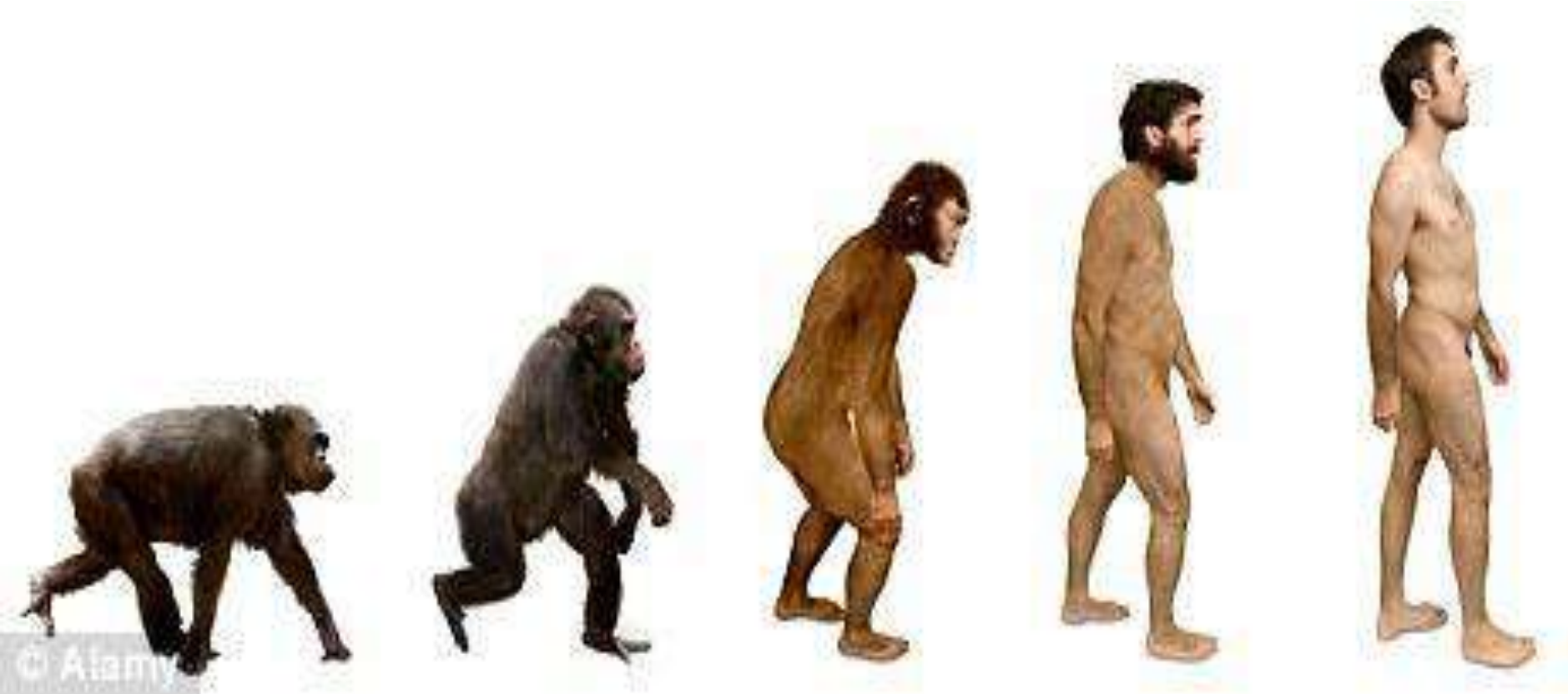
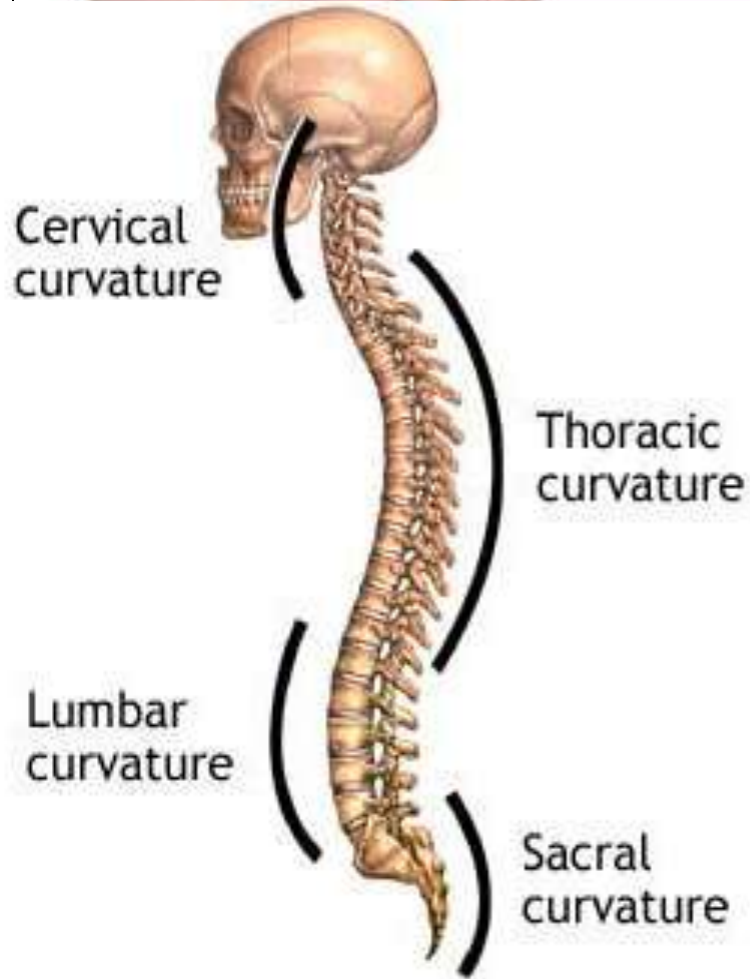
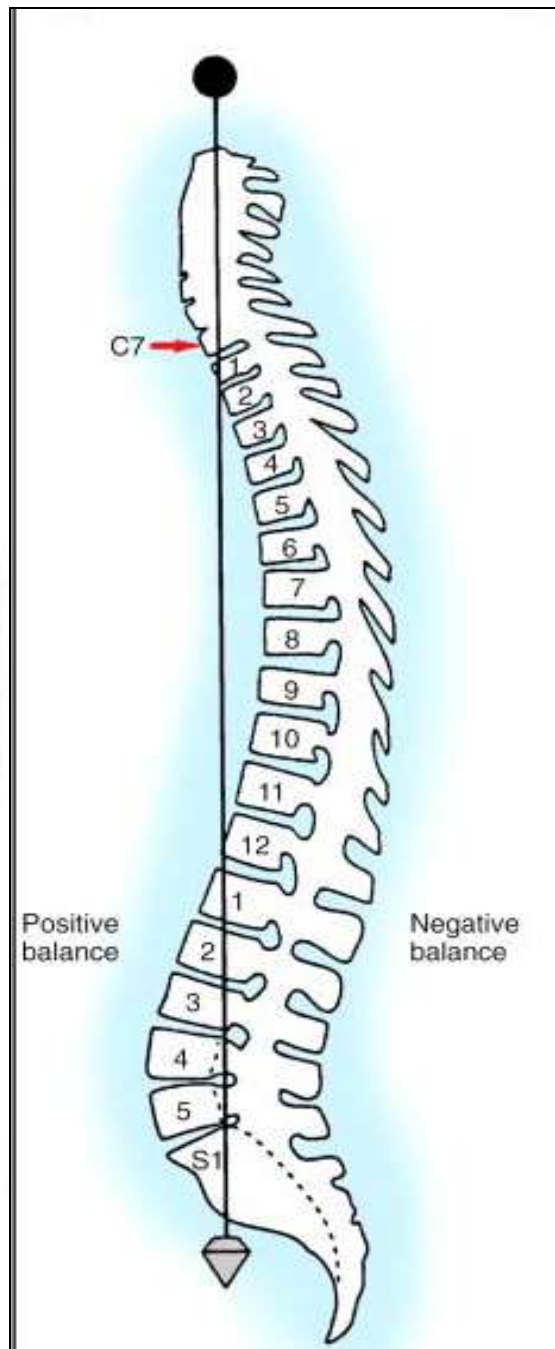


Understanding sagittal balance of spine and its implications in various spinal pathologies

Why erect position ?



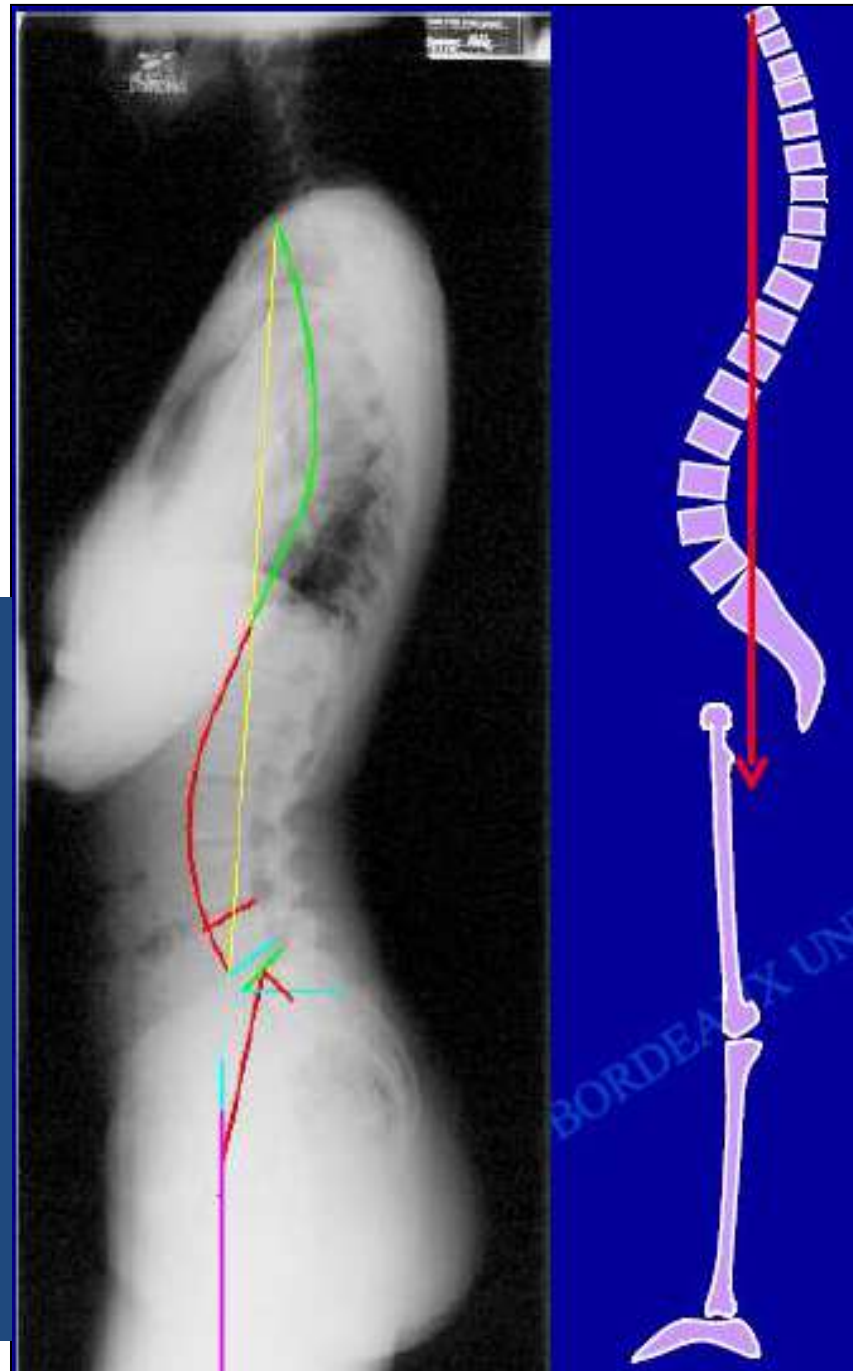




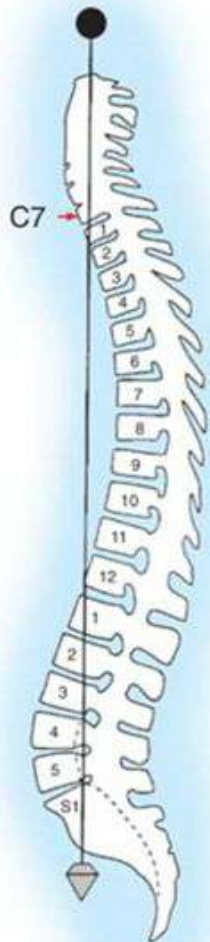
How to measure sagittal balance ?

C7 plumb line

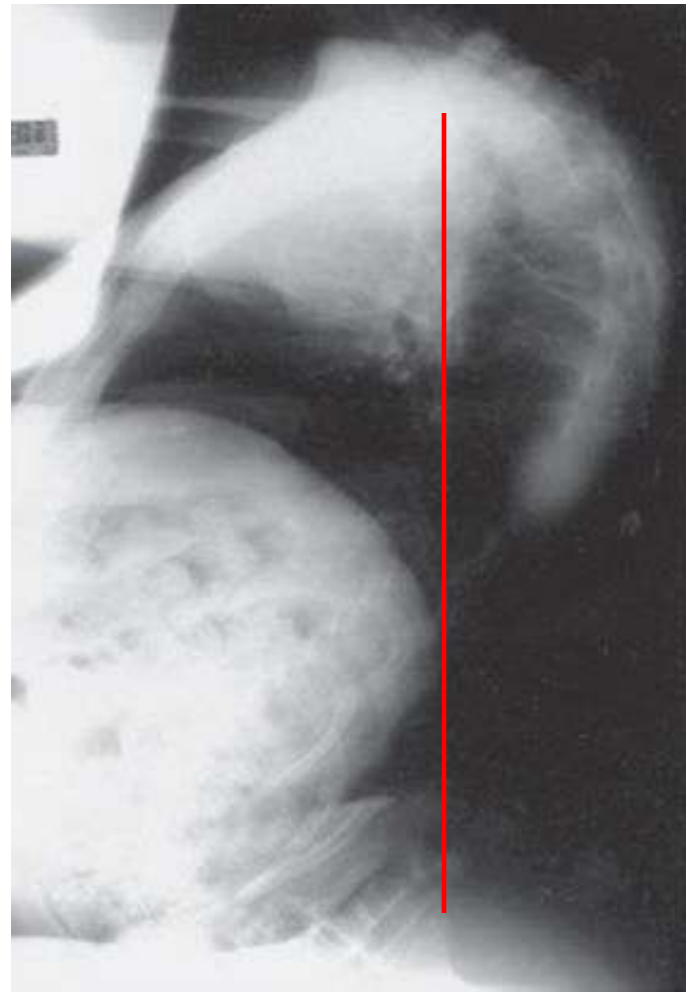
- Sagittal balance is the alignment of C7 to the posterior superior aspect of the sacrum on an upright radiograph.
- Should be plus or minus 2 centimeters from the posterior superior aspect of the sacrum.



Positive Sagittal imbalance



Negative Sagittal imbalance



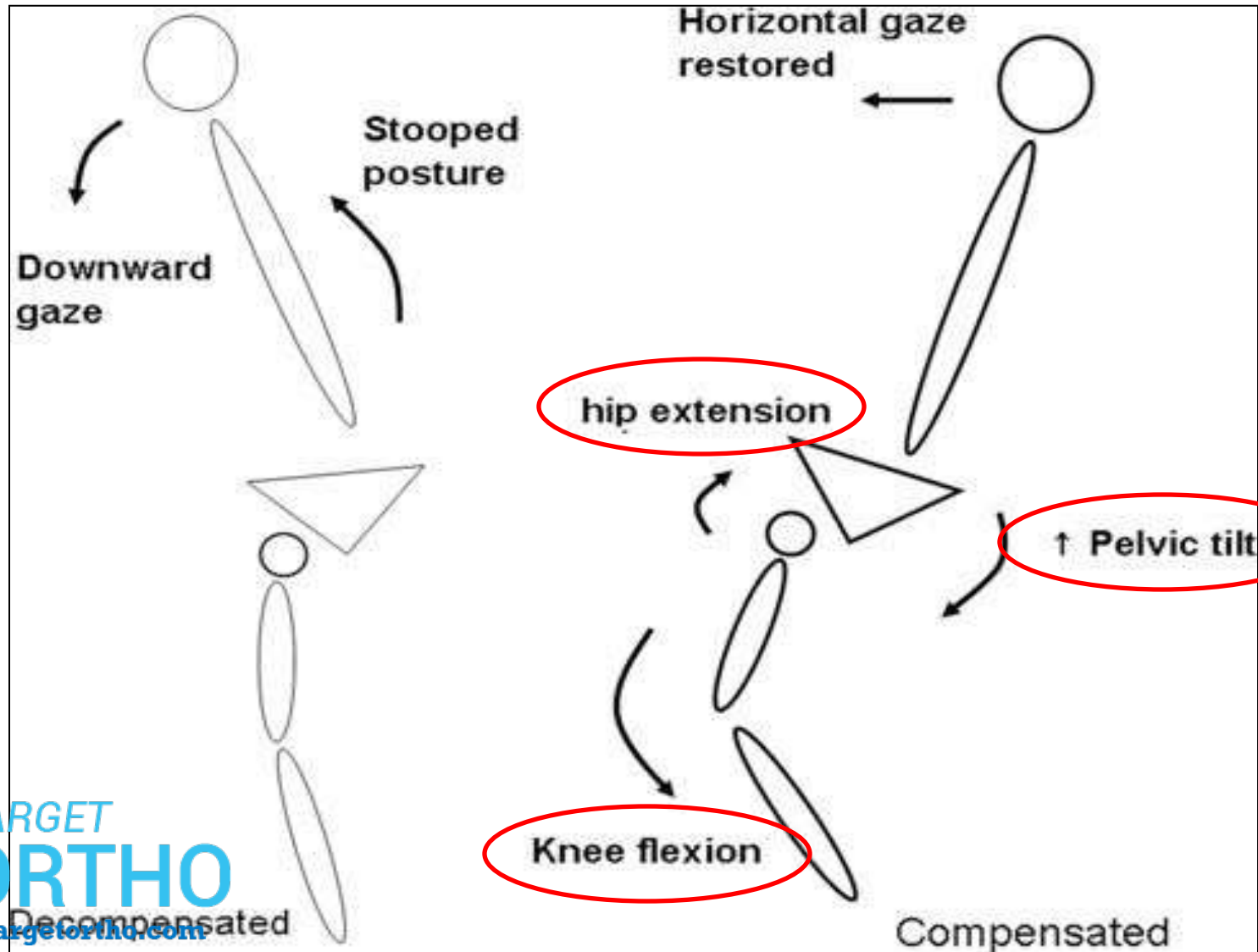
Balancing mechanism for positive sagittal imbalance

To bring the centre of gravity back:

1. Increasing the lumbar lordosis
2. Pelvis retroversion
3. Hip extension and Knee flexion

Balancing mechanism

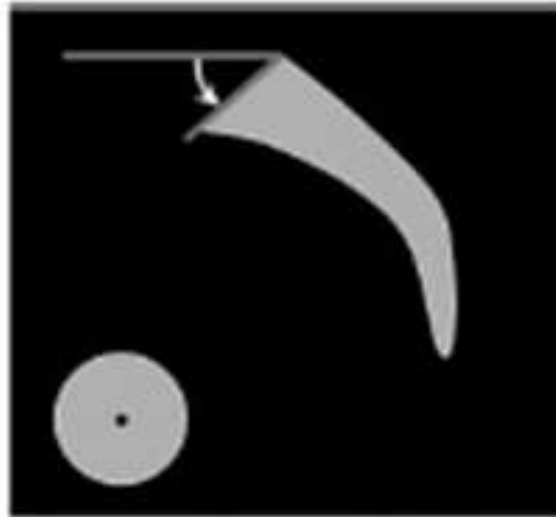
Hip and knee



Balancing mechanism

Spinopelvic parameters

- The relation of the pelvis to the spine, spinopelvic balance - contributes to overall sagittal balance.
- Defined by 3 different set of parameters

