



The importance of the sagittal profile in spinal deformity surgery

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BMI Healthcare

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June 2014





Outline

- ✧ Understanding & measuring the sagittal profile
- ✧ Pathological changes in sagittal profile
- ✧ Surgical reconstruction options
- ✧ Clinical evidence / cases



Sagittal plane: divides into right & left halves



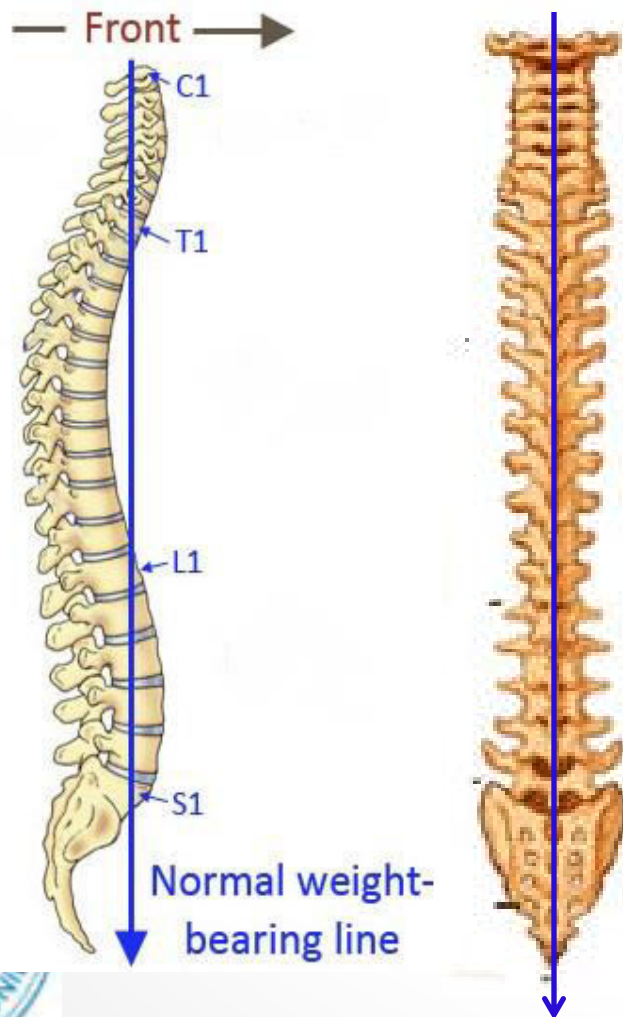
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Balance: Head over heels!



The spinal 'fingerprint'



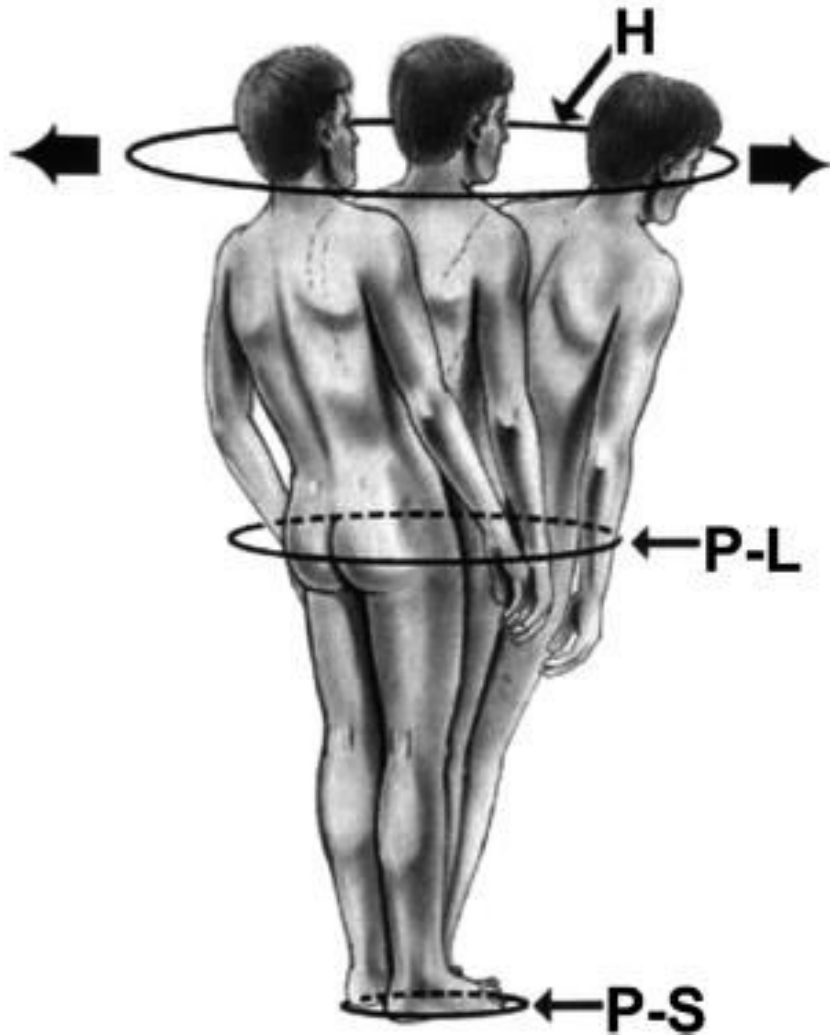
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J. Dubousset



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Sagittal Plane Alignment...

... More Than Just the Spine



→ Thoracic kyphosis

→ Lumbar lordosis

→ Pelvic morphology/
version

→ Lower extremity

**Global
Alignment**



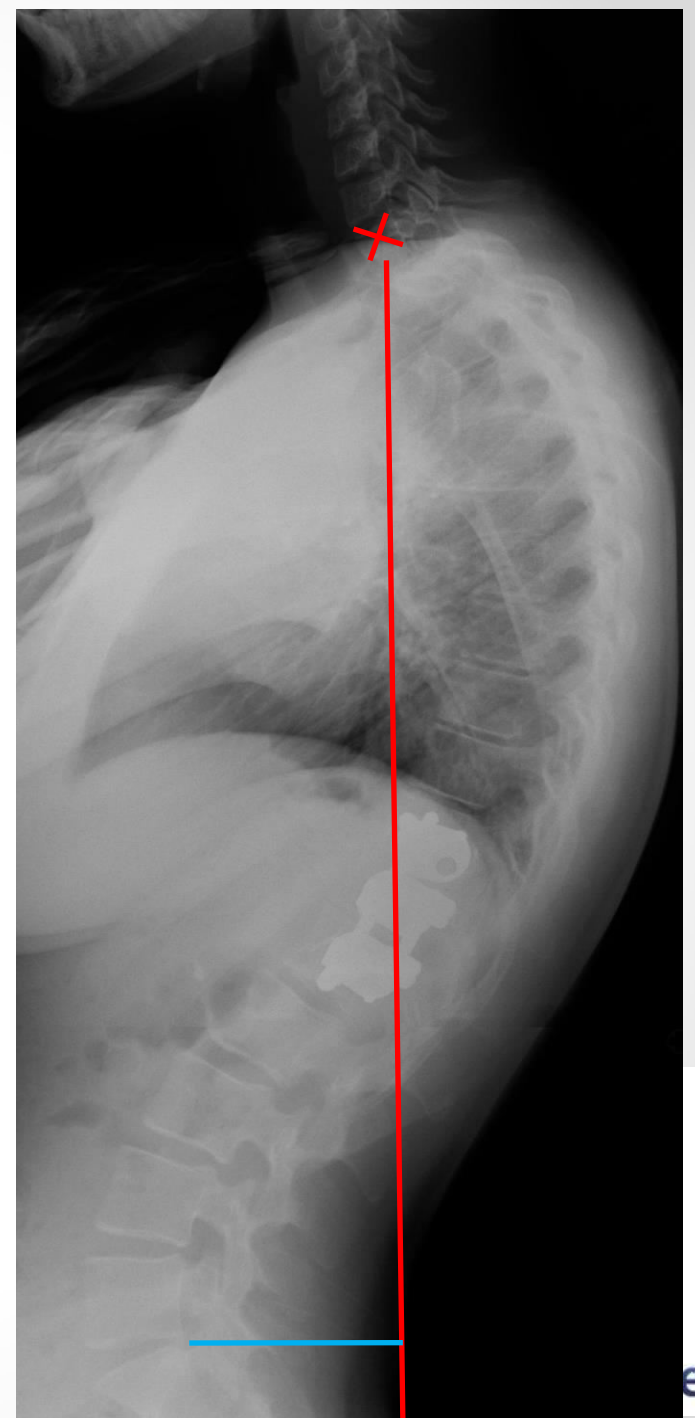
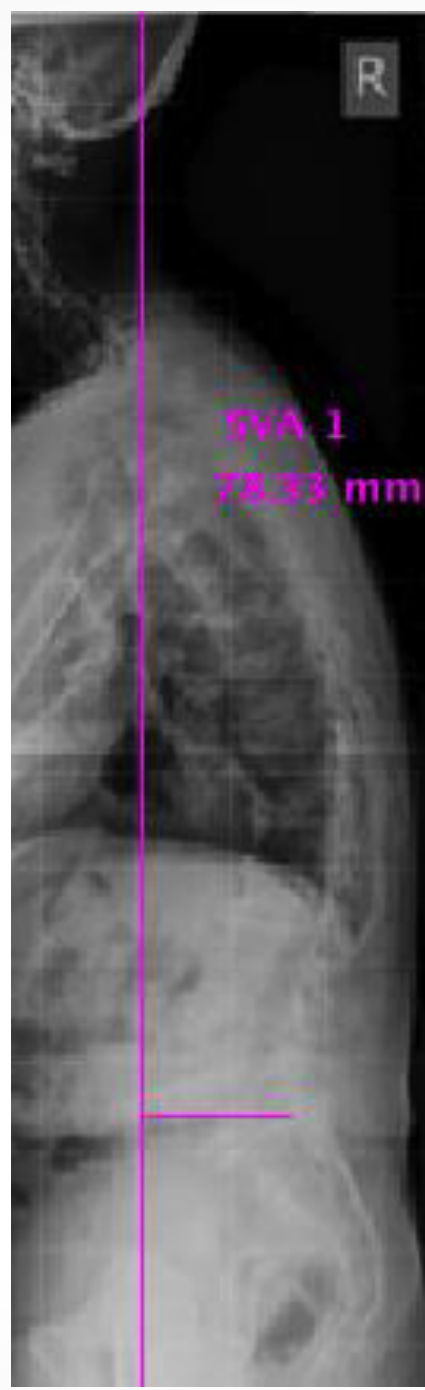
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Sagittal vertical axis

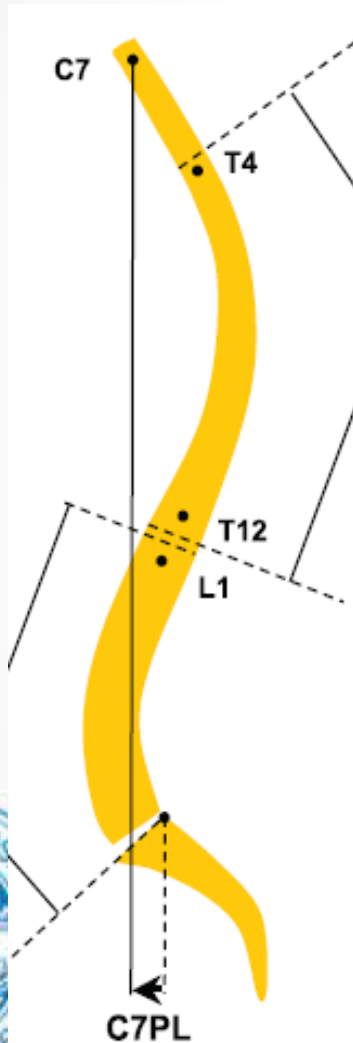


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Radiographic measures



- ✧ **Lumbar lordosis** L1 S1
- ✧ **TL junction** T10 L2
- ✧ **Thoracic kyphosis** T4 T12

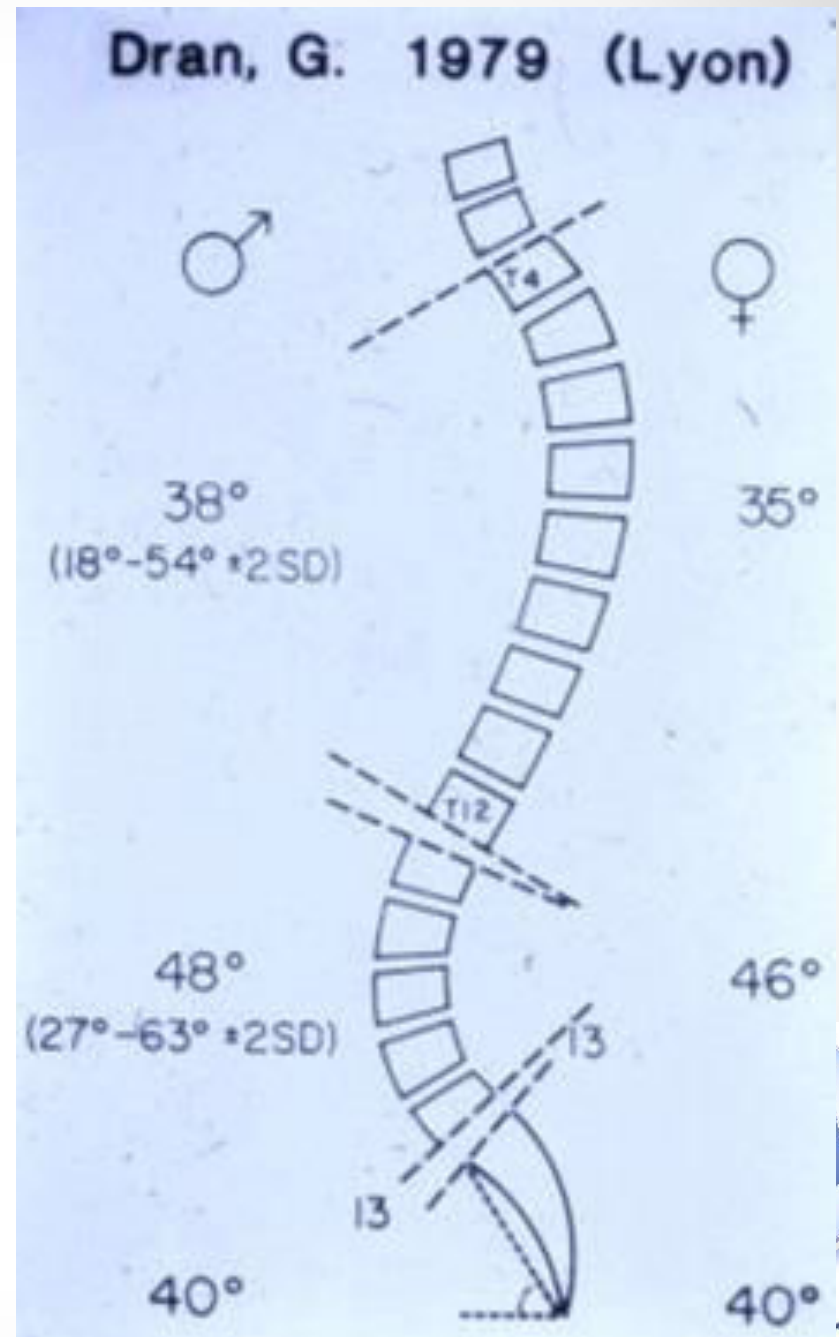


Thoracic kyphosis:

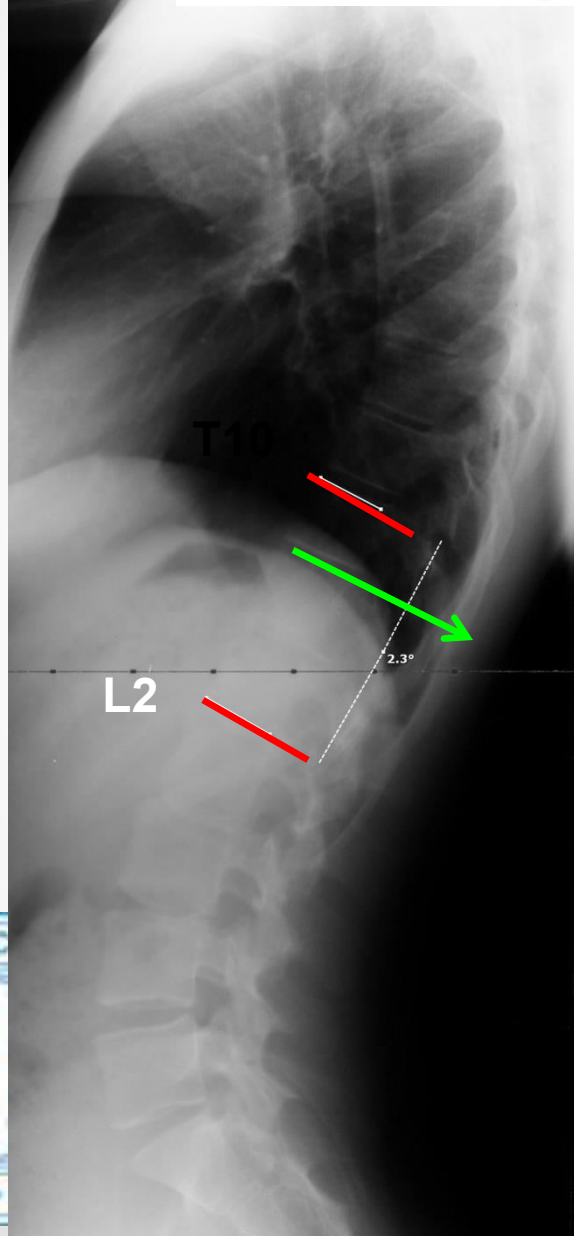
$38^\circ \pm 18$

Lumbar lordosis:

$48^\circ \pm 18$



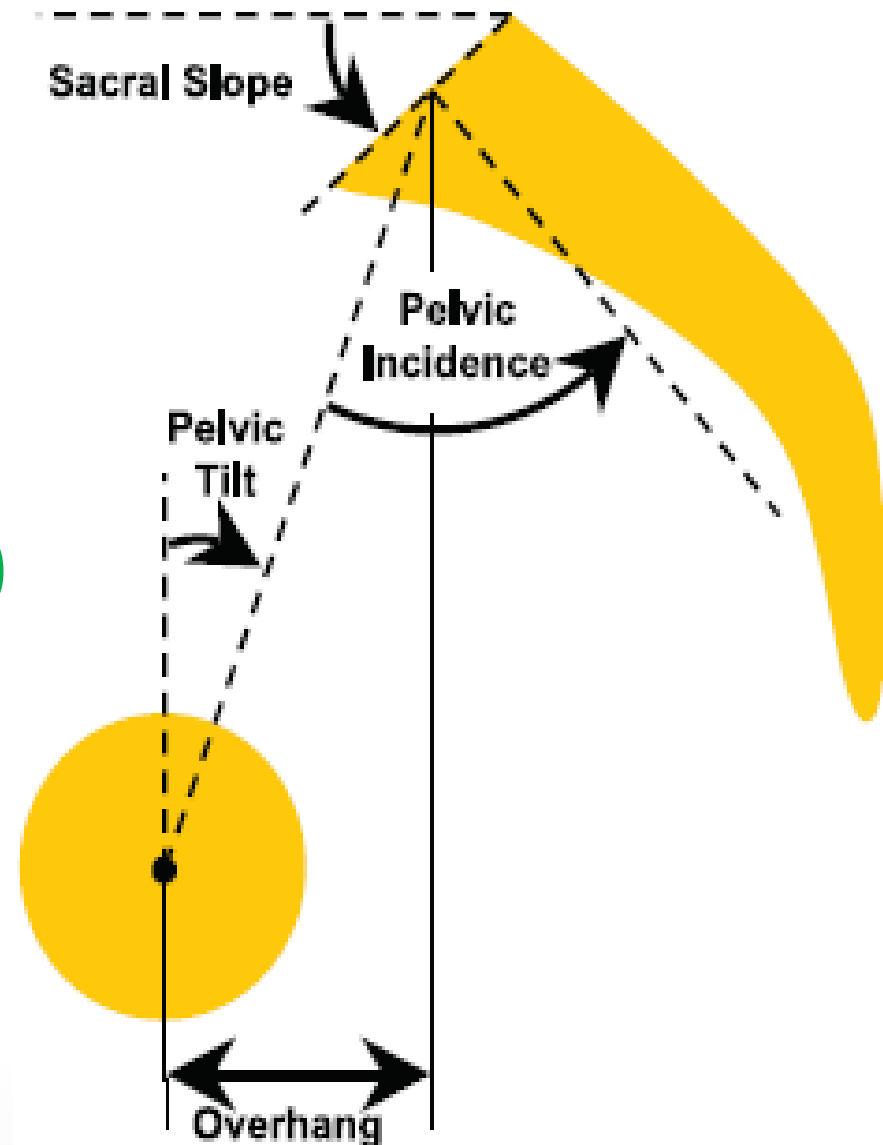
TL Junction



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Pelvic measures

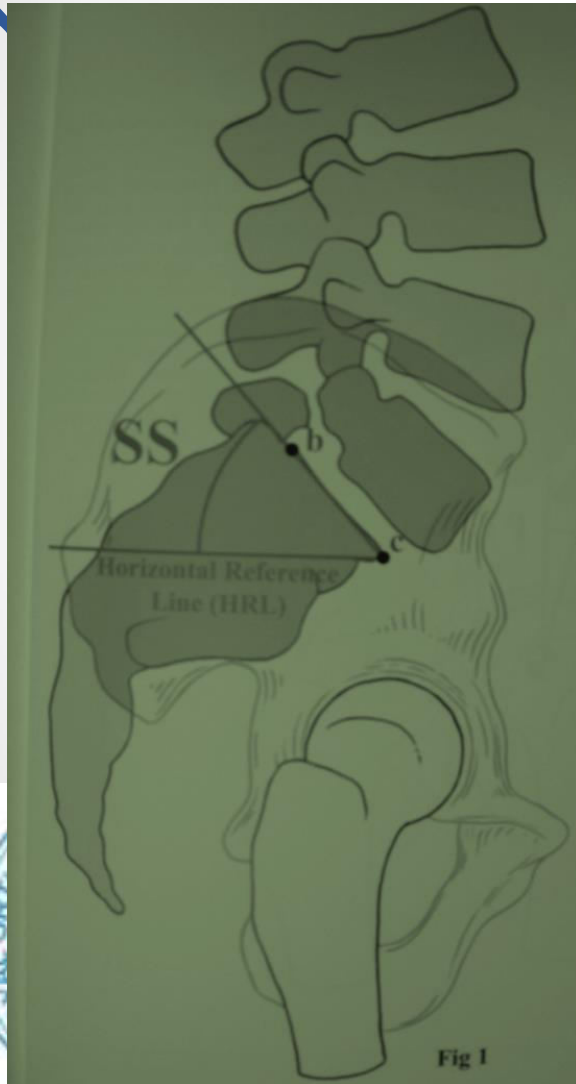
- ✧ Sacral slope (SS)
- ✧ Pelvic tilt (PT)
- ✧ Pelvic incidence (PI)



