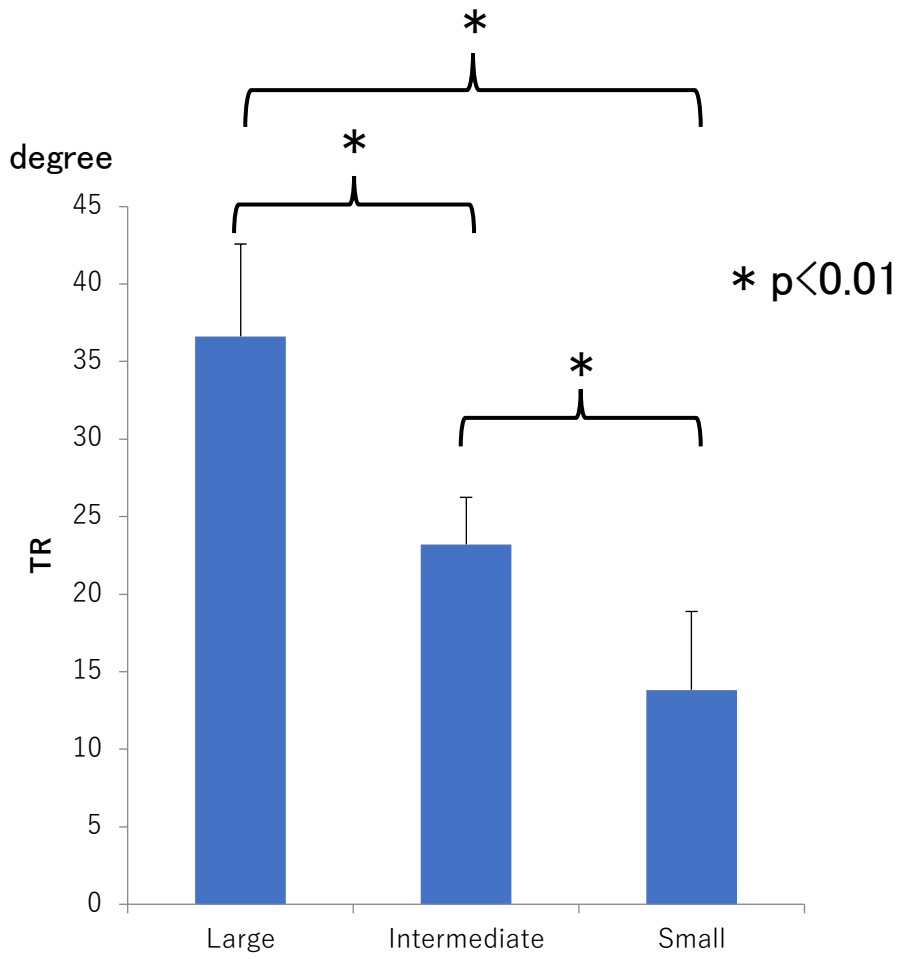
The ankle joint axis (AJA): The line between the medial and lateral malleoli (6).

Tibial torsion angle (TTA): The angle between the proximal, most posterior line and the AJA (6)



✓ Total rotation (TR) was defined as the angle between the FNAx and the AJA at knee extension during standing.





✓ The volunteers were divided into three groups (large (L), n=10; intermediate (I), n=19; and small (S), n=9) based on the TR at knee extension during standing using hierarchical cluster analysis.

Evaluations

- Correlations between the FNAn, TTA, TR, and axial rotation of the knees at extension (ARK)
- Femoral axial rotation angle relative to the tibia, and varus–valgus angle between the three TR groups
- Medial and lateral AP translation between the three TR groups (AP translation was calculated as a percentage relative to the proximal AP dimension of the tibia)

Statistical analysis

A two-way analysis of variance (ANOVA) and post hoc pairwise comparisons (Bonferroni test) were used to compare the rotation and varus–valgus angles between the groups.

A one-way ANOVA and post hoc pairwise comparisons (Bonferroni test) were used to compare the TR between the groups.