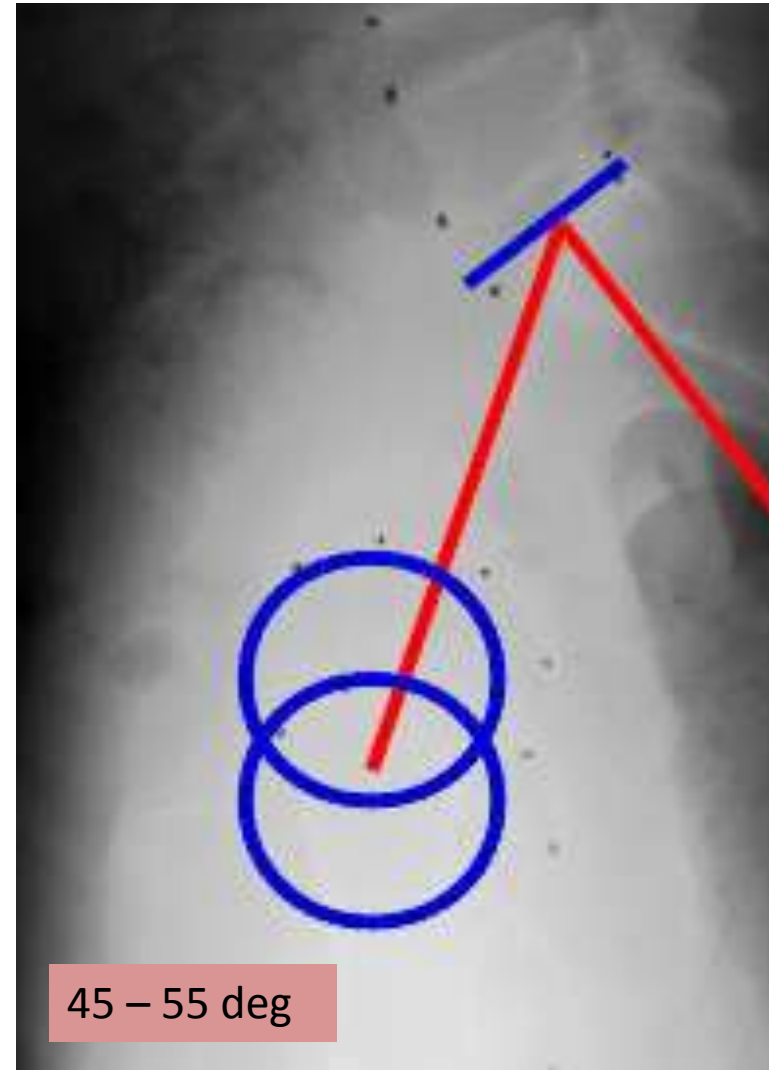


Sacral Slope

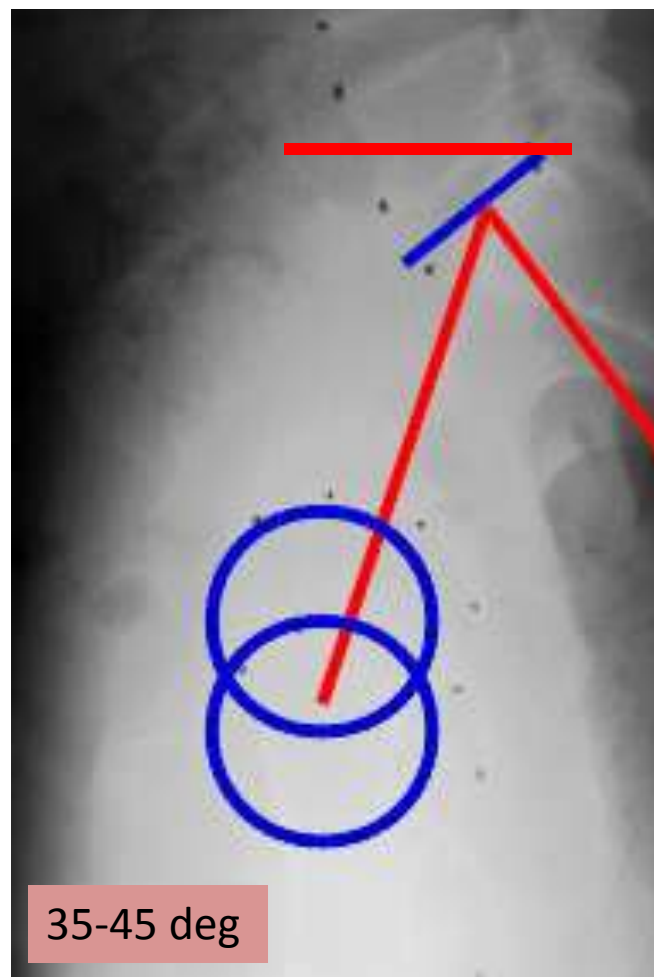
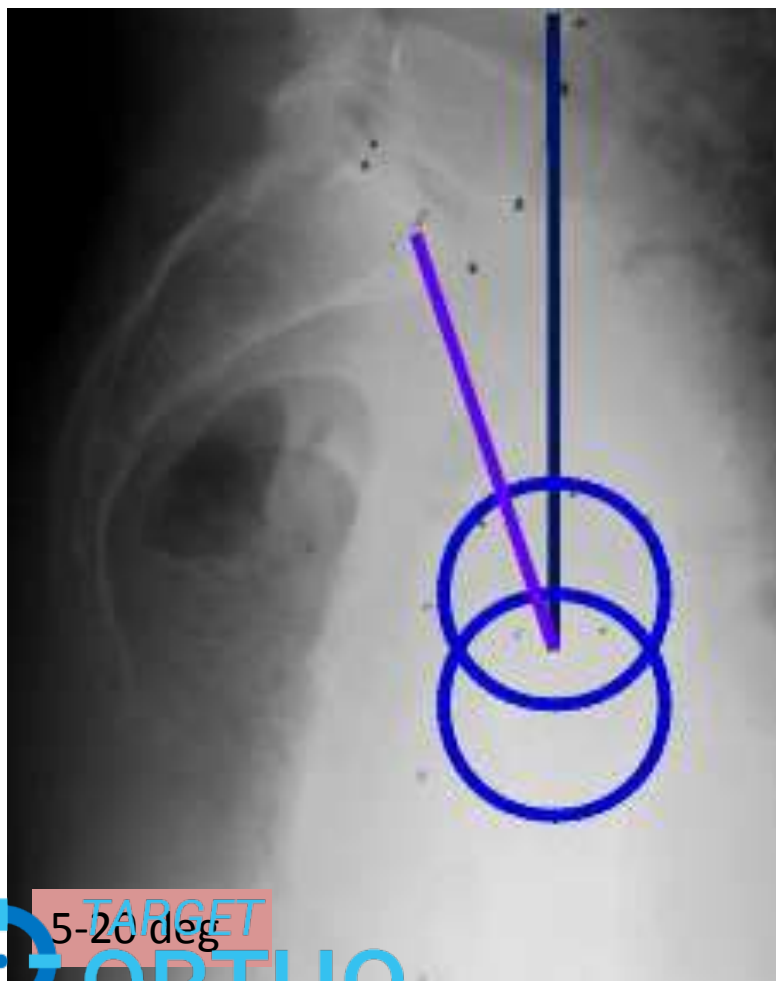
Pelvic Incidence

Pelvic incidence

- Relation between sacral plate and the femoral heads.
- Constant morphological parameter for one person.
- Not posture dependant
- Linear correlation between age and PI
- PI stabilizes in early adolescence
- Does not change after skeletal

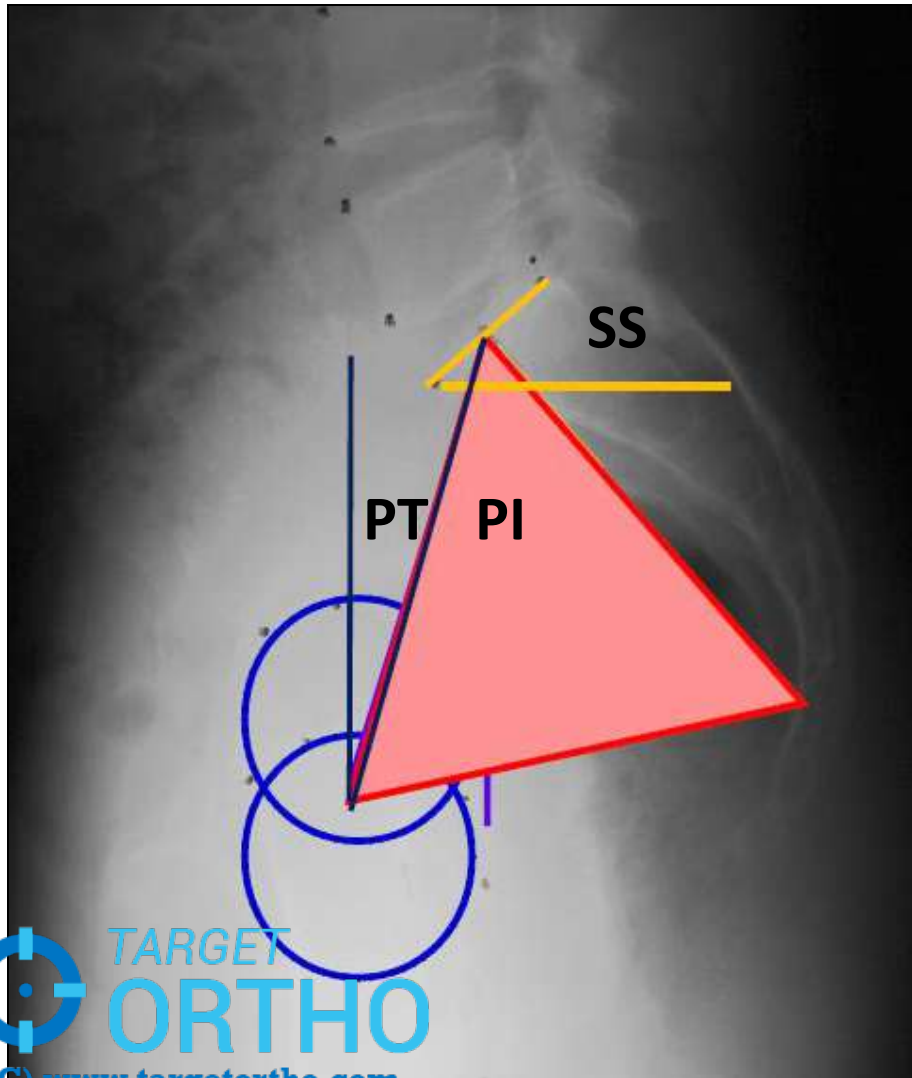


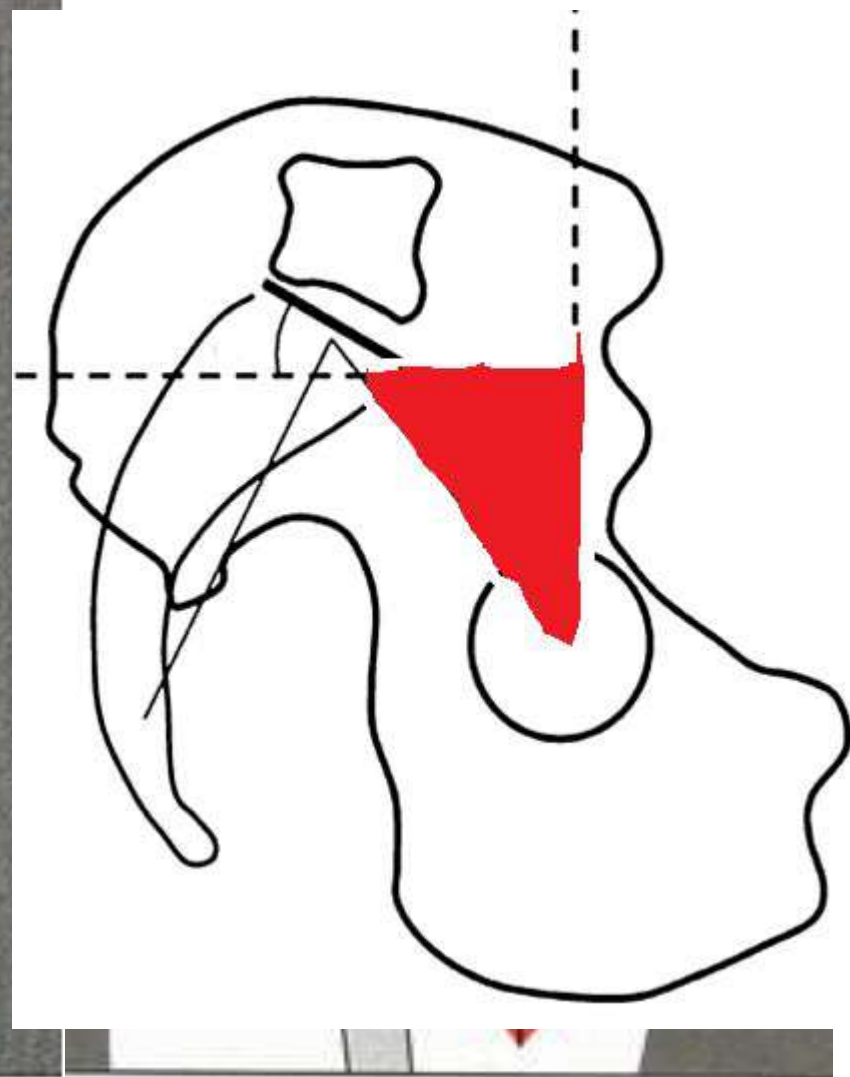
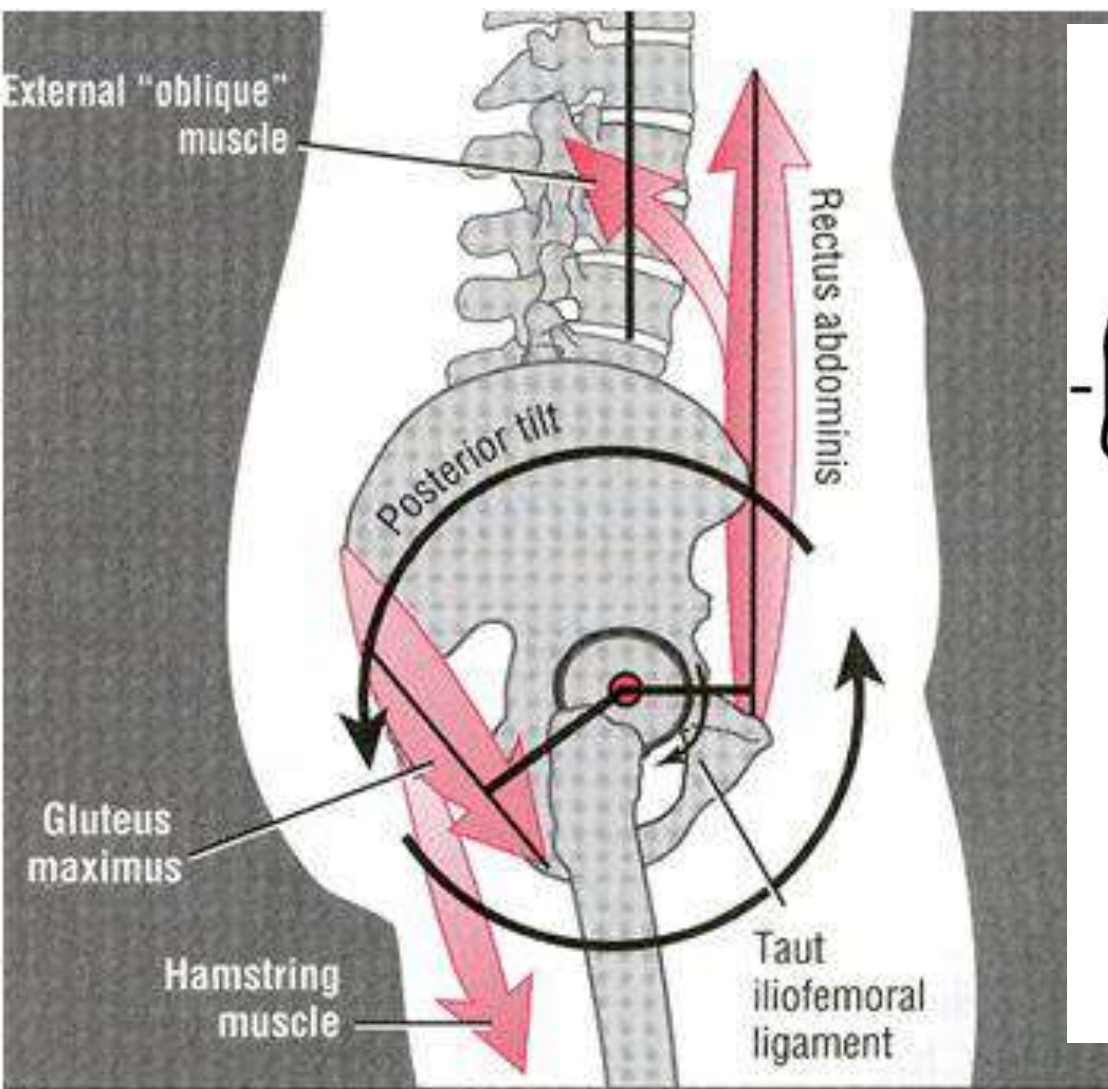
Pelvic tilt & Sacral slope