Sacral slope

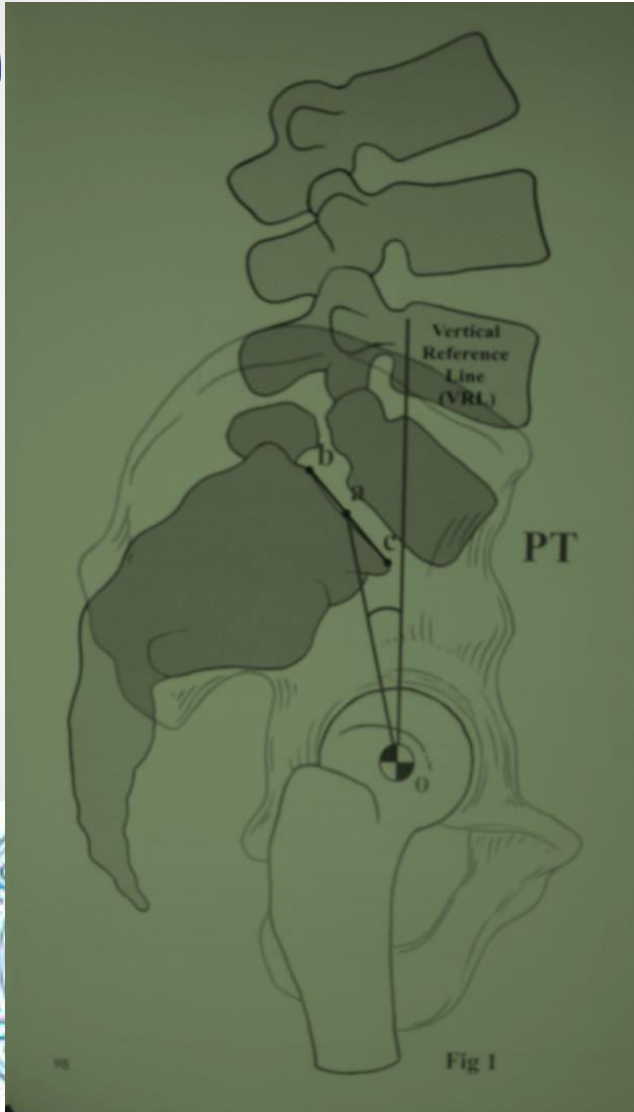
✧ Horizontal & cranial sacral end plate tangent

✧ $41^{\circ} \pm 8.4^{\circ}$ (Vialle JBJS 2005)

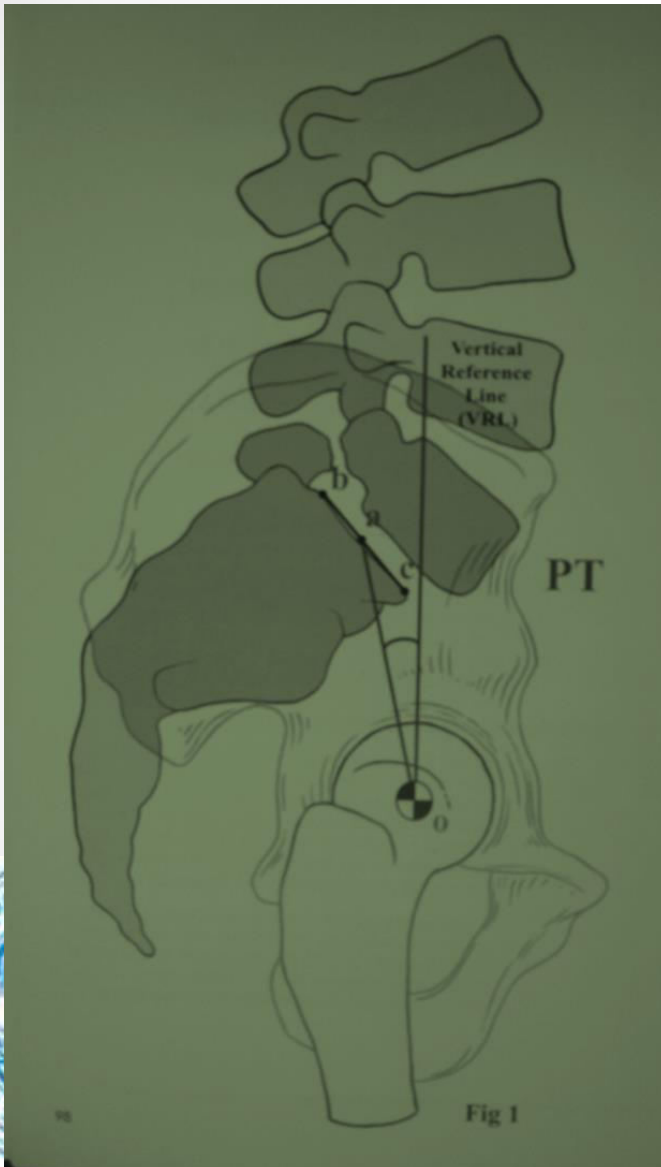


Pelvic tilt

- ✧ Vertical line between
 - 1) middle of cranial sacral end plate
 - 2) centre of the bicoxo-femoral axis
- ✧ $13^{\circ} \pm 6^{\circ}$ (Vialle JBJS 2005)

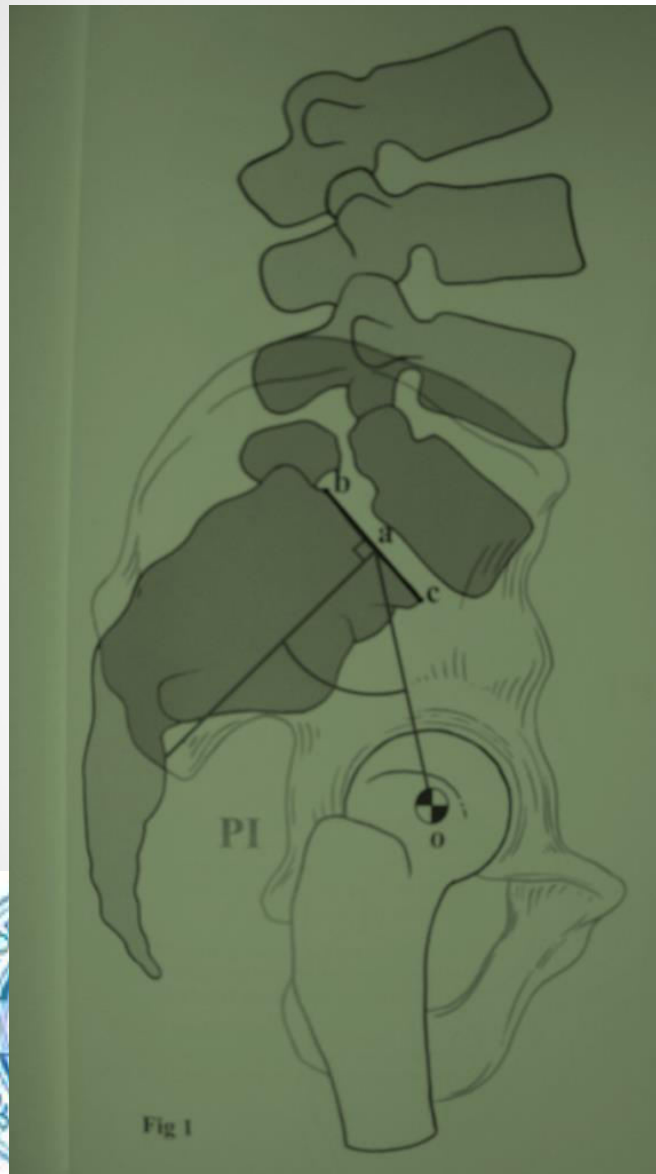


Significance of pelvic tilt



- ✧ Centre of gravity over LL
- ✧ Maintains sacral plate posterior to the hip
- ✧ Increases with age

Pelvic incidence



✧ Key parameter

✧ Perpendicular to:

the middle of the sacral end
plate

mid-point of femoral heads

✧ $55^{\circ} \pm 10.6^{\circ}$ (Vialle JBJS 2005)

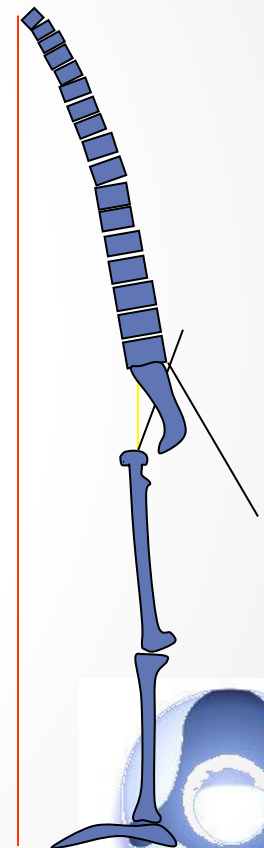
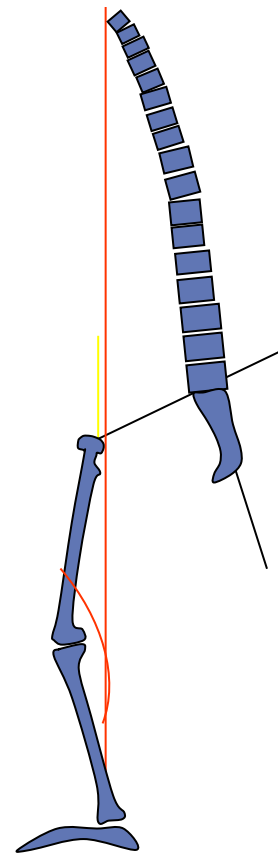
Spino-pelvic compensation

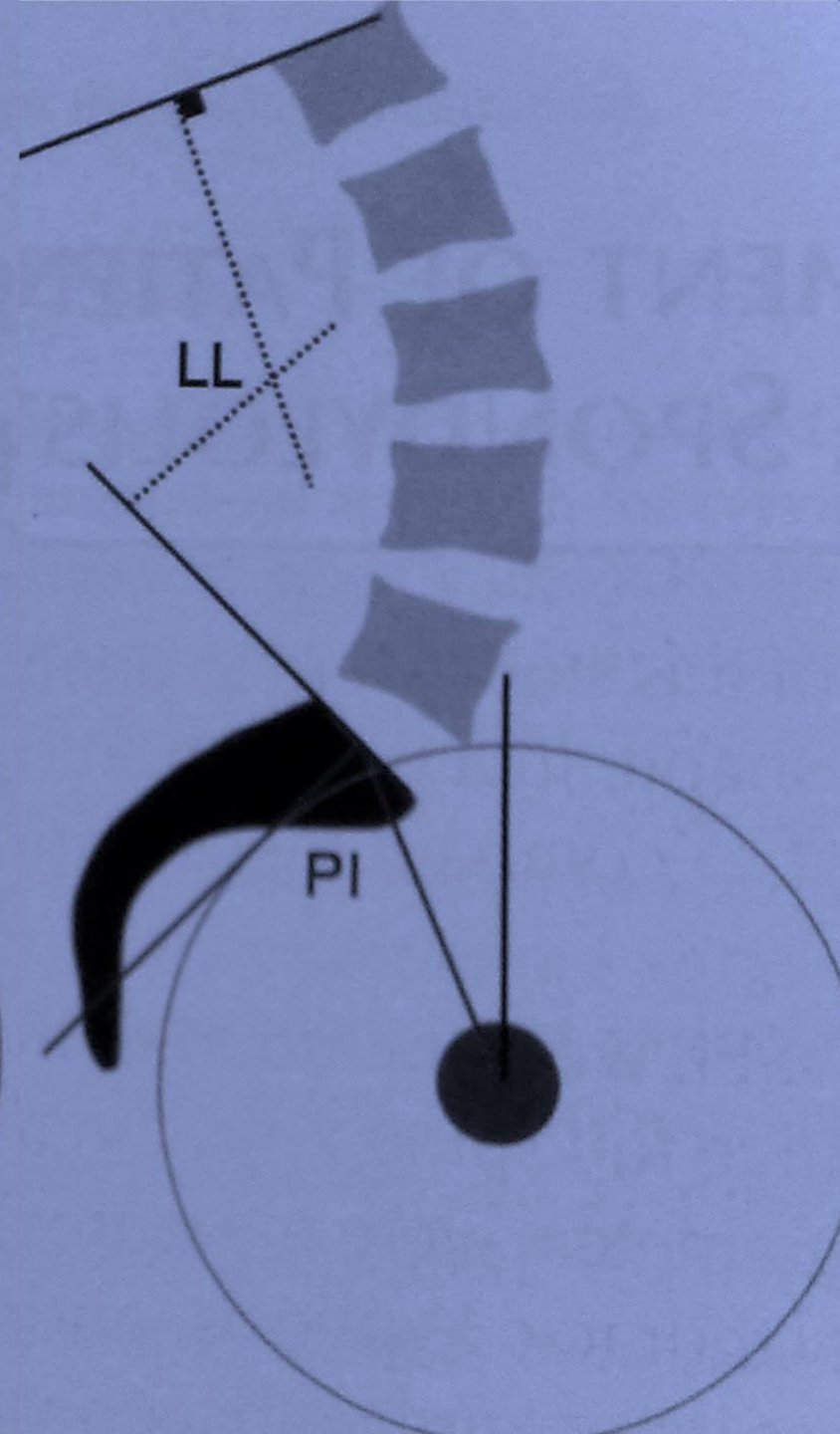
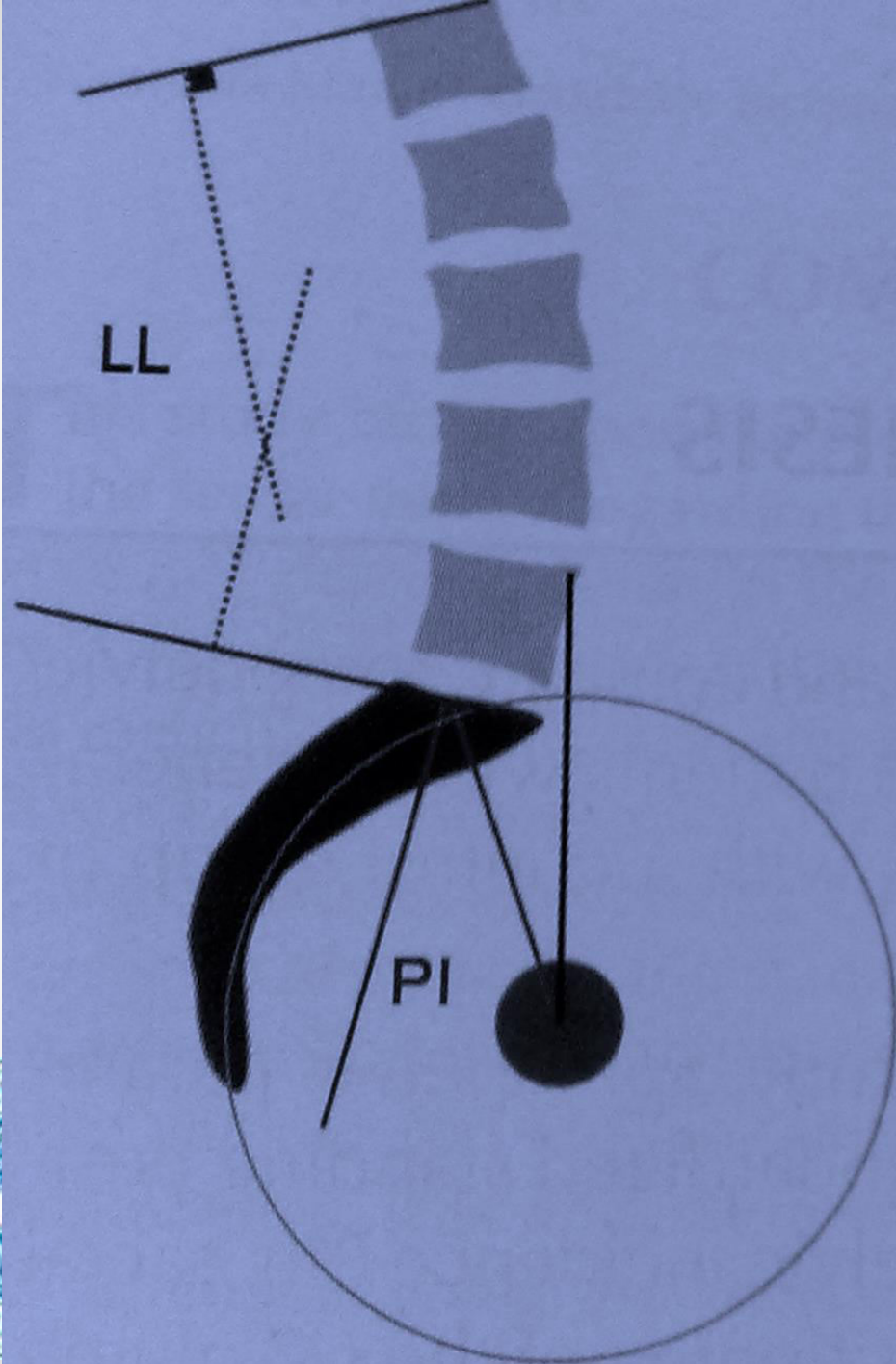
✧ PI regulates PT

✧ Higher PI



Better compensation





SRS-Schwab Adult Spinal Deformity Classification: A Validation Study

Curve types

T Thoracic only

with lumbar curve $< 30^\circ$

L TL / Lumbar only

with thoracic curve $< 30^\circ$

D Double Curve

with at least one T and one TL/L, both $> 30^\circ$

S Sagittal Deformity

for coronal curve $< 30^\circ$ AND moderate to severe modifier(s)

Modifiers

PI minus LL

A : within 10°

B : moderate $10-20^\circ$

C : marked $> 20^\circ$

Pelvic Tilt

L : PT $< 20^\circ$

M : PT $20-30^\circ$

H : PT $> 30^\circ$

Global Balance

N : SVA $< 4\text{cm}$

P : SVA 4 to 9.5cm

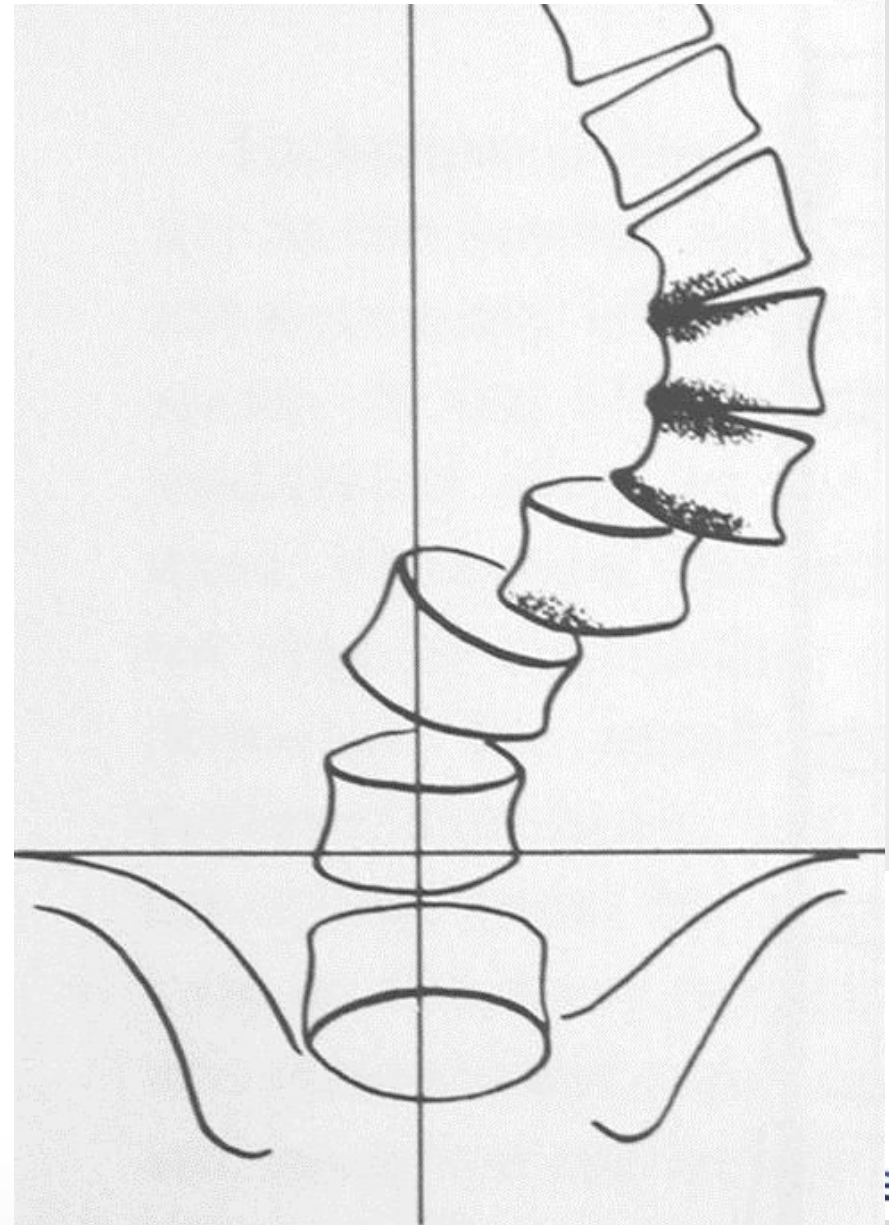
VP : SVA $> 9.5\text{cm}$



The sagittal plane deformity



The coronal plane deformity



Spino-pelvic pathology patterns

Progressive kyphosis



Gravity line drifts forwards



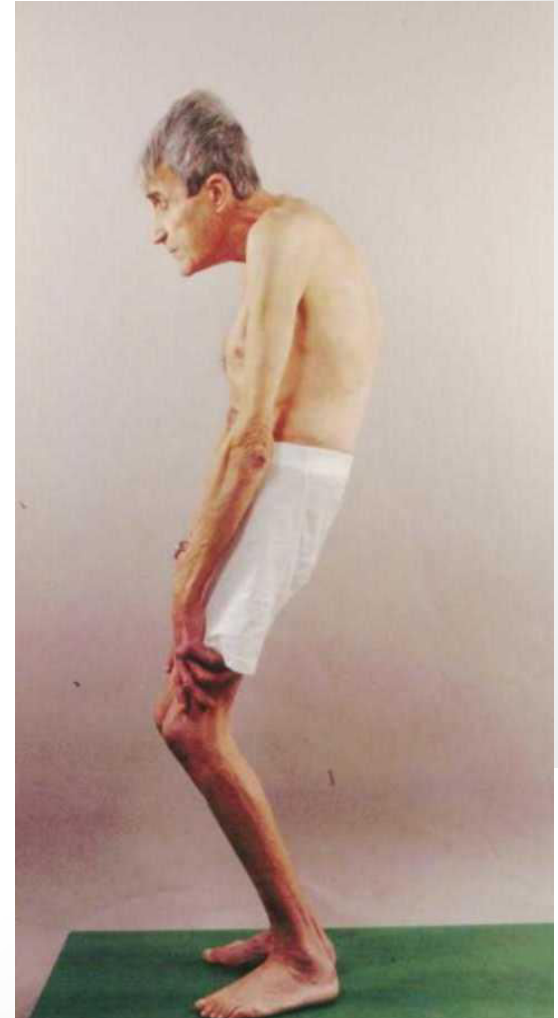
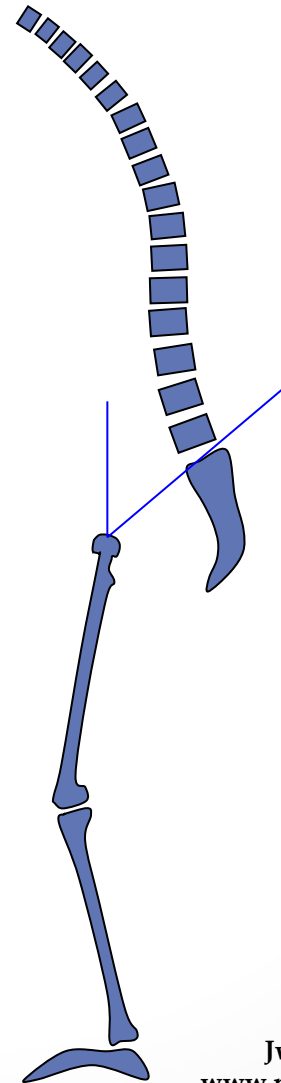
Pelvis rotates backwards