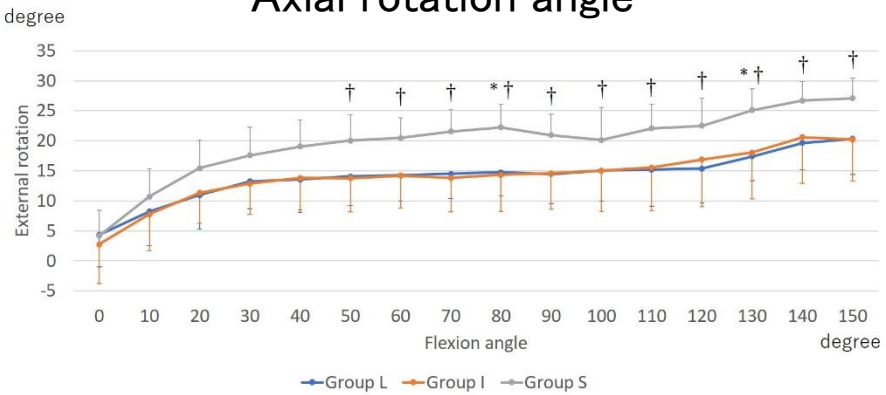
Pearson's correlation coefficient was used to analyze the correlation between the FnAn, TTA, TR, and ARK.

Results

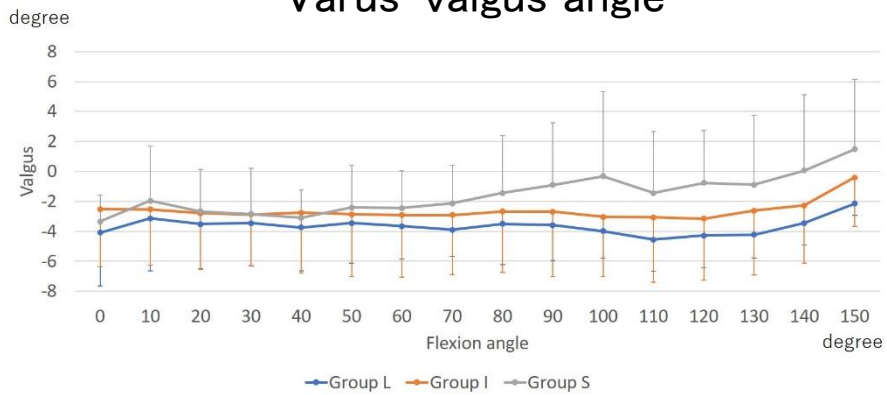
*: Group L vs Group S (p<0.05)
†: Group I vs Group S (p<0.05)
§ : Group L vs Group I (p<0.05)

	Correlation coefficient	p-value
FNAn vs TTA	0.24	0.15
FNAn vs TR	-0.48	0.002
FNAn vs ARK	-0.35	0.03
TTA vs TR	0.49	0.001
TTA vs ARK	0.21	0.20