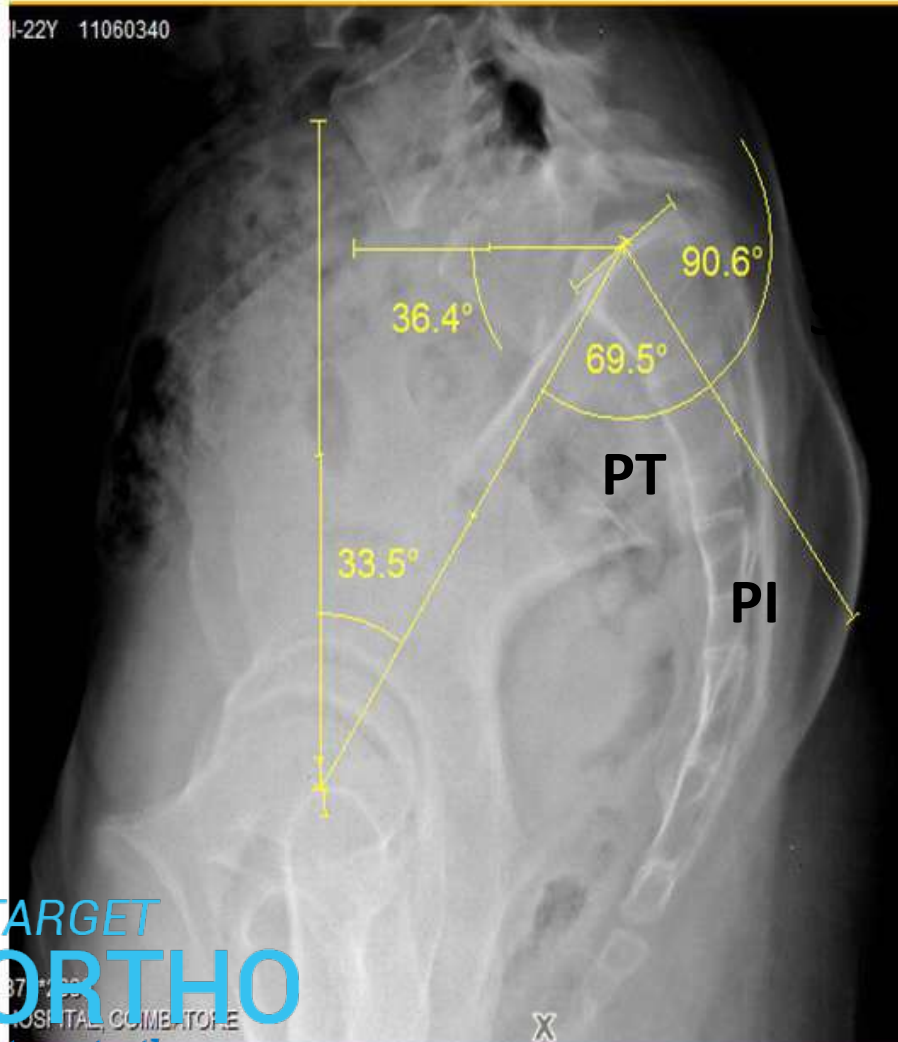
$$PI = PT + SS$$

$$PI = PT(< 50\%) + SS(> 50\%)$$





$PI = PT + SS$



Pelvic incidence - 69.5 degrees

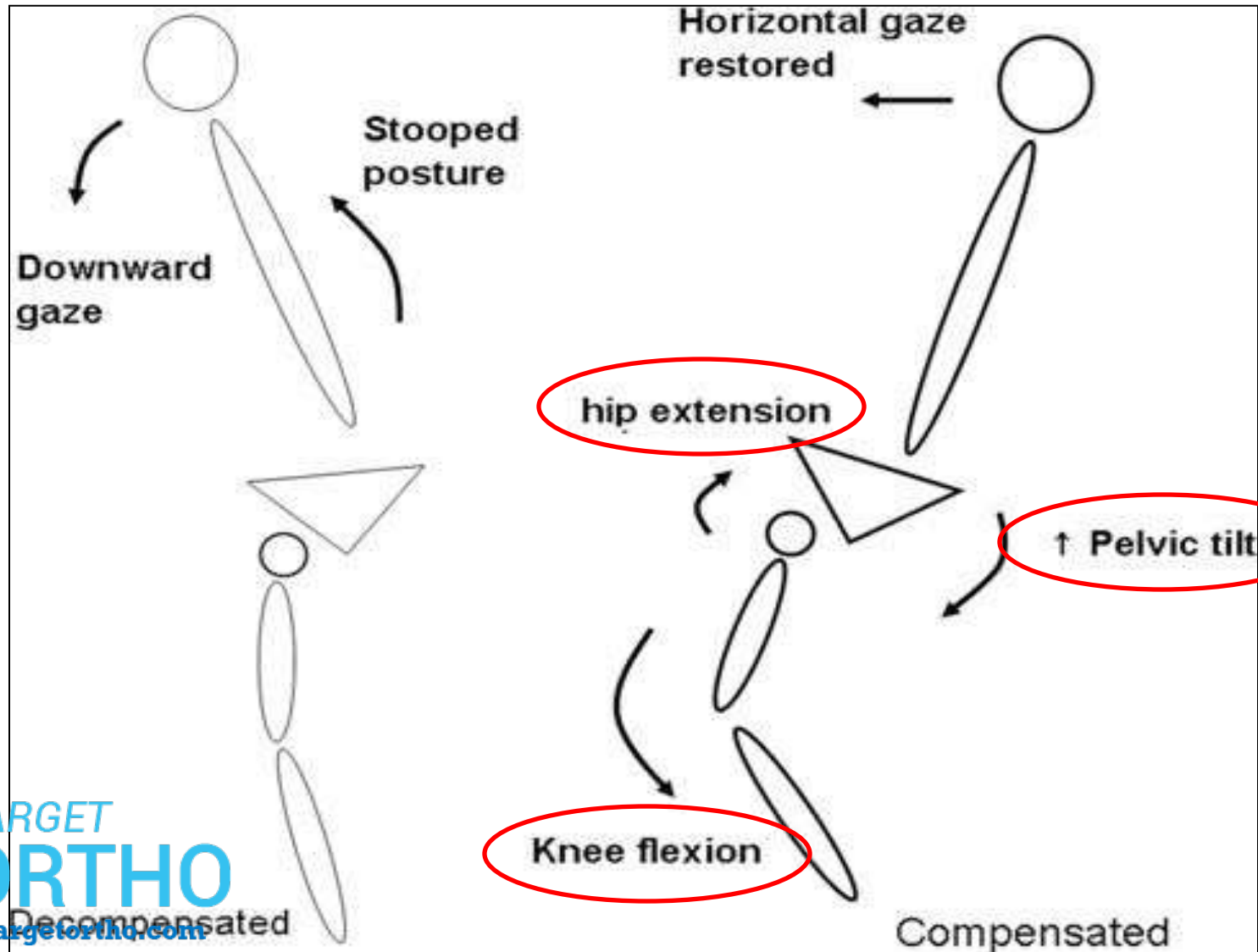
Pelvic tilt – 33.5 degrees.

Sacral slope – 36.4 degrees.

Pelvic incidence =
sacral slope + pelvic tilt.

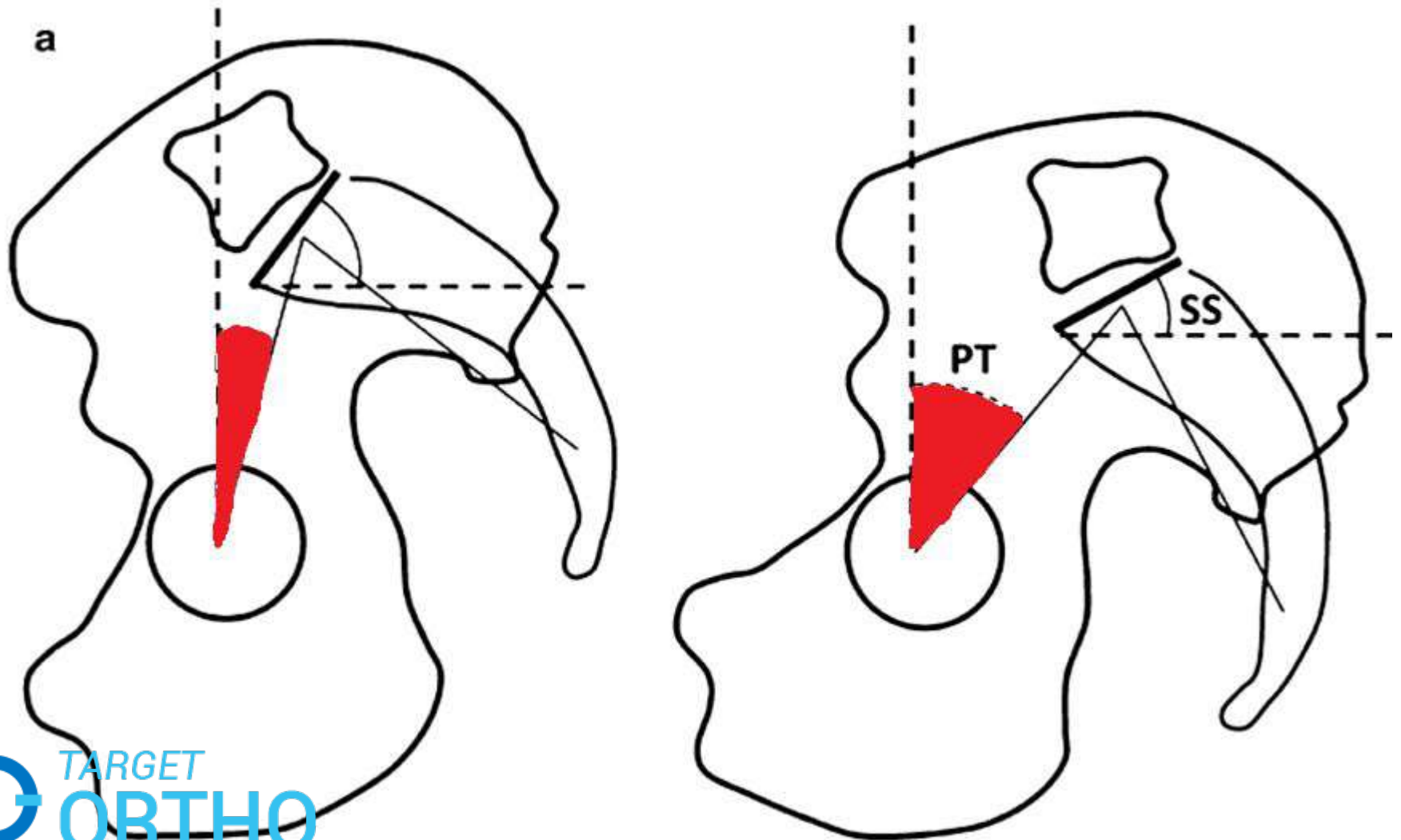
Balancing mechanism

Hip and knee



Balancing mechanism in patients with high PI

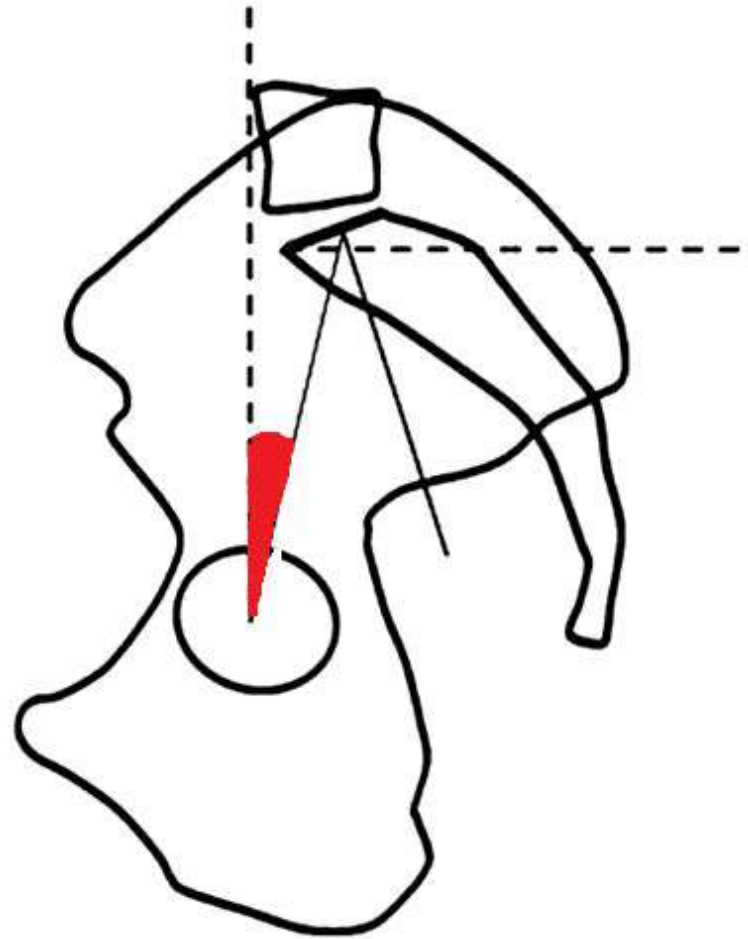
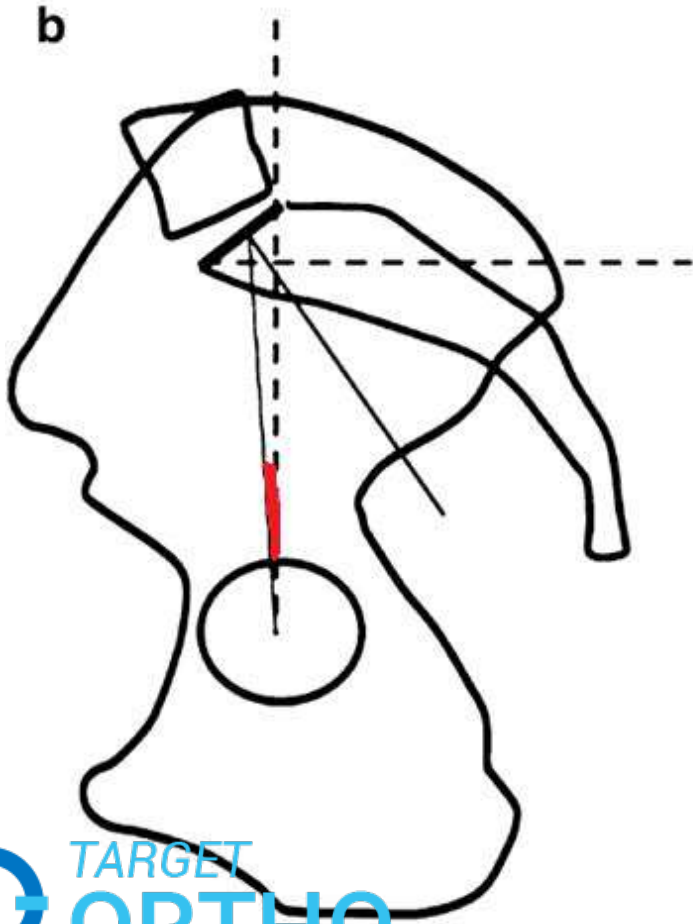
Spinopelvic parameters



Balancing mechanism in patients with low PI

Spinopelvic parameters

b



Failure of compensatory mechanism



SPONDYLOLISTHESIS

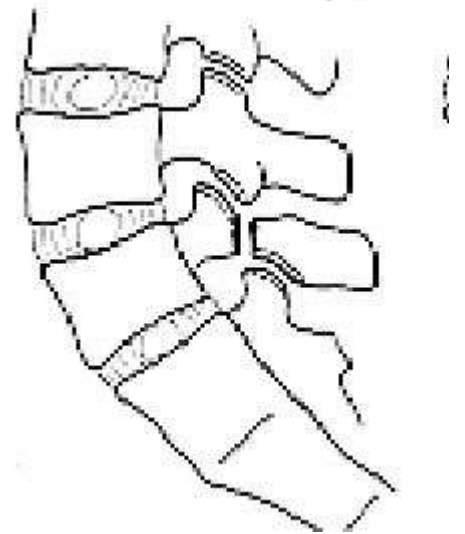


Incidence

- 5% of the population
- Rare under 5yrs
- 6% progress
- Never seen in paraplegics from birth

Spondylolisthesis

- *Greek word*
- “spondylous” –vertebrae
- “Lysis” -break or defect
- “olisthesis” -slip or slide down a slippery incline



Spondylolisthesis

- Some progress/some do not
- Some are painful/some are not
- Some are deforming /some are not
- Some responds to posterior fusion alone/some do not

Classification

- Wiltse –Newman-Macnab
Classification(1976)

Anatomic classification

- Marchetti-Bartolozzi
Classification(1994)

Developmental classification

Wiltse's Classification

Types	Definition
Dysplastic	• Congenital abnormalities of the facets • No pars interarticularis defect
Isthmic	• Defect in the pars interarticularis that allows forward slipping of L5 on S1.
Degenerative	• Results from intersegmental instability of a long duration with subsequent remodeling of the articular processes
Traumatic	• results from fractures in the area of the bony hook other than the pars interarticularis,
Pathological	• This type results from generalized or localized bone disease

Wiltse, Newman, McNab's Classification



Dysplastic

Abnormalities of L5 or S1

No Pars Defect

Developmental dysplasia

- Not congenital
- Dysplasia of L5 & S1 structures
- Potential condition at birth

Developmental dysplasia

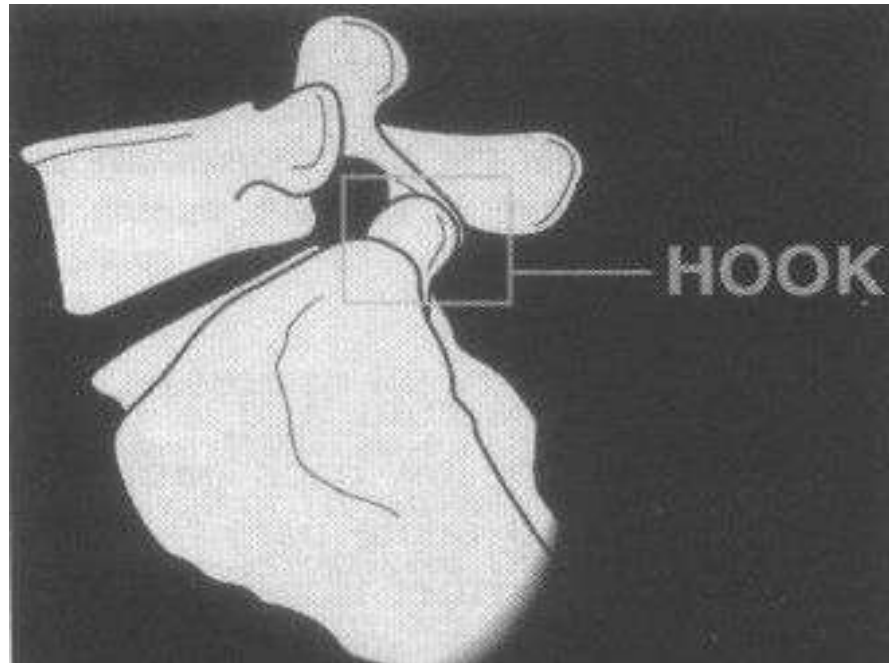
- Multifactorial oetiology
- Intra uterine development (thalidomide)
- Genetic

Occurrences in families

Higher incidence in Eskimos

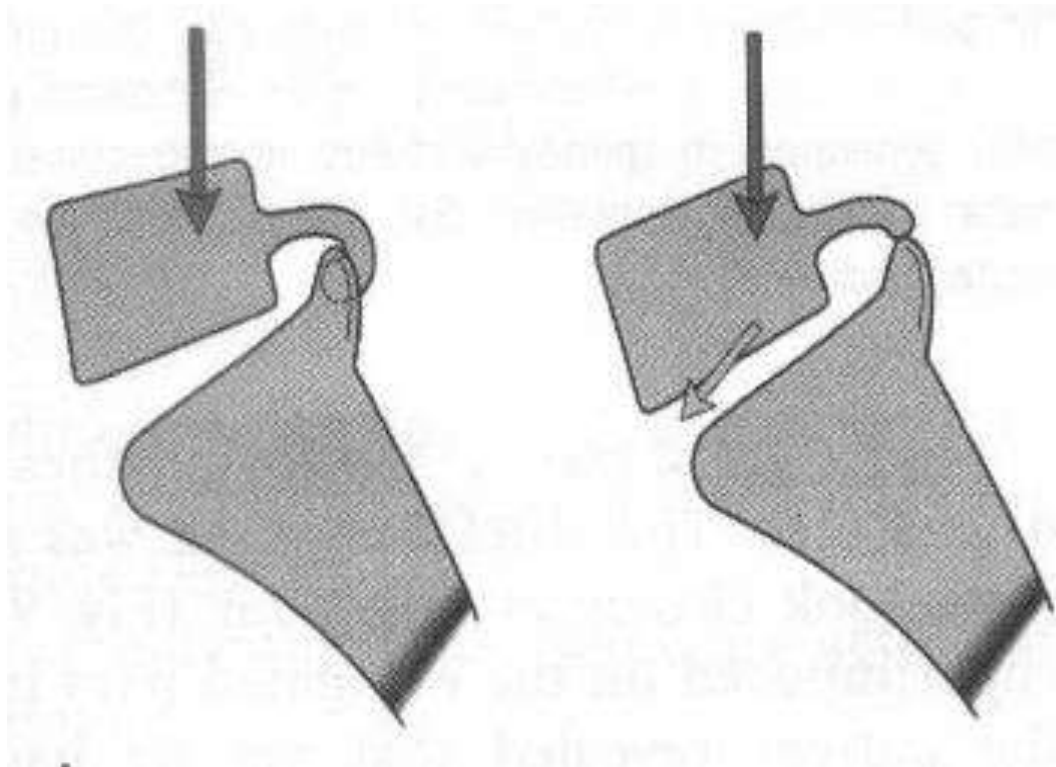
Occurrences at Several levels

Bony hook & catch



- **Bony hook – Pedicle, Pars, inferior facets of L5**
- **Catch – normal size & positioned sacral facets**