Sacral slope decreases



Knee flexion



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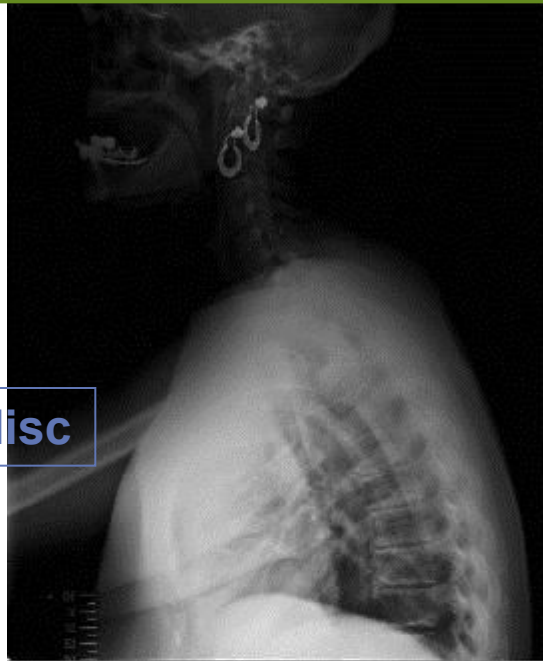
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Type 1: Non-harmonious spine

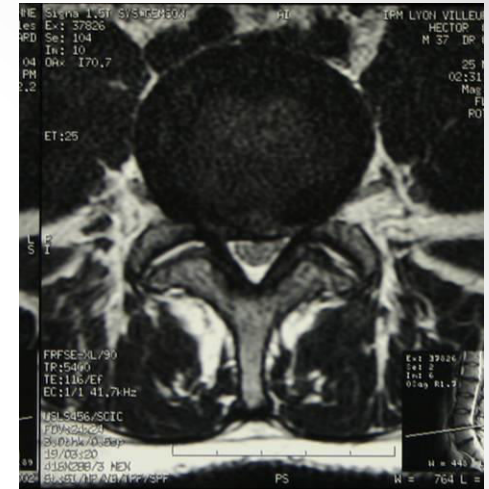
Thoraco lumbar disc

Junctional listhesis



Type 2: Harmonious but Flat Back

Early disc degeneration





**Type 3: The most harmonious
("probably a good back")**



Type 4: Harmonious but hyper-curved.

- When young: very strong
 - High PI
 - Good lordosis
- With aging
 - will lose lordosis
 - pelvic tilt increases to compensate for anterior imbalance

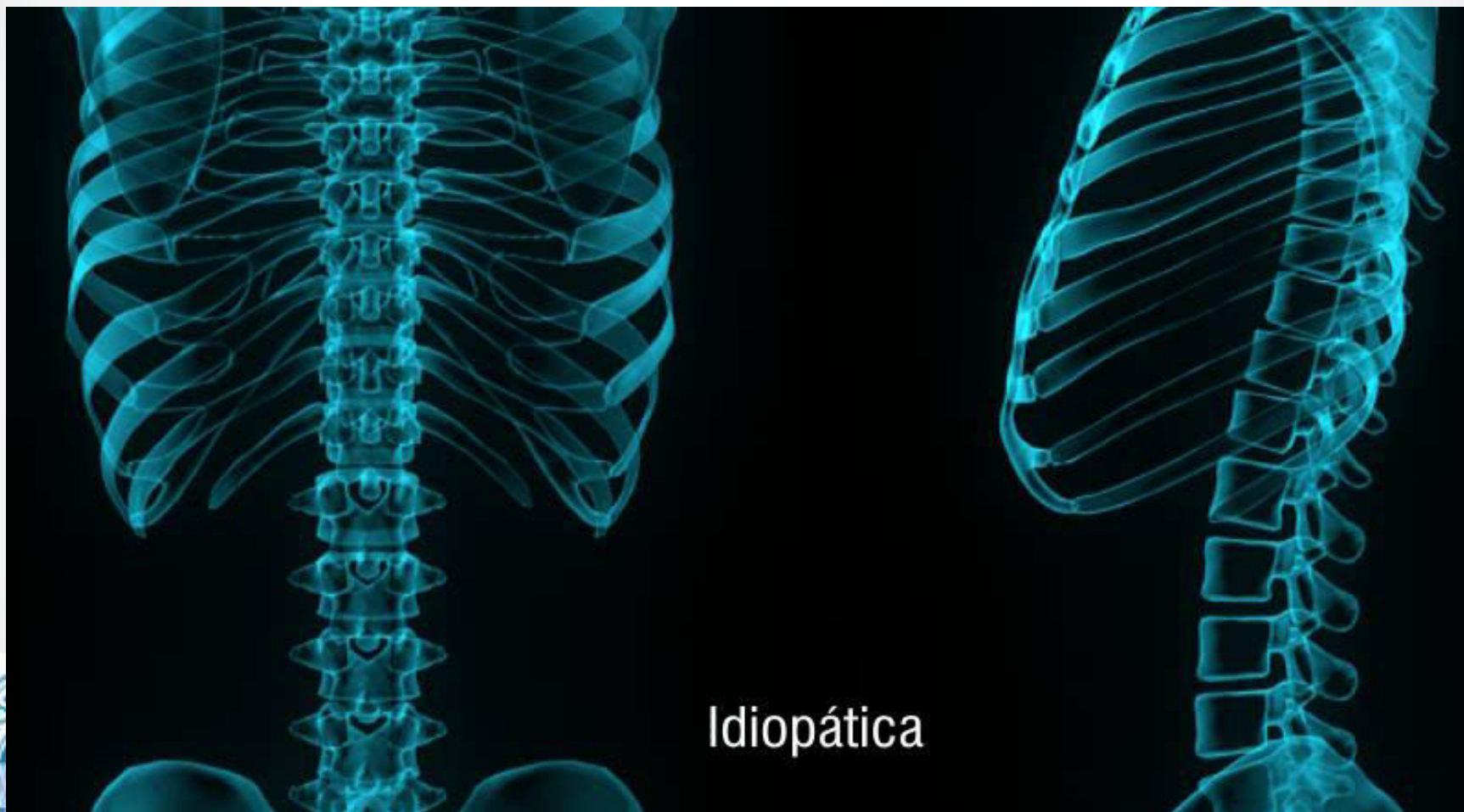


Lumbar stenosis + spondylolisthesis

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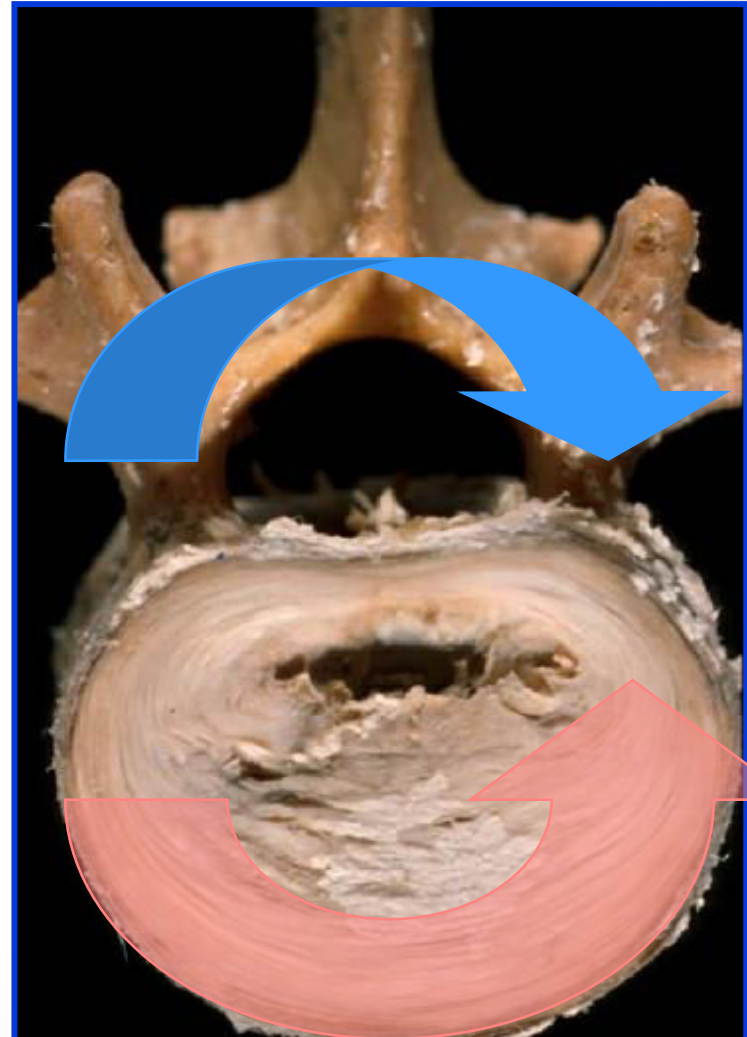
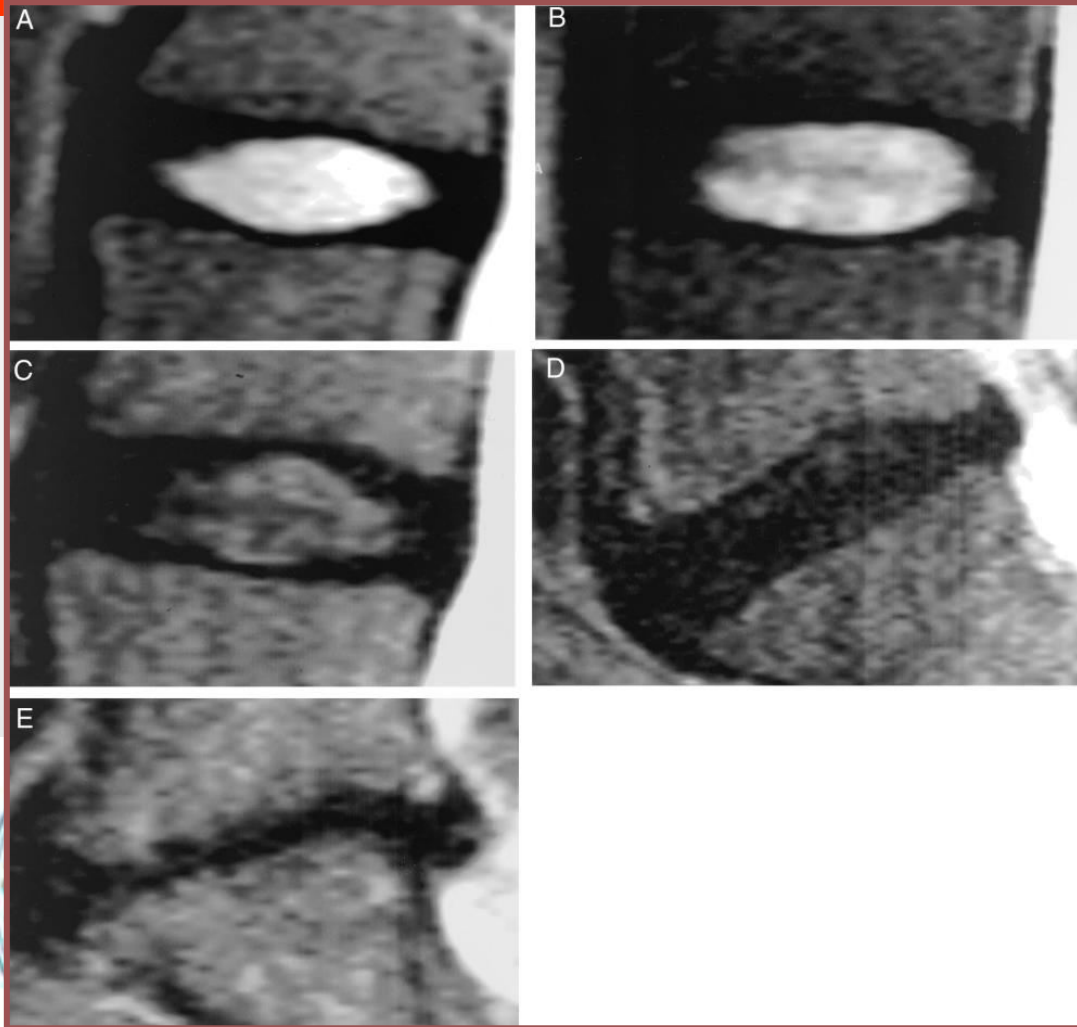




Idiopática



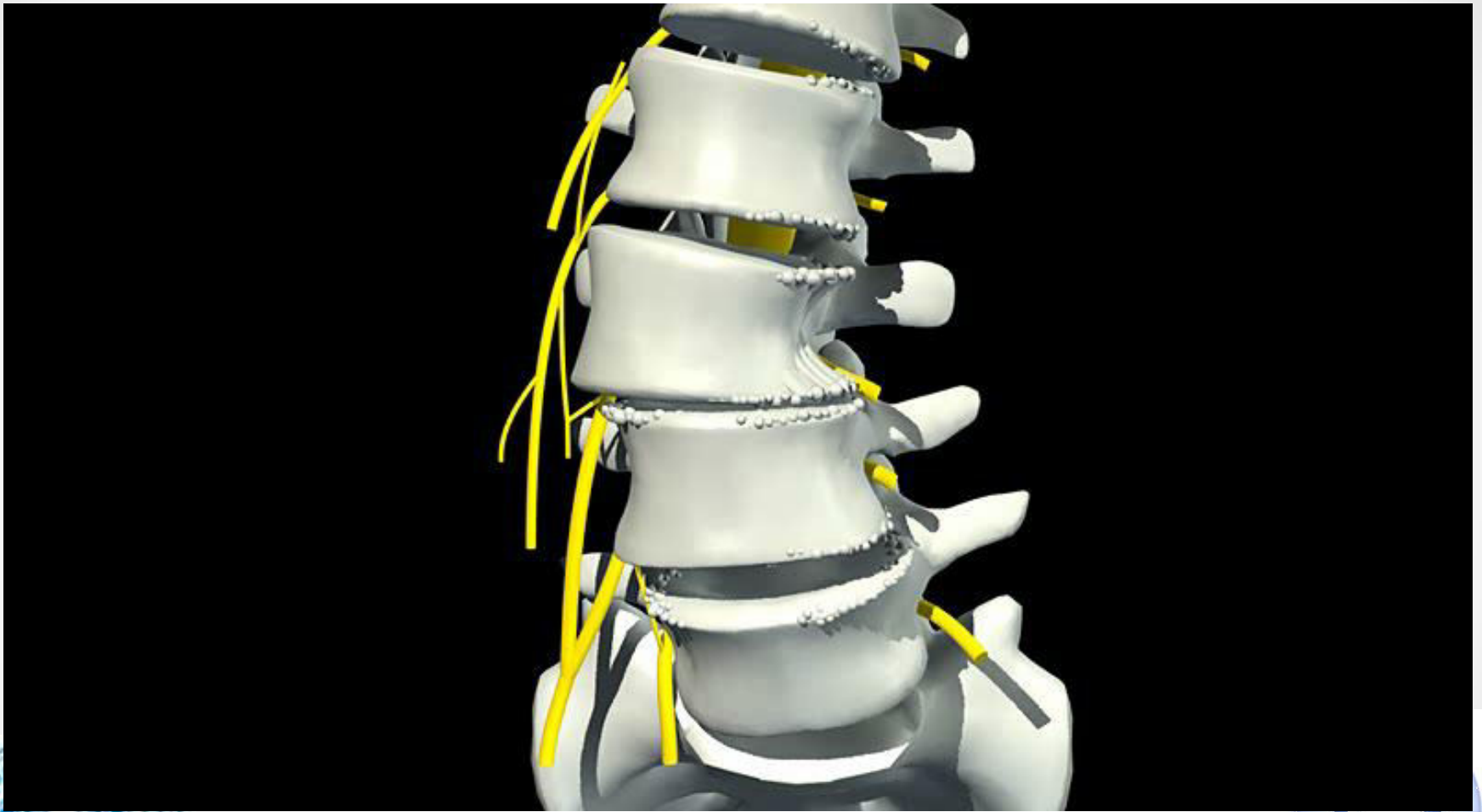
Disc degeneration





ine

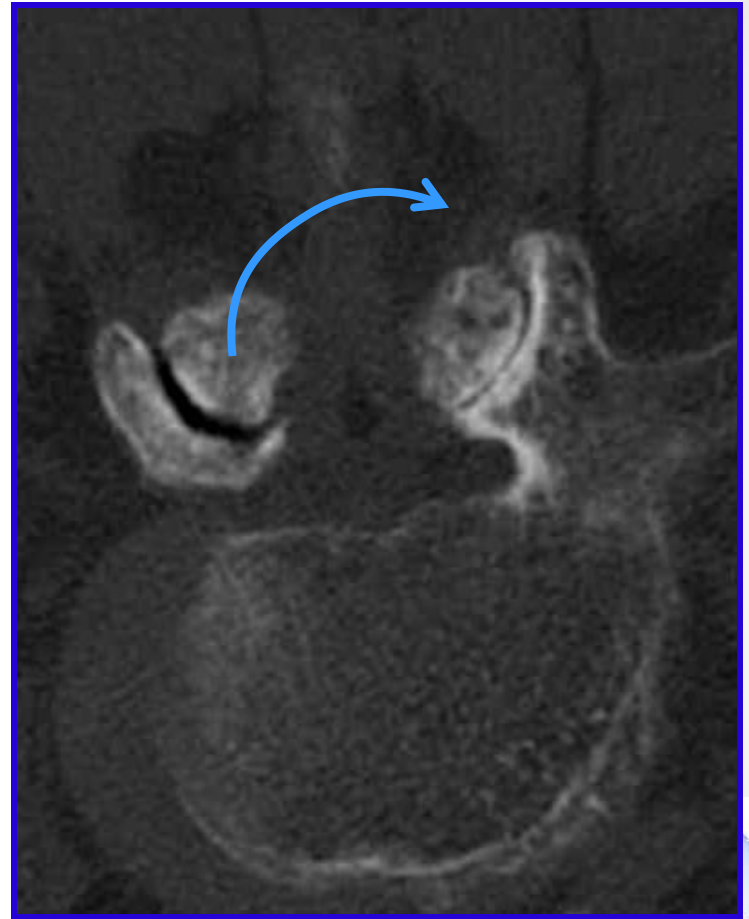
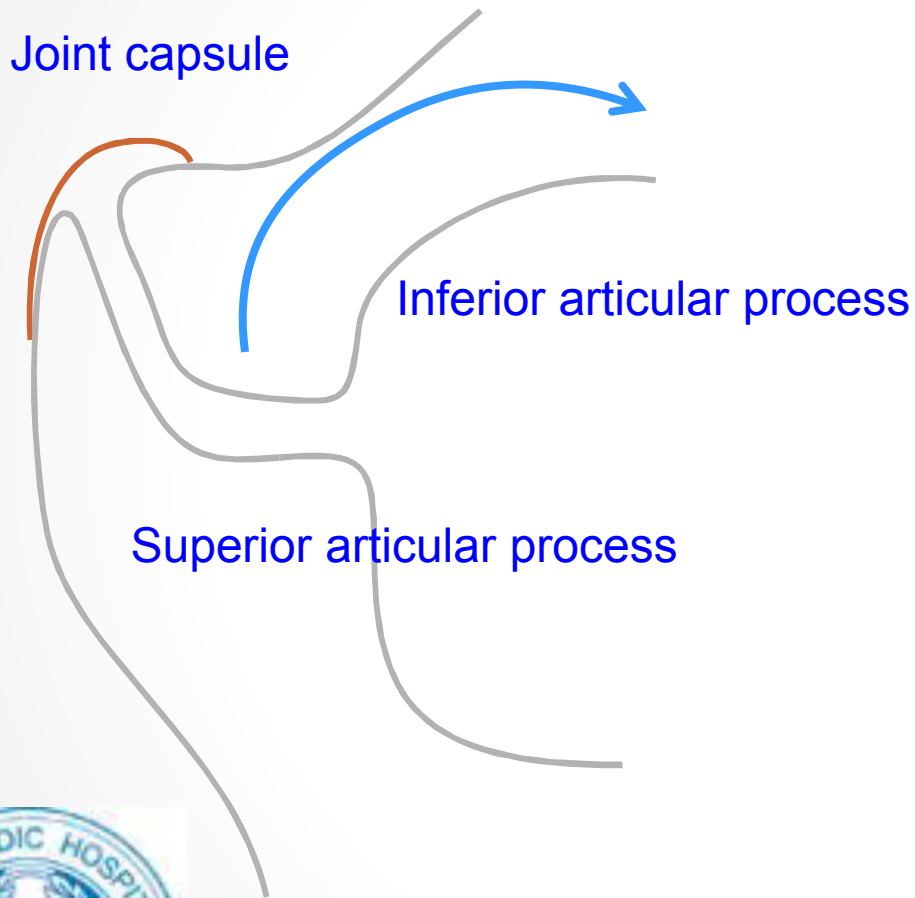




