Compensatory Mechanisms & the Effect of Age on Sagittal Balance in Spondylolisthesis: An Analysis Utilizing the Pelvic Radius Technique

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SSA '12

Sydney, April 29th 2012

Wentworth Spine Clinic

Dalcross Adventist Hospital

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Mokhtar	Nil	
McCombe	Royalties:	Medtronic, Paradigm Spine
	Stock options:	Paradigm Spine
	Consultant:	Medtronic, Paradigm Spine
Saravanja	Nil	
Sergides	Research support:	Medtronic
White	Consultant:	Medtronic
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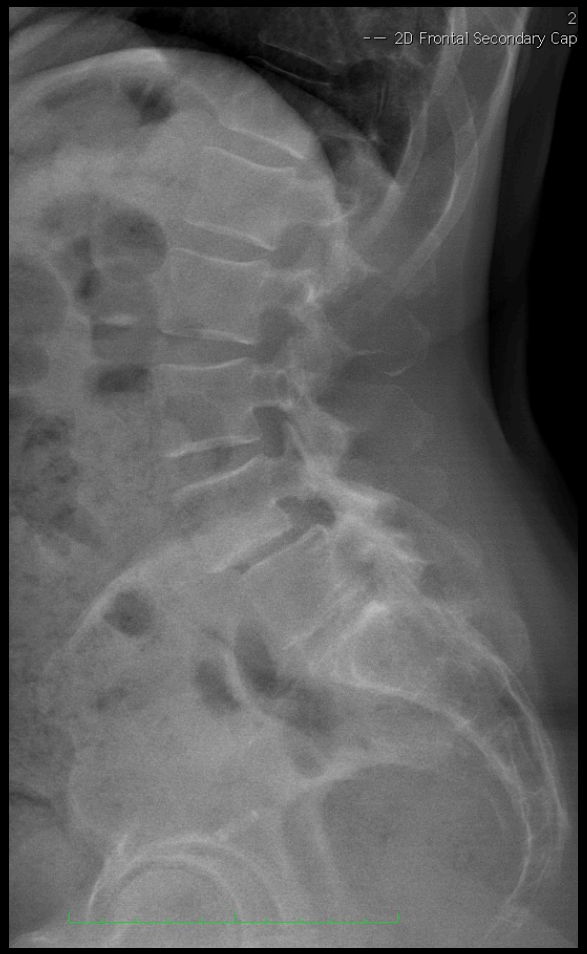
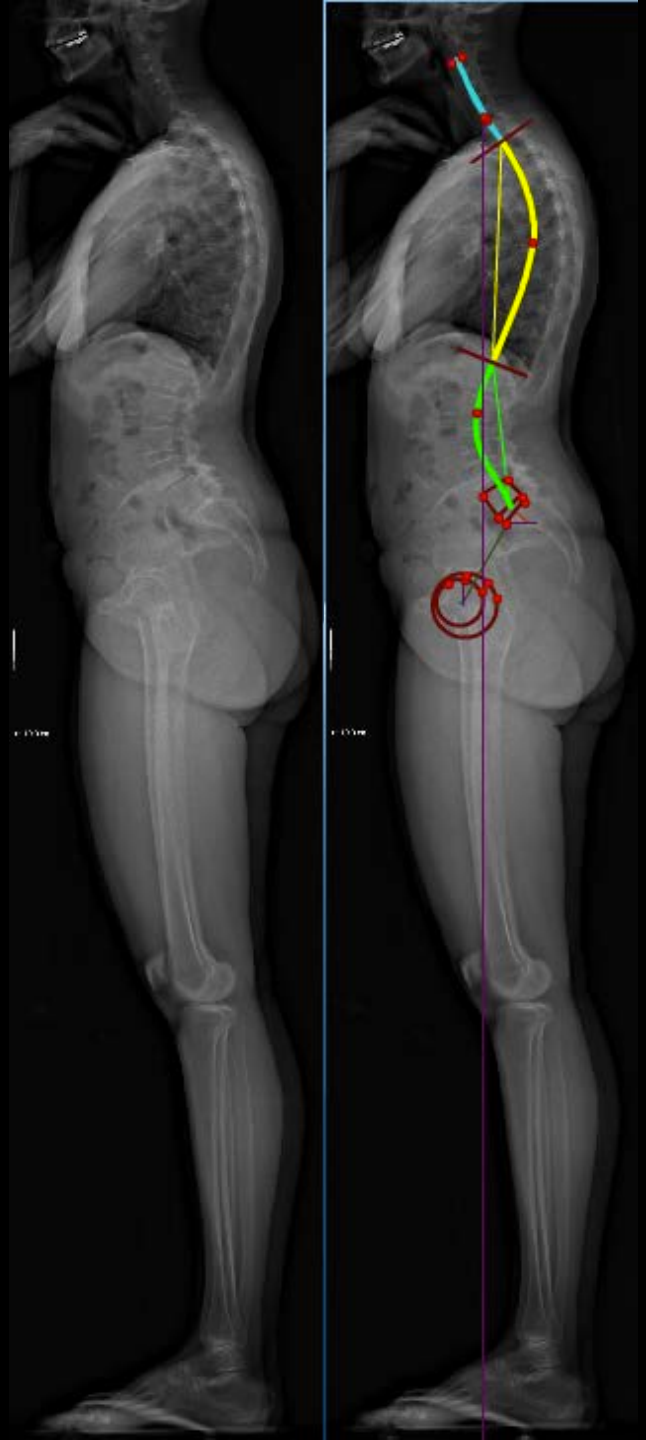
Sydney, 2012

Background

- Few studies have investigated age & sagittal alignment
- None have examined this in spondylolisthesis





Pelvic parameters :

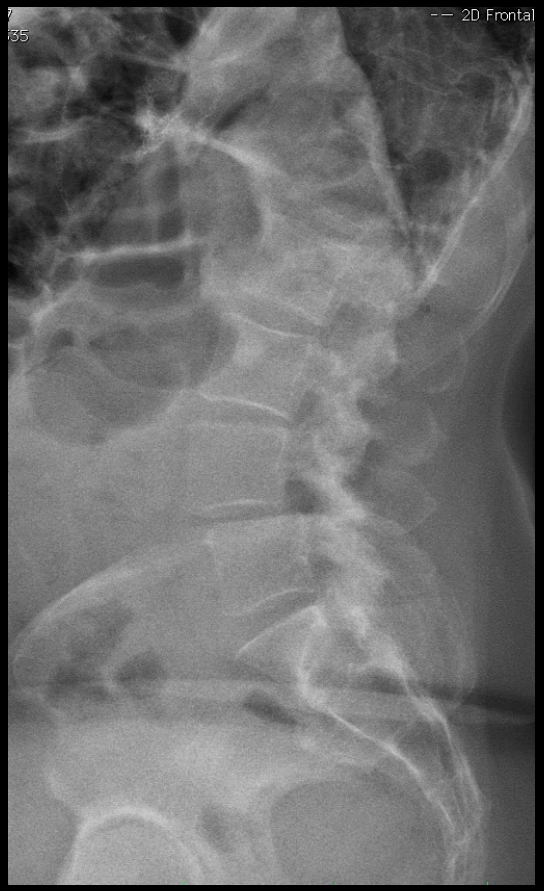
			Very small — Average — Very high
Shape	Pelvic incidence	77.85	
	L5 incidence	48.53	
Position	Pelvic tilt	29.03	Strong retroversion — Strong anteversion
	Sacral slope	48.81	

Balance parameters :

Spinal Kyphosis	SSA	134.24	Hyper Kyphosis — Hypo Kyphosis
C7 Plumbline	Hip to C7 / Hip to S1 post.	0.31	In front of femoral heads — Sacral plate posterior edge — Behind sacrum

Type of back :

Type 4 — Lumbar lordosis angle = 70.62° — Thoracic Kyphosis angle = 57.02°



Shape

			Very small	Average	Very high
Shape	Pelvic incidence	58.57			
	L5 incidence	27.38			
			Strong retroversion		Strong anteversion
Position	Pelvic tilt	28.14			
	Sacral slope	30.43			

Balance parameters

			Hyper Kyphosis		Hypo Kyphosis
Spinal Kyphosis	SSA	123.71			
			In front of femoral heads	Sacral plate posterior edge	Behind sacrum
C7 Plumbline	Hip to C7 / Hip to S1 post.	1.15			