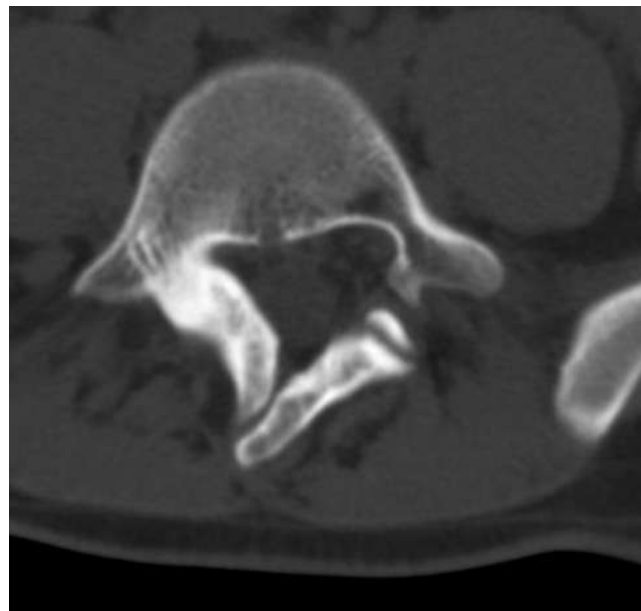
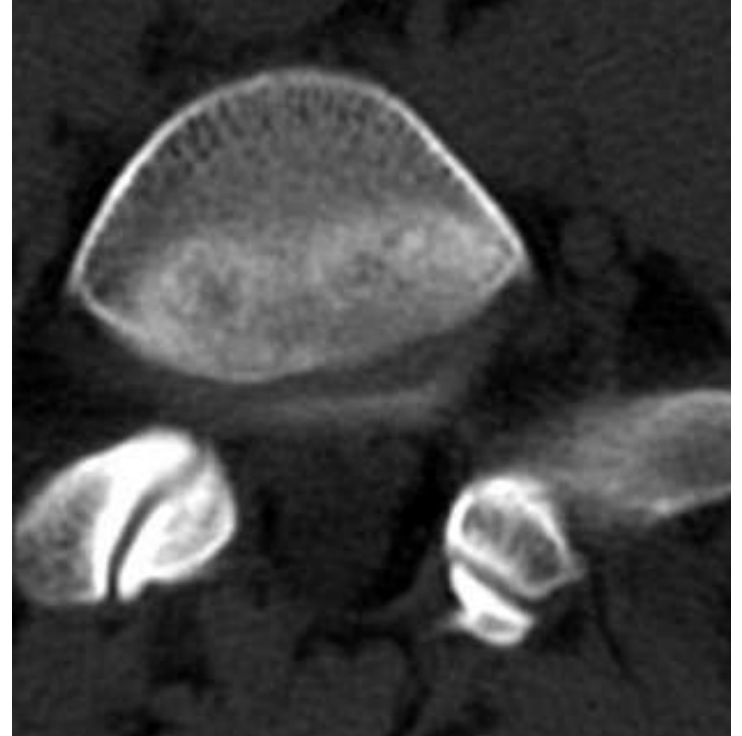
Bony hook & catch



Dysplasia

- Elongated or parted pars
- Deficient L5 or S1 lamina
- Facet trophism/facet abnormalities





High vs low dysplastic



Wiltse, Newman, McNab's Classification



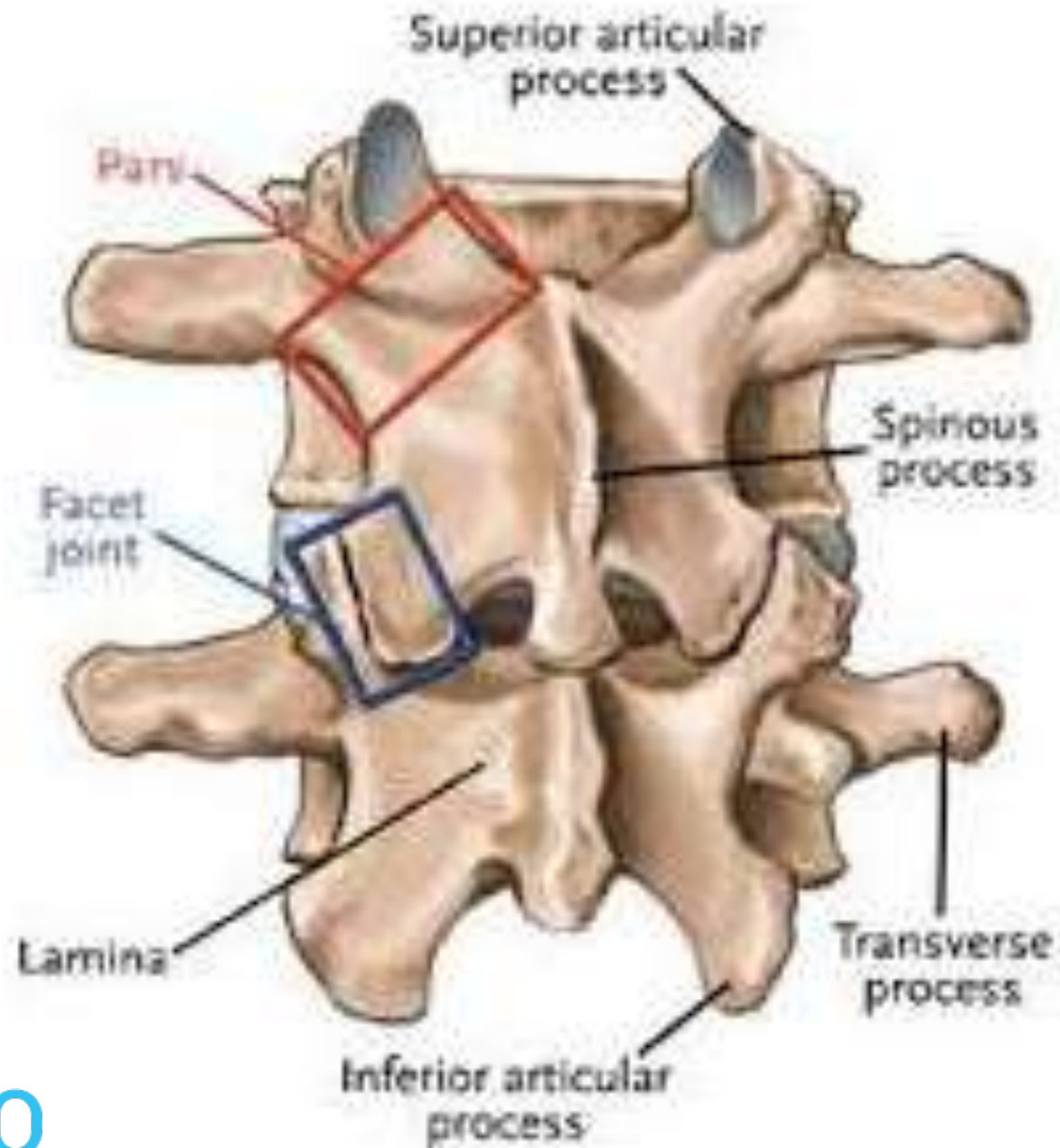
II - Isthmic

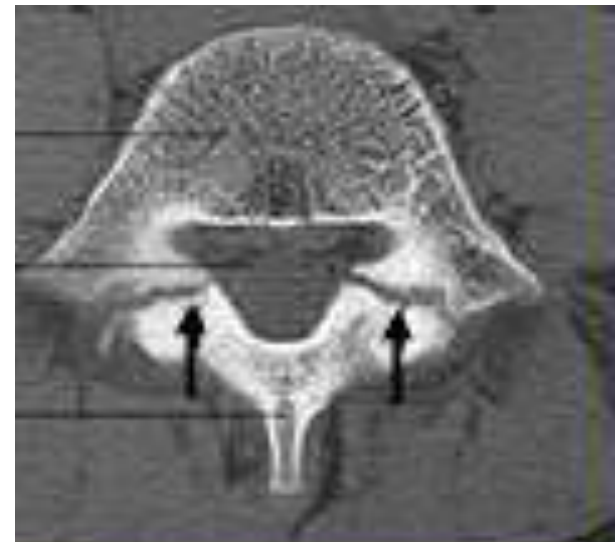
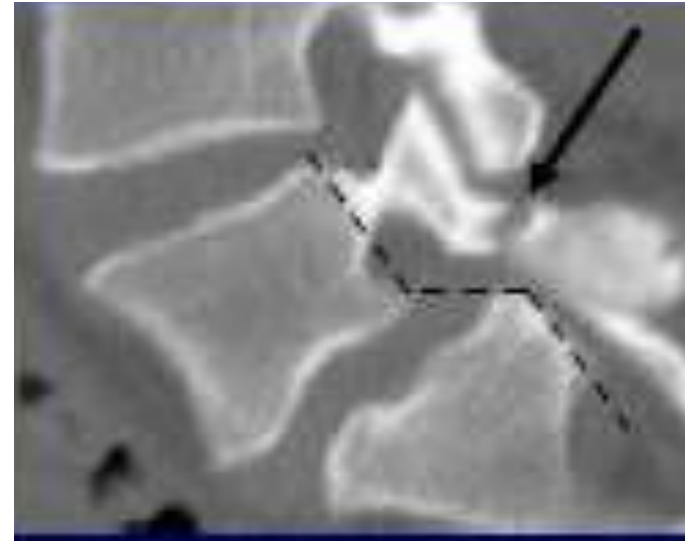
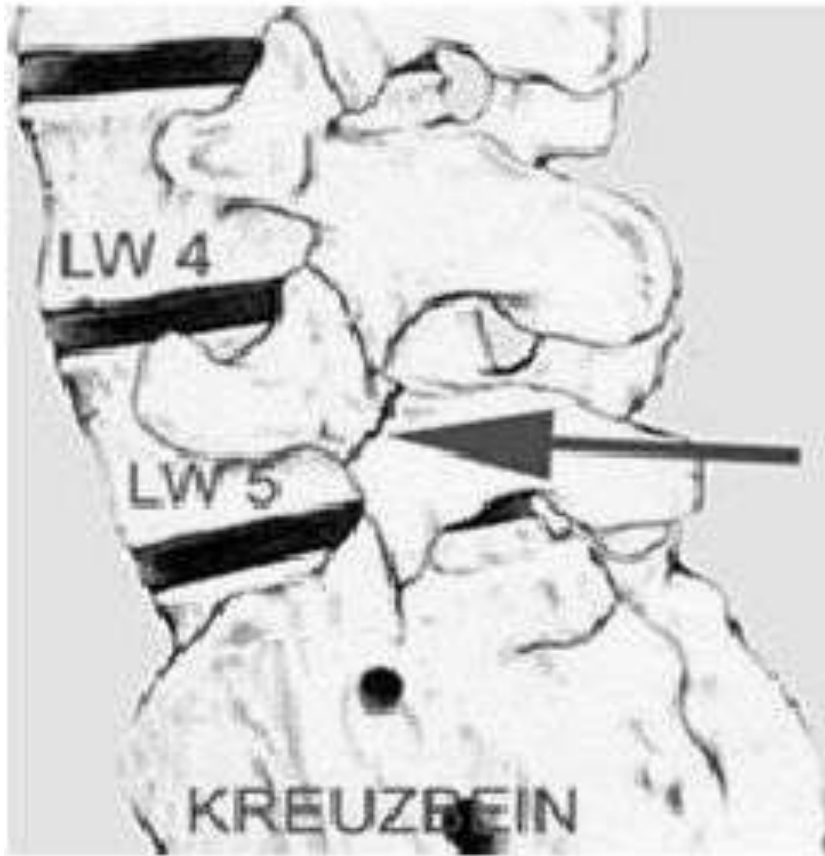
Pars Defect

A - Lytic (Stress Fracture)

B - Elongated But Intact

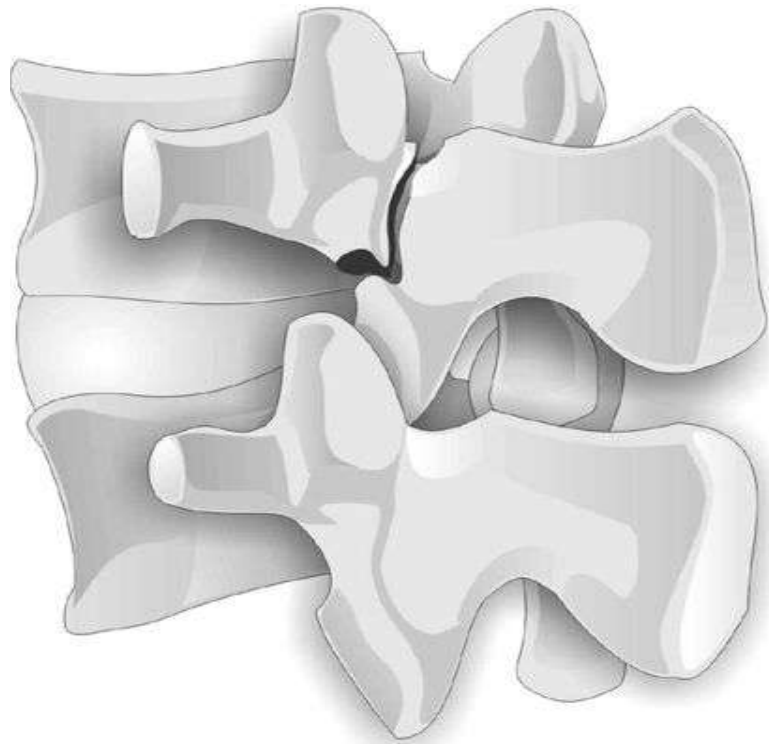
C - Acute Fracture Of Pars



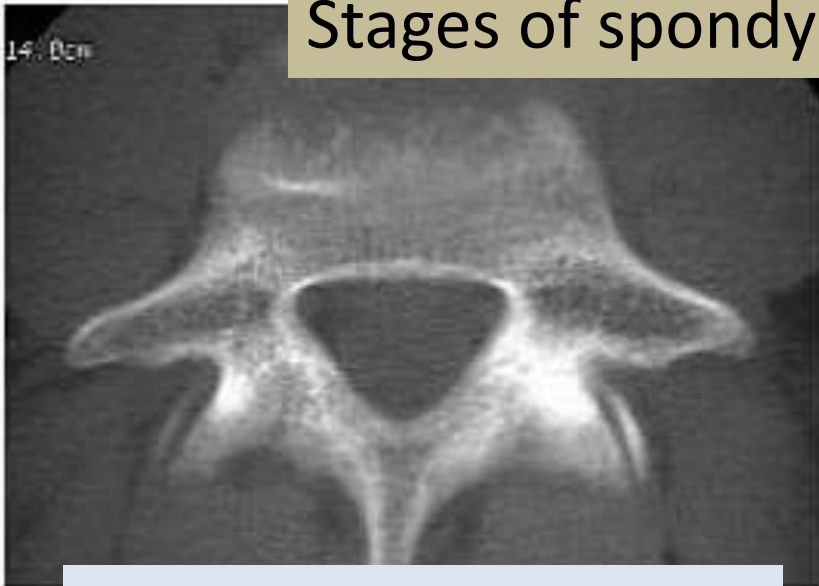


Confusing issue-isthmic defect(type 2 of Wiltse)

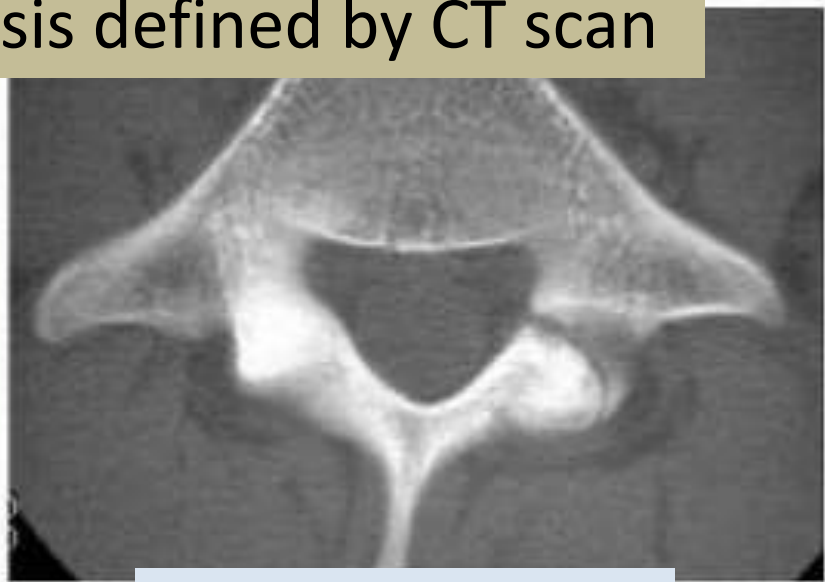
SPONDYLOLYSIS



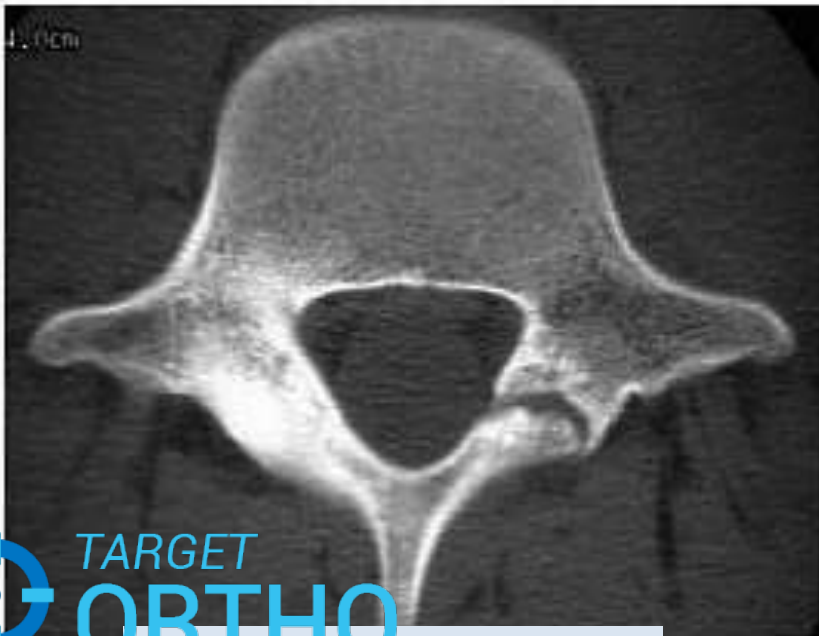
Stages of spondylosis defined by CT scan



