Sagittal imbalance is a poor prognostic factor after proximal femoral fracture: a 3-year multicenter prospective cohort study

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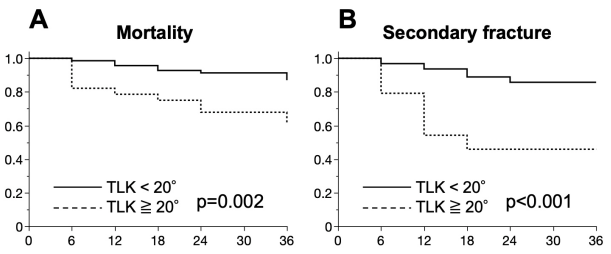
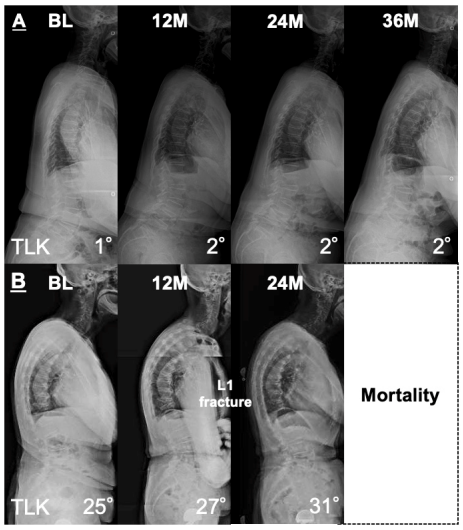
INTRODUCTION:
Proximal femoral fractures in older adults significantly reduce life expectancy and often lead to secondary fractures and deteriorated daily activities. Although global fracture liaison services have improved osteoporosis assessment, recent studies using bisphosphonates have shown limited success in preventing secondary fractures and reducing mortality. Prognostic studies mostly focus on vertebral fractures, which are linked to poor outcomes and increased mortality, with severe thoracic vertebral fractures predicting secondary fractures. Sagittal imbalance, associated with declines in daily activities, falls, fractures, and mortality, may influence the prognosis of proximal femoral fractures. This study hypothesizes that sagittal imbalance parameters significantly impact the prognosis of these fractures and aims to identify the most predictive parameters.

METHODS:
This multicenter prospective cohort study included patients who underwent surgery for fragility-induced proximal femoral fractures at four hospitals between April 2020 and March 2021. Data collected included age, sex, BMI, comorbidities (diabetes, CKD, COPD, thyroid disease, malignancies), medication use, osteoporosis treatments, alcohol consumption, smoking status, and fracture history. BMD was measured at 1 week, 12, 24, and 36 months post-surgery. Sagittal spine parameters and serum bone turnover markers were also evaluated. Patients were followed up at 6, 12, 18, 24, and 36 months post-surgery to monitor mortality and secondary fractures. Radiographs were taken if secondary fractures were suspected. Reasons for missed follow-ups were investigated via telephone.

RESULTS: Out of 307 patients initially registered, 115 were excluded (13 did not consent, 15 had contralateral femoral fractures, and 87 could not undergo standing spinal radiography). Out of 192 patients analyzed, 22 (11.5%) died and 23 (12.0%) experienced secondary fractures within 36 months. Mortality was significantly associated with older age (86.55 vs. 78.12 years; $P<0.001$), higher CKD prevalence (18.2% vs. 2.4%; $P=0.004$), warfarin use (13.6% vs. 2.4%; $P=0.025$), and more prior vertebral fractures (2.41 vs. 0.68; $P<0.001$). The thoracolumbar kyphosis (TLK) was greater in the mortality group (21.65° vs. 11.12°; $P<0.001$). Secondary fractures were associated with older age (82.78 vs. 77.85 years; $P=0.037$), higher use of sleeping pills (39.1% vs. 13.7%; $P=0.007$) and antidepressants (21.7% vs. 5.5%; $P=0.019$), more prior vertebral fractures (1.61 vs. 0.62; $P<0.001$), and higher C7-S1 sagittal vertical axis (SVA) (139.04 vs. 59.24 mm; $P<0.001$). Multivariate analyses confirmed previous vertebral fractures and TLK as significant predictors of increased mortality and secondary fractures. Patients with TLK <20° had significantly higher survival rates compared to those with TLK ≥20° ($P=0.002$ for mortality and $P<0.001$ for secondary fractures) (Fig.1 and 2).
DISCUSSION AND CONCLUSION: Our study underscores the significant prognostic value of TLK and previous vertebral fractures in predicting outcomes after proximal femoral fractures. This adds a new perspective by linking sagittal imbalance, easily assessed through simple radiographs, to mortality and secondary fractures. While previous research often focused on BMD, our results suggest that structural spinal alterations like TLK are crucial. Sagittal imbalance is associated with decreased ADL and increased mortality. TLK was closely linked to prior vertebral fractures, indicating its negative impact on patient outcomes and reinforcing its use as a practical prognostic indicator. Previous vertebral fractures significantly increase the risk of subsequent fractures, independent of BMD. These findings support the concept of "very high fracture risk" in osteoporosis, advocating for aggressive treatment strategies. Integrating spinal imaging and kyphosis evaluation into routine assessments can help tailor effective rehabilitation and surgical interventions. In conclusion, TLK and previous vertebral fractures are critical prognostic factors for patients with proximal femoral fractures, suggesting comprehensive treatment plans incorporating sagittal balance assessments.


A
Mortality
1.0
0.8
0.6
0.4
0.2
0
0 6 12 18 24 30 36
TLK < 20°
TLK ≧ 20°
p=0.002
B
Secondary fracture
1.0
0.8
0.6
0.4
0.2
0
0 6 12 18 24 30 36
TLK < 20°
TLK ≧ 20°
p<0.001


A BL
12M
24M
36M
TLK 1°
2°
2°
2°
B BL
12M
24M
L1 fracture
Mortality
TLK 25°
27°
31°