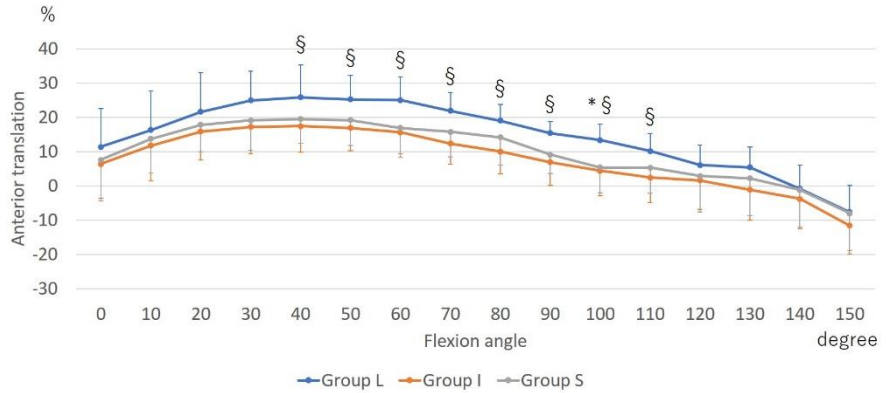
Axial rotation angle



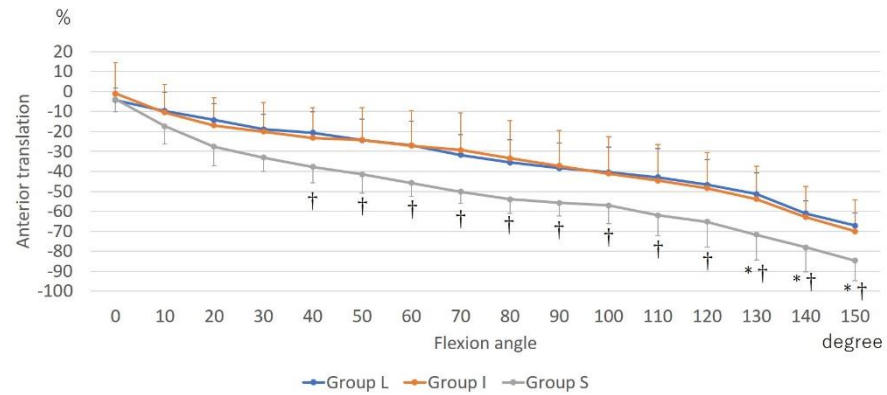
Varus–valgus angle



Medial AP translation

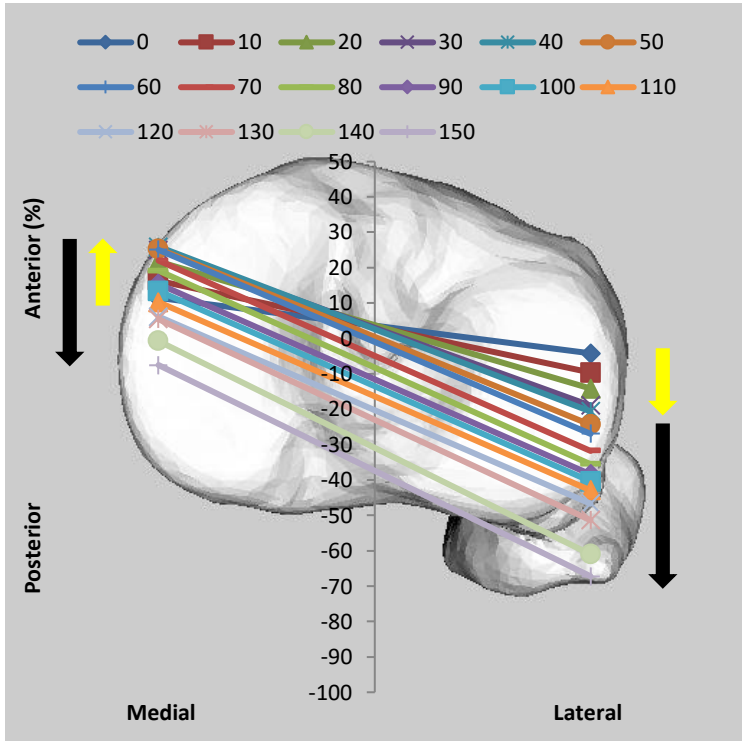


Lateral AP translation

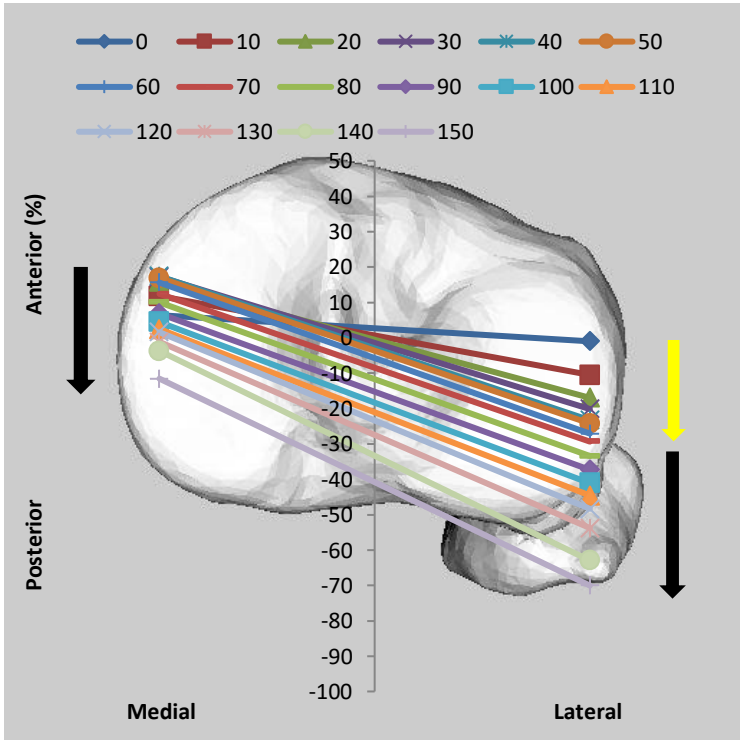


Kinematic pathway

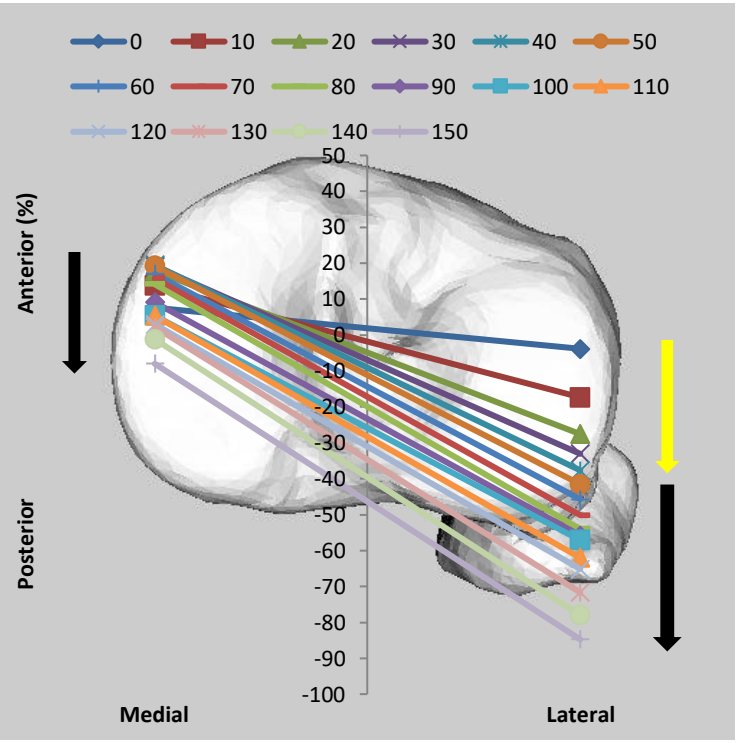
Group L



Group I



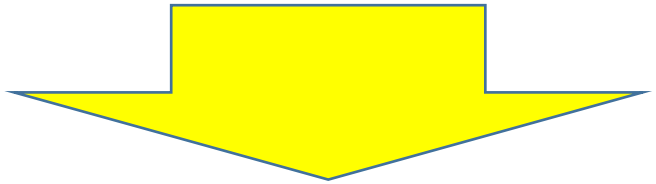
Group S



Discussion

✓In this study, the medial side of the femur in group L was located more anteriorly than that in groups I and S during mid–flexion. A central pivot motion and a subsequent bicondylar rollback were observed during flexion in group L; a paradoxical medial anterior motion was observed at early–flexion and the medial AP translation with flexion was larger in group L.

- Paradoxical anterior motion has been reported in ACL–deficient knees, indicating poor satisfaction (19, 20).
- In knees that have undergone total knee arthroplasty (TKA), medial anterior translation was associated with less favorable clinical outcomes (21).
- Low femoral anteversion, excessive tibial external torsion, and excessive tibial external rotation relative to the femur were associated with increased medial contact pressure (10, 11, 13).
- Femoral anteversion is lower in knees with medial OA than in healthy knees (8, 22), and the tibial external torsion is positively associated with medial joint loading (14).