Type of back

False Type 2 => previous Type 3/4

Lumbar lordosis angle = 60.36°
Thoracic Kyphosis angle = -69.4°

Pelvic parameters :

			Very small / Average / Very high
Shape	Pelvic incidence	39.65	
	L5 incidence	28.01	
Position	Pelvic tilt	21.45	Strong retroversion / Strong anteversion
	Sacral slope	18.2	

Balance parameters :

Spinal Kyphosis	SSA	90.81	Hyper Kyphosis / Hypo Kyphosis
C7 Plumbline	Hip to C7 / Hip to S1 post.	-1.83	In front of femoral heads / Sacral plate posterior edge / Behind sacrum

Type of back :

Type 2 | Lumbar lordosis angle = 5.07° | Thoracic Kyphosis angle = 24.27°

Objectives

Age *vs.*

1. Spino-pelvic sagittal alignment
2. Sagittal compensation mechanisms

Methodology

- Cross-sectional observational study
- Pre-operative radiographs
- 382 consecutive surgical patients
  - Isthmic: 85
  - Degenerative: 297

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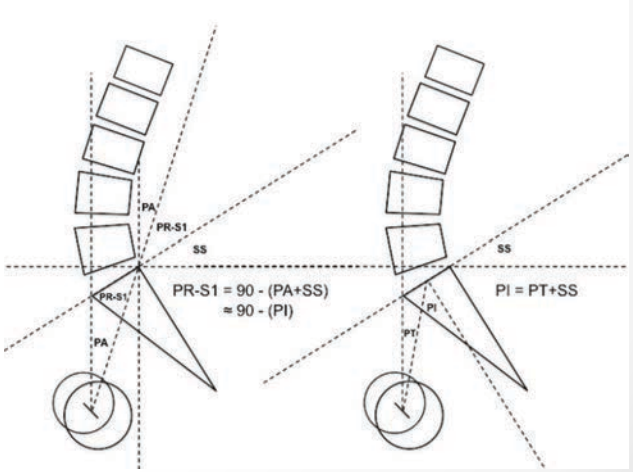
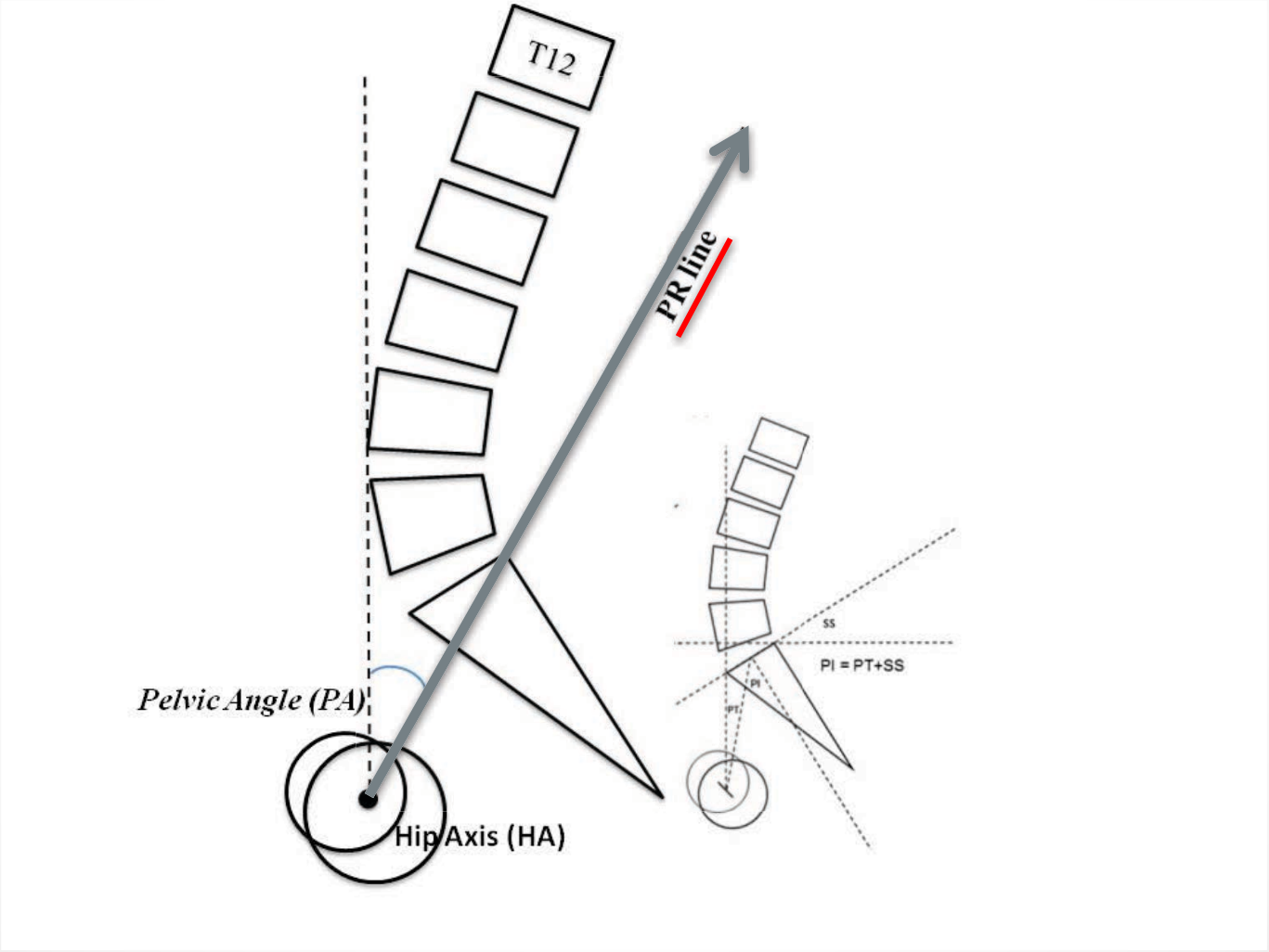
- Cross-sectional observational study
- Pre-operative radiographs
- 382 consecutive surgical patients
  - Isthmic: 85
  - Degenerative: 297
- Inclusion criteria:
  - Isthmic or degenerative spondylolisthesis
  - Failed conservative management
- Exclusion criteria:
  - History of prior surgery, trauma, tumour, infection
  - Concomitant coronal plane deformity

X-ray Measurement

- 36-inch erect films
- Manual acquisition
- Pelvic Radius Technique (Jackson et al. *Spine* 2000)
  - Pelvic lordosis (**PRS1**)
  - Pelvic angulation (**PA**)
  - Total lumbar lordosis (**T12S1**)
  - Total lumbo-pelvic lordosis (**PRT12**)



