

The influence of knee flexion angle on sagittal spinopelvic alignment in patients with knee osteoarthritis

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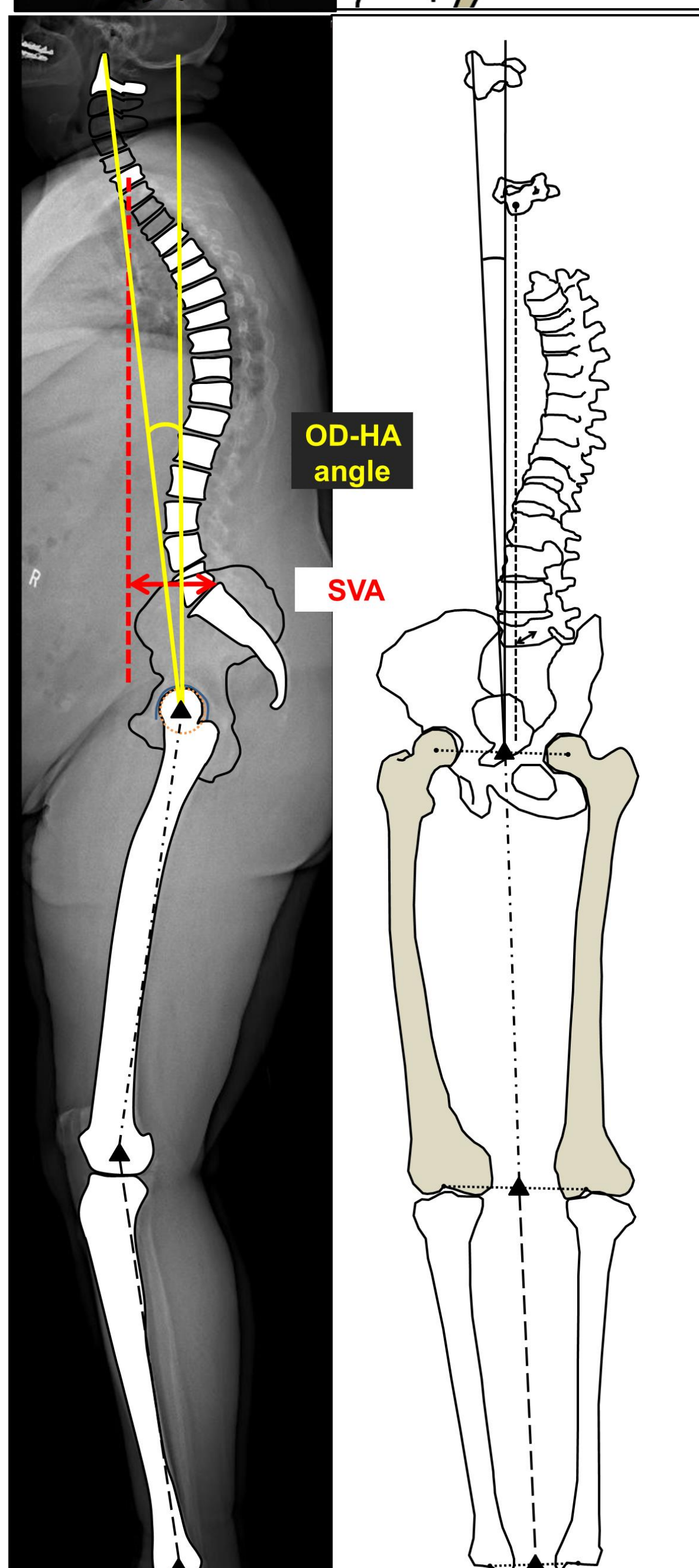
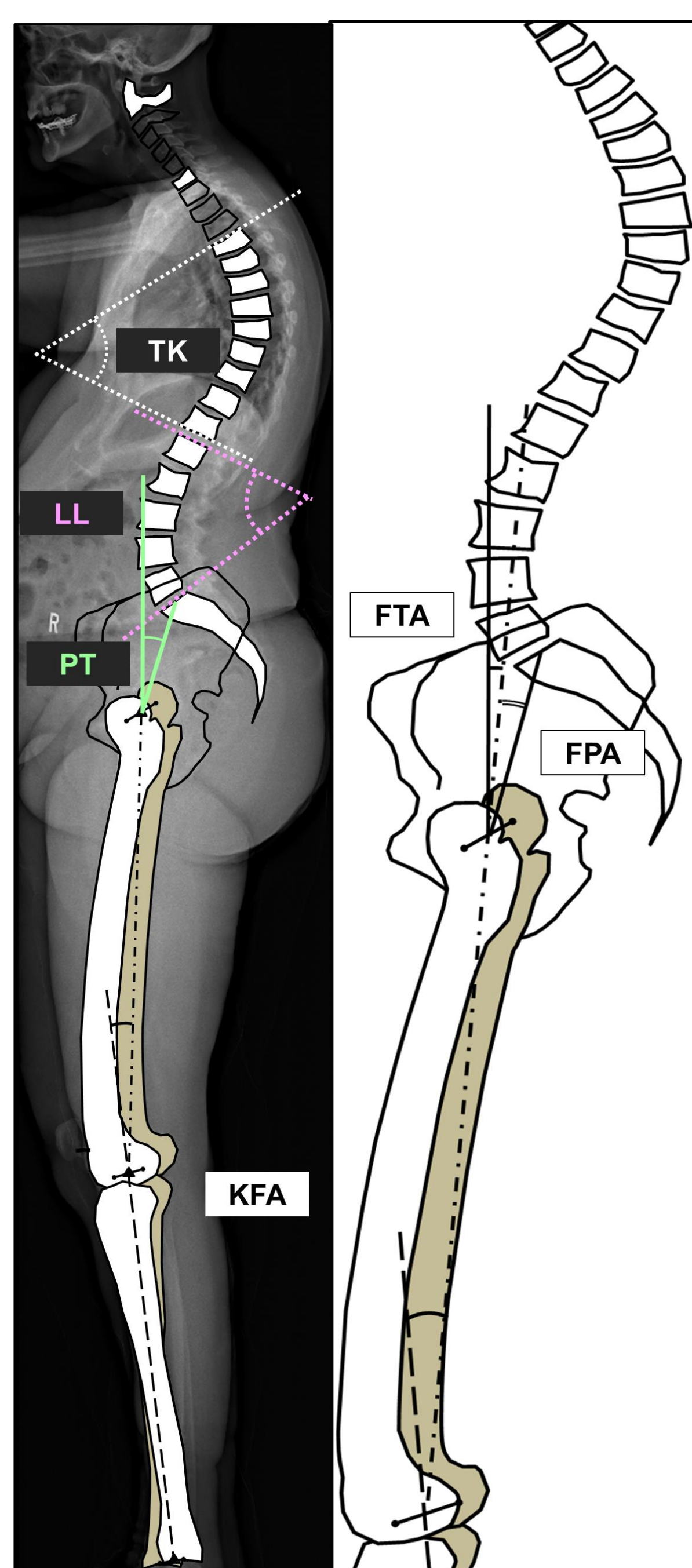
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BACKGROUND

