Should Knee Flexion be Accounted for in Spinal Deformity Surgery Planning?

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INTRODUCTION:

Compensatory mechanisms in the spine are thought to help patients with deformities maintain sagittal alignment. Pelvic retroversion and thoracic hypokyphosis are key mechanisms that help maintain balance. When these mechanisms are exhausted, patients often flex their hips and bend their knees. We hypothesized that patients with different degrees of Pelvic Incidence (PI) have the capacity to compensate via pelvic retroversion prior to initiating lower extremity compensation.

METHODS:

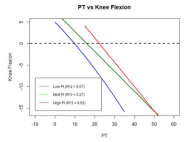
This was a retrospective radiographic analysis of the EOS images at a single institution. Various spinal sagittal parameters and lower extremity knee flexion measurements were performed. Patients were subcategorized according to PI. Knee flexion in these groups was correlated with various sagittal parameters to determine whether there were differences when knee flexion occurred based on the PI.

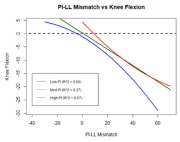
RESULTS:

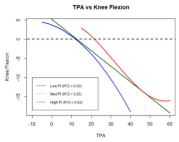
Knee flexion was independently correlated with PI, pelvic tilt (PT), PI-lumbar lordosis mismatch (PI-LL), and T1 pelvic inclination angle (TPA) in multiple linear regression analysis ($p < 0.05$). In patients with lower PI, knee flexion occurred at a PT of 10-15°, PI-LL mismatch of-5-0°, and TPA of about 10-15°. In those with high PI, knee flexion occurred at a PT of approximately 25-30°, PI-LL mismatch of approximately 15-20°, and TPA about 25°. Those with a lower PI also more rapidly increased knee flexion with further increases in PI-LL mismatch and TPA compared to those with a higher PI.

DISCUSSION AND CONCLUSION:

This study demonstrates that patients with different PI have different capacities to compensate for increasing sagittal plane deformity prior to initiating knee flexion lower extremity compensation. Those with a lower PI retroverted their pelvis less and begin knee compensation earlier than those with a higher PI. These findings are important for surgical planning in patients with differing PI who are compensating for knee flexion.







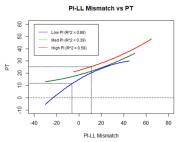


Table 1 – Baseline demographics and sagittal parameter measures

Number measured	175	
Age	56.5	±19.2
Gender (M:F)	95	15:80
T4-T12 TK	32.2	±13.0
L1-S1 LL	-41.7	±18.3
SS	34.7	±10.6
PT	22.9	±11.0
PI	54.3	±14.4
PI-LL	9.7	±19.9
TPA	21.5	±14.0
SFA	218.6	±237.6
KA	-0.8	±9.9

Table 2 - Linear regression comparing sagittal parameters (PT, PI, PI-LL mismatch and TPA) to knee flexion angle (KA).

Linear Regression			
KA vs PT	coefficient	Std Error	P-value
PT	-0.11	0.10	0.30
KA vs PT and PI			
PT	0.07	0.17	0.554
PI	-0.24	0.09	0.012
KA vs PT, PI and PI-LL mismatch			
PT	0.5	0.17	0.003
PI	-0.43	0.09	<0.001
PI-LL mismatch	-0.21	0.09	0.021
KA vs PT, PI and TPA			
PT	0.39	0.16	0.036
PI	-0.18	0.09	0.05
TPA	-0.36	0.16	0.026