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Facet joint changes



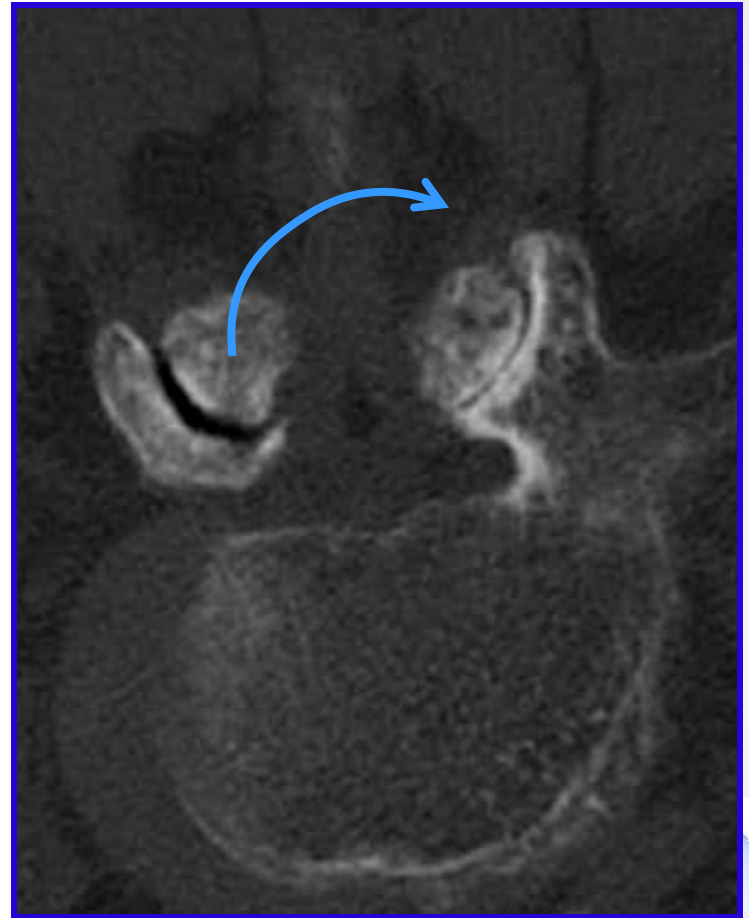
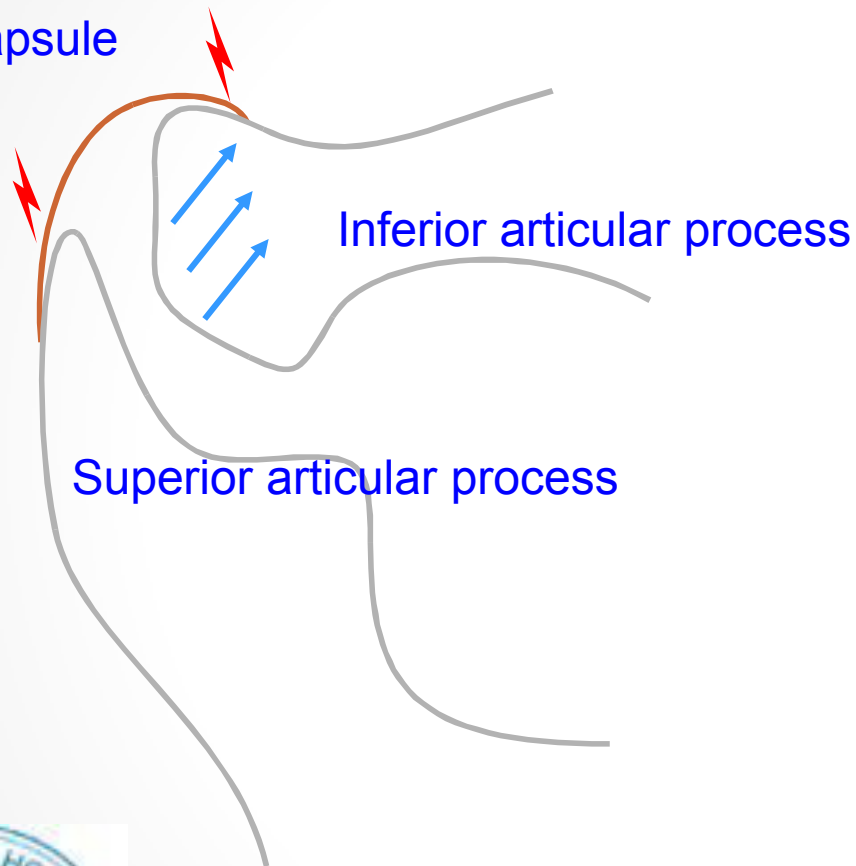
Increased axial rotation in disc degeneration

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Courtesy Bronek Boszczyk



Facet joint changes



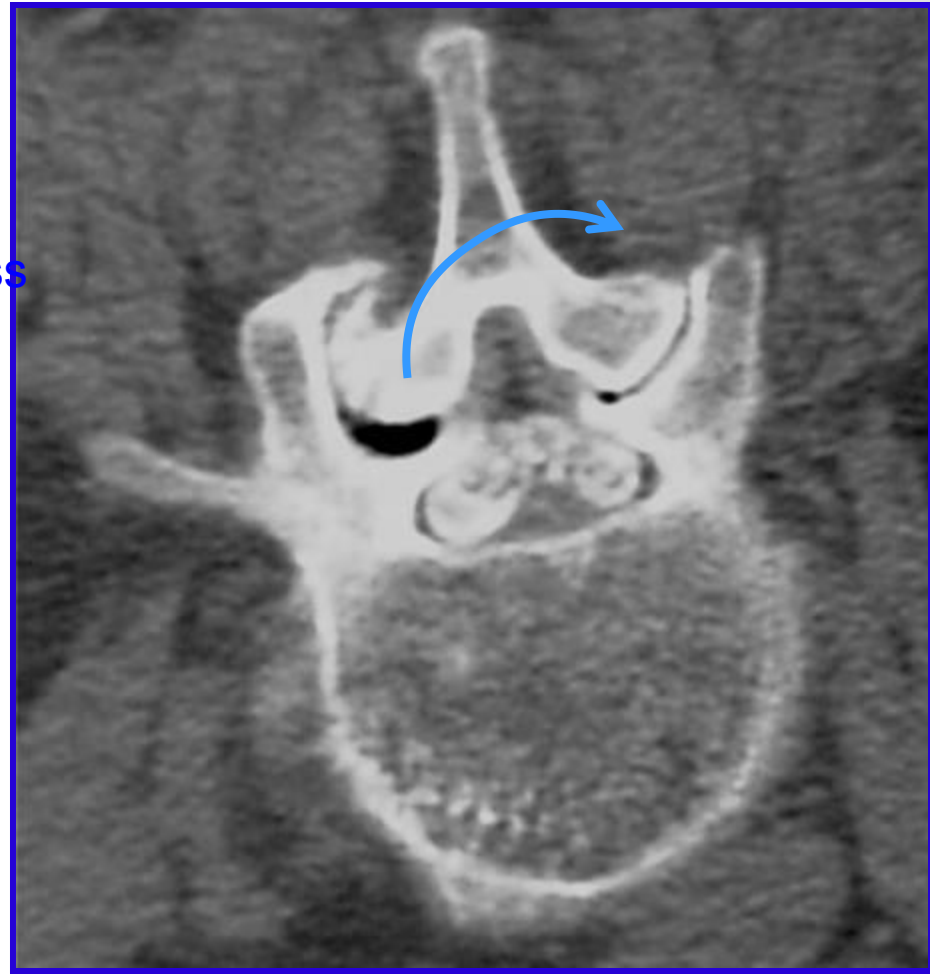
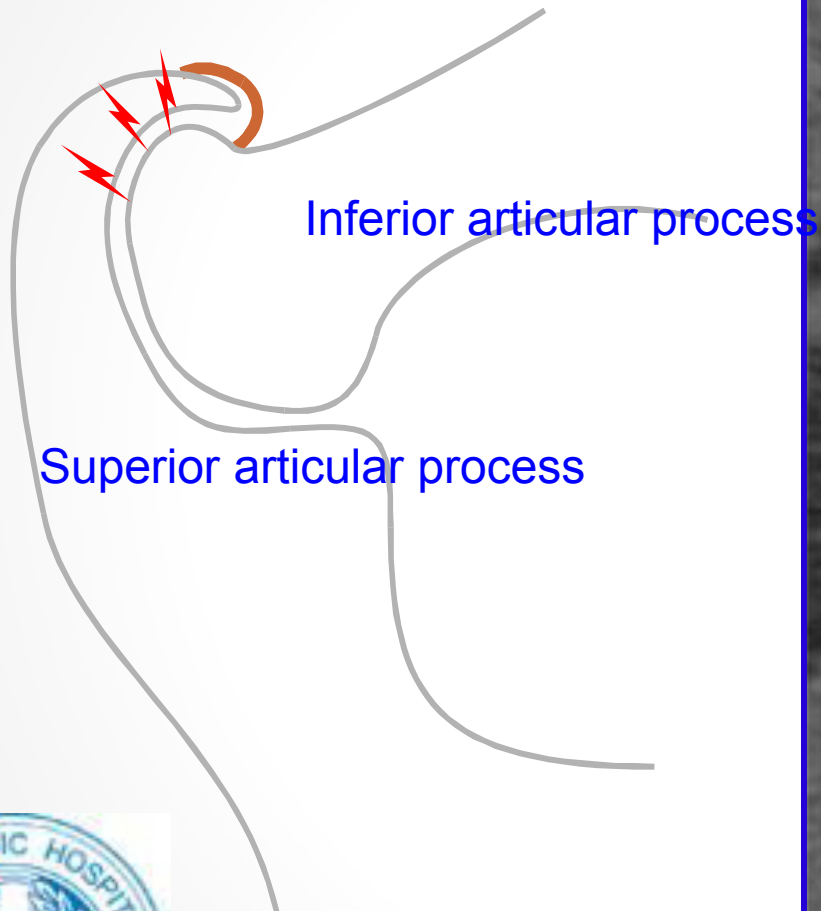
Increased axial rotation in disc degeneration results in shear of the enthesis and direct pressure upon the capsule



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Courtesy Broniek Boszczyk
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Facet joint changes



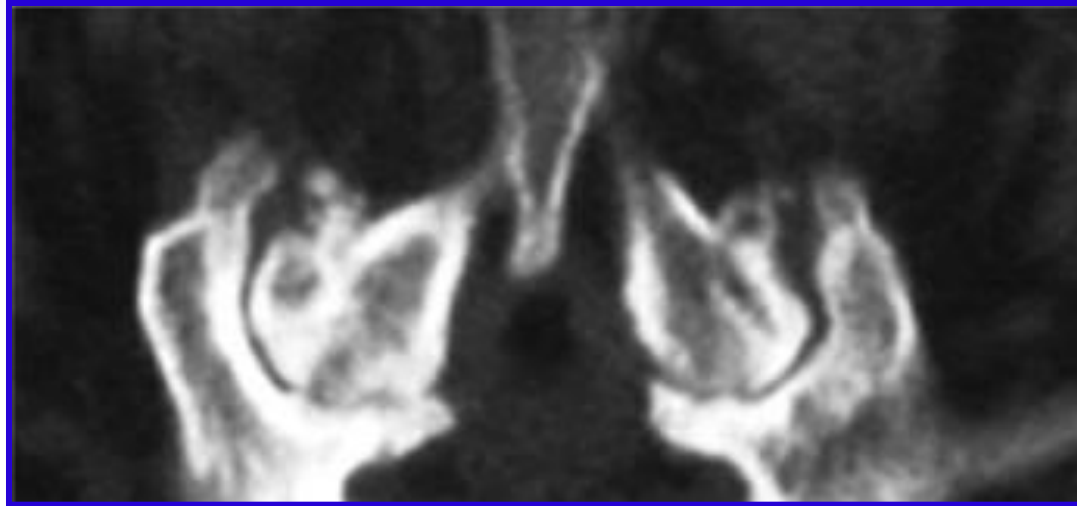
Encompassing joint formation develops through direct contact of enthesophytes in advanced degeneration

Dr. Ashish Mehta
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Courtesy Bronek Boszczyk



Facet joint changes



In contrast to other joints, reactions of the joint capsule / enthesis are seen before permanent cartilage damage

Early restoration of disc biomechanics may prevent progression to stage of permanent damage



Vernon-Roberts & Pirie Rheumatol Rehabil
1977

Fujiwara et al. Eur Spine J 1999

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Courtesy Bronek Boszczyk
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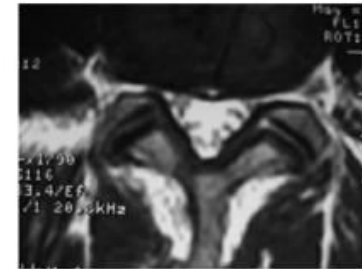


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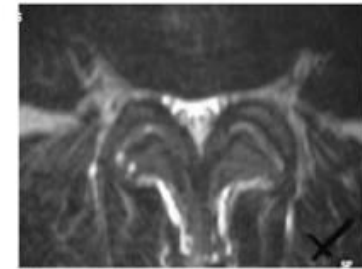
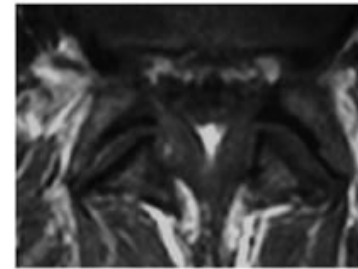
Facet joint degeneration

- ✧ Joint width
- ✧ Articular erosions
- ✧ Sub-chondral sclerosis
- ✧ Osteophytes

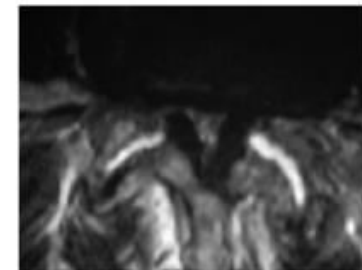
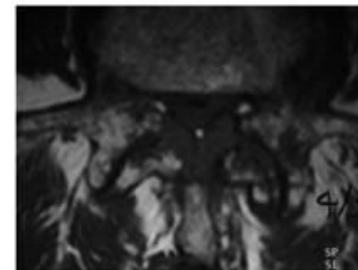
Grade 0



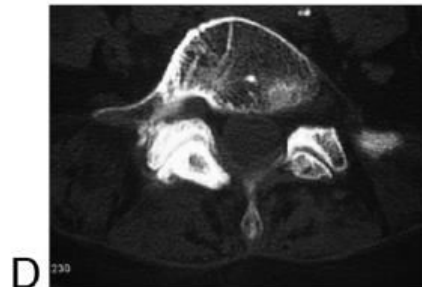
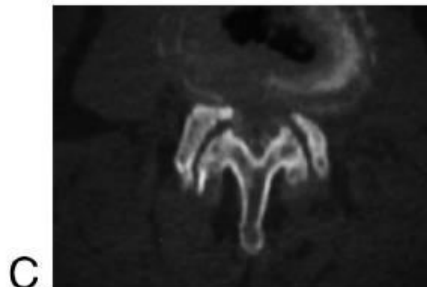
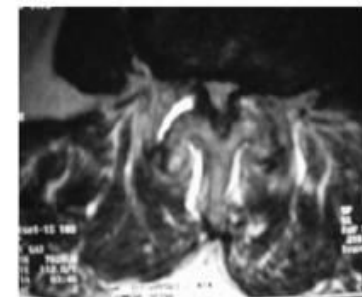
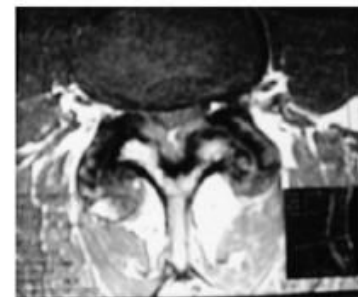
Grade 1



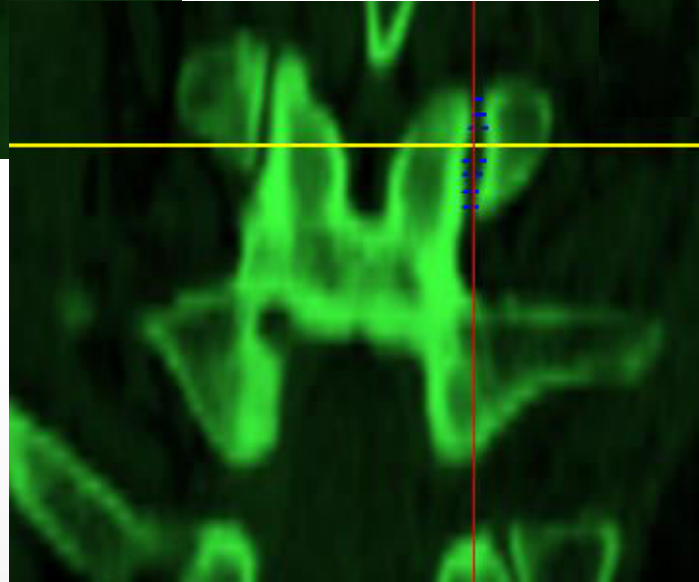
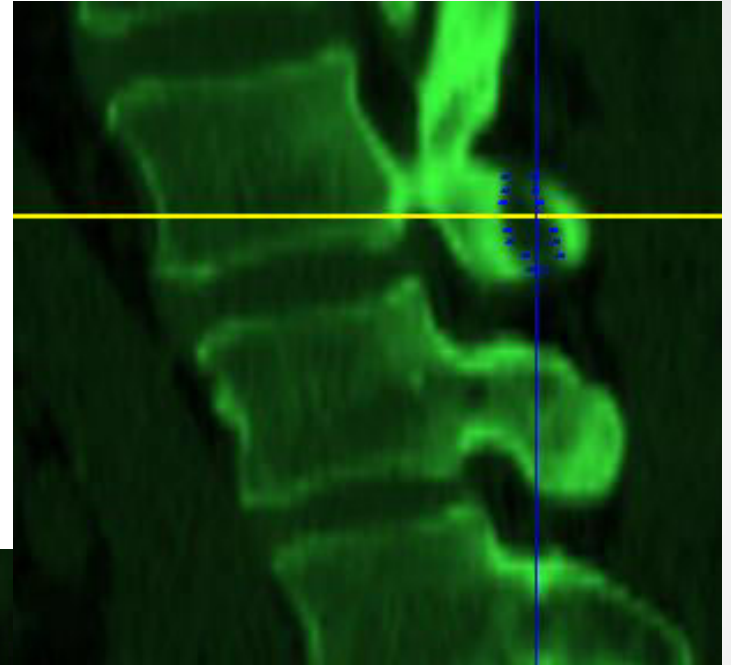
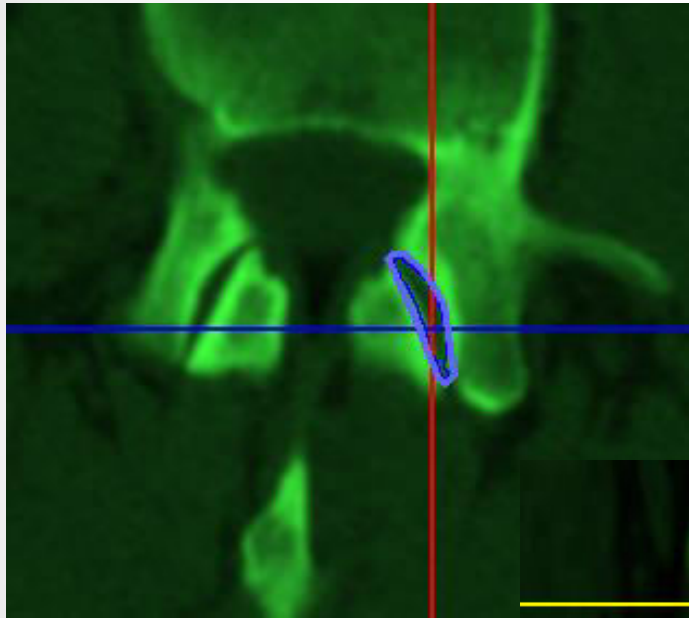
Grade 2



Grade 3



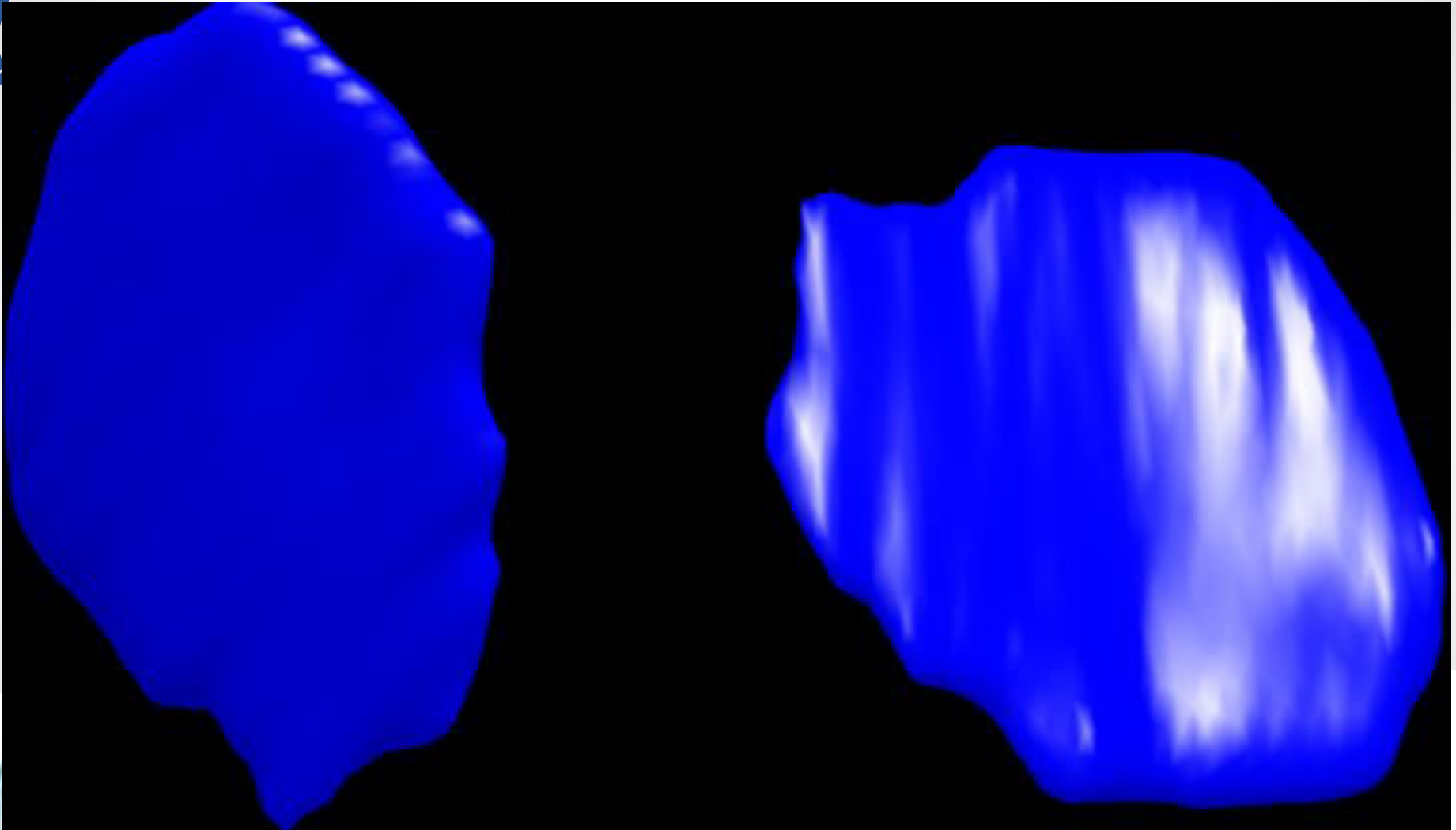
Facet joint changes



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Two views of a typical facet joint contact
space *object* (for a normal spine)