Jackson's Pelvic Radius technique



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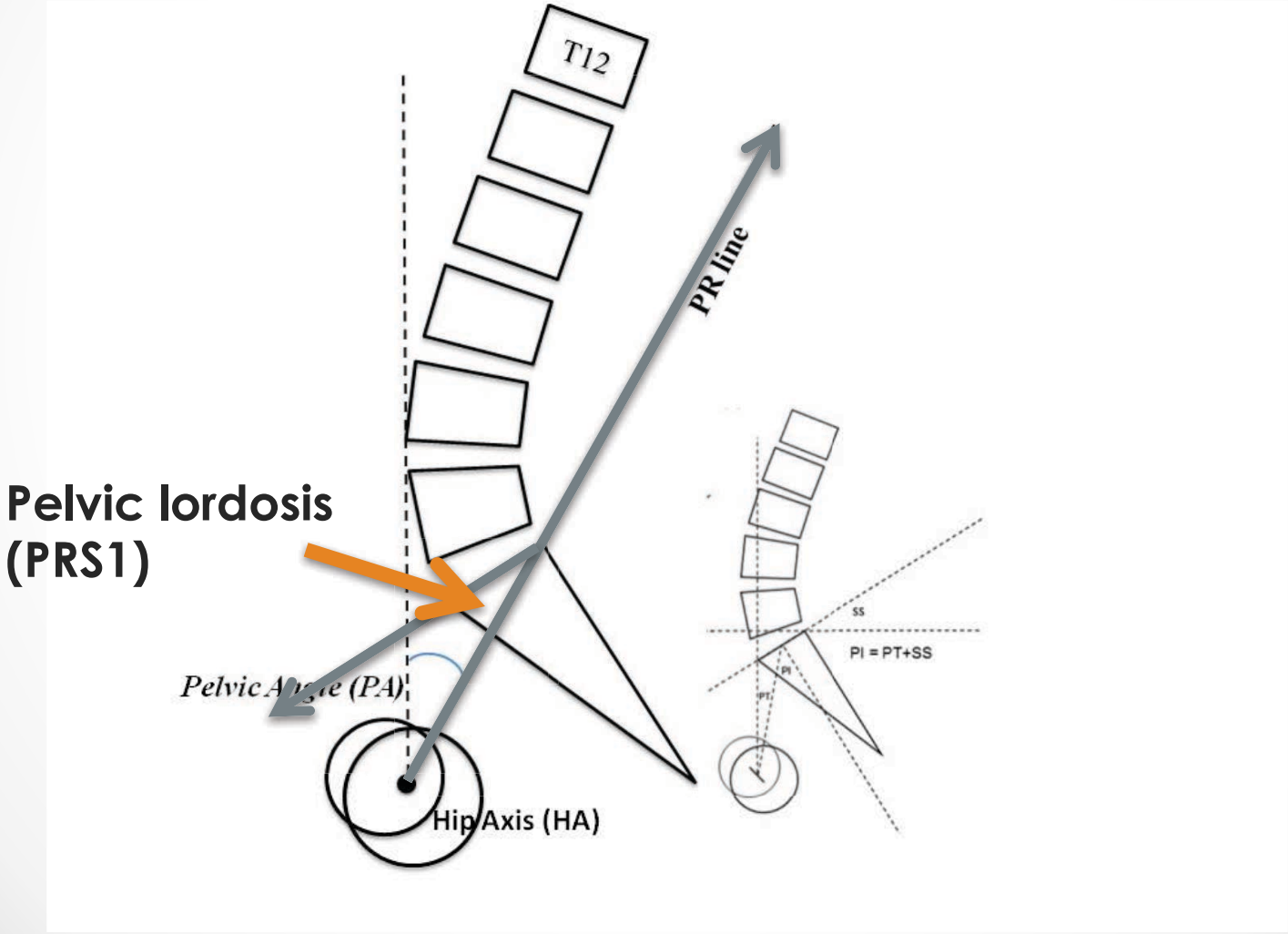

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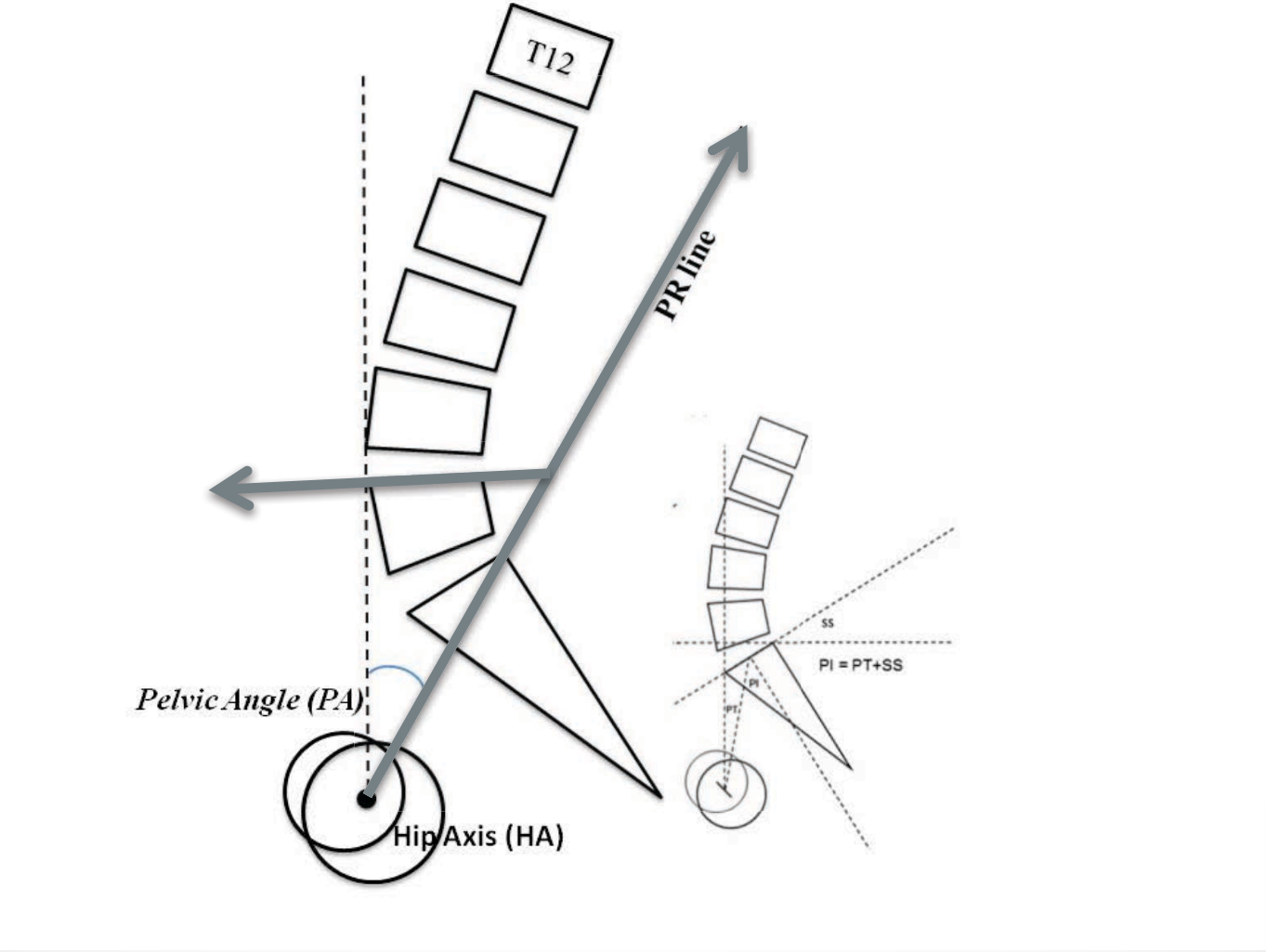

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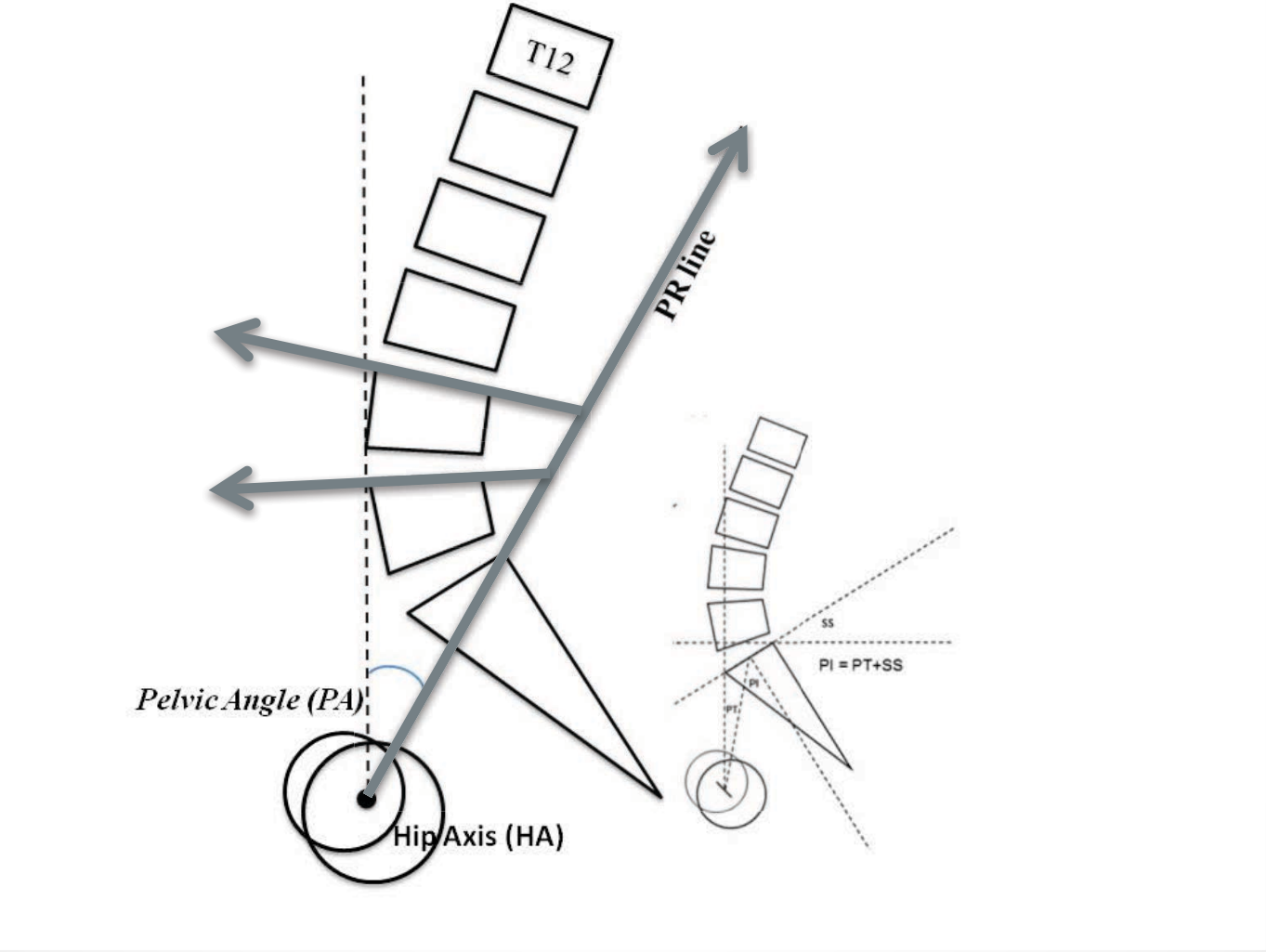