- Abnormal spinopelvic alignment in the sagittal plane is thought to contribute to the sagittal imbalance and the pathogenesis of chronic low back pain [1].
- Knee flexion is a compensatory mechanism in cases of sagittal imbalance [2].
- Therefore, malalignment of the osteoarthritic (OA) knee may contribute to abnormal spinopelvic alignment in the sagittal plane and sagittal balance.

The purpose of this retrospective study was to assess the correlation between knee flexion angle (KFA) and sagittal spinopelvic alignment and sagittal balance parameters of patients with end-stage knee OA in a weight-bearing standing position using a low-dose biplanar imaging system.



METHODS: Patients and data selection

161 patients (n = 161) selected as follows:

- End-stage knee OA
- Pre-operative bi-planer X-rays preoperatively obtained with EOS™ 2D/3D system, a low-dose system acquiring simultaneous radiographs in sagittal and coronal planes of the patient from head to feet between January 2018 to May 2019.

Excluded 39 patients (n = 39)

- Previous spinal fracture or surgery
- Spondylolisthesis or Scoliosis with curves of >20 degrees
- Hip OA or post hip prosthesis implantation

122 patients (n = 122): 50 male, 72 female) selected

- 50 male / 72 female
- 64.9 ± 11.0 years (range: 30 to 88)
- BMI (average 33.1 ± 7.6, range: 13 to 84)

METHODS: Studied parameters

All parameters were calculated in the patient's reference frame

Global sagittal alignment parameters

- Thoracic Kyphosis (TK) °: T4 to T12
- Lumbar lordosis (LL) °: L1 to S1
- Pelvic tilt (PT) °: sacral endplate to femoral head
- Femoro-pelvic angle (FPA) °: femoral mechanical axis to a line between sacral endplate to femoral head (It indicated sagittal alignment of the hip joint)
- Femoral tilt angle (FTA) °: femoral mechanical axis to vertical
- Knee flexion angle (KFA) °: mechanical axis of femur and tibia

Sagittal balance parameters

- Sagittal vertical axis (SVA) mm: horizontal distance between plumb line from C7 to posterosuperior S1 corner
- Odontoid hip axis angle (OD-HA) °: highest point of odontoid process connecting to axis of femoral head

METHODS: Statistical analysis

- Shapiro-Wilk normality test
- Pearson's product-moment correlation coefficients (R_p) or Spearman's rank-order correlation coefficients (R_s) among all parameters were calculated.
- Statistical significance was set at $p < 0.05$ (SPSS version 24).

RESULTS

| | Mean | SD | Range |
|-----------|------|------|---------------|
| TK (°) | 41.2 | 13.5 | 11.8 – 74.7 |
| LL (°) | 54.5 | 11.6 | 20.6 – 81.7 |
| PT (°) | 14.9 | 9.1 | -5.7 – 44.0 |
| FPA (°) | 12.8 | 10.4 | -17.4 – 39.9 |
| FTA (°) | 3.0 | 5.1 | -8.0 – 16.7 |
| KFA (°) | 9.4 | 7.6 | -11.6 – 38.2 |
| SVA(mm) | 30.3 | 38.7 | -58.4 – 137.8 |
| OD-HA (°) | 1.2 | 4.6 | -9.1 – 12.8 |

Table 1. Descriptive analysis of the measured sagittal alignment and sagittal balance parameters.

TK: Thoracic Kyphosis; LL: Lumbar Lordosis; PT: Pelvic Tilt; FPA: Femor-pelvic Angle; FTA: Femoral Tilt Angle; KFA: Knee Flexion Angle; SVA: Sagittal Vertical Axis; OD-HA: Odontoid Hip Axis Angle.

| | TK | LL | PT | FPA | FTA | KFA | SVA | OD-HA |
|------|-------|--------|--------|--------|---------|-----------|-----------|----------|
| TK | 1.000 | *0.567 | 0.003 | 0.059 | 0.016 | † 0.148 | † 0.026 | 0.074 |
| LL | | 1.000 | -0.117 | 0.035 | *-0.239 | † -0.115 | *† -0.260 | -0.180 |
| PT | | | 1.000 | *0.833 | 0.095 | † 0.064 | † 0.060 | *-0.198 |
| FPA | | | | 1.000 | *-0.296 | *† -0.247 | † -0.138 | *-0.412 |
| FTA | | | | | 1.000 | *† 0.793 | *† 0.489 | *0.500 |
| KFA | | | | | | 1.000 | *† 0.352 | *† 0.315 |
| SVA | | | | | | | 1.000 | *† 0.838 |
| ODHA | | | | | | | | 1.000 |

Table 3. Correlation coefficient among all parameters.

$p=0.05$ *=significant difference; Correlation coefficient: R_p or † R_s ;

DISCUSSION

- Significant correlation between KFA and FPA, FTA, SVA, OD-HA angle
- Significant correlation between FTA and LL, FPA, SVA, OD-HA angle
 - ⇒ Larger knee flexion led to hip flexion, posterior femoral tilt, anterior sagittal balance
 - Strong correlation between KFA and FTA indicated that femoral tilt was major factor of knee flexion
 - Larger FTA led to loss of lumbar lordosis, hip flexion, anterior sagittal balance

Previous Studies

- Simulated knee flexion resulted in loss of lumbar lordosis, hip flexion, and anterior shift of sagittal balance. [3]

Current Study

- Patients with flexion contracture of the knee shifted balance anterior to resist posterior sagittal imbalance produced by knee flexion. The mechanism that shifts the balance anterior is loss of lumbar lordosis and hip flexion.
- Correction of the sagittal malalignment of the knee by realignment surgery such as total knee arthroplasty may improve the anterior sagittal imbalance.

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