Volume (mm^3)
309.50

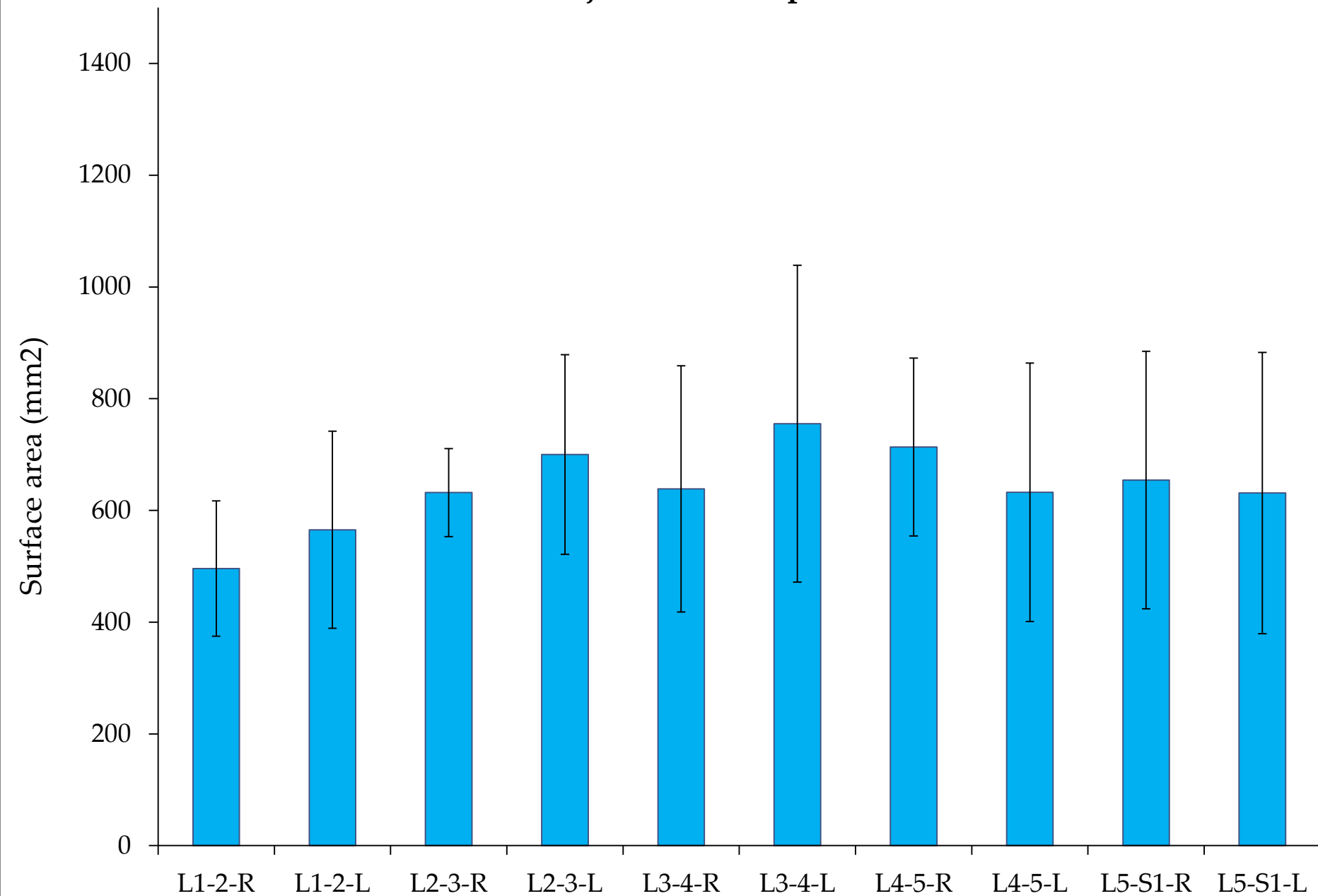
Surface area (mm^2)
404.25

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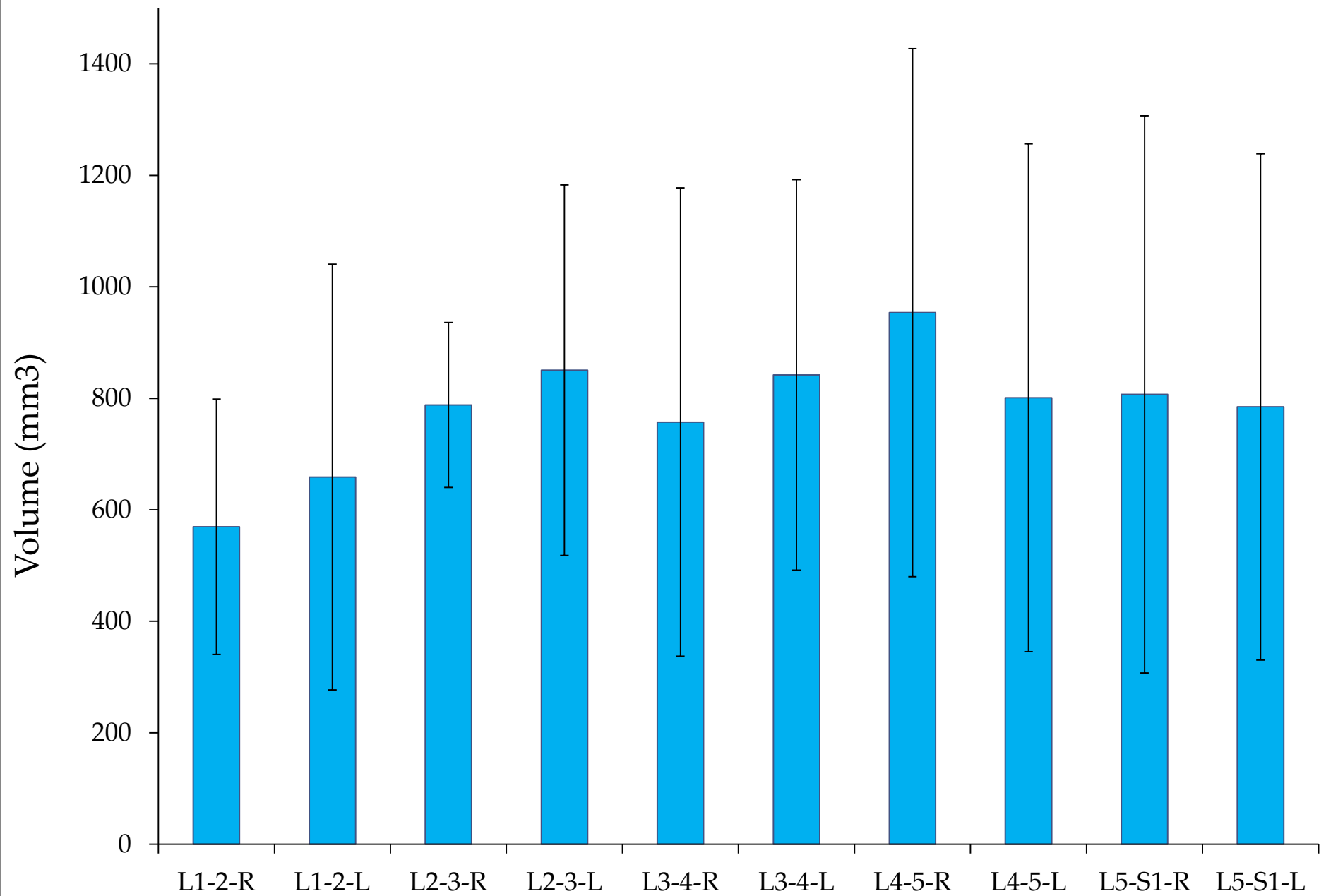
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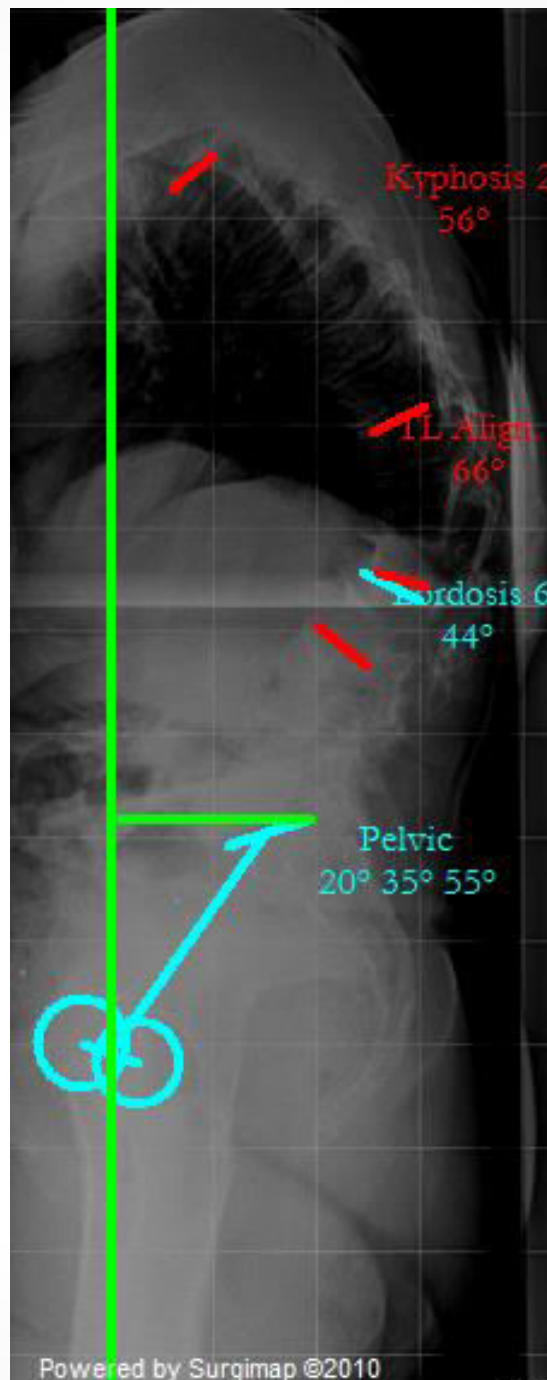


Surface area of the facet joint contact space (mean \pm stdev)



Volume of the facet joint contact space (mean \pm stdev)





59 / F

AP Cobb 26°

CSL 7 cm

Pelvic:

PI 55°

SS 20°

PT 35°

LL 44°

TL 66°

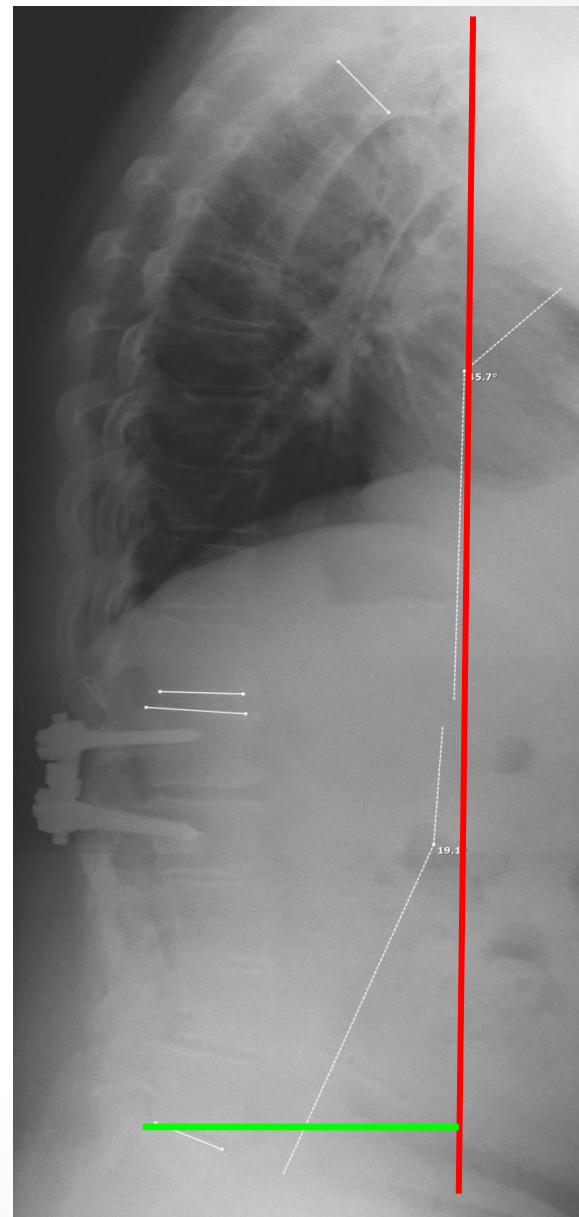
TK 56°

SVA 11 cm

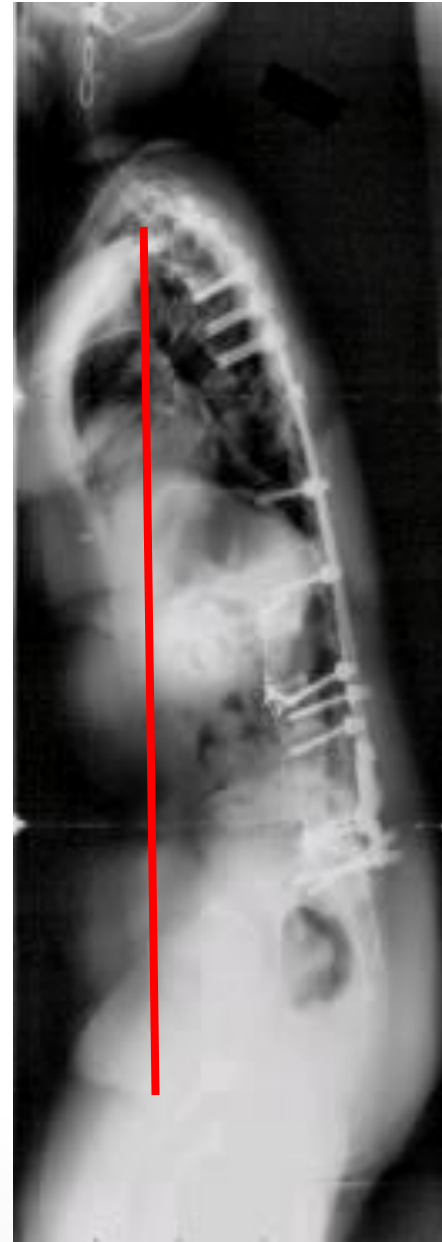


Clinical effects of plumb-line shifts

Glassman, Bridwell et al. Spine 2005



deformity





15 9:45AM

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Standing lat



Hyperext lat



Aim 1: achieve fusion

- ✧ Good pain relief; 69 – 87%

Kostuik Clin Orthop 1973

Swank JBJS Am 1981

- ✧ Improvement in the lumbar lordosis

- ✧ Anterior column load sharing

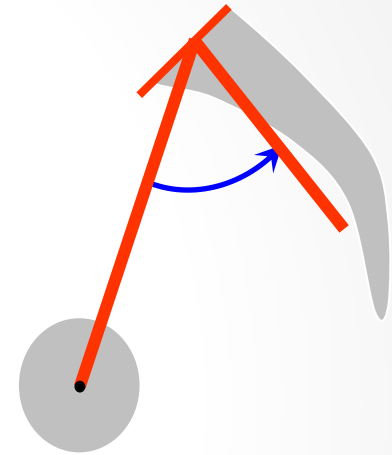


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Aim 2: adaptation of lordosis

- ✧ Excise facet joints
- ✧ 'Open' degenerate disc spaces
- ✧ Measure the PI, and build in the lordosis



$$LL = PI \pm 9^{\circ}$$



Adult Deformity: Surgical goals

- ✧ Normalize & balance contours
- ✧ Fuse the least number of segments
- ✧ Neural decompression
- ✧ Obtain solid biological fusion



Adult Deformity: principles of surgery

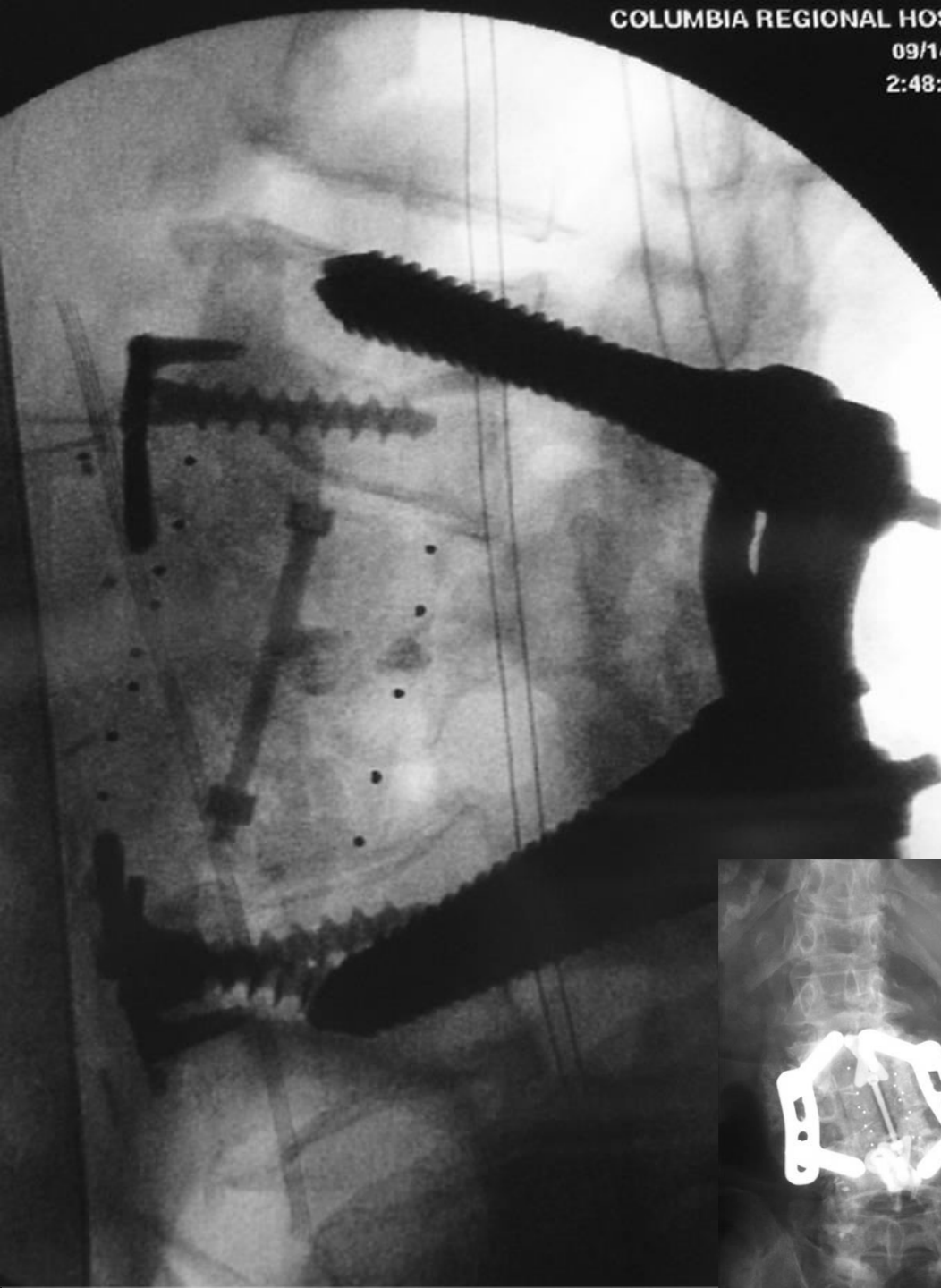
- ✧ Traction + erect full spine films
- ✧ Measure parameters
- ✧ Levels to instrument
- ✧ Levels to decompress
- ✧ Anterior column management