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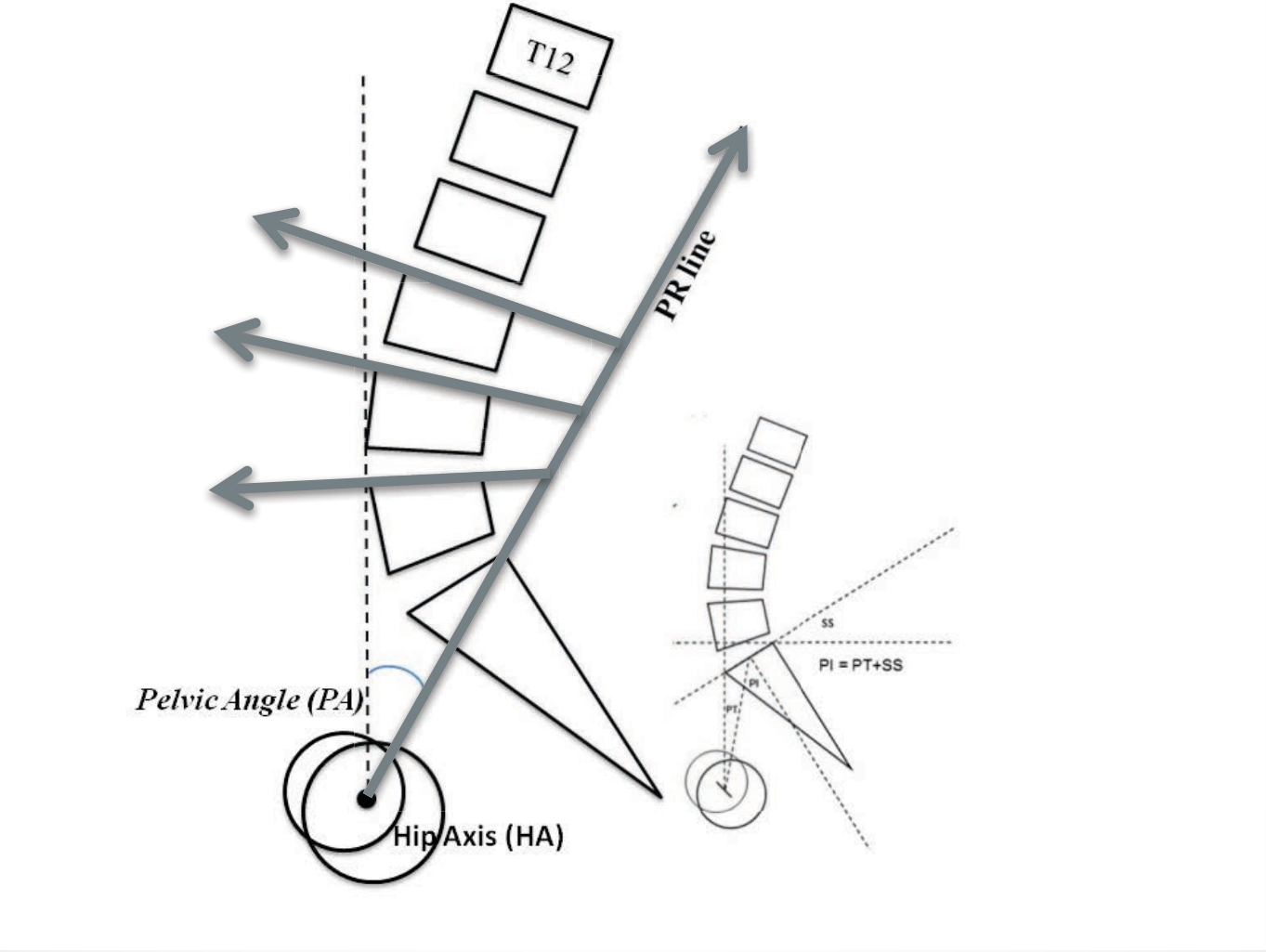
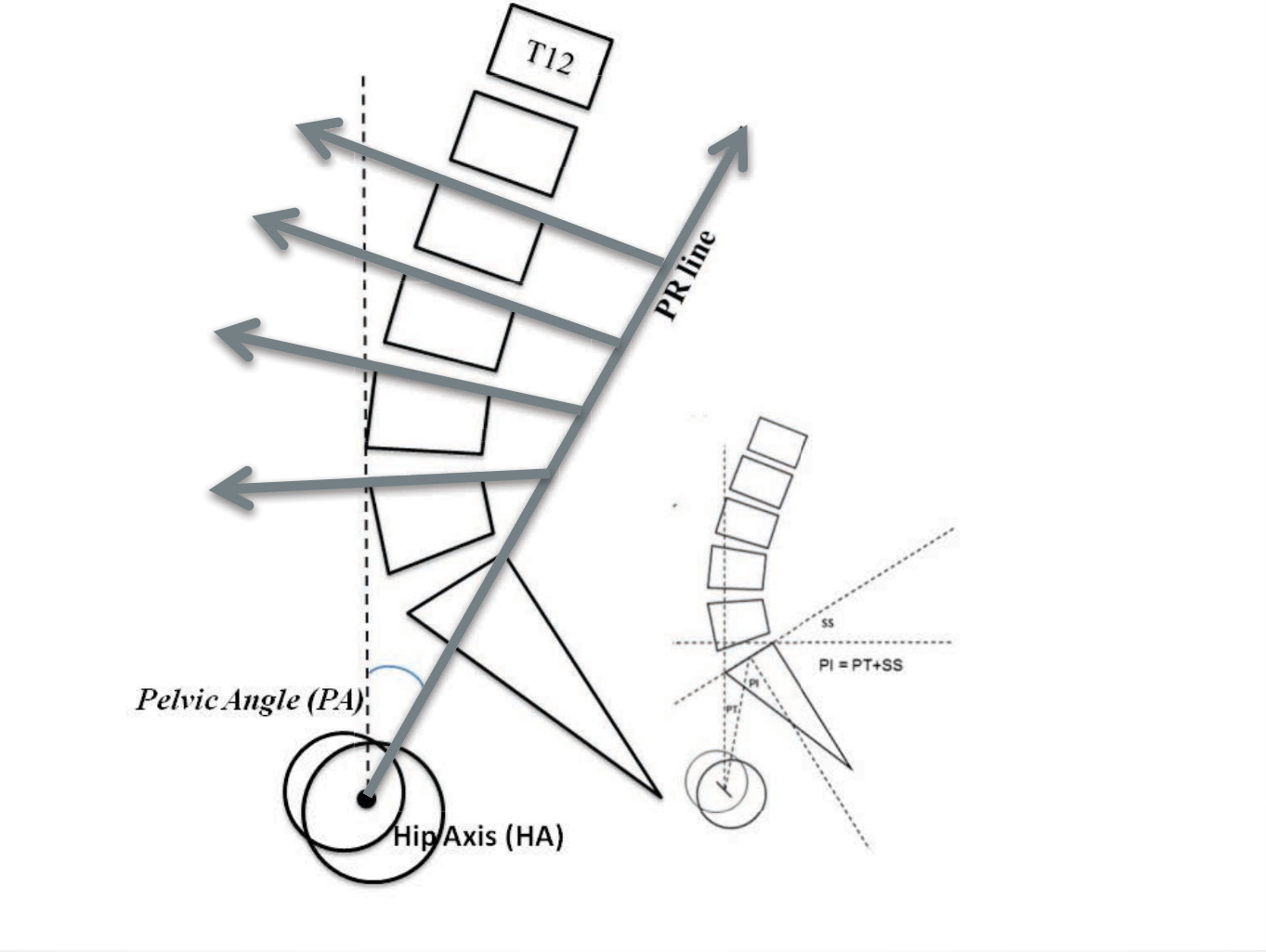
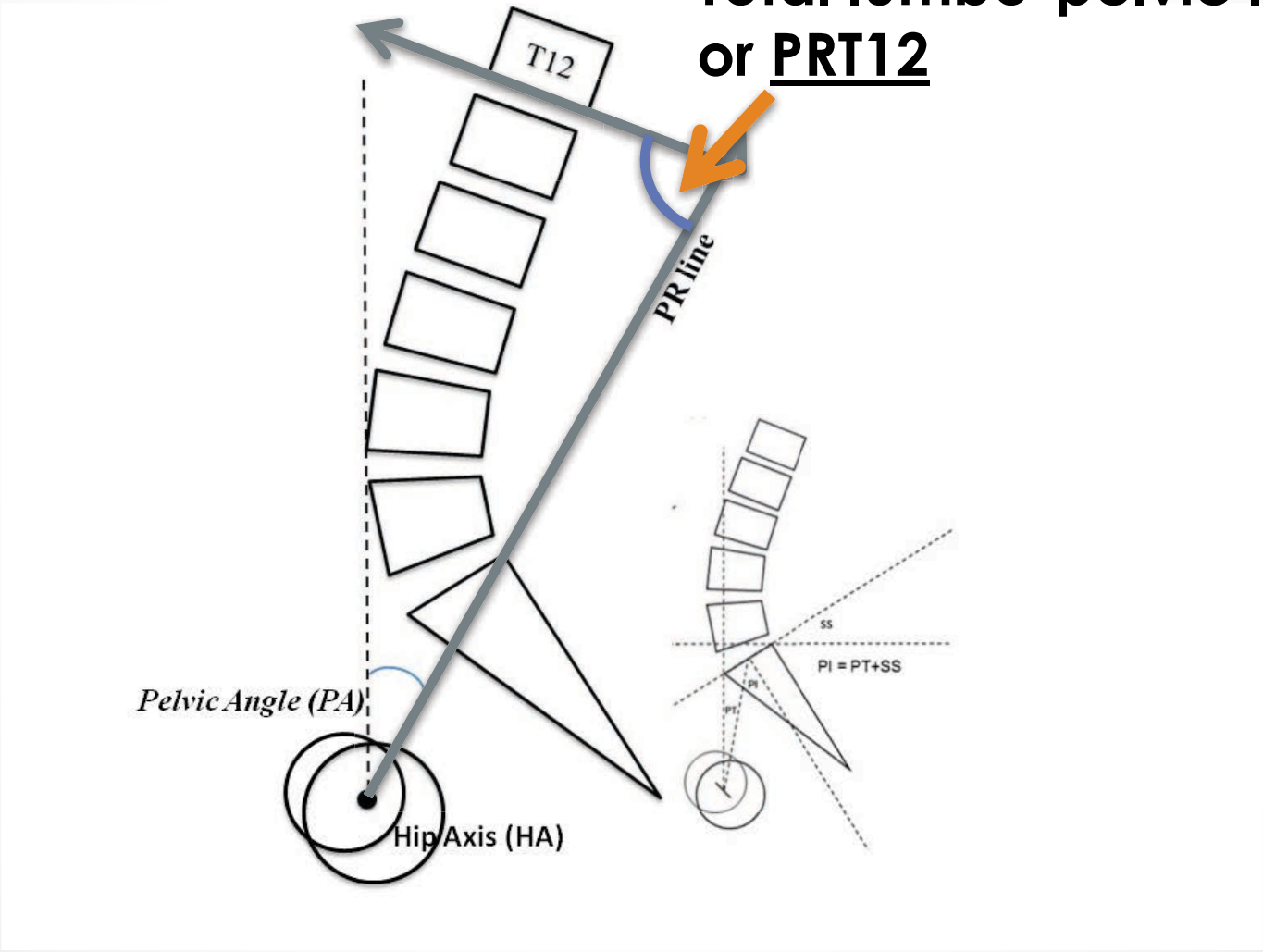