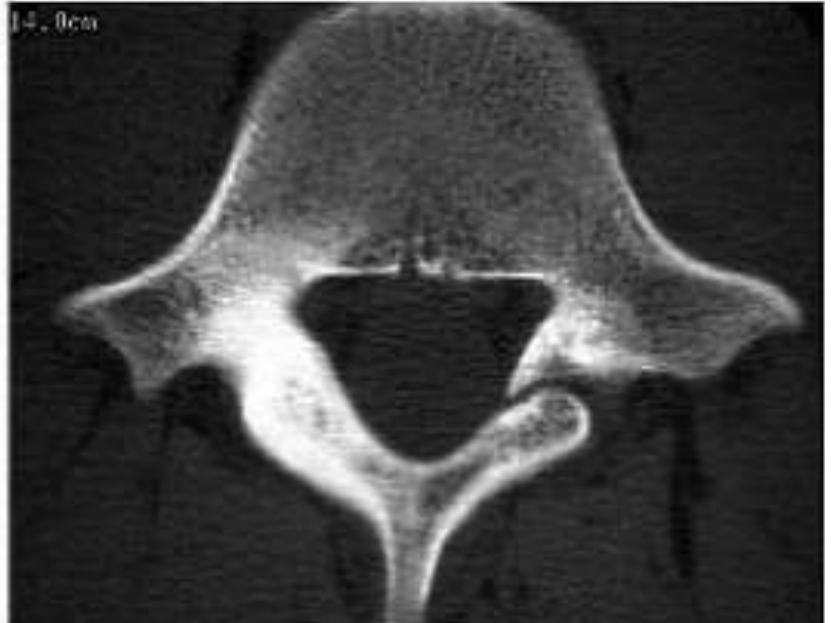
Prespondylolytic stress reaction



Unilateral microfracture



Unilateral macrofracture

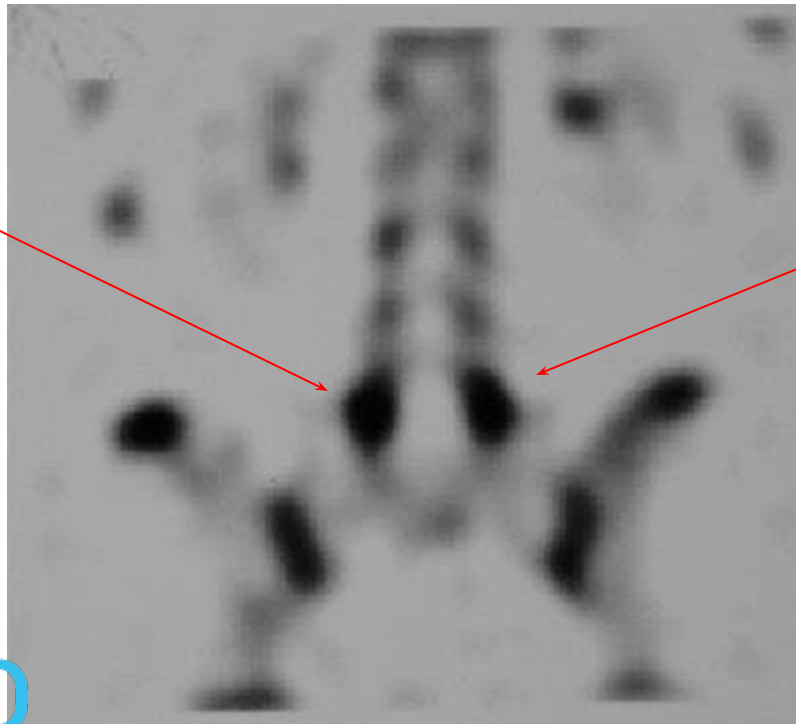


Unilateral pseudarthrosis or nonunion

SPECT Scan

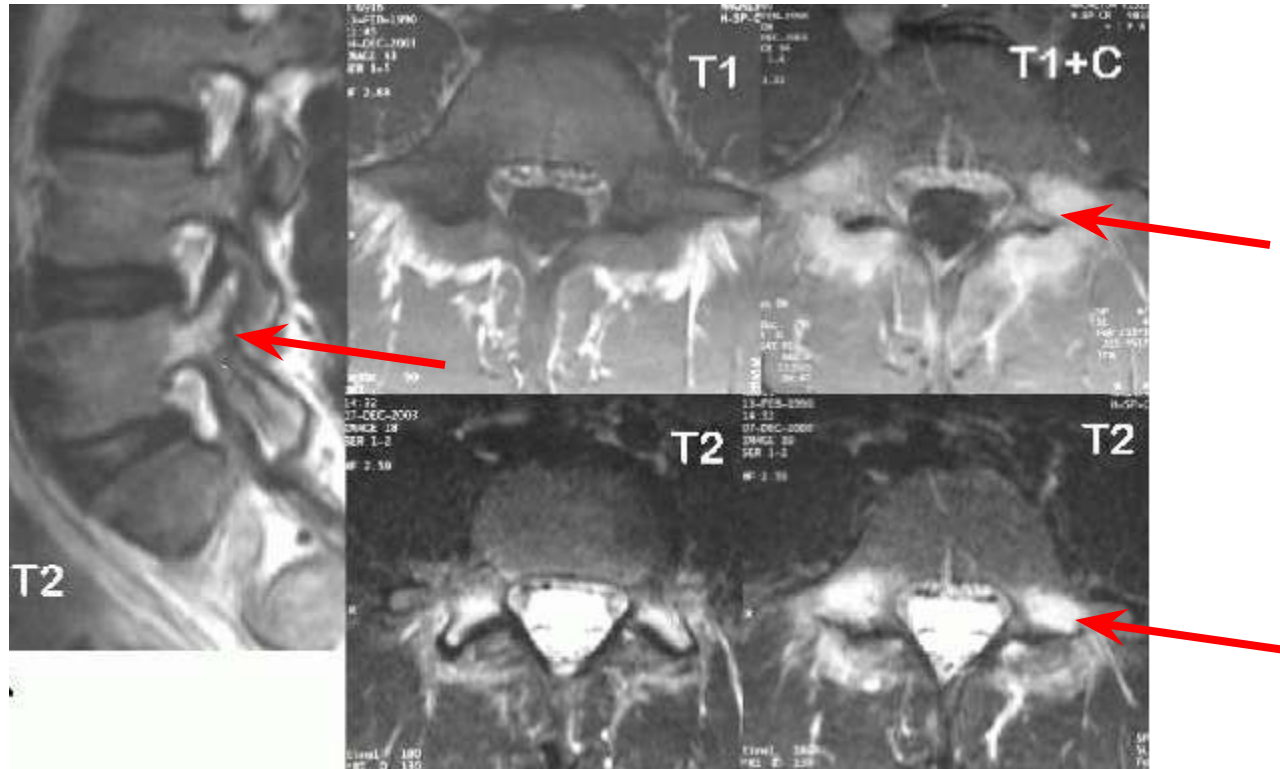
Acute spondylolysis -positive

Chronic Spondylolysis- reverts normal.



- SPECT SCAN most Sensitive in Lysis.
- **Hot Spot**- Active or Fresh Lesion.
- **Cold Spot**-Chronic or metabolically Inactive Lesion.

Magnetic resonance Imaging



- MRI of lysis at an early stage
- Hyperintense signal T2 WI
- Hypo-intense in T1 WI, that enhances on postcontrast

Clinical Features - Lytic, Dysplastic

- Palpable step
- Heart shaped buttock due to vertical sacrum
- Olisthetic scoliosis



Clinical Features - Lytic, Dysplastic

- Altered gait because of the tight hamstrings; flexed hip, flexed knee, and equinus positioning
- Foreshortened trunk with protruding abdomen and lower rib cage impinging on the iliac crests
- Significant hyperextension of the thoracolumbar spine above the lumbosacral kyphosis



Clinical Features - Lytic, Dysplastic

- Common symptom is Back pain
- Occasionally leg pain
- Aggravated by sports and other activities
- Slipping occurs between 9 -15 yrs
- No slipping after 20 yrs

Wiltse, Newman, McNab's Classification



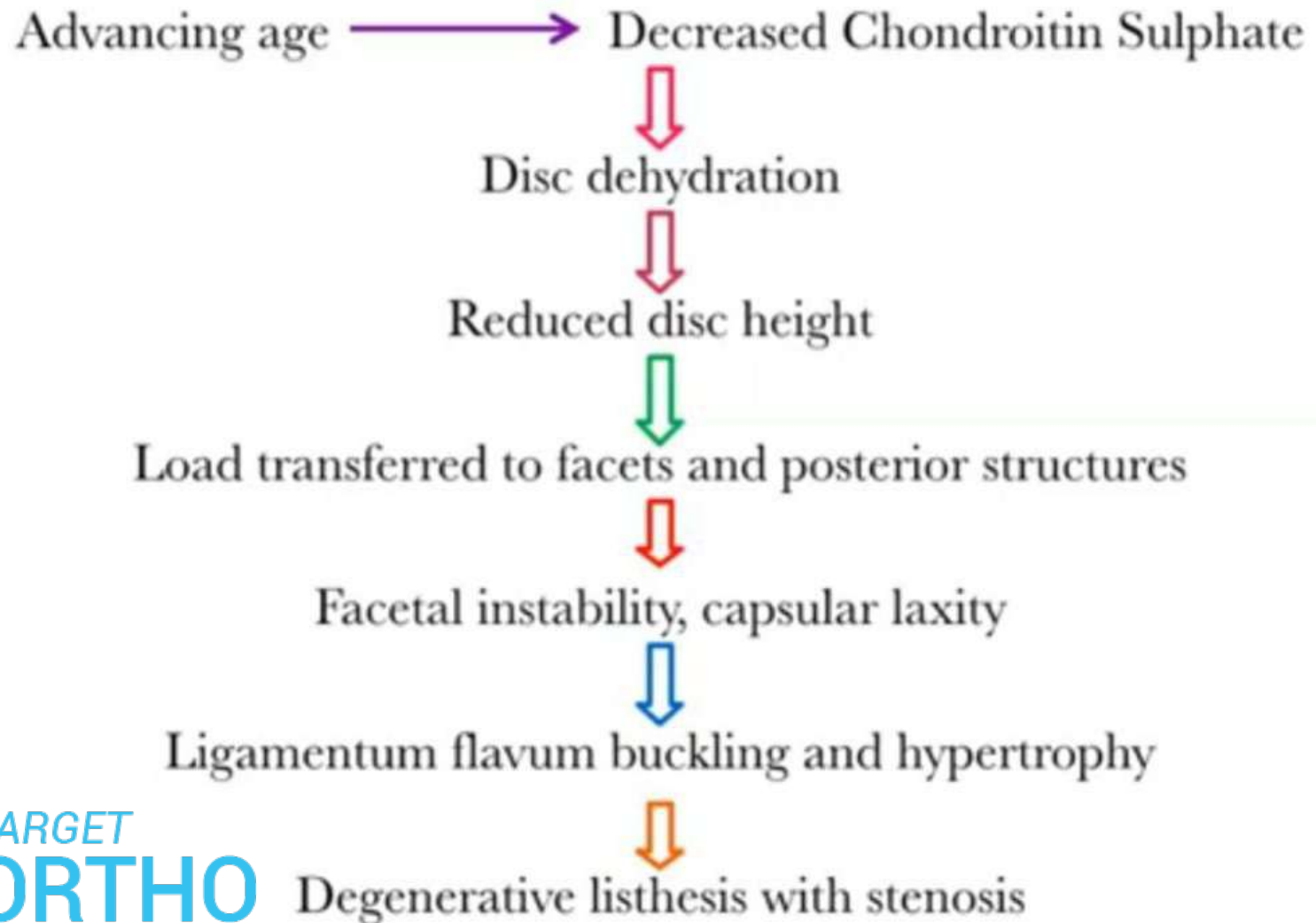
III - Degenerative

Degeneration

No Pars Defect

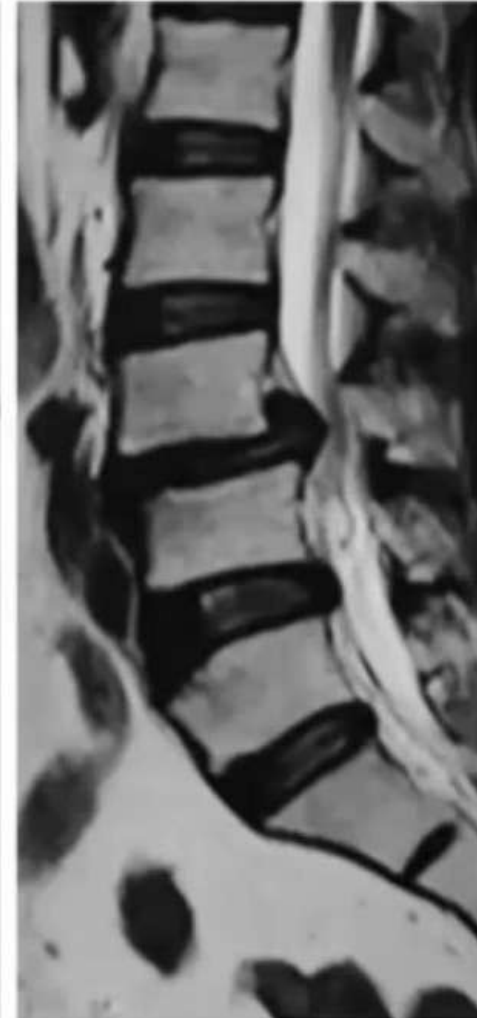
Common At L4-5

Degenerative listhesis



Clinical Features - Degenerative

- Common symptom is Back pain
- Neurogenic claudication
- Radicular symptoms
- Degenerative changes in X ray and MRI

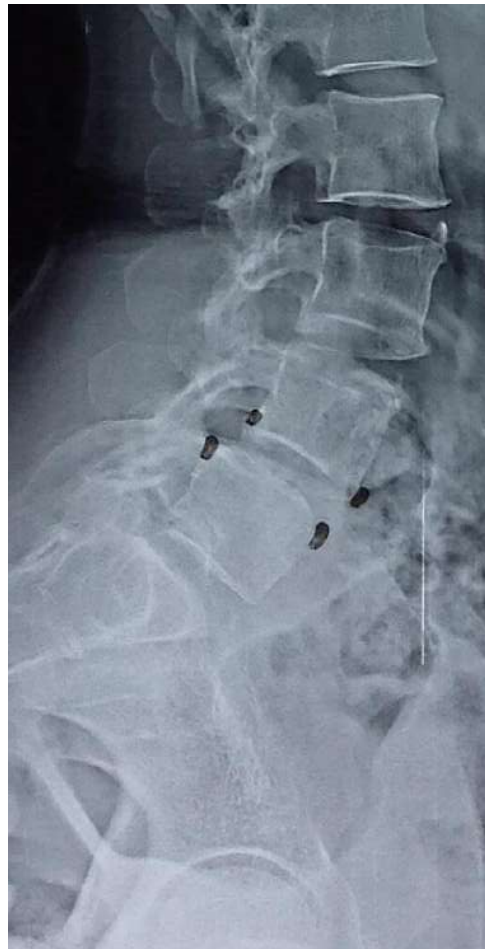


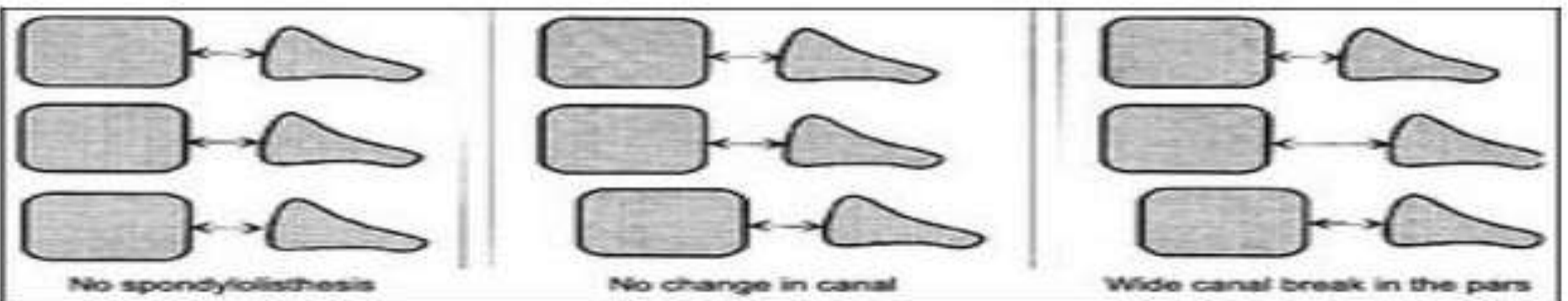






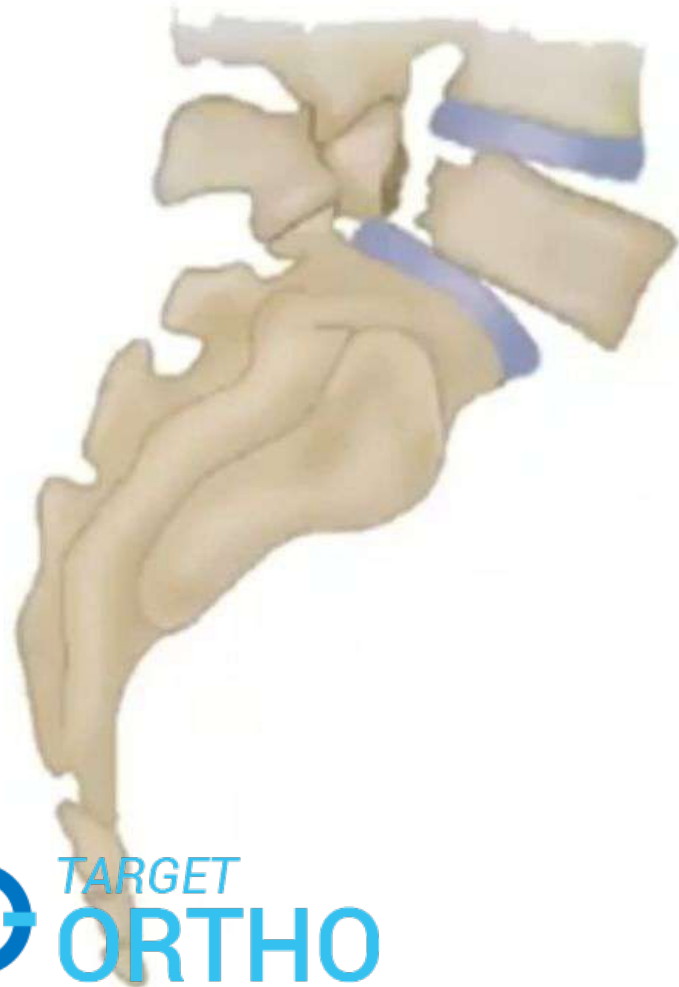
Instability





	Degenerative spondylolisthesis	Lytic spondylolisthesis
Isthmic lysis	No	Yes
Displacement of spinous process	Anterior, with the vertebral body	No, or posterior displacement
Spinous process step-off	With the spinous process of the lower vertebra	With the spinous process of the upper vertebra
Sagittal diameter of the central canal	Decreased	Increased
Foramen	Variable stenosis secondary to osteoarthritic changes	Stenosis secondary to loss of height and pseudo disc bulging

Wiltse, Newman, McNab's Classification

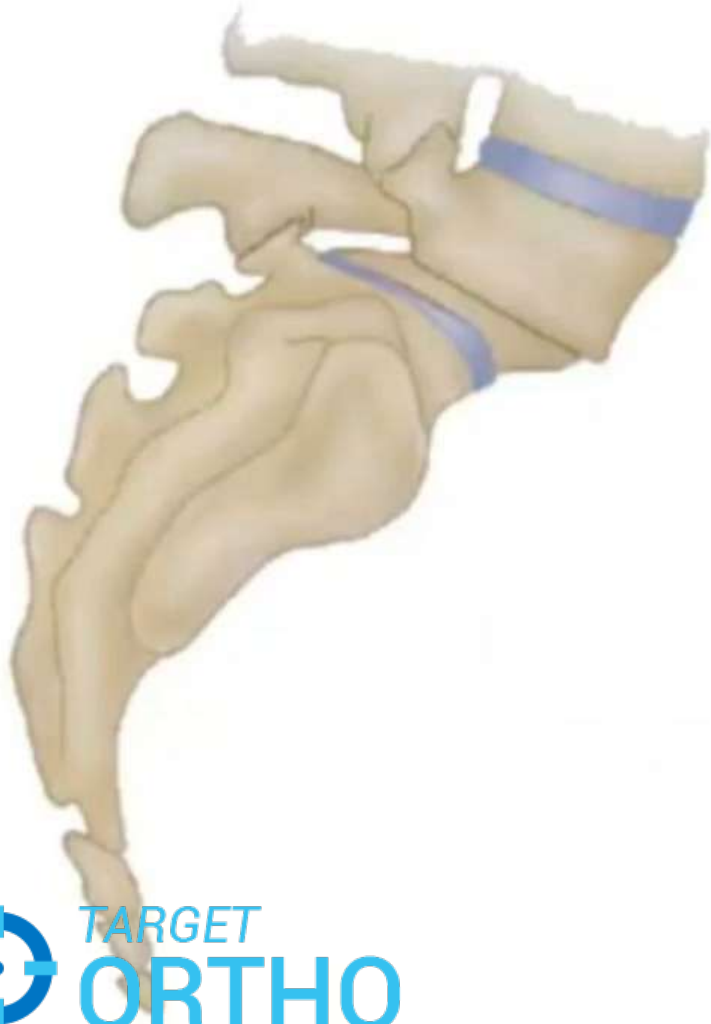


IV - Traumatic

Fractures of pedicle, lamina
or facet

No pars fracture

Wiltse, Newman, McNab's Classification



V - Pathological

Abnormalities of bone

Osteogenesis Imperfecta

Marchetti's Classification

Developmental	Acquired
High dysplastic With lysis With elongation	Traumatic Acute fracture Stress fracture
Low dysplastic With lysis With elongation	Post surgery Direct surgery Indirect surgery
	Pathological
	Degenerative

Clinical Presentation

1. Asymptomatic

- detected incidentally on the xrays.