MM
86Y







18 1:54PM





Advanced surgical strategies

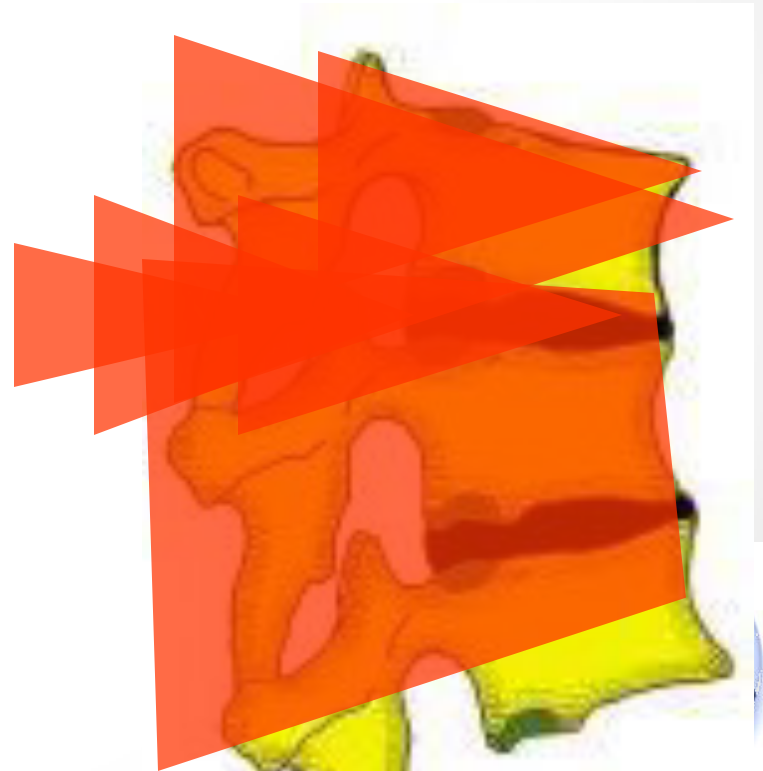


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Osteotomies

1. partial facet joint
2. complete facet joints
3. partial body[#]
4. partial body and disc [#]
5. complete body + discs [#]
6. >1 body, adjacent [#]



posterior vs. anterior/posterior

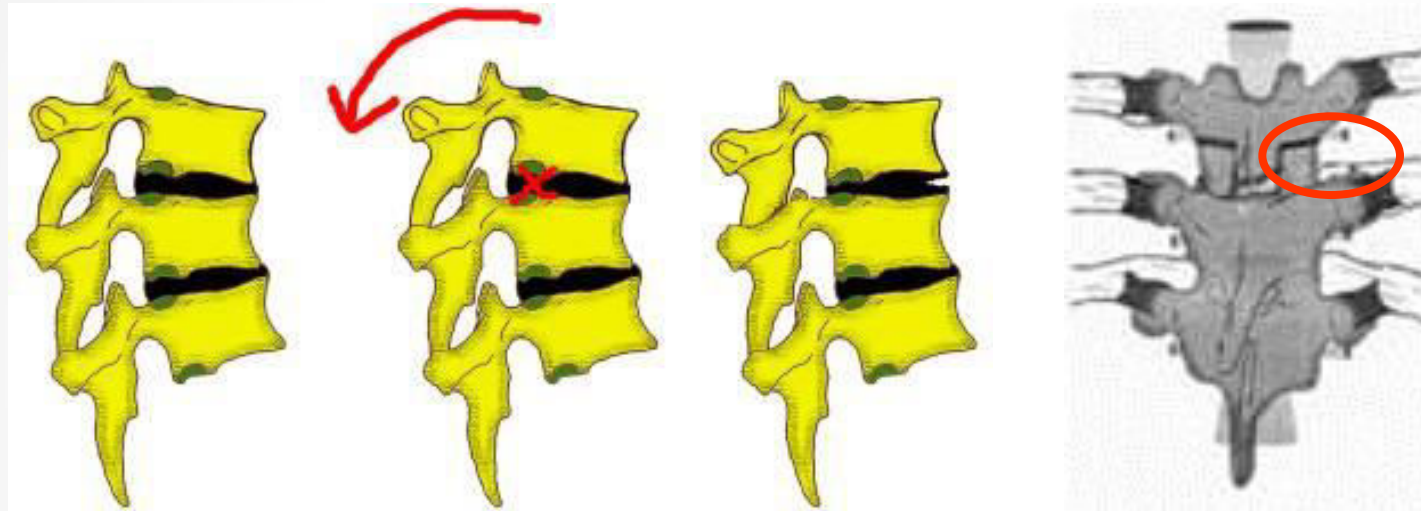
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Grade I - Partial Facet Resection



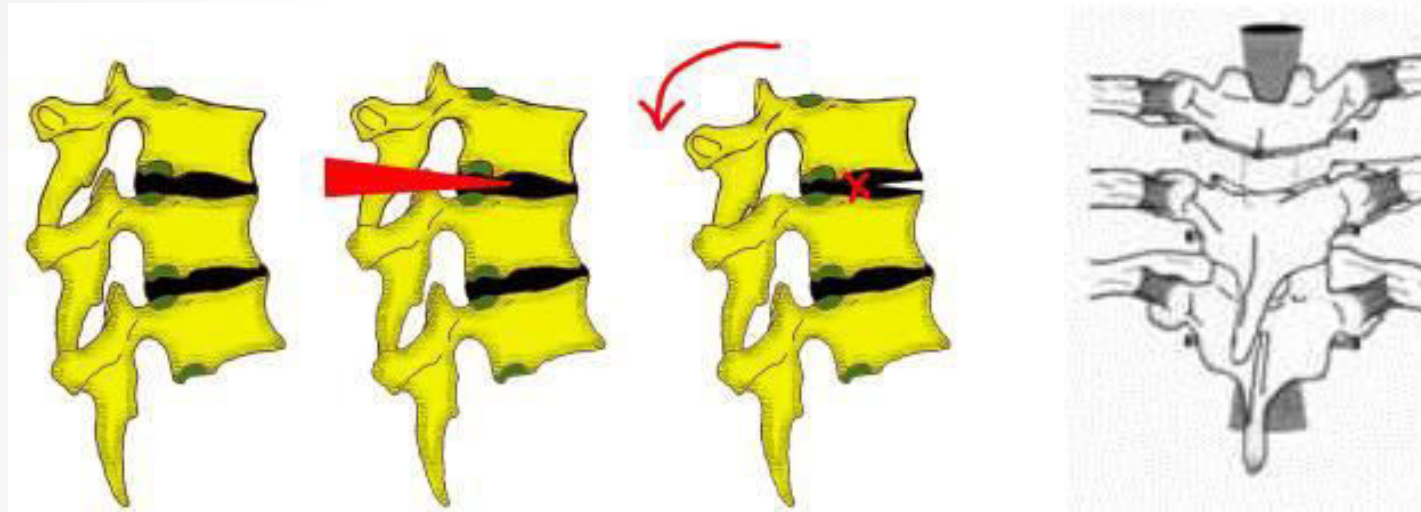
Best suited when anterior column flexibility
Inferior facet resection + capsule



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Grade II - Complete facetectomy



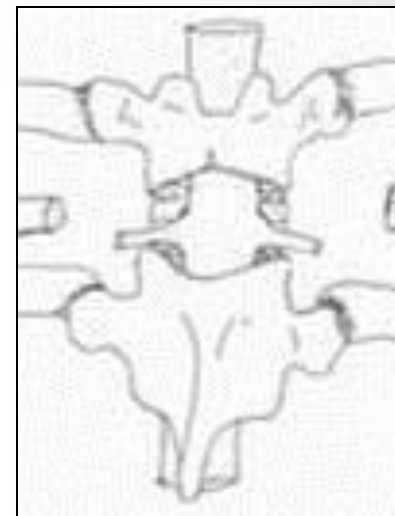
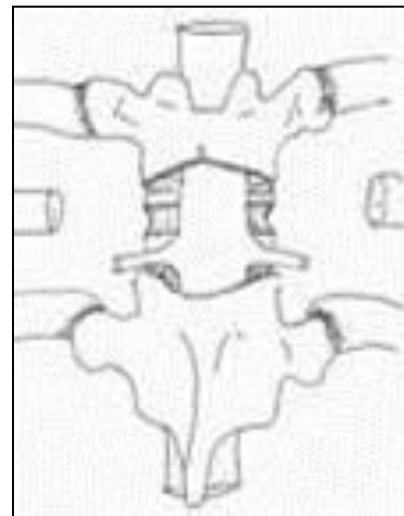
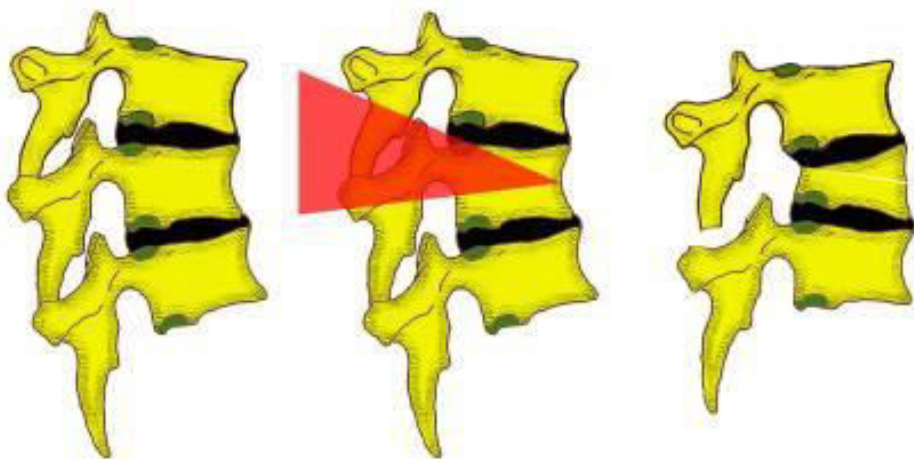
Anterior column mobility necessary
Superior and inferior facet resection
Spinous processes



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Grade III - Partial body resection



Most suited when $>20^\circ$ segmental correction needed

Appropriate even through fusion

All levels of spine possible

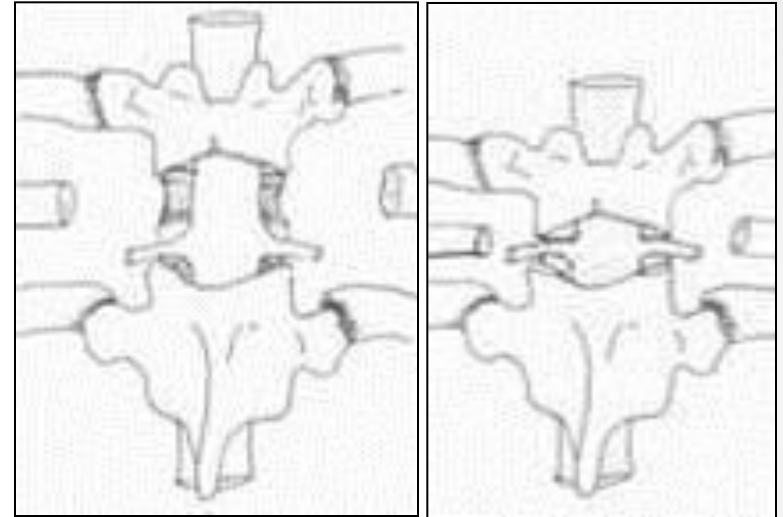
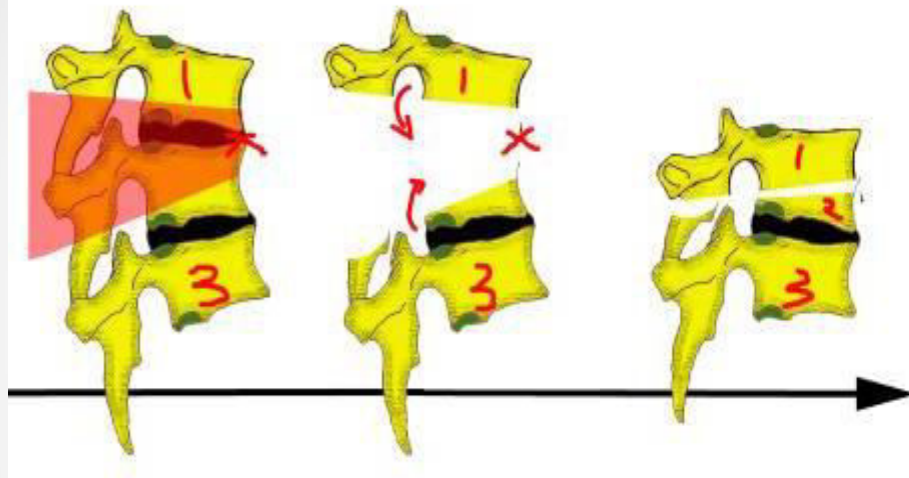
Preferable below conus



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Grade IV - partial vertebra + disc



Permits limited 3-plane correction

Rib resection necessary in thoracic spine

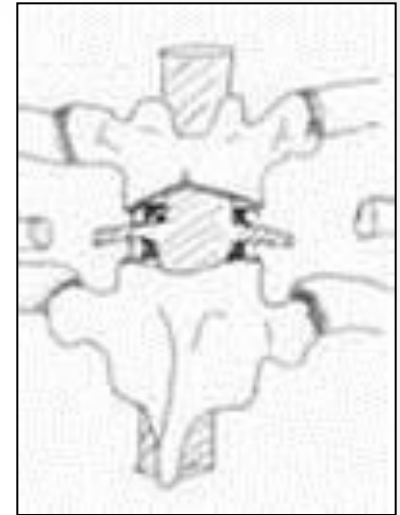
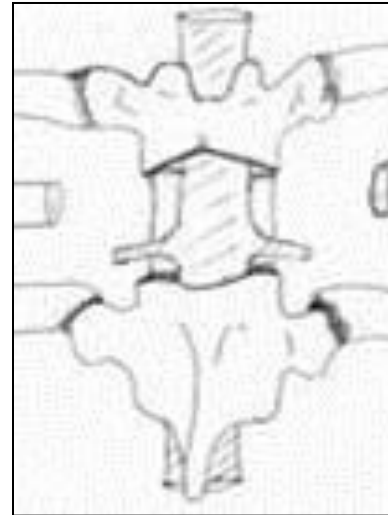
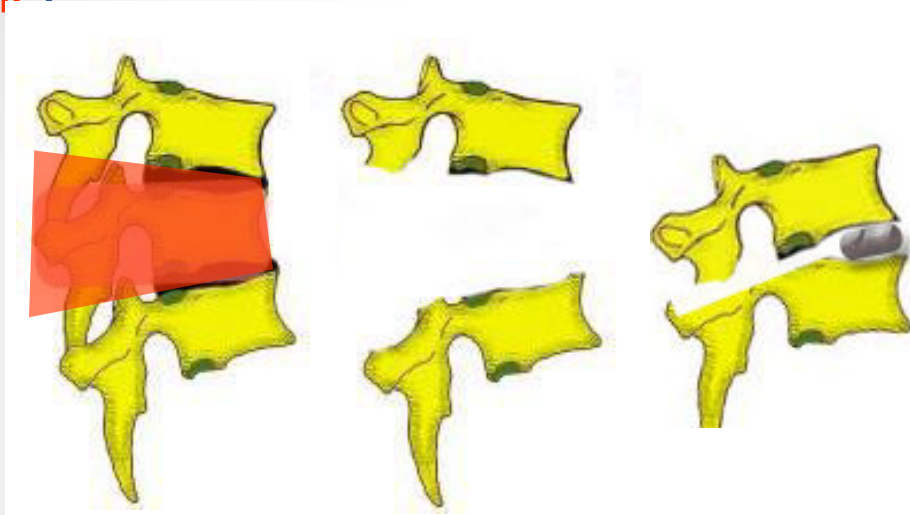
Add anterior support/cage when marked shortening



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Grade V - Complete vertebra + discs



Permits 3-plane correction

Rib resection necessary in thoracic spine

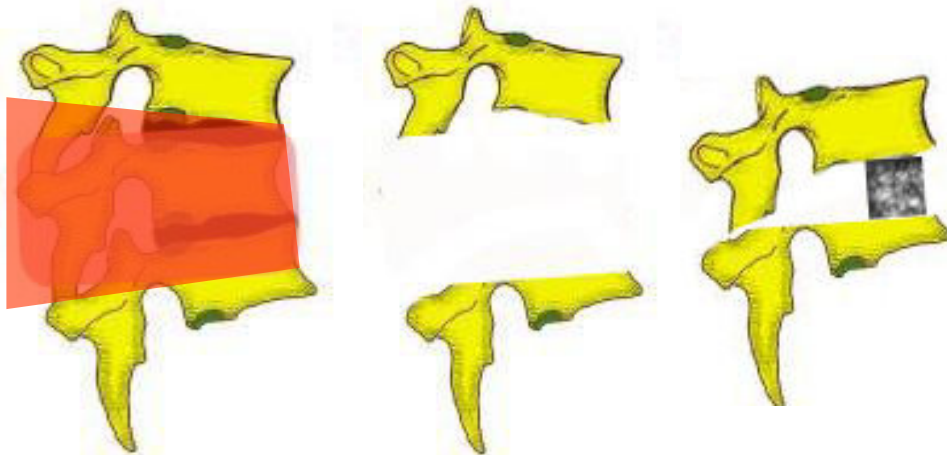
Add anterior support/cage



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Grade VI - More than 1 Vertebra + discs



Permits 3-plane correction
Rib resection necessary in thoracic spine
Add anterior support/cage



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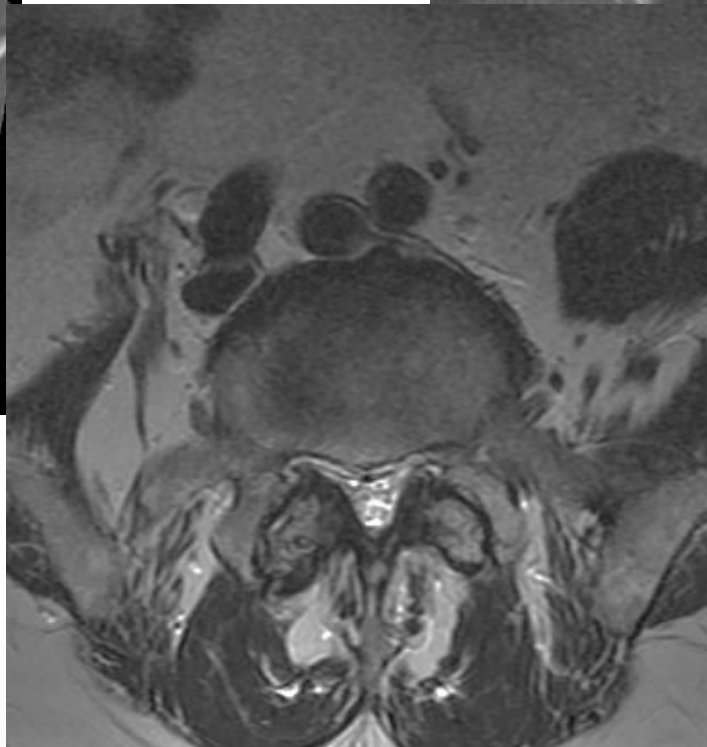
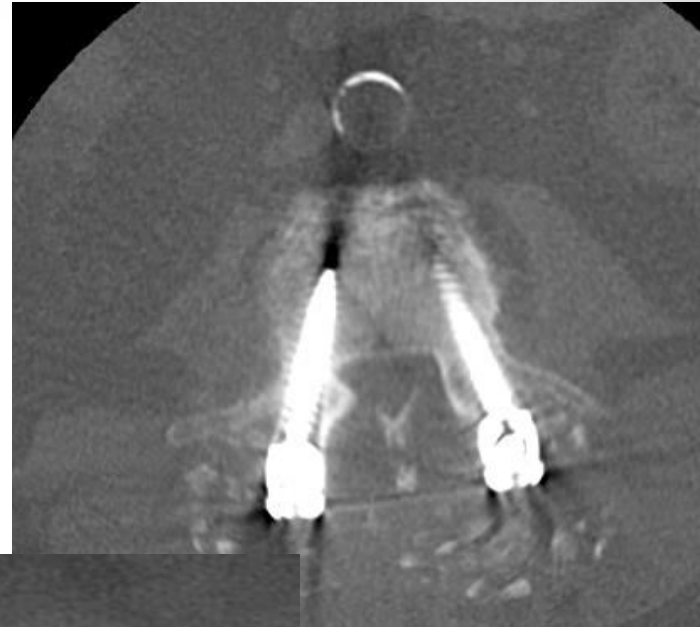
Facetectomy



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Facetectomy





Instrumentation related strategies

...



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✧ **Screws; alternative bone anchors**

✧ **Rods**

✧ **Reduction strategies**

✧ **Connector options**

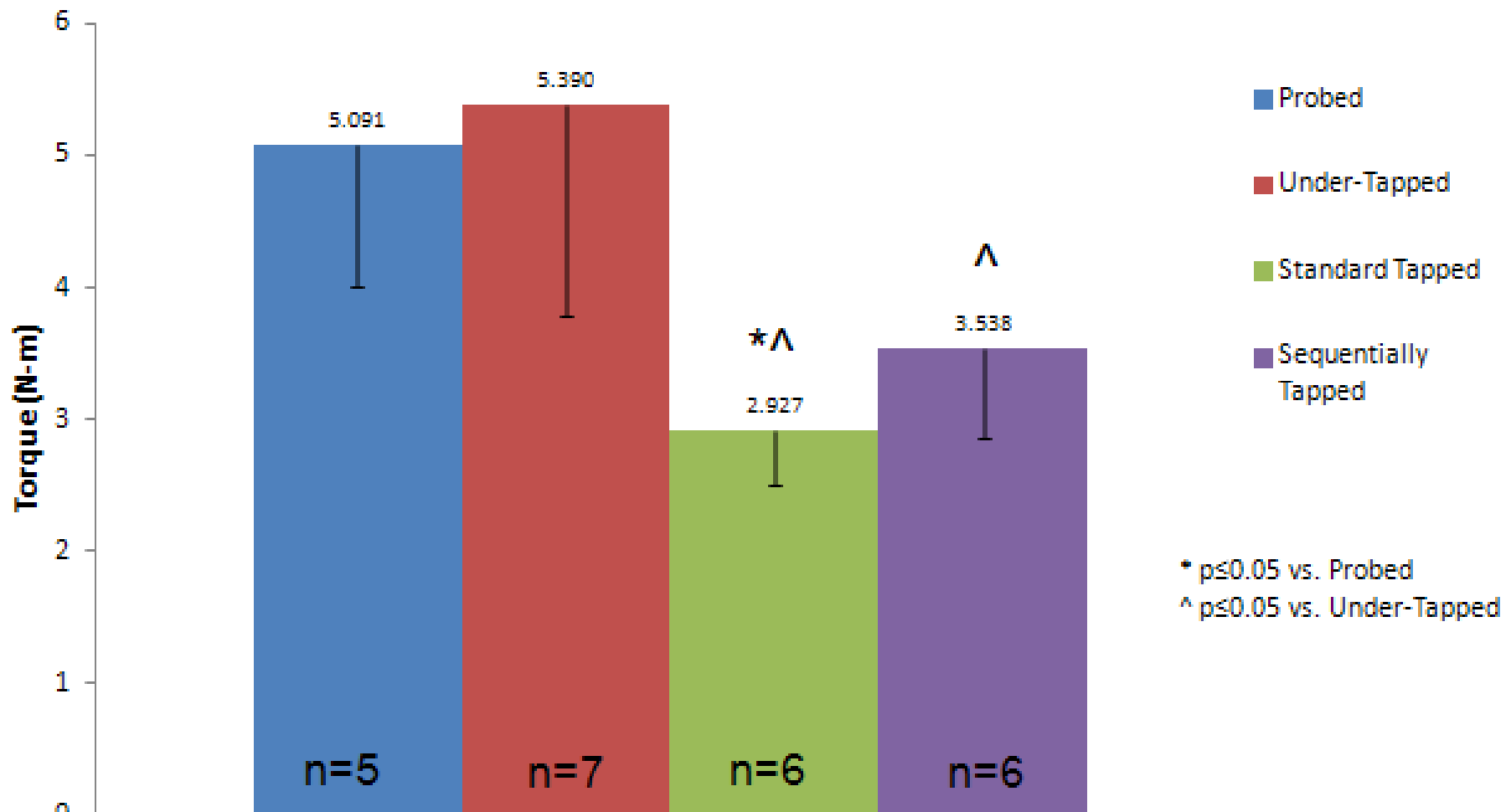
✧ **Anterior column**



Pedicle Screw Pullout Strength of Four Different Screw Hole Preparation Techniques