Jackson's Pelvic Radius technique

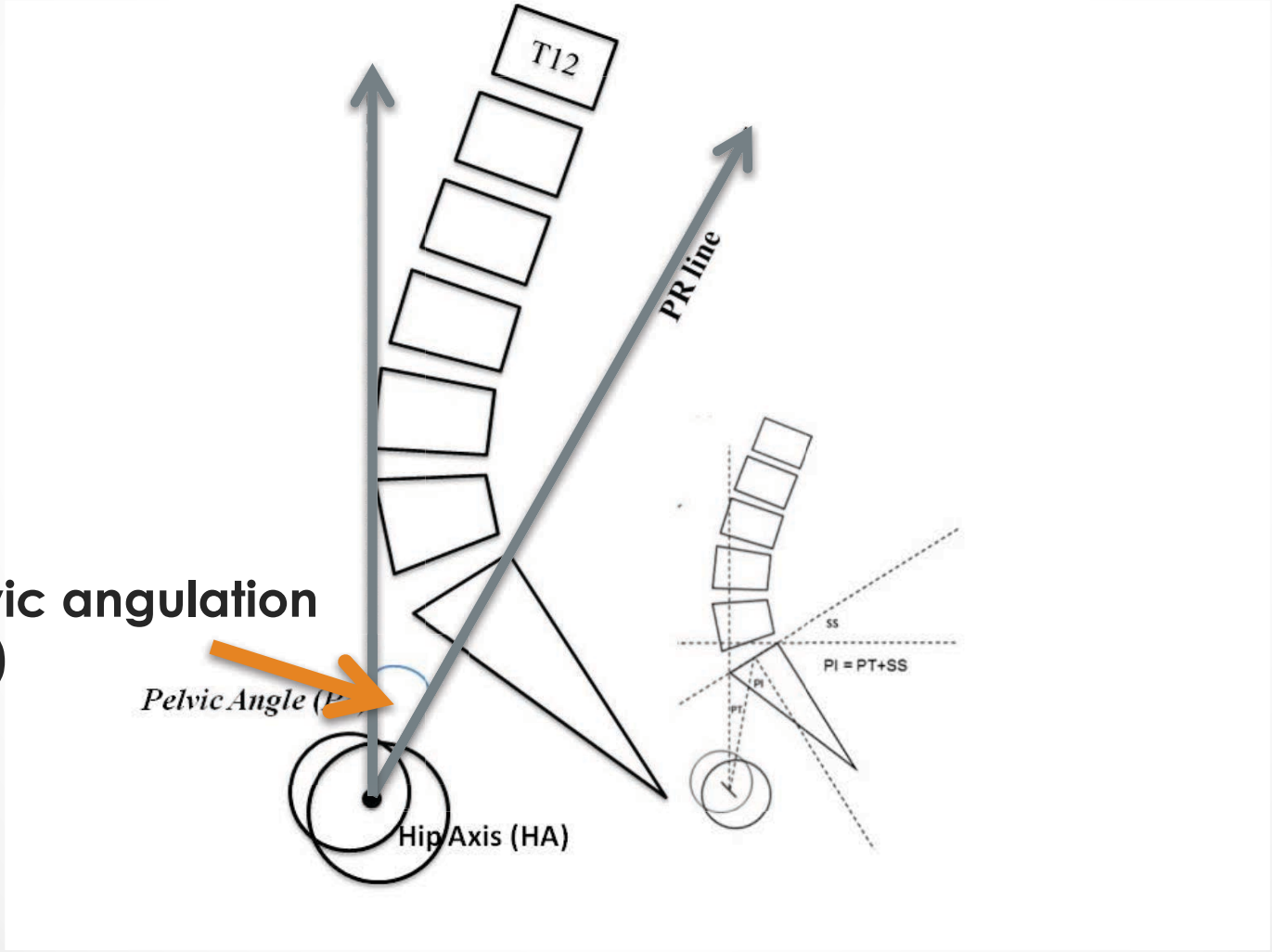


Jackson's Pelvic Radius technique

Total lumbo-pelvic lordosis or PRT12



Jackson's Pelvic Radius technique



Statistical analysis

- Age on alignment:
  - Univariate correlations:
    - Age *vs.* Jackson Measures
      - All
      - Isthmic subgroup
      - Degenerative subgroup
- Age on compensation mechanisms:
  - Multivariate correlations: focal lordosis, lordosis above, total lumbar lordosis, total lumbo-pelvic lordosis and pelvic lordosis
    - All patients
    - Stratified into ages: <45 years, 45-60, >60 years
- SPSS software (version 19.0). Significance set at $P < 0.05$.

Results (1)

- Degenerative spondylolisthesis patients (n=297):
  - No significant correlations

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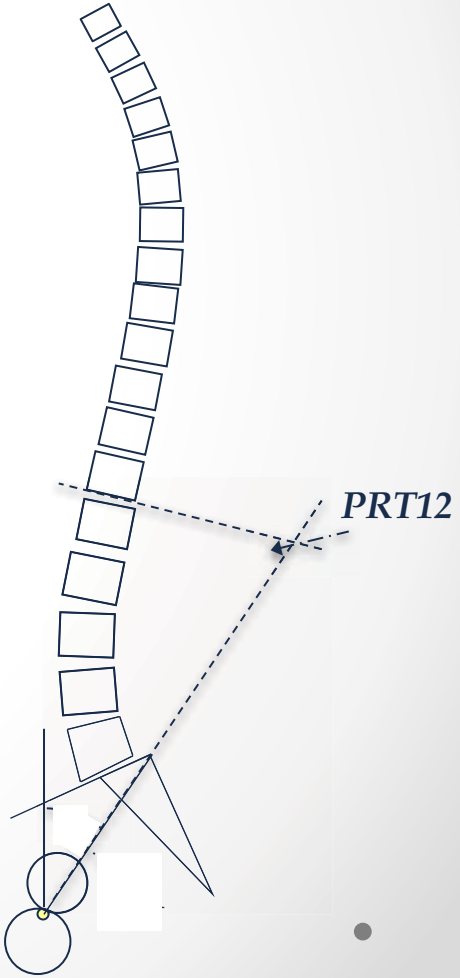
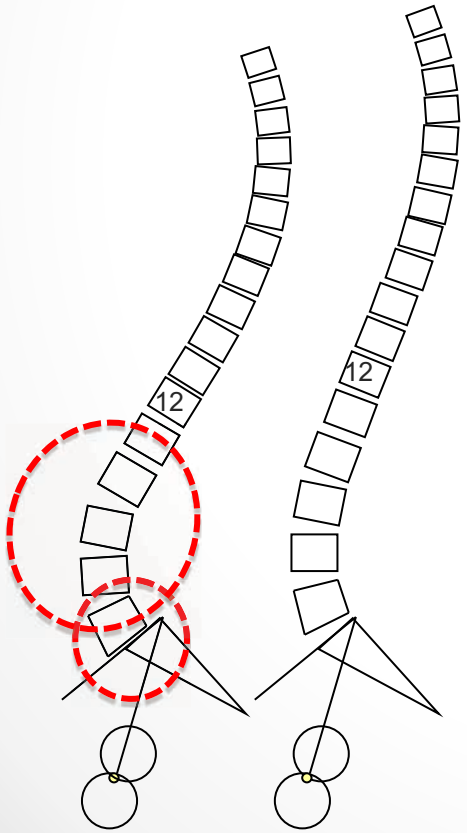
- Degenerative spondylolisthesis patients (n=297):
  - No significant correlations

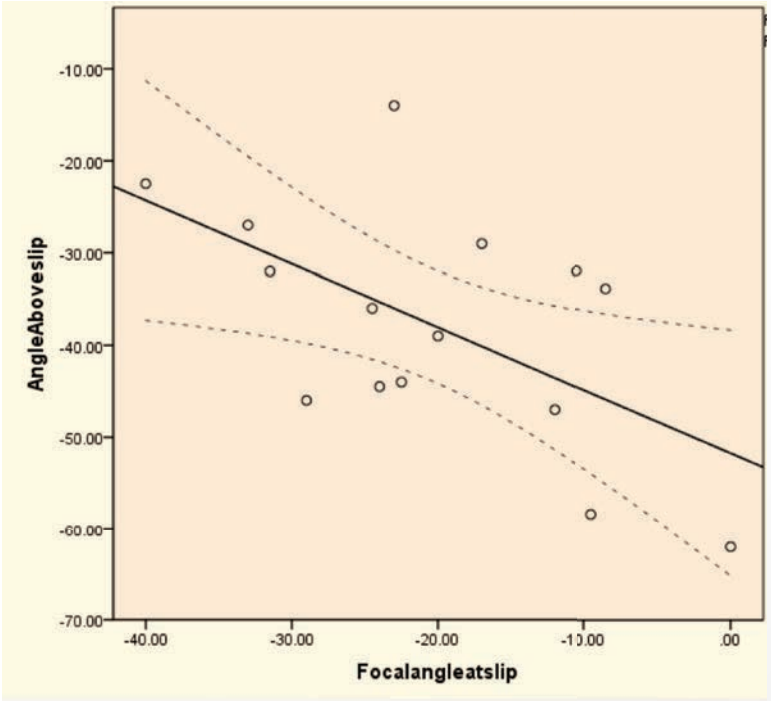
- Isthmic spondylolisthesis patients (n=85):
  - Significant correlations vs. age *(p=0.002)*:
    - PRT12 (= -0.45)
    - Pelvic angulation (r = 0.44)



Results (2)

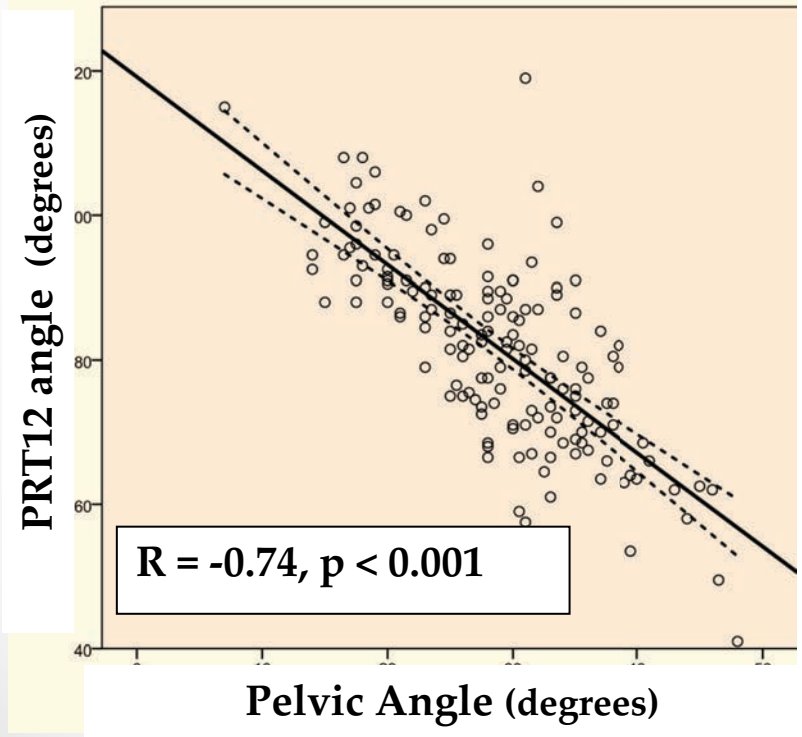
- Isthmic spondylolisthesis, younger subgroup (n=24)
  - focal lordosis at the level of the slip vs. lumbar lordosis above ($r = -0.58$, $p = 0.02$)