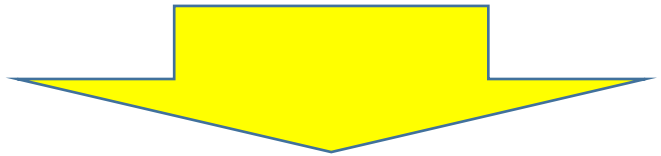


A large TR may induce excessive medial AP translation and joint contact pressure, which may progress to medial knee OA.

Discussion

- ✓ In this study, the femurs of volunteers in group S had more axial external rotation than those of the volunteers in groups L and I. The lateral side of the femurs of volunteers in group S had more posterior movement from mid-flexion to high-flexion than those of the volunteers in groups L and I.
- Large femoral anteversion and low tibial torsion did not affect the medial compartment contact pressure (10).

- ✓ In the current study, the FNAn was negatively correlated with TR, and the TTA was positively correlated with TR.
- Greater femoral external rotation and posterior translation of the lateral side of the femur were associated with high patient-reported outcome measures in patients who underwent TKA (21, 23).



A small TR may lead to more favorable knee kinematics.

Conclusions

- ➢ Individuals with a larger TR have more anterior medial translation of the femur relative to the tibia with a central pivot.
- ➢ Individuals with a smaller TR have more external rotation and posterior lateral translation of the femur relative to the tibia.

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