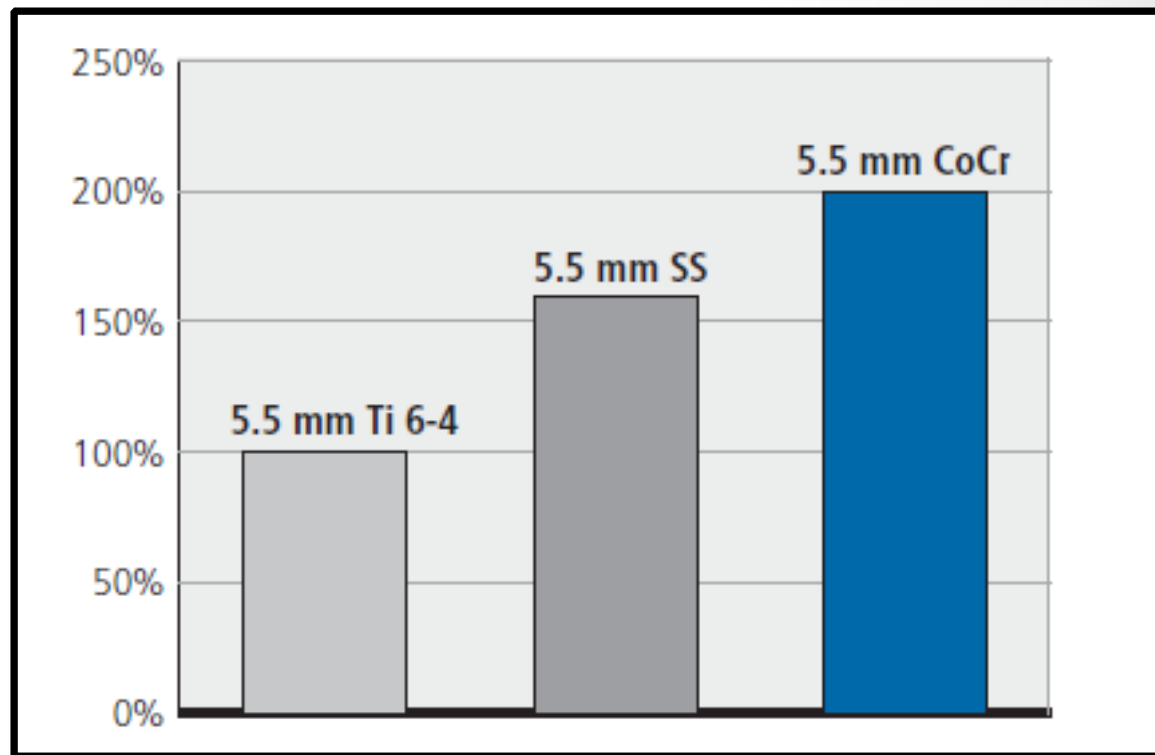
Jwalant Mehta, FRCS (Orth), M.D.; Mark Moldavsky M.S.; Kanaan Salloum; Brandon Bucklen PhD; Saif Khalil PhD

Pedicle Screw Insertion Torque



CoCr Stiffness/Modulus

Firebird 5.5mm Cobalt Chrome Rods offer a 100% increase in stiffness compared to 5.5mm Titanium rods

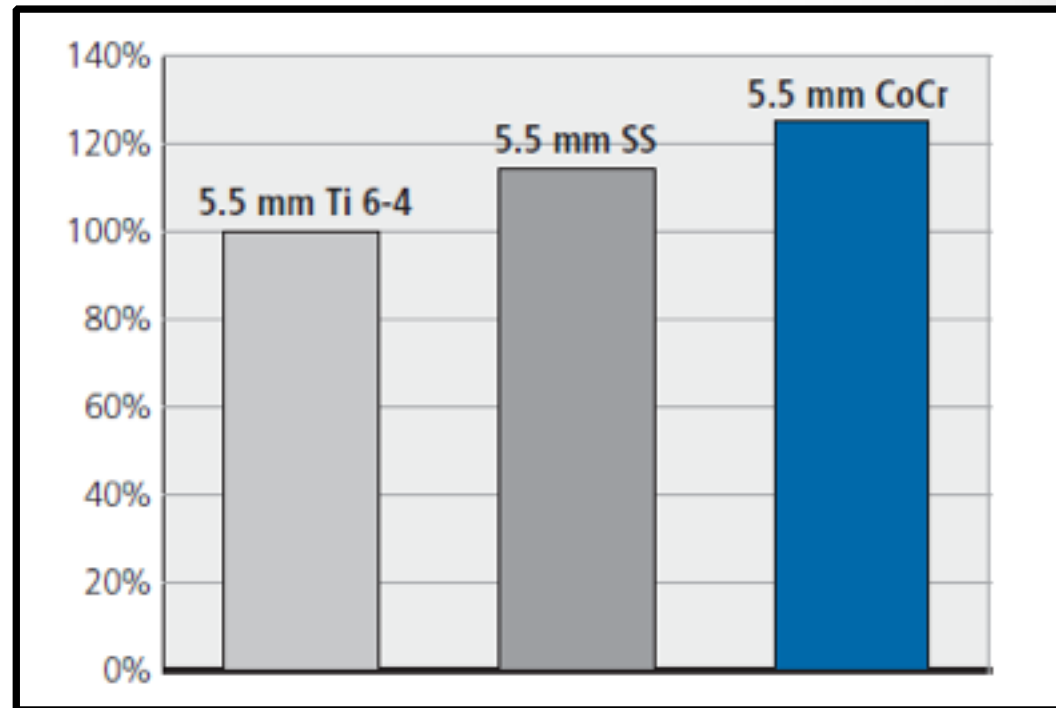


Stiffness expressed as a percentage of Titanium 5.5mm Ti 6-4 ELI Rod Stiffness



CoCr Strength/Yield

Firebird 5.5mm Cobalt Chrome Rods offer a 25% increase in strength compared to 5.5mm Titanium rods

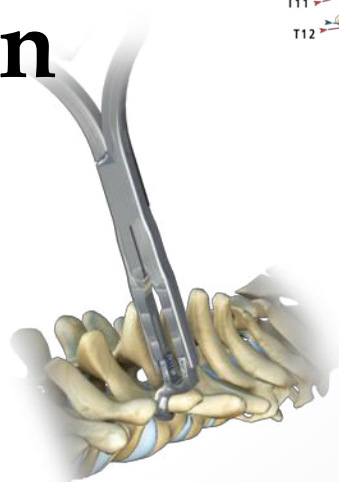
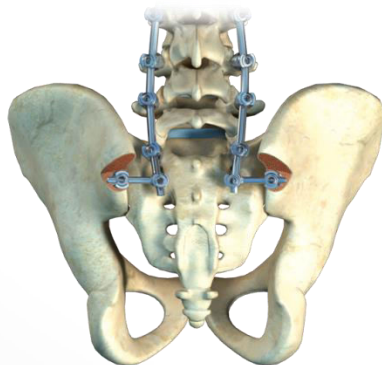
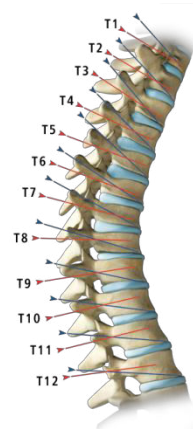


Strength expressed as a percentage of Titanium 5.5 mm Ti 6-4



Firebird™ Deformity Correction System

Iliac Fixation
Hook Fixation
Thoracic Fixation
Reduction/Rotation



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Iliac Bone Screws



Iliac Bone Screws

7.5 – 10.5mm diameters

60 – 100mm lengths

(10mm inc.)

2 of each per tray

Utilize all Firebird modular bodies



Mono Axial Lateral Offset Connector

**Available in lengths from 15-35mm, 5mm incr.
Utilize modular head holders for insertion
80mm length for intra-op customization**

Gripping features



Low Profile Offset Heads

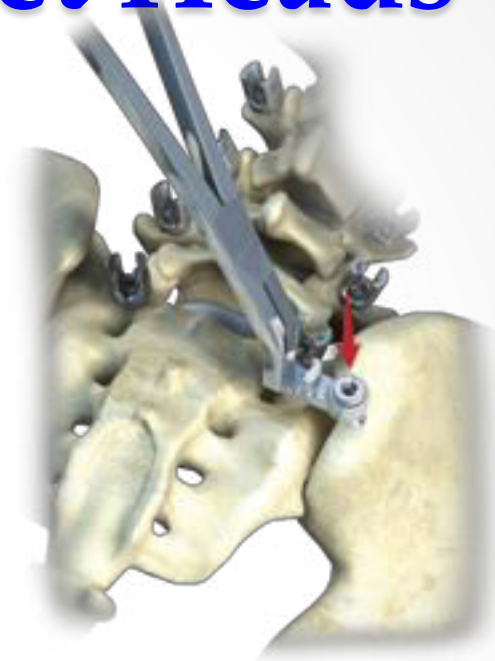
Lowest profile option

Modular bone screw compatible






Now with an integrated set screw over the bone screw connection point

Lengths:

8 – 35mm, 3mm increments



Firebird Hooks

Implant	Image	Size / Style	Features / Use
Angled Hook		Left, Right Small, Medium (throat)	Supralaminar Ramped base reduces the potential for canal encroachment by blade
Laminar Hook		Small, Medium, Large (throat) Narrow, Wide (blade)	Infralaminar or supralaminar In the canal or as a transverse process hook
Offset Hook		Left, Right Medium, Large (throat)	Infralaminar or supralaminar Permits medialization of the rod when used on the transverse process
Pedicle Hook		Small, Medium, Large (throat)	Infralaminar Bifid tip engages pedicle of thoracic vertebra
Thoracic Hook		Small, Medium (throat) Narrow, Wide (blade)	Infralaminar or supralaminar Ramped base of hook reduces the potential for canal encroachment by the blade



Thoracic Fixation

Rods, 5.5 X 450mm

Cobalt Chrome

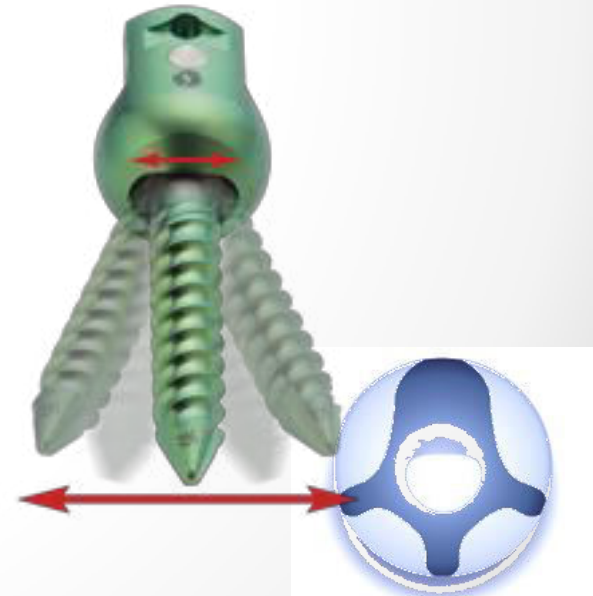
Titanium



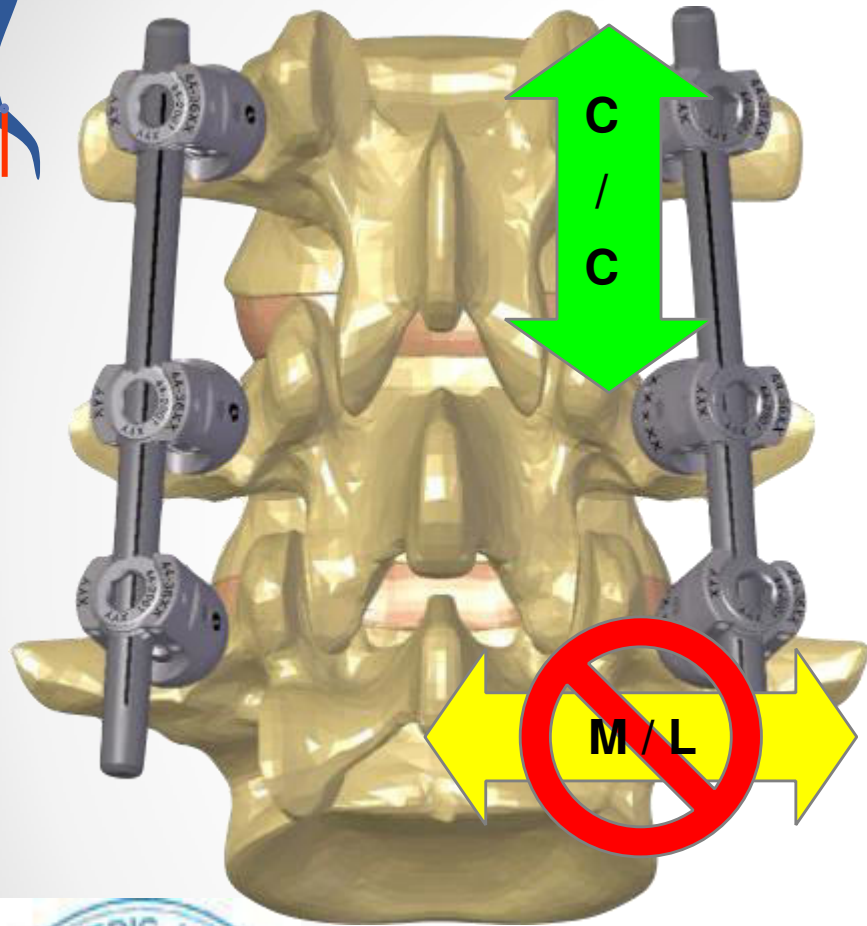
Uniplanar Screws

Diameter = 4.0 – 6.5mm

Length = 25 – 45mm



Uni-Planar Screws



Cephalad/Caudad
Allows Cephalad/Caudad
movement
Assist with rod placement in
kyphotic deformities

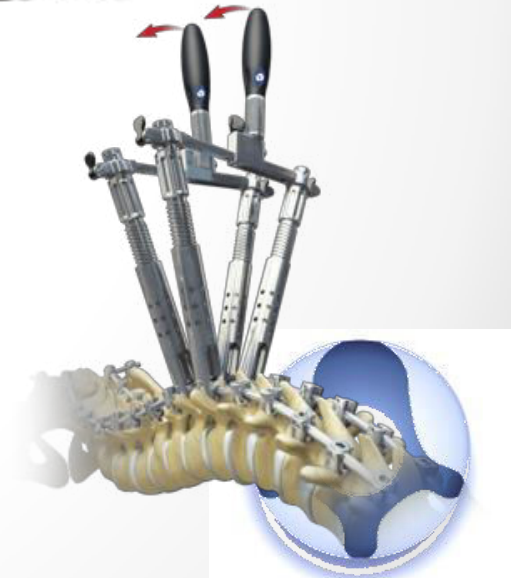
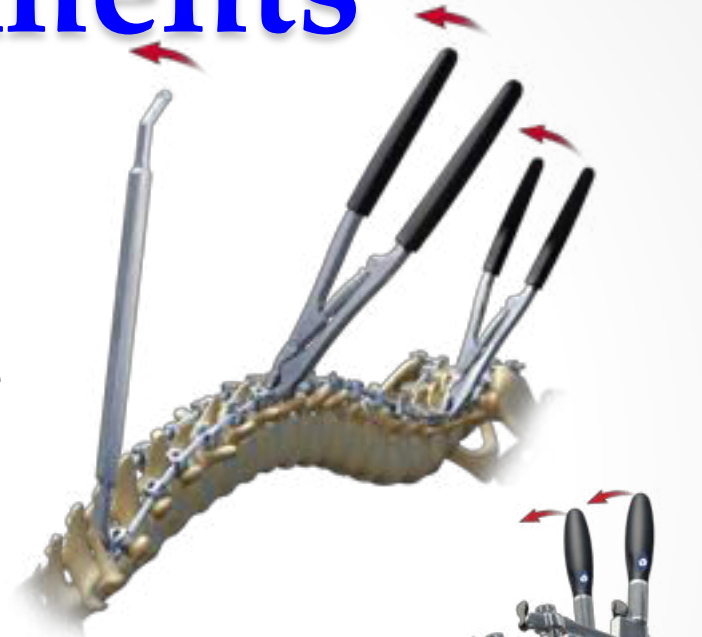
ateral

Split for Mon



Reduction/Rotation Instruments

Linear Rod Reducer
Coronal Benders
Reduction/Rotation Tube
Ratcheting Connector
Rotation Handle
Rod Gripper
Driver
Hex Wrench
Set Screw Driver



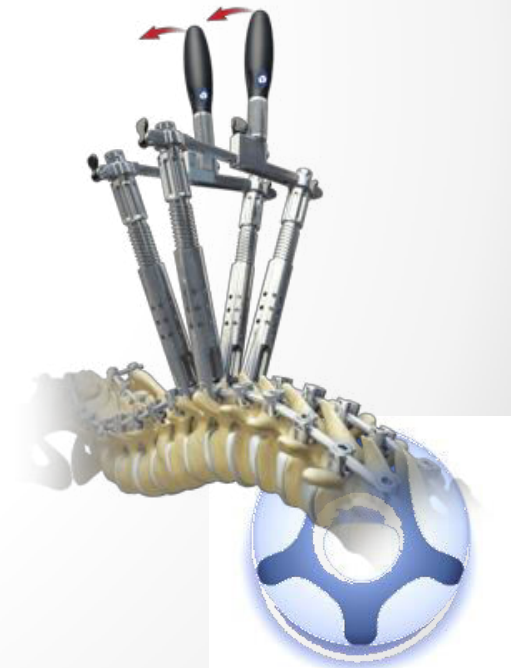
Direct Vertebral Rotation Instrument

Bi-Lateral Rotational
Secures to
facilitate

Complete DVR
Instrument



Small
5° – 90°
Expansion



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Direct Vertebral Rotation Technique



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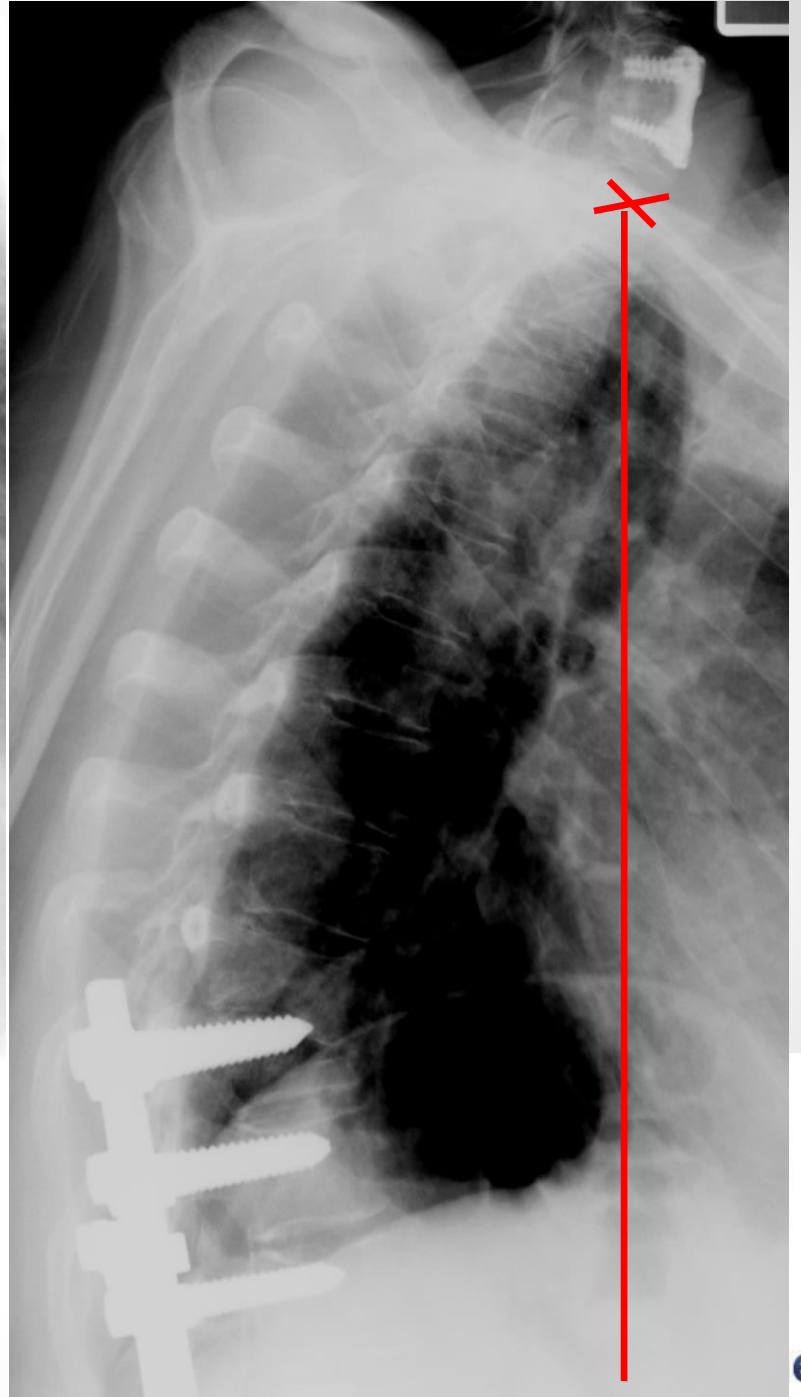
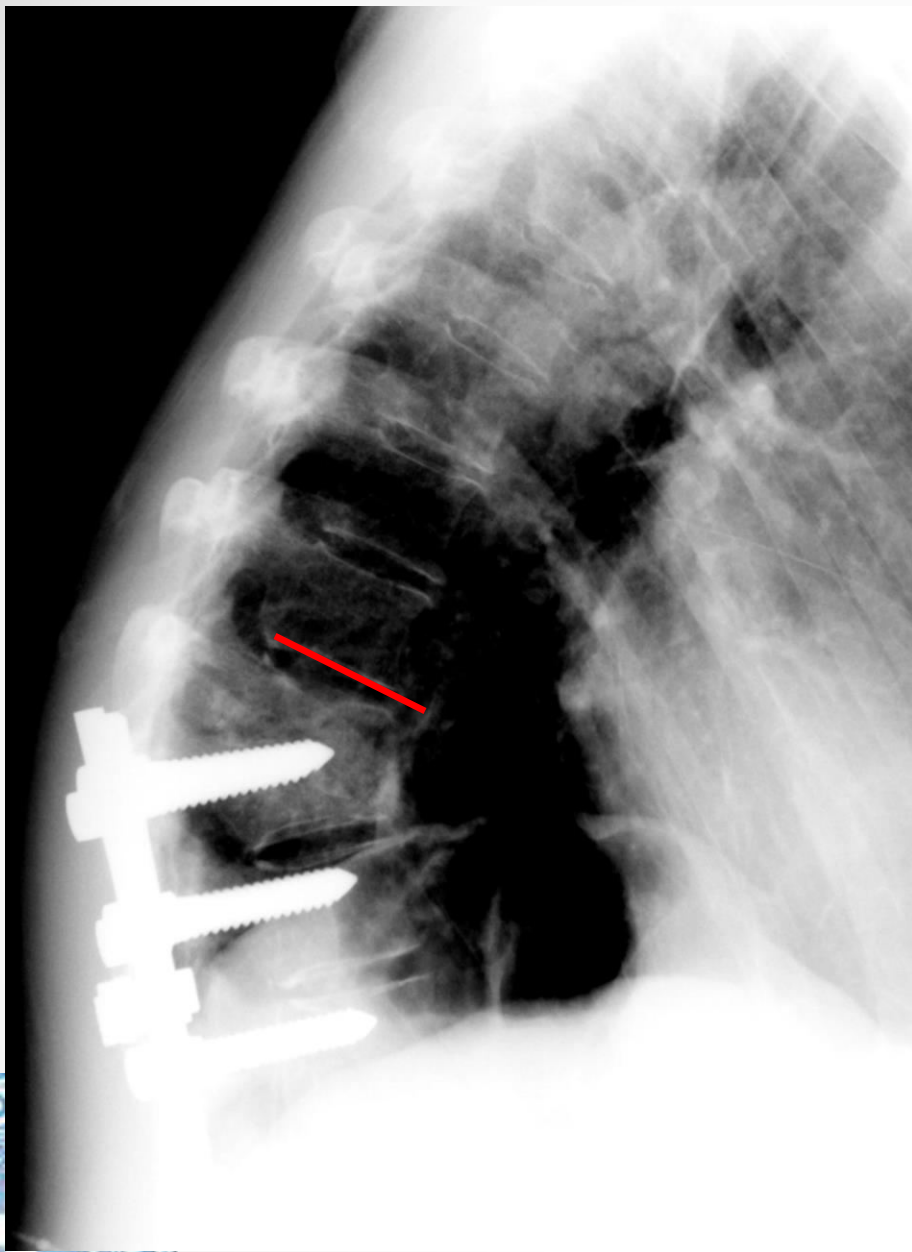
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Problems