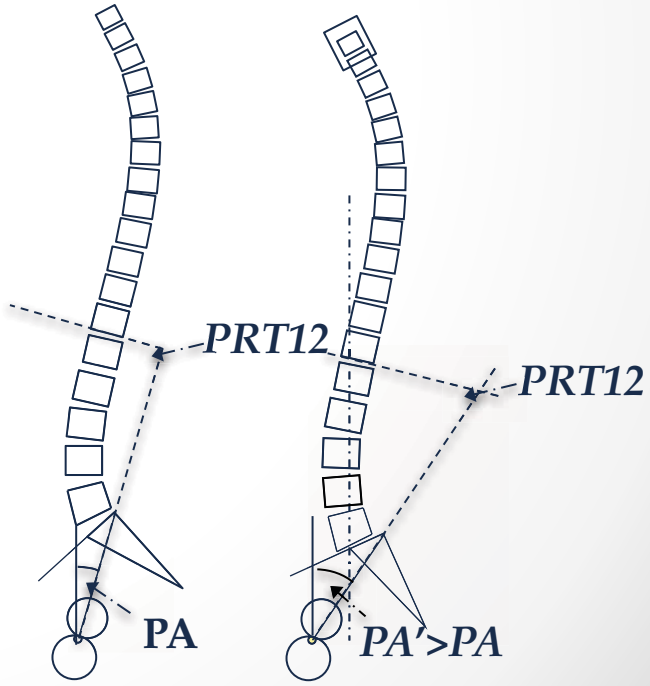




Results (3)

- Degenerative spondylolisthesis (n=297):
  - Pelvic angulation *vs.* total lumbo-pelvic lordosis (r = -0.74, P<0.001)