2. Axial back pain

- mechanical pain

- instability pain(CATCH felt during flexion – extension ROM)

3. Radiculopathy and neurodeficits

4. Gait abnormalities

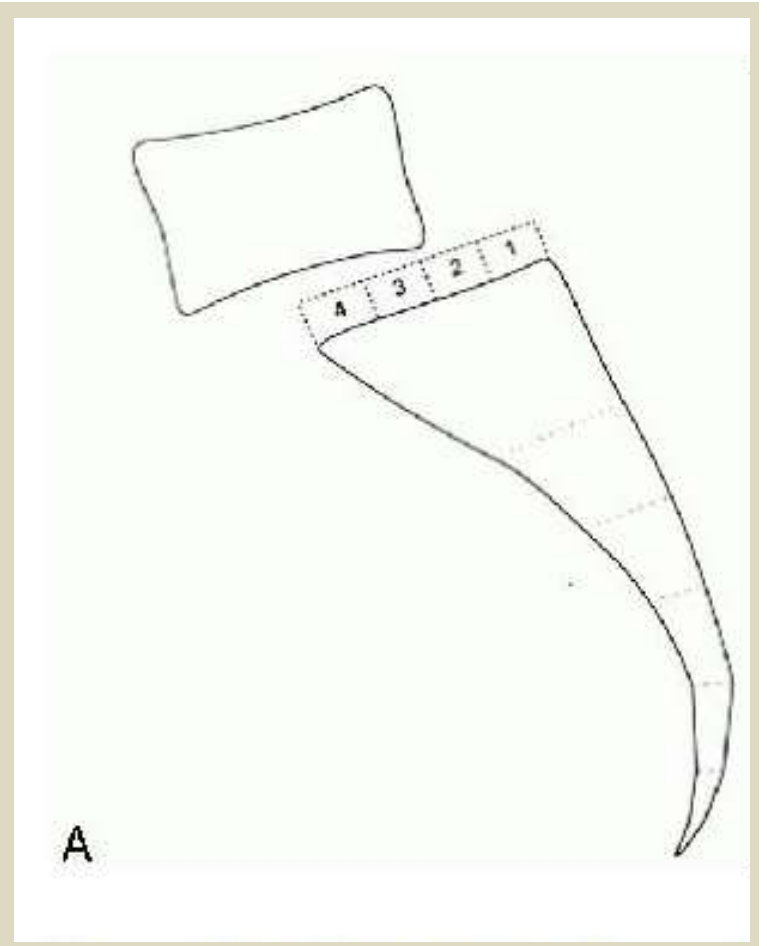
5. Cauda equine syndrome-rarely.

Radiology

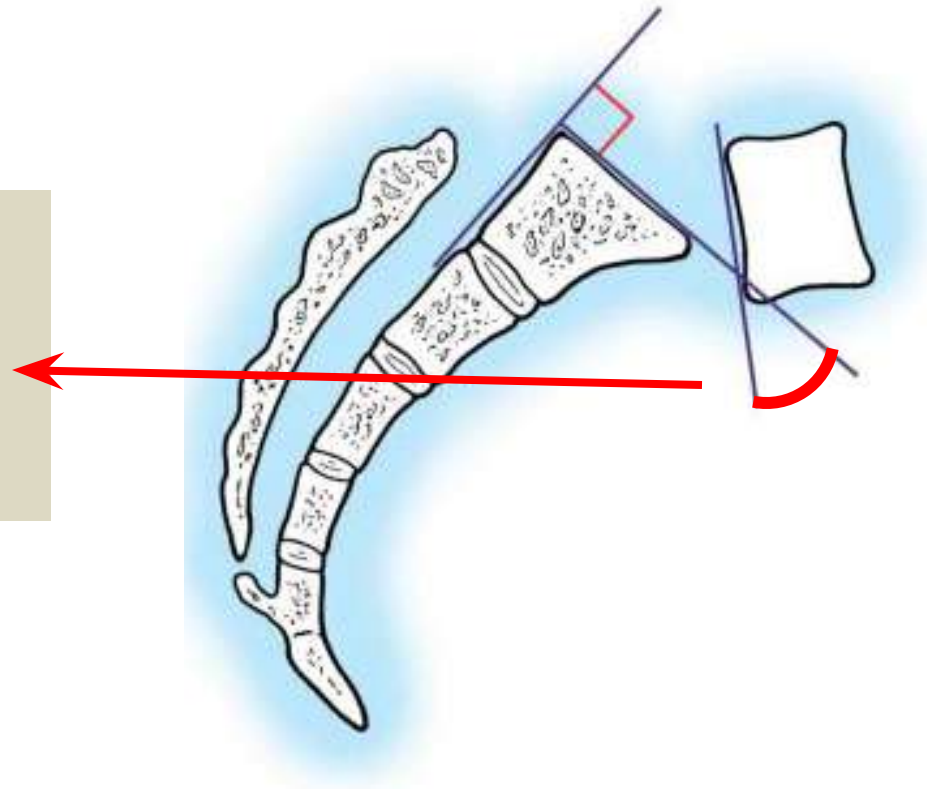
Imaging

Grading:

- 0 = no slip
- 1 = 0 – 25%
- 2 = 25- 50%
- 3 = 50 -75%
- 4 = 75-100%
- 5=dislocation



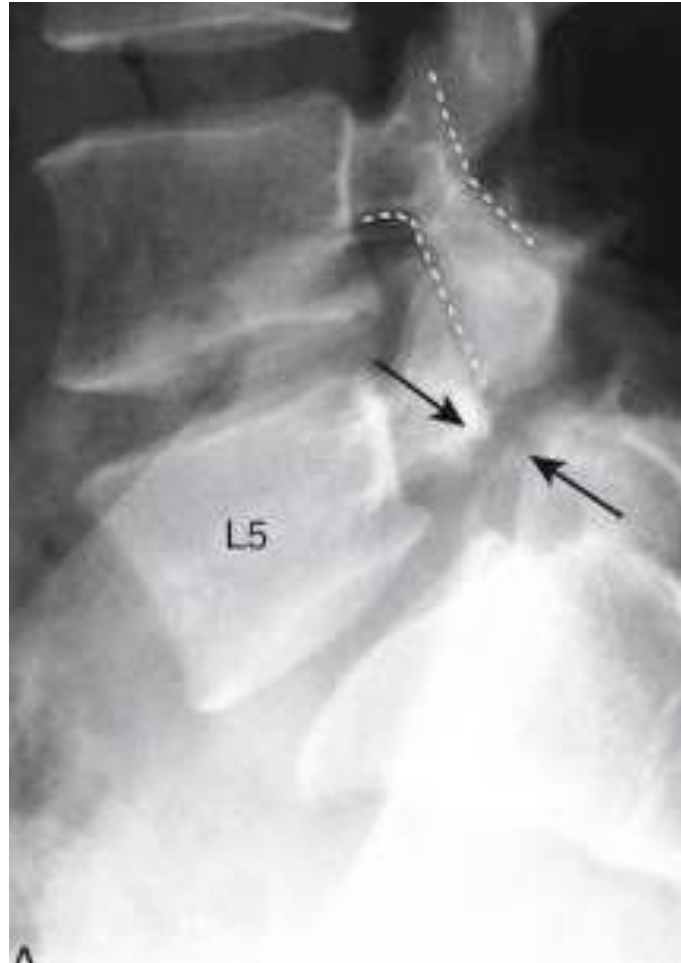
Slip Angle



- Lumbosacral slip angle or kyphotic malalignment of lumbosacral junction
- Predicts progression of slip
- if more than 55 degrees, high risk of progression

X- ray

- Initial imaging modality – standing lateral view





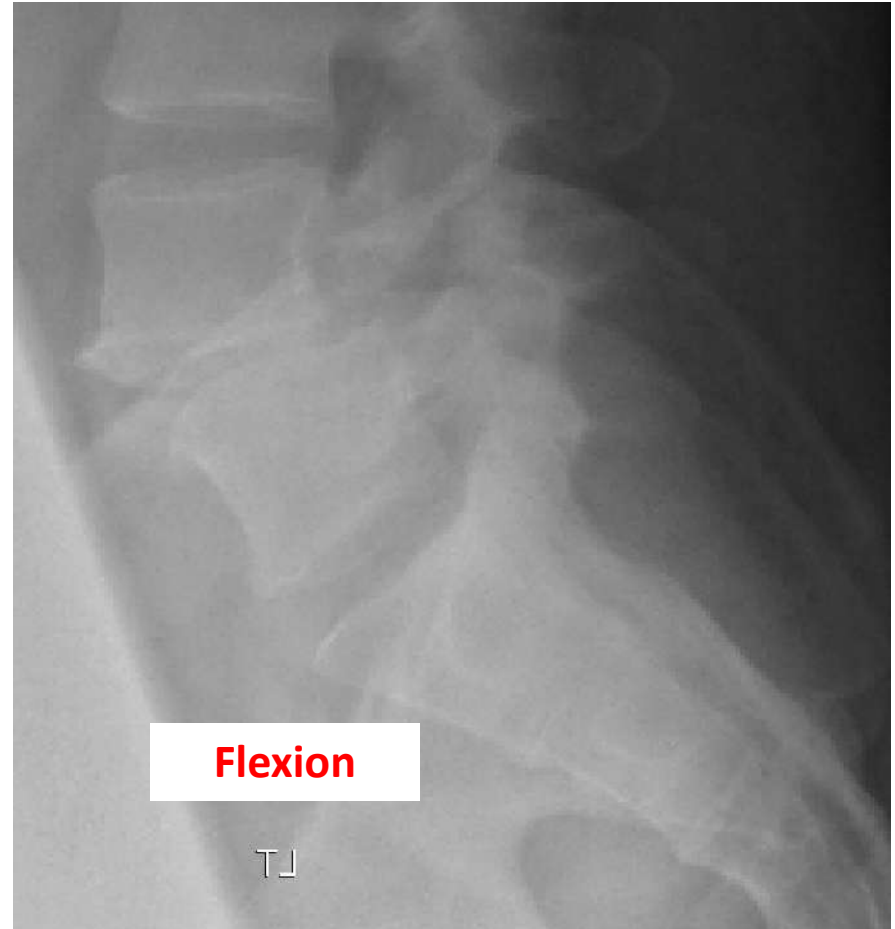
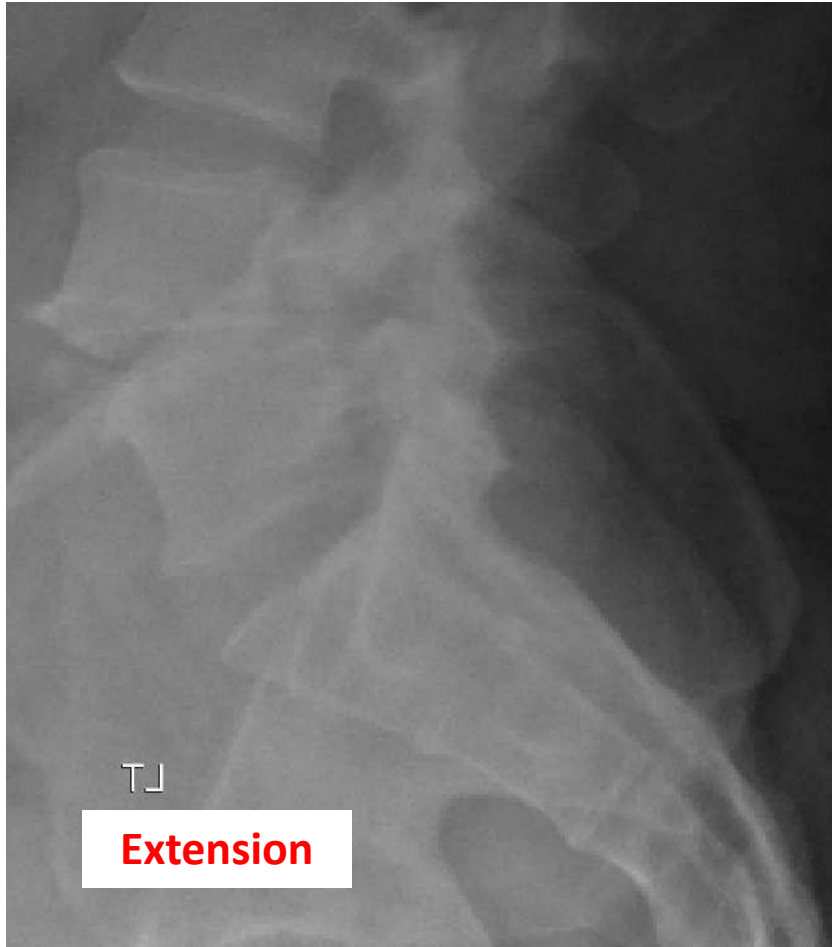
[R]

[F]

C4980
W2259

What next?

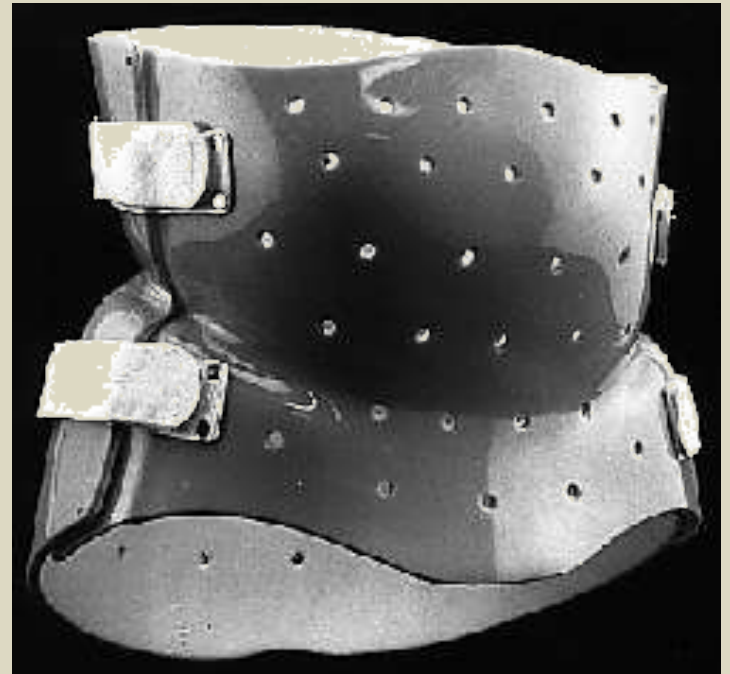
Stress views



Treatment

Principles of Conservative Treatment

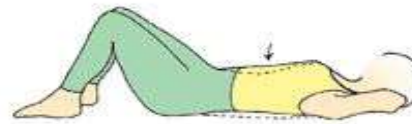
1. NSAIDS: short course
2. Weight loss
3. Steroid injections
 - Only in Acute phase
 - Not for long term use
4. Bracing



Spondylosis/Spondyloisthesis Exercises

Physical therapy:

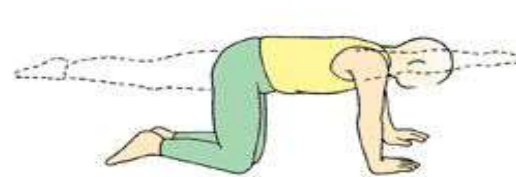
1. Physiotherapy
2. Aerobic conditioning



Pelvic tilt



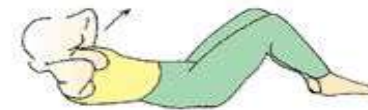
Dead bug



Quadruped arm/leg raises



Piriformis stretch



Partial curl



All-fours-to-heels sit

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Middle Path Regime

- Majority of the individuals are asymptomatic
- Initial non operative trial
- Exercise program are superior
- Surgery if conservative fails

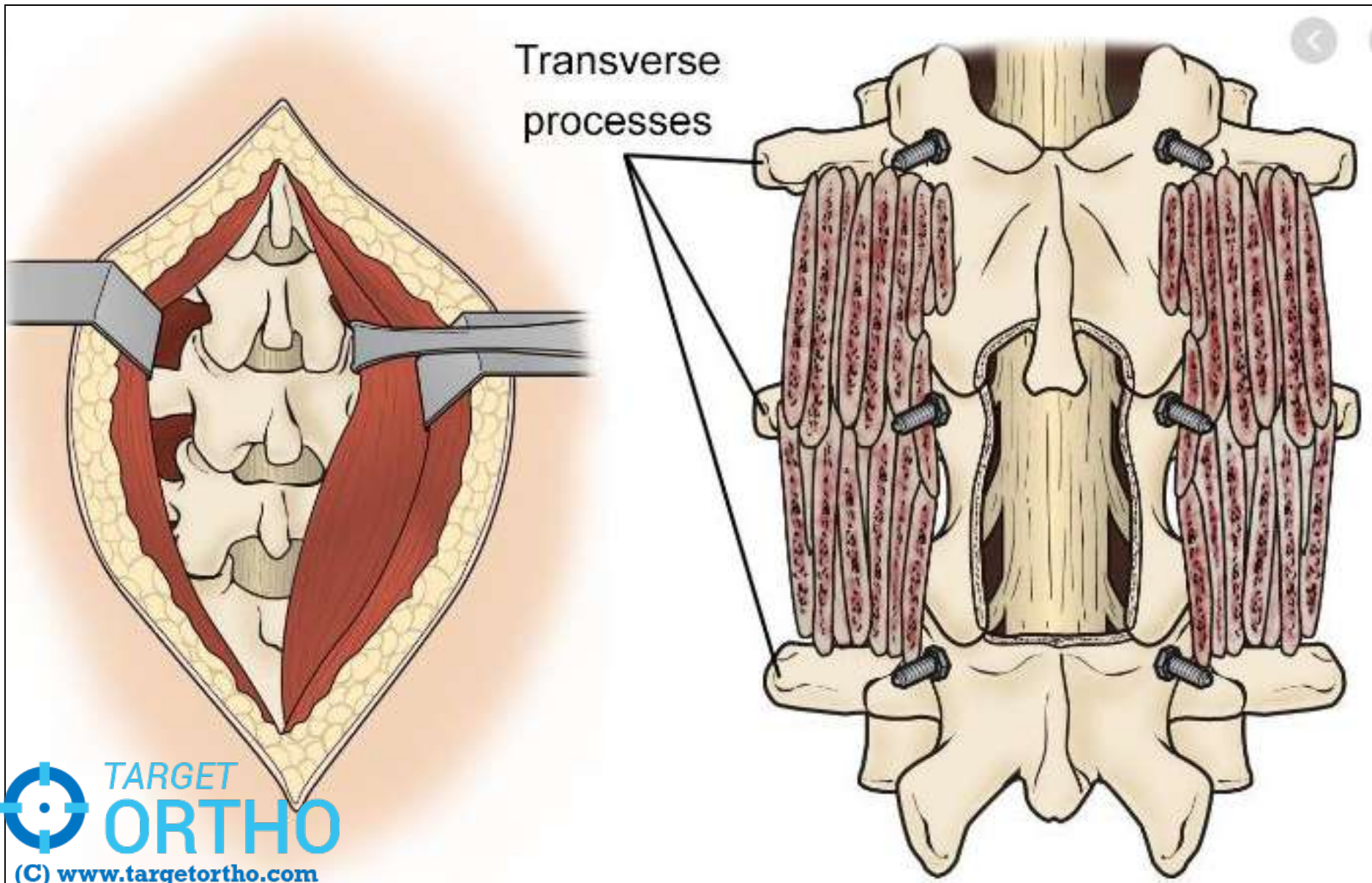
Low grade listhesis surgery

- Decompression by laminectomy/ flavectomy
- Pedicle screw fixation
- Fusion

Posterolateral fusion

Interbody fusion

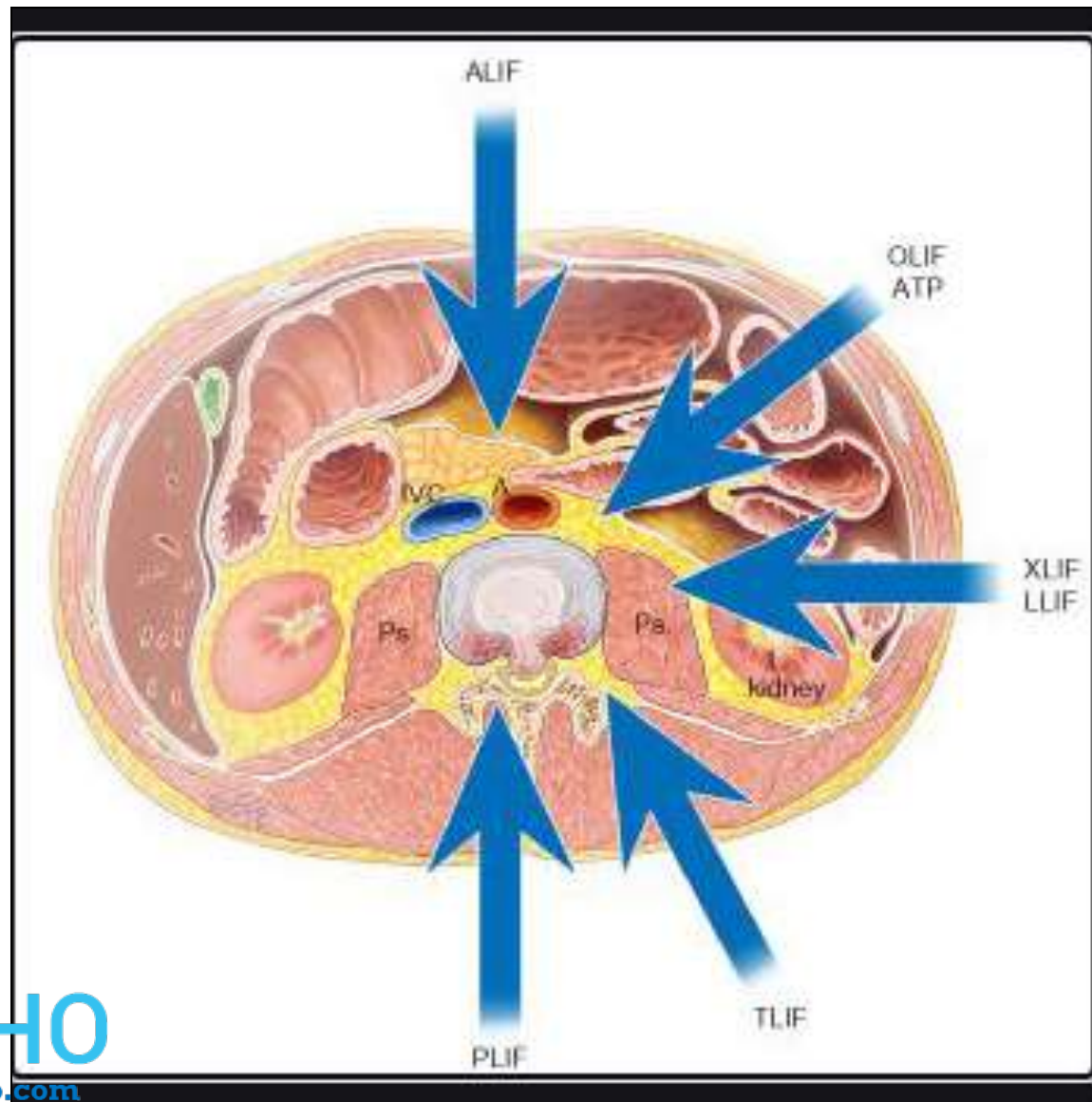
Posterolateral fusion



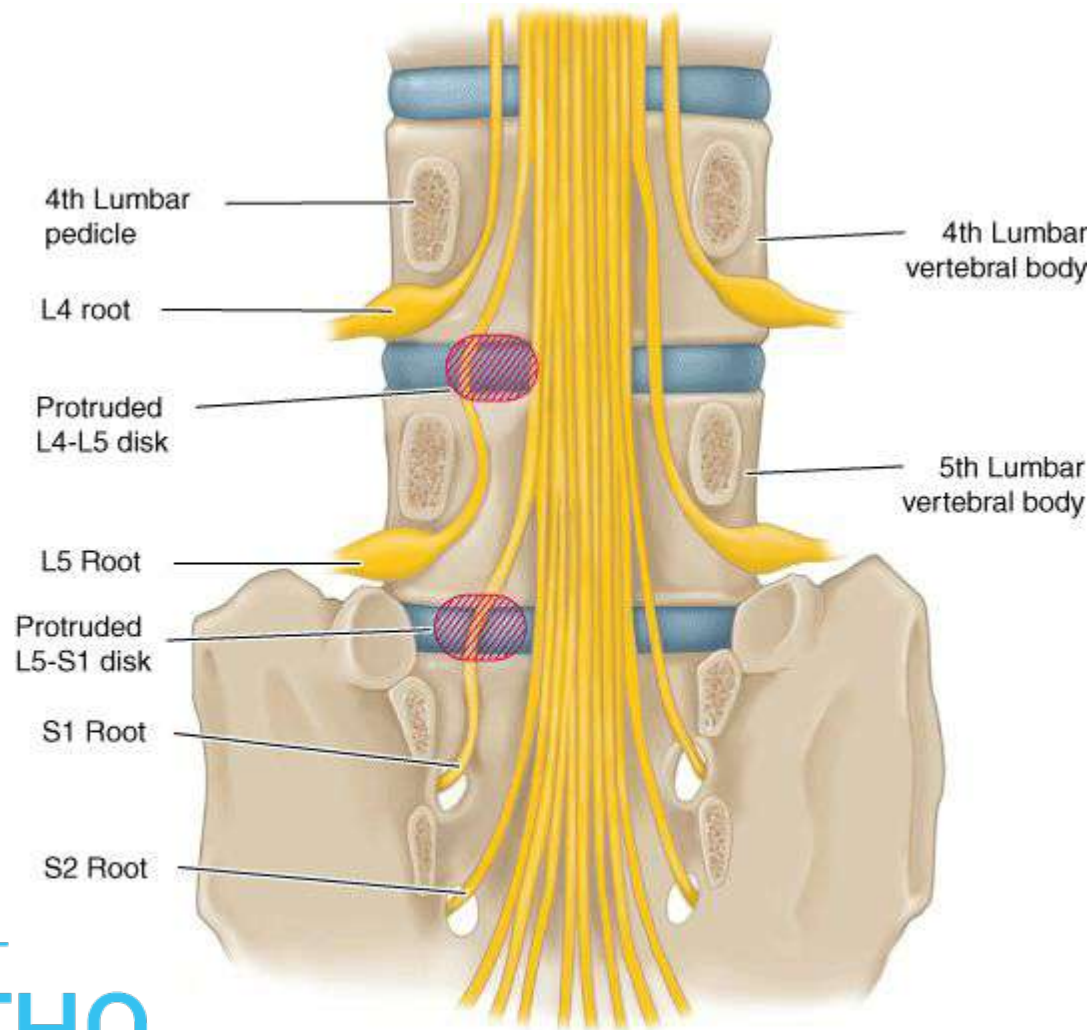
Instrumented posterolateral fusion

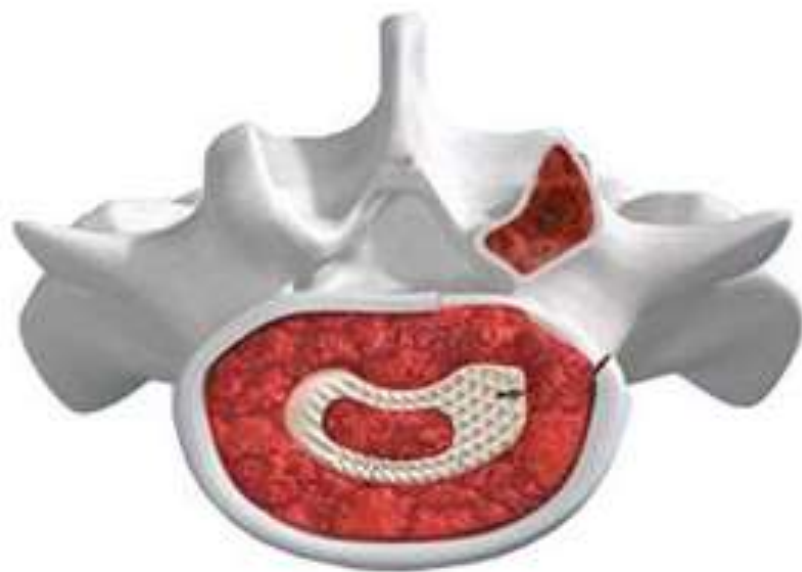


Interbody fusion

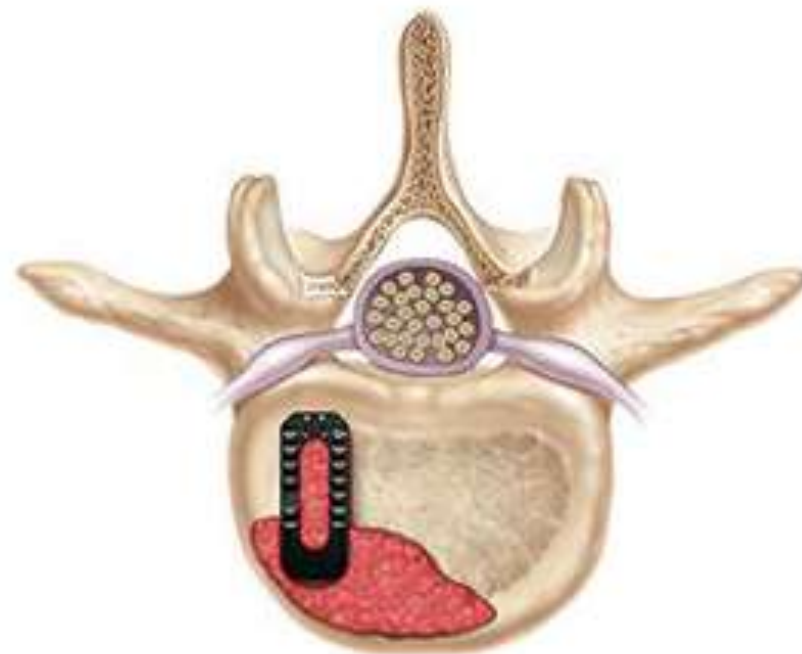


PLIF vs TLIF





TLIF

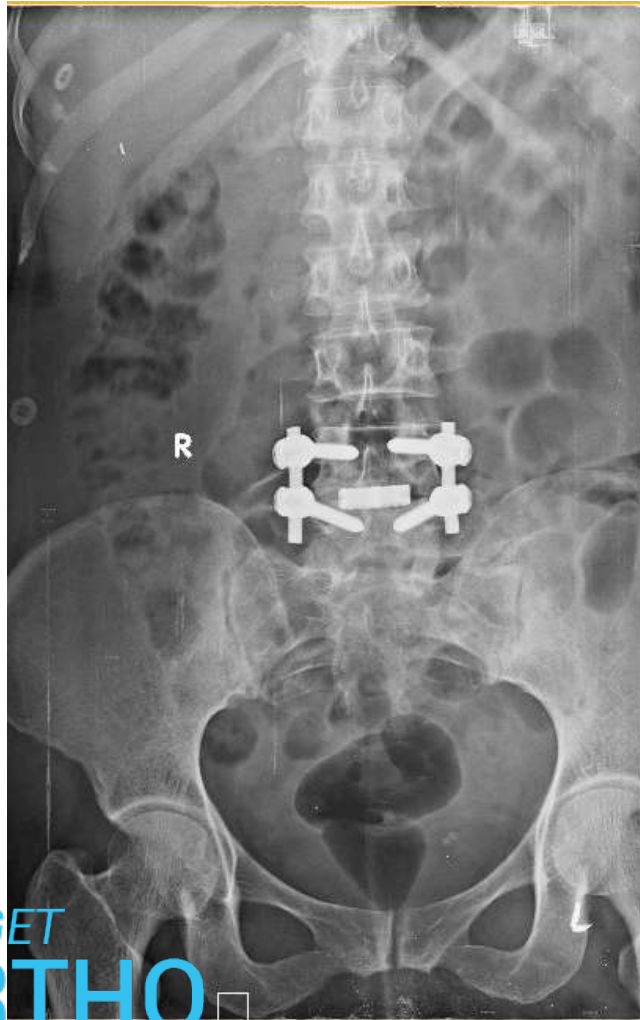


PLIF

Posterior lumbar interbody fusion



TLIF

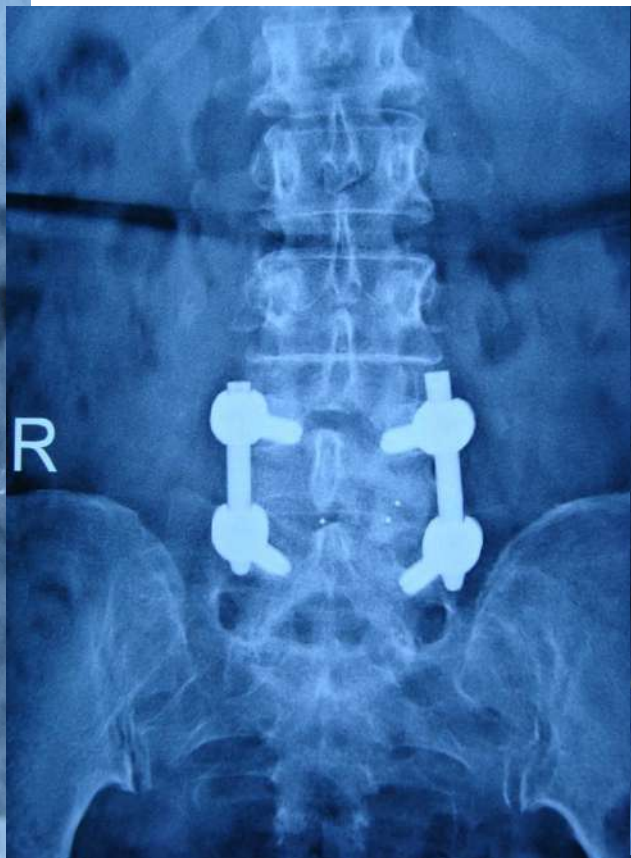


MIS-TLIF

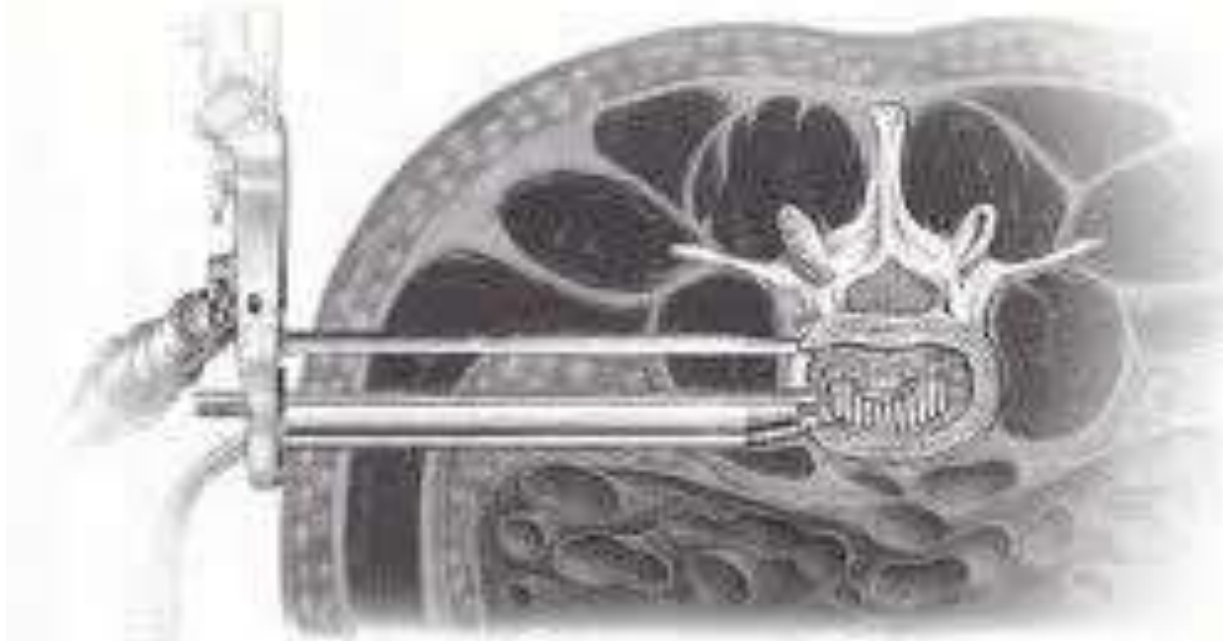


MIS-TLIF

- Decrease muscle crush injuries -retraction
- Avoid detachment of muscles to the posterior bony elements,
- Maintain the integrity of the dorsolumbar fascia
- Decrease the size of the surgical corridor to coincide with the area of the surgical target site.



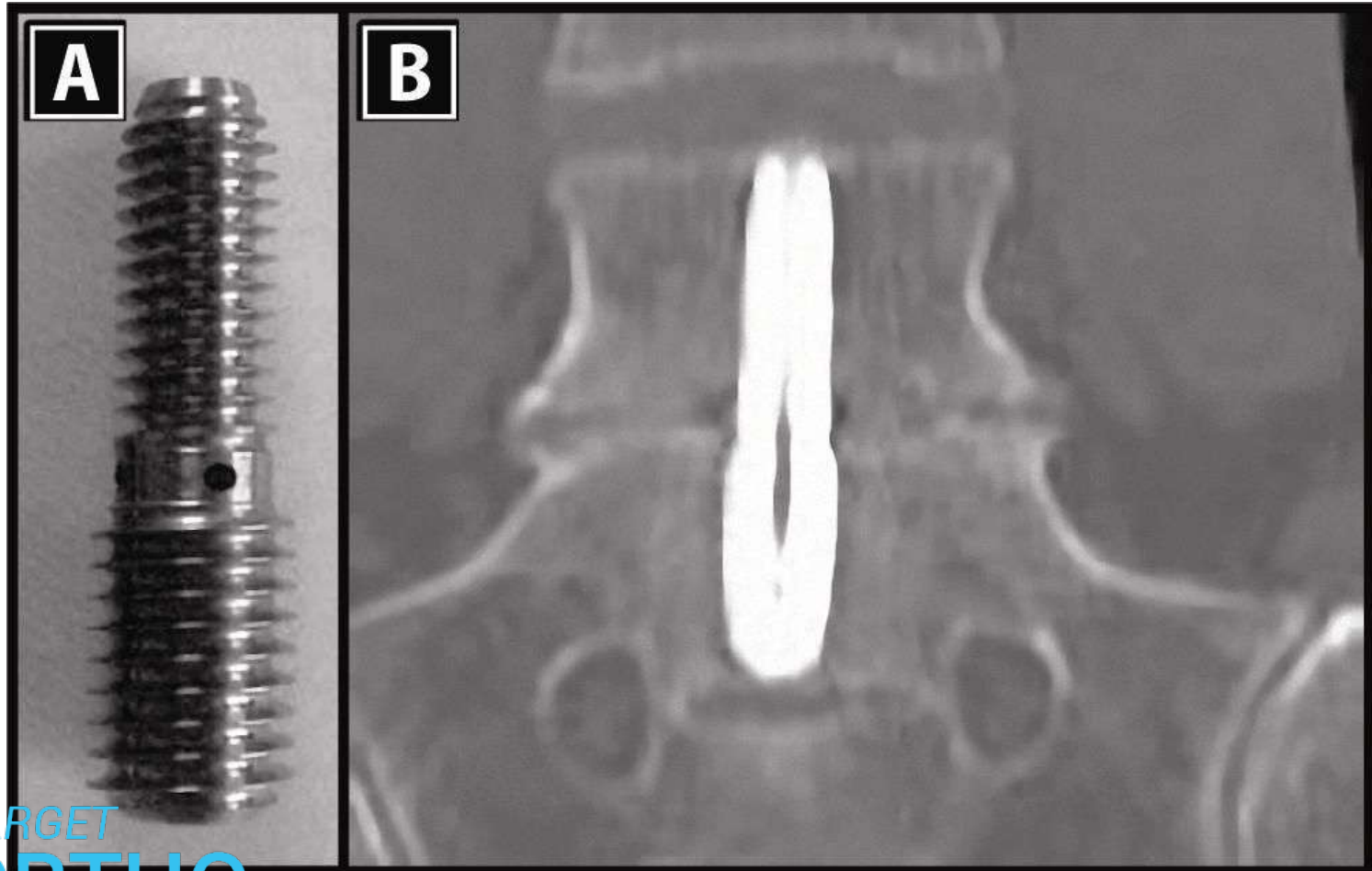
XLIF



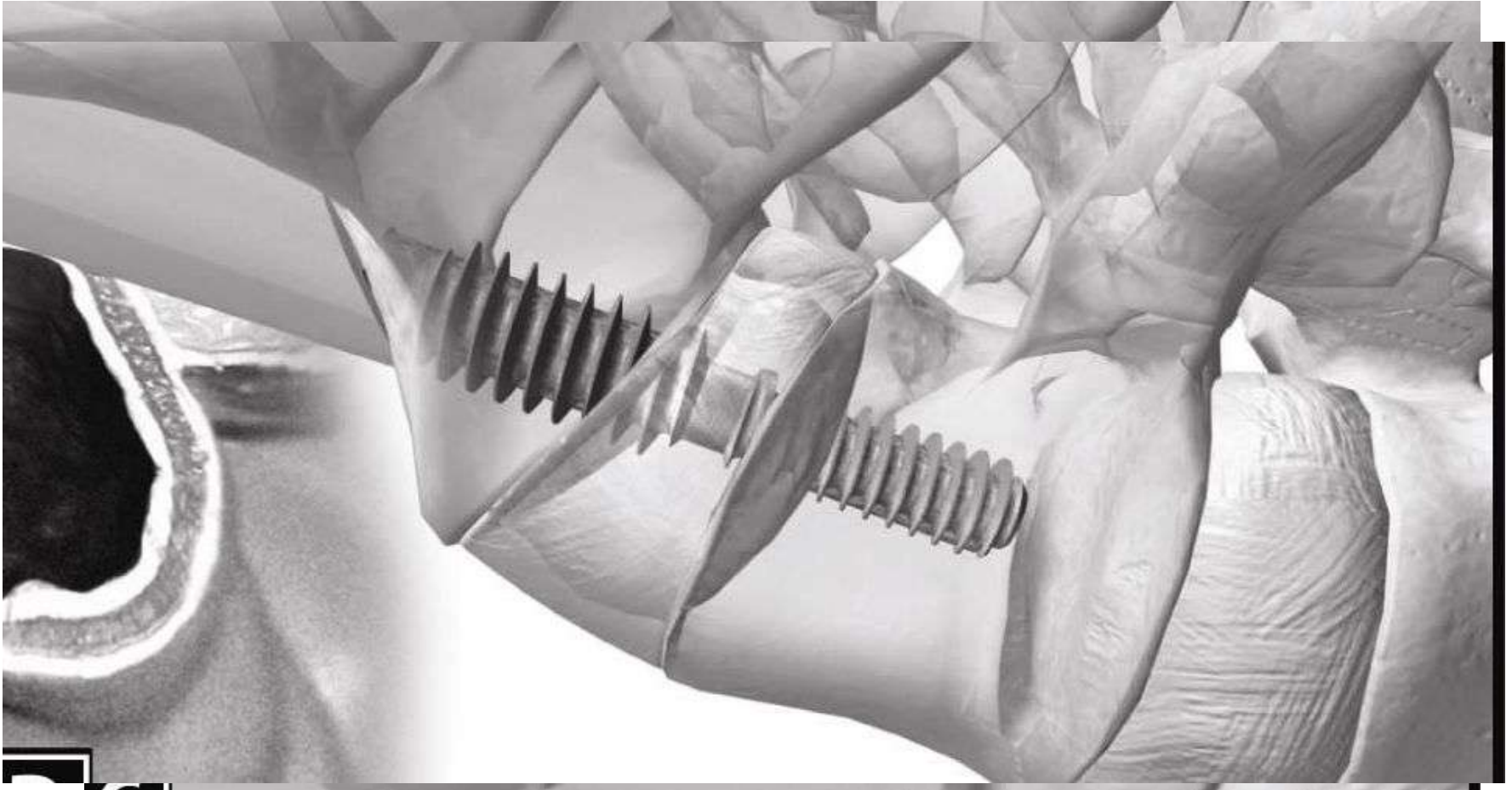
XLIF

- XLIF is performed through a lateral, retroperitoneal,
- Transpsoas approach to the anterior column,
- Uses real-time directional neuromonitoring to ensure safe passage through the psoas muscle, avoiding the nerves of the lumbar plexus

AXIAL LIF



Steps in Axial LIF



High grade listhesis

Decompression + fusion

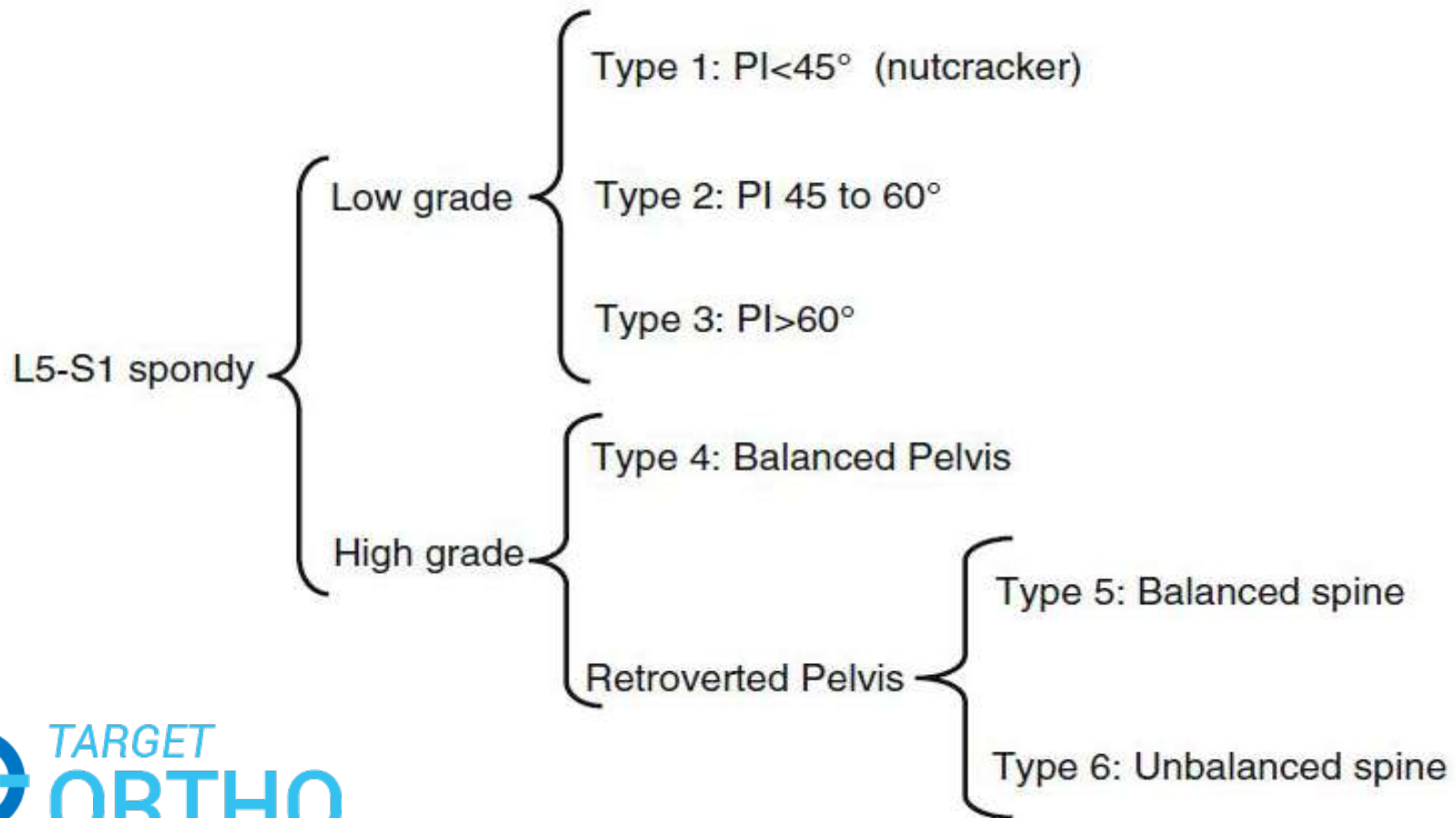
Reduce

Insitu

Partial reduction

Spino-pelvic sagittal balance of spondylolisthesis

SDSG L5-S1 Spondylolisthesis Classification



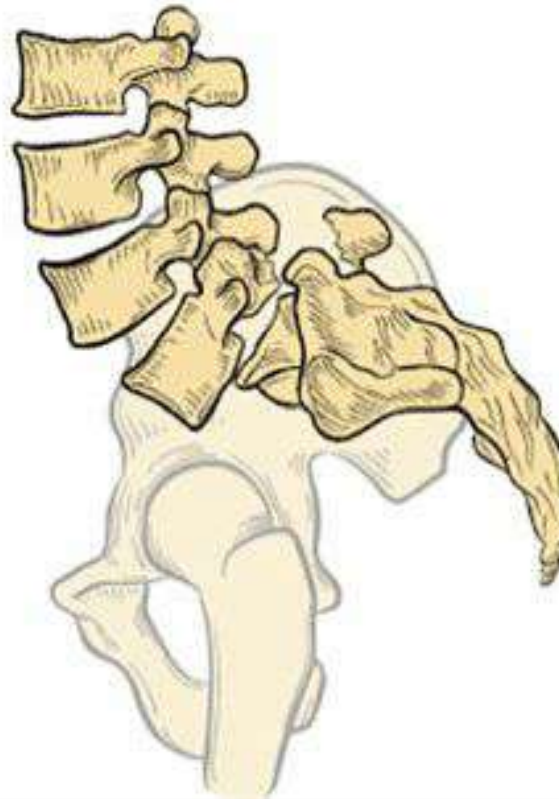
High grade

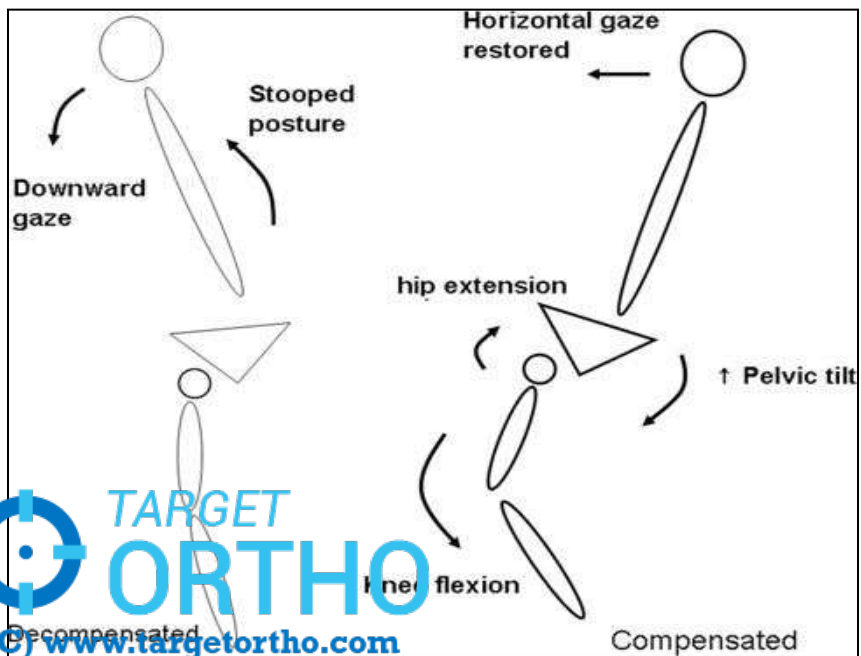
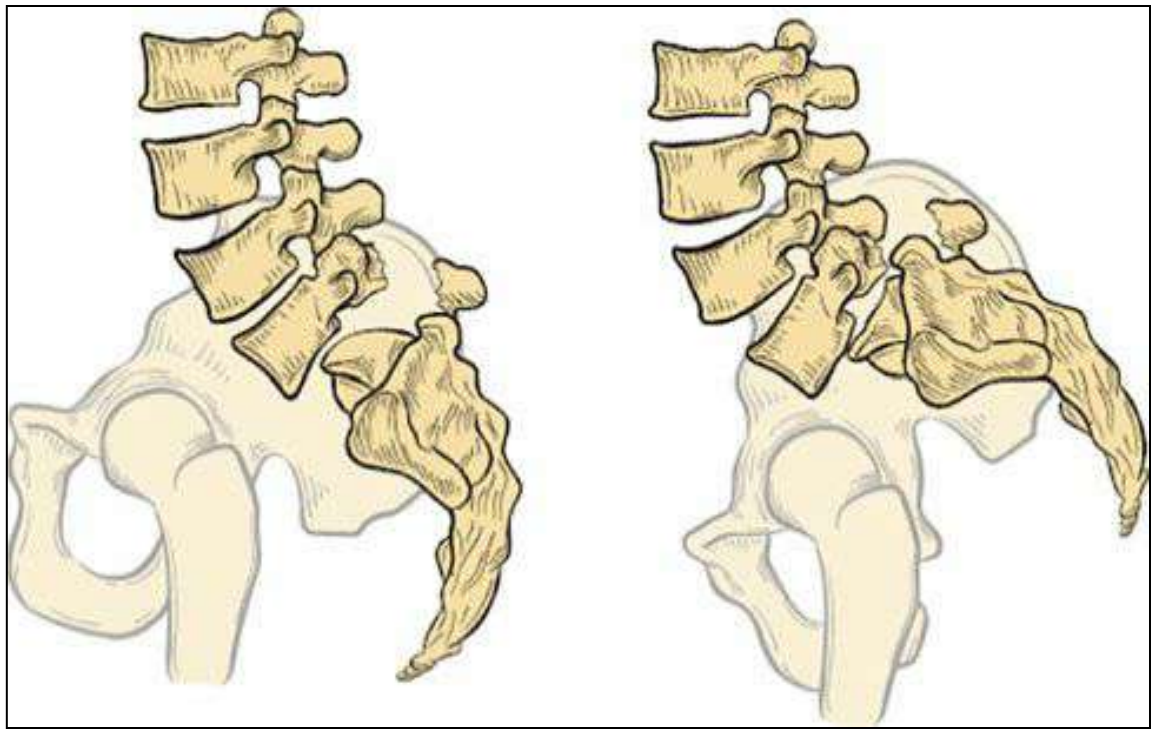
Type 4: Balanced Pelvis

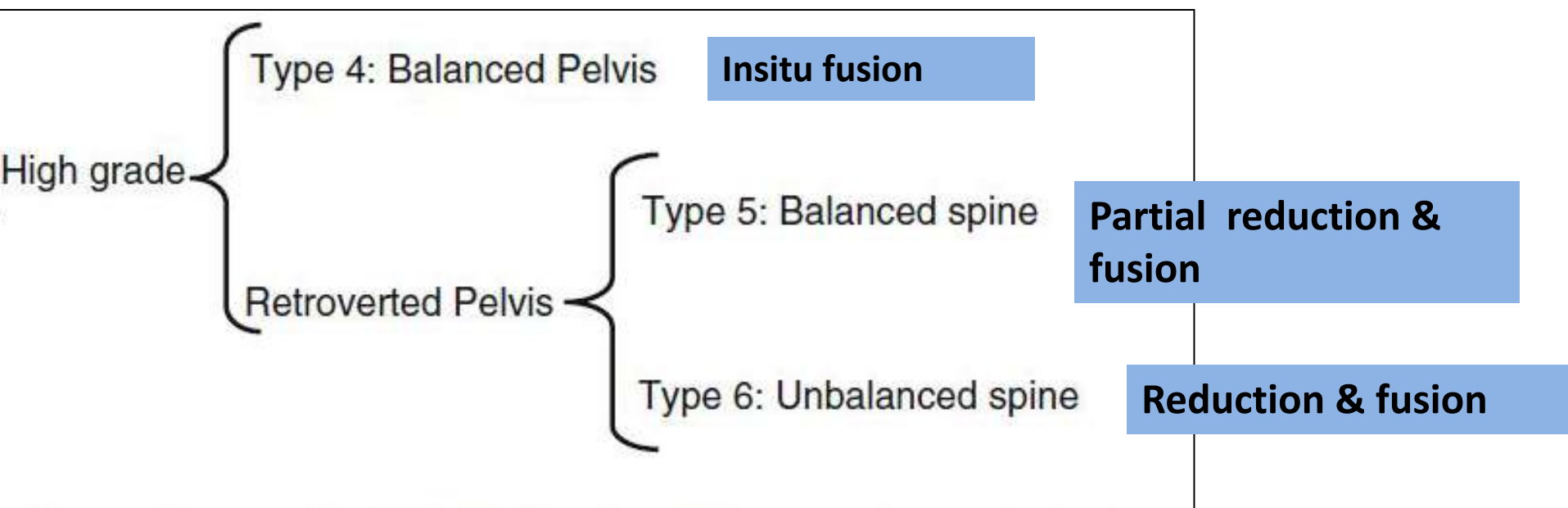
Retroverted Pelvis

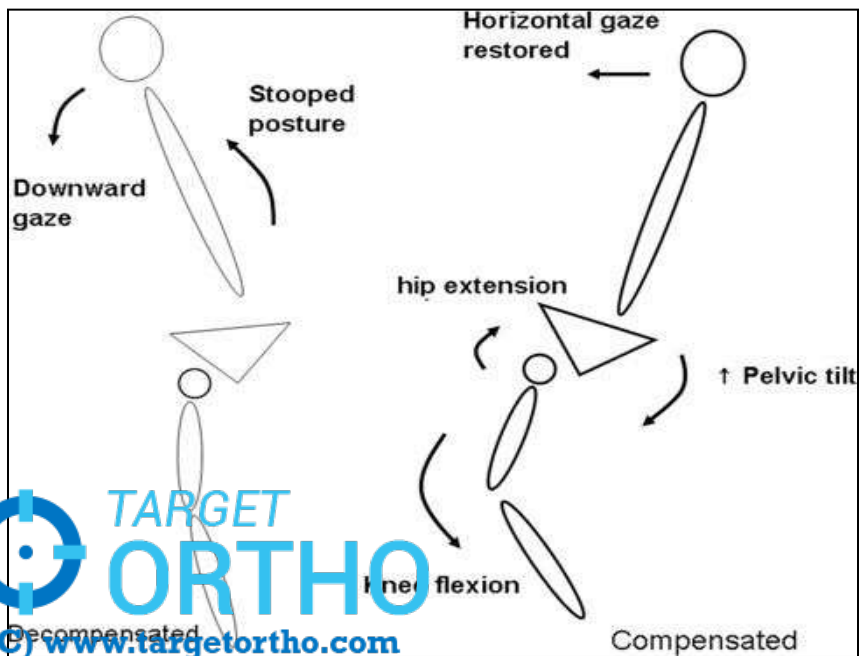