- ✧ Realistic expectations
- ✧ Medical co-morbidities
- ✧ Osteoporosis
- ✧ Junctional problems







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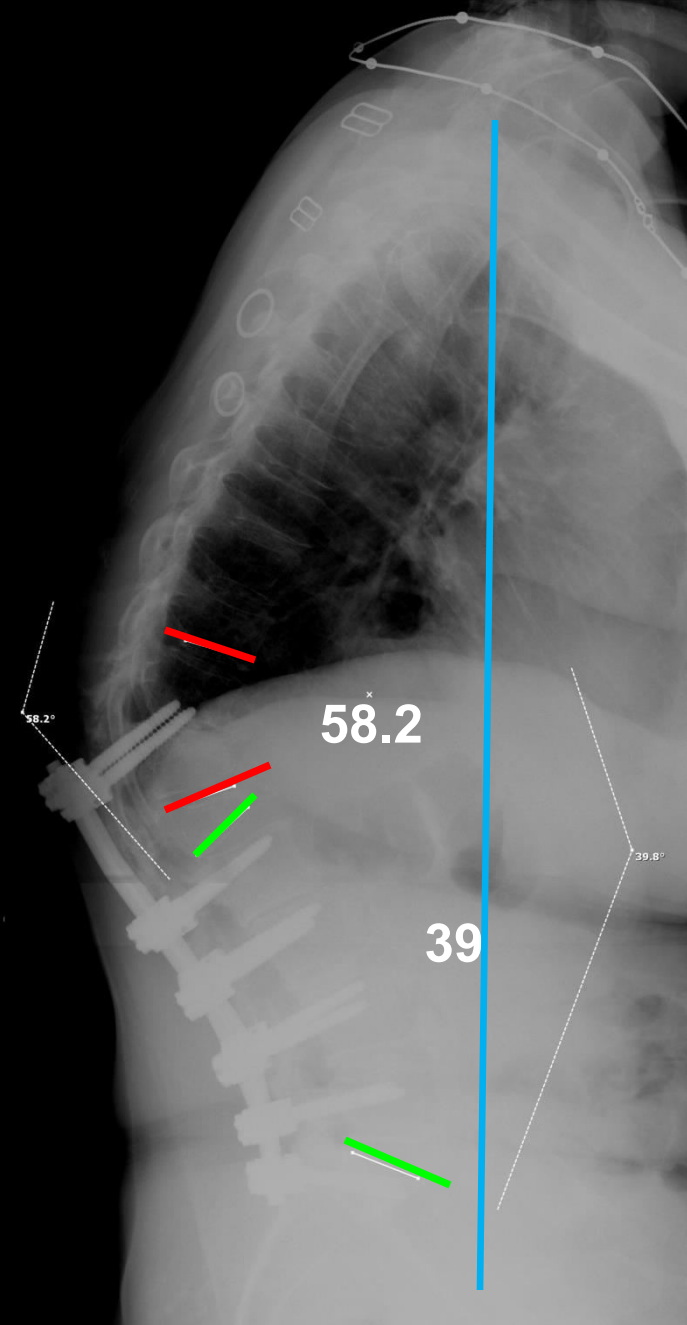
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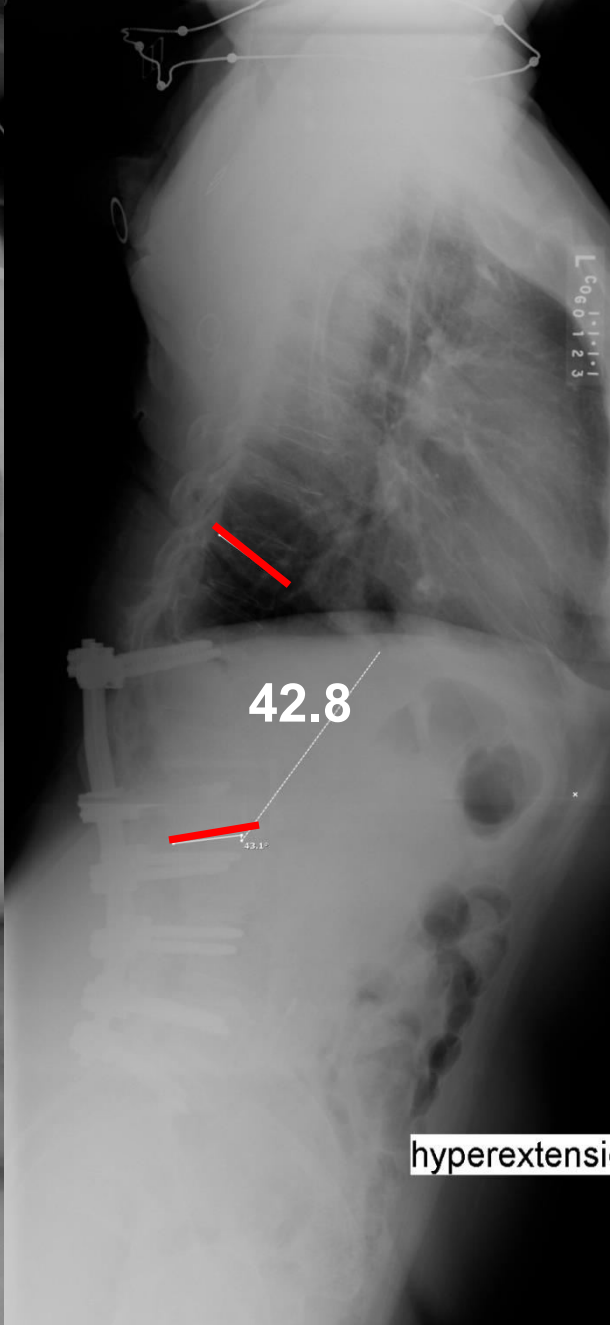


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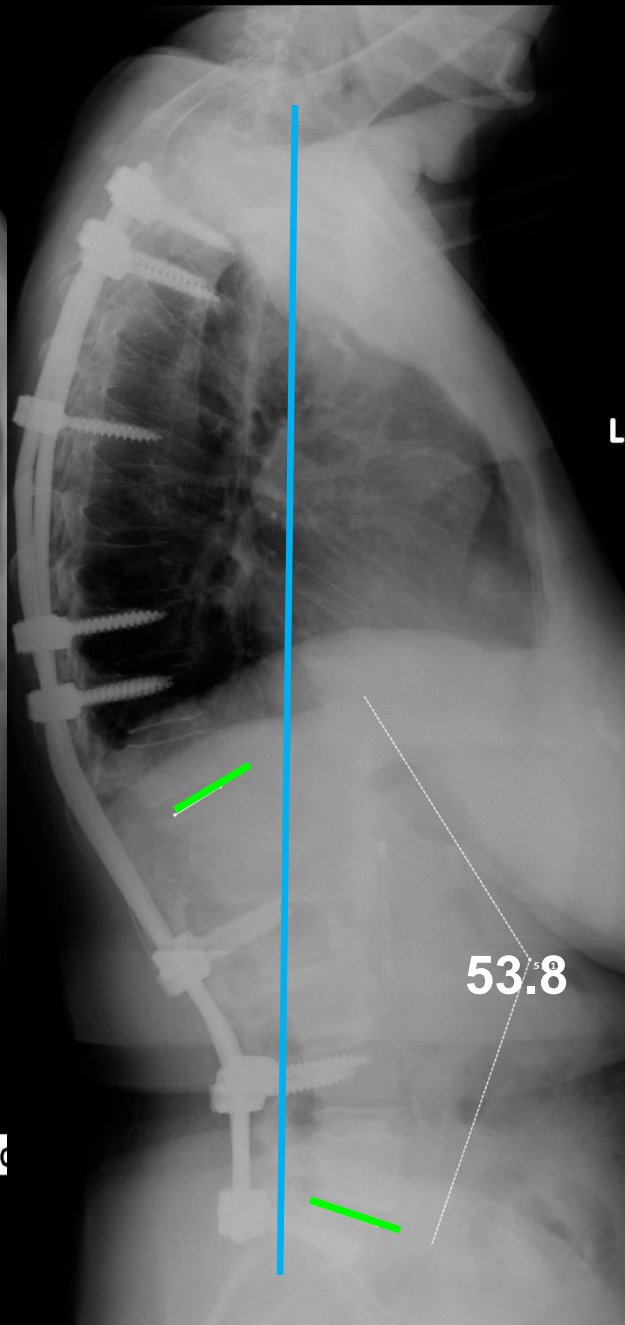
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Pre-op standing lateral

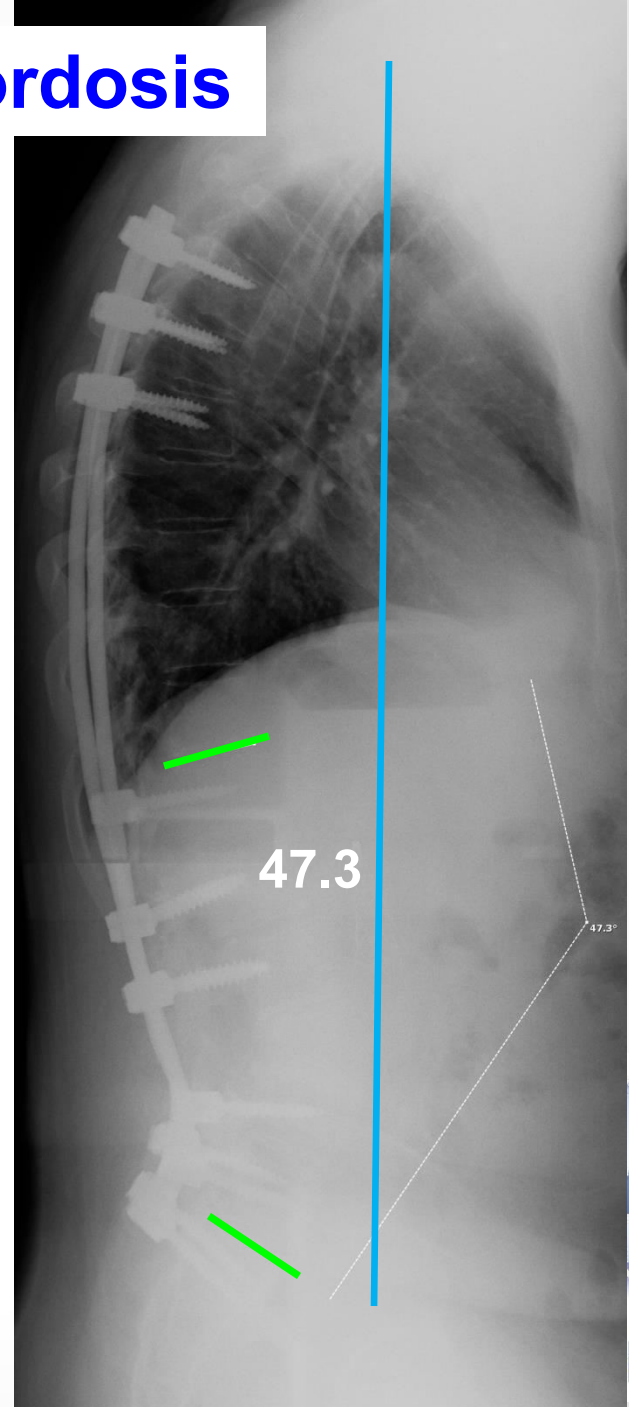
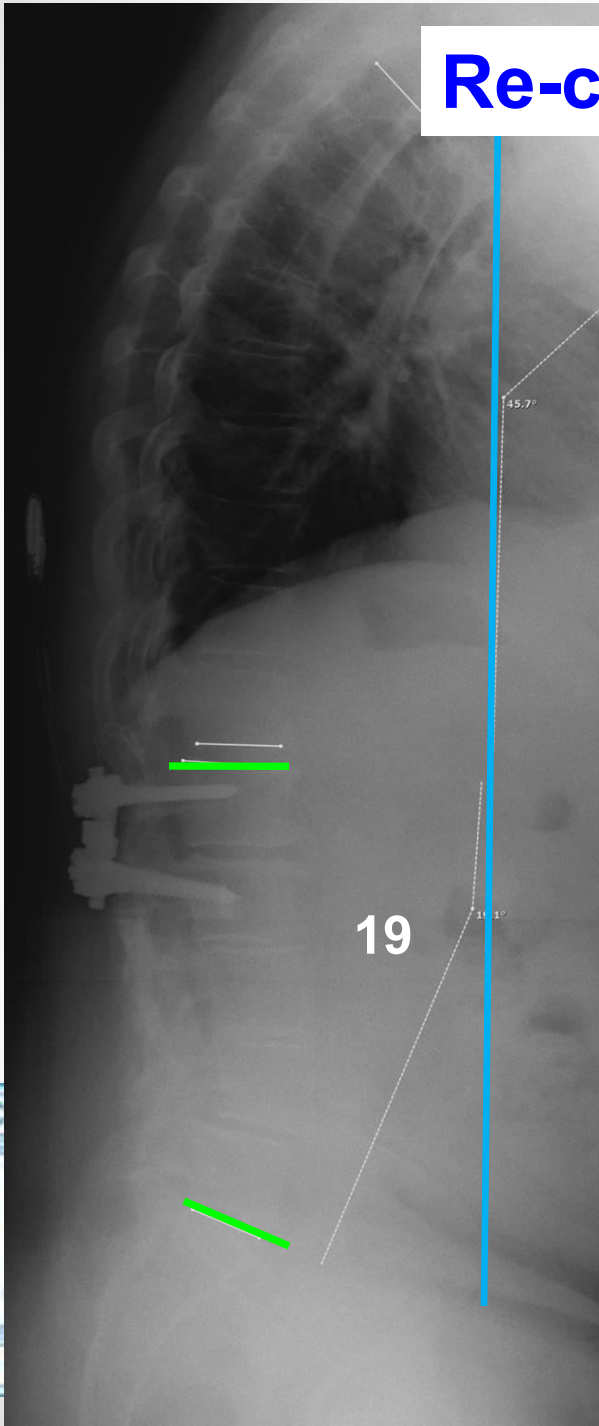


Hyper-extension lateral



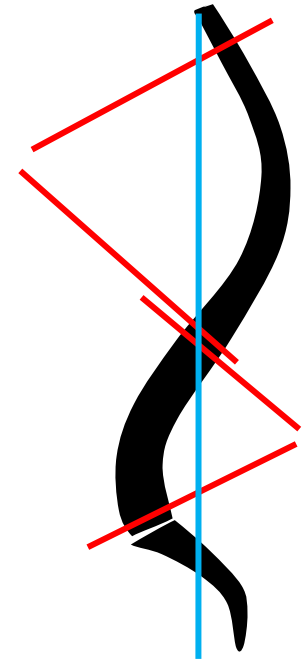
Post-op standing lateral

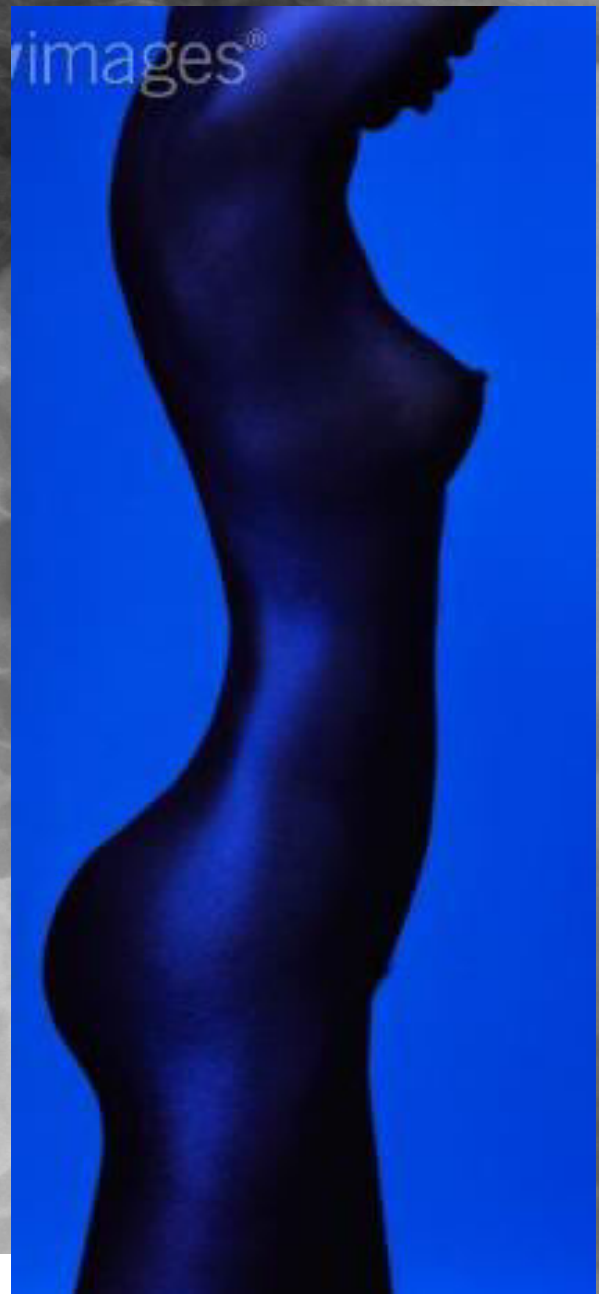
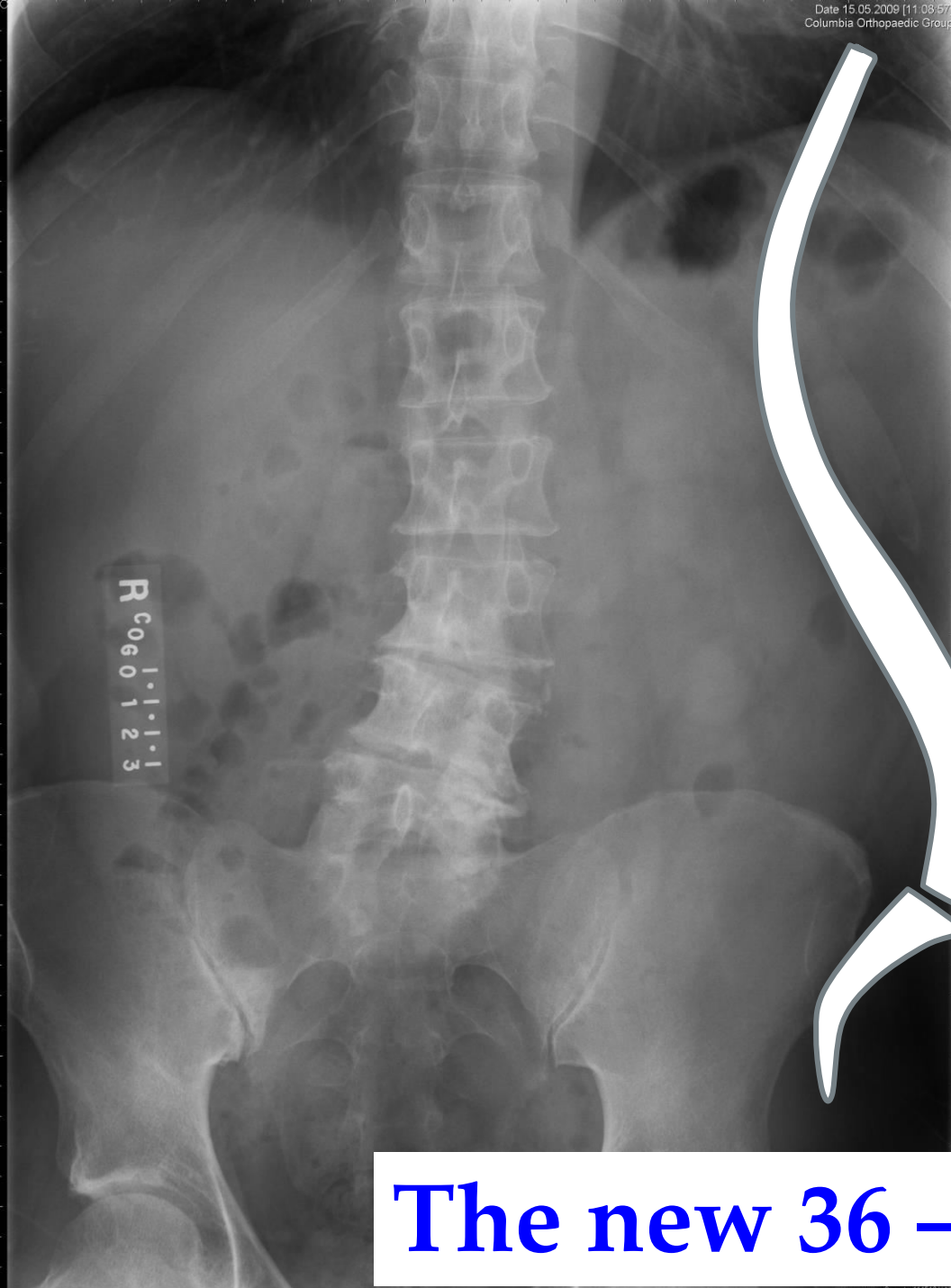
Re-create lordosis



Aims of intervention

- ✧ Restore balance without stressing junction
- ✧ Adaptation of the lordosis
- ✧ Restore plumb line





The new 36 – 24 - 36