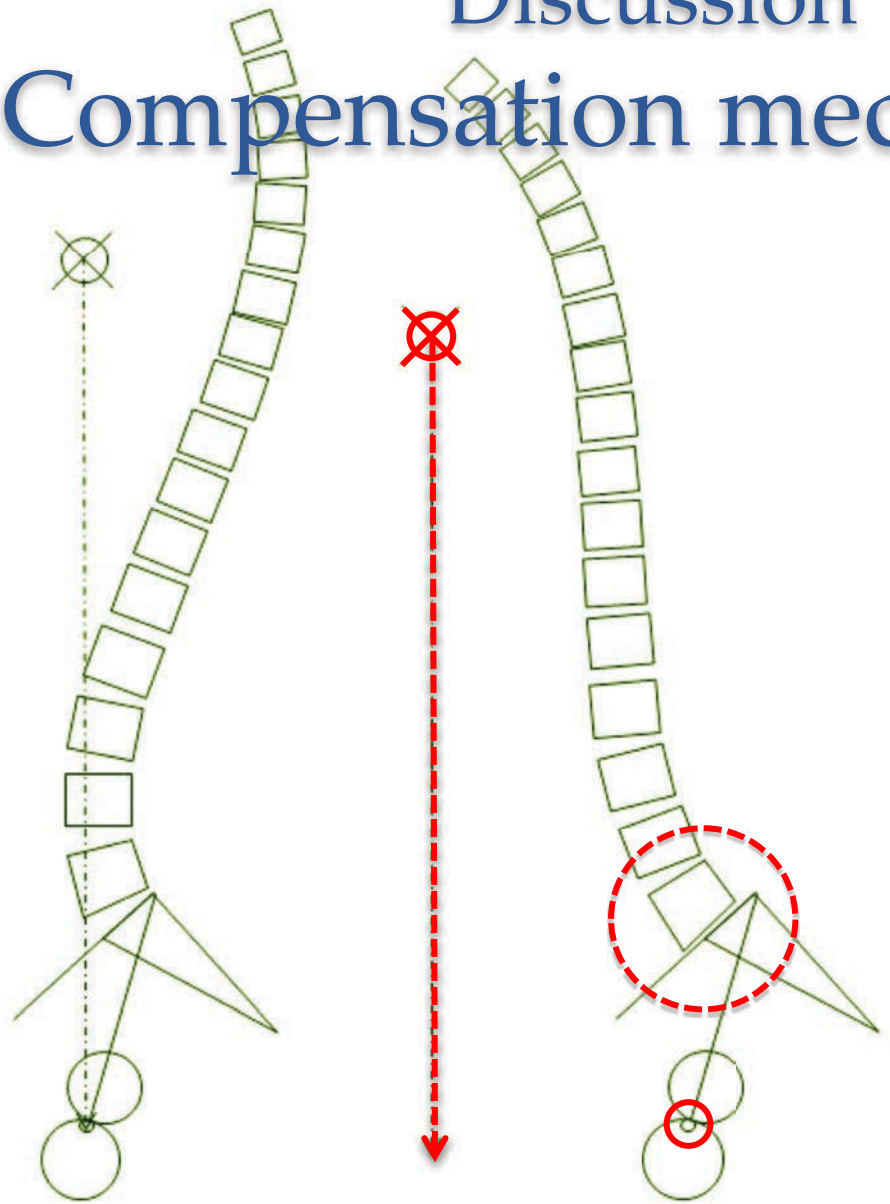
Discussion

Compensation mechanisms

Normal

Discussion

Compensation mechanisms

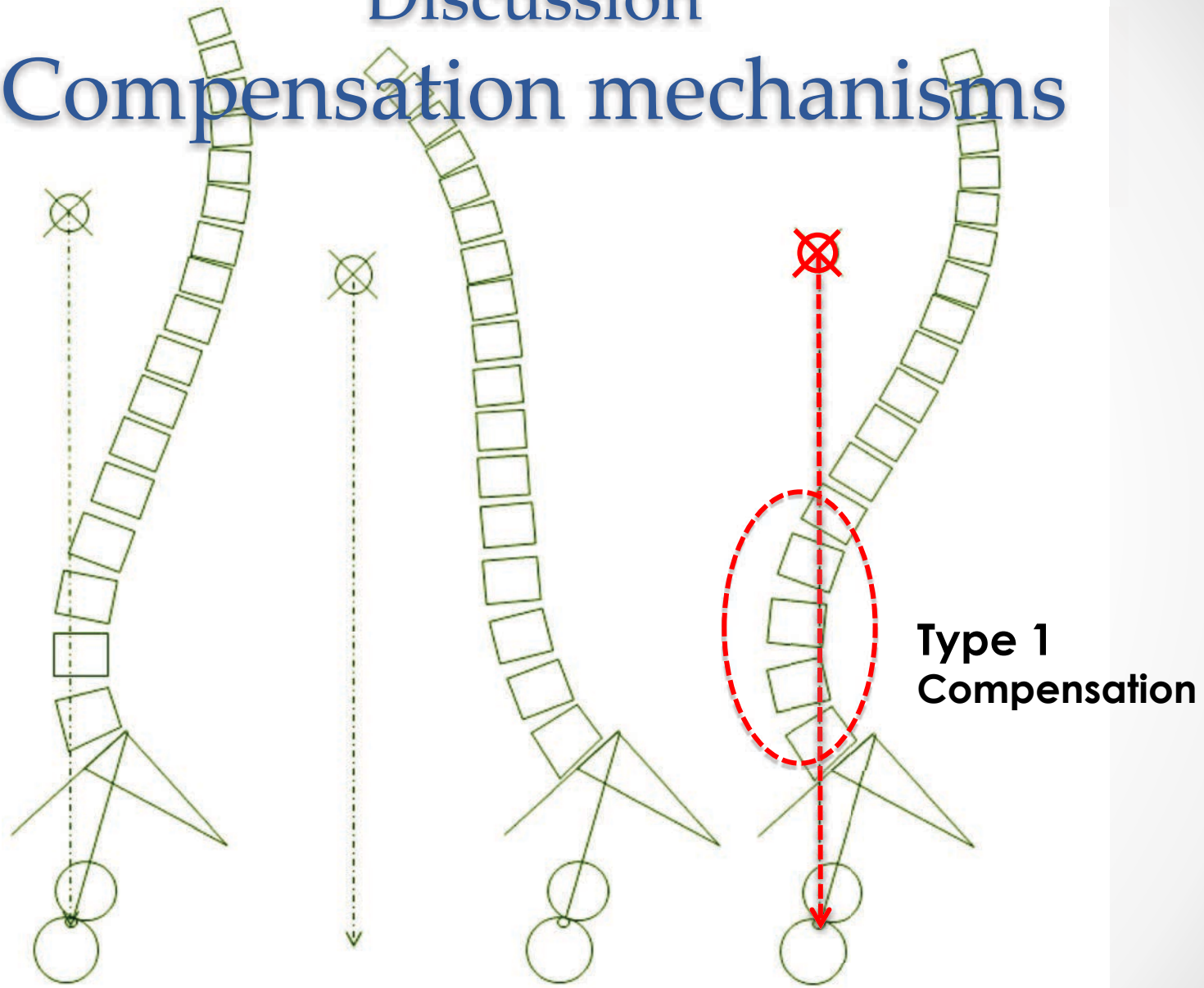


Normal

Uncompensated

Discussion

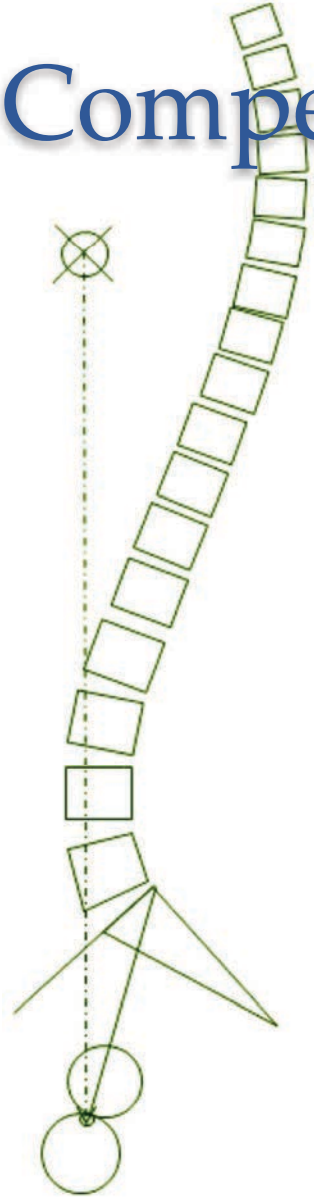
Compensation mechanisms

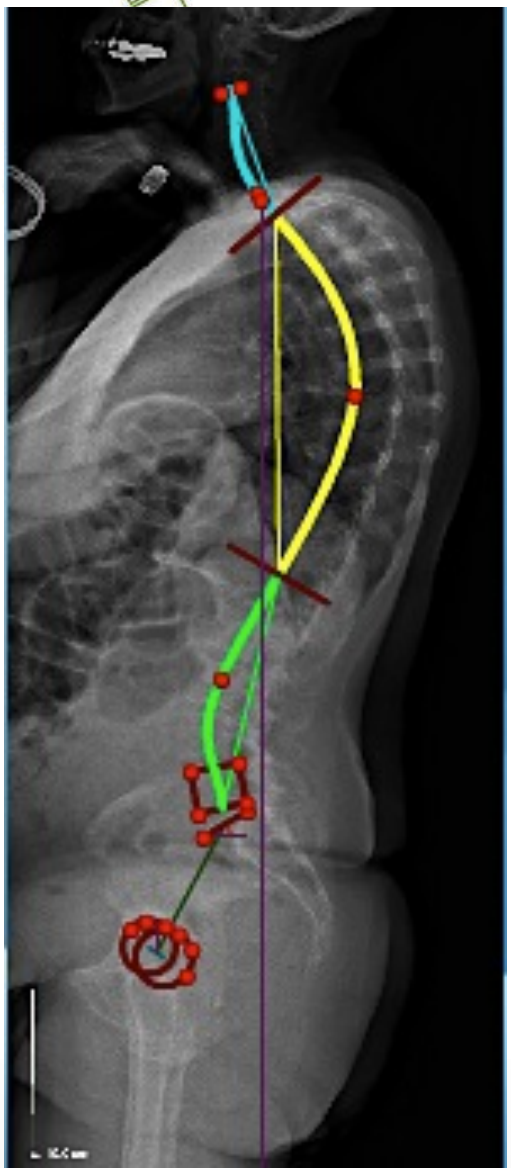


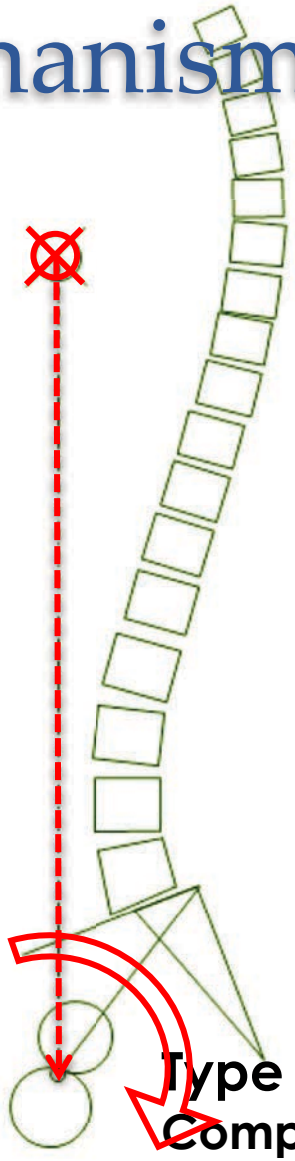
Type 1
Compensation

Discussion

Compensation mechanisms





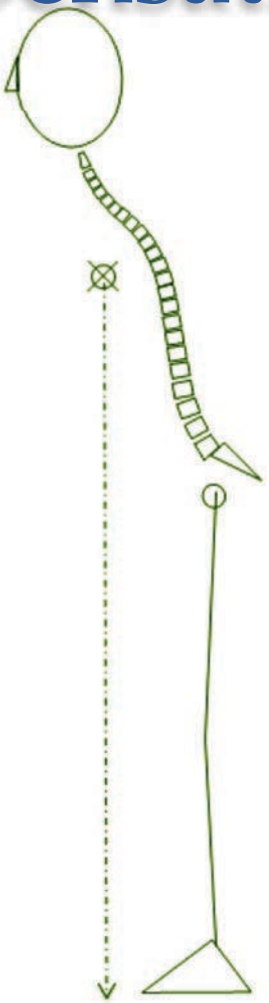


Type 2 Compensation

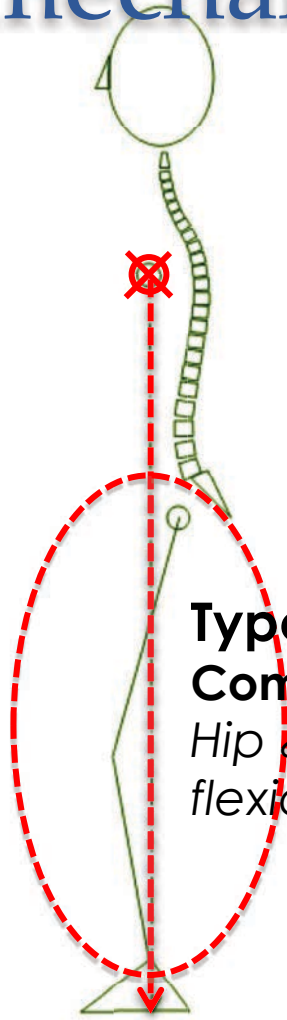
Pelvic retroversion

Discussion

Compensation mechanisms



Uncompensated



Type 3 Compensation

Hip & knee flexion

Conclusions

- Isthmic spondylolishesis… with age:
  - total lumbopelvic lordosis (PRT12) ↓
  - pelvic angulation (PA) ↑
- Younger patients can maintain balance:
  - ↑ lordosis at segments above focal kyphosis. (**Type 1**)
- Older patients compensate:
  - pelvic retroversion… ↑ pelvic angulation (PA). (**Type 2**)
- We postulate combined hip & knee flexion may represent a 3rd compensation mechanism (**Type 3**), used when Type 1 & 2 mechanisms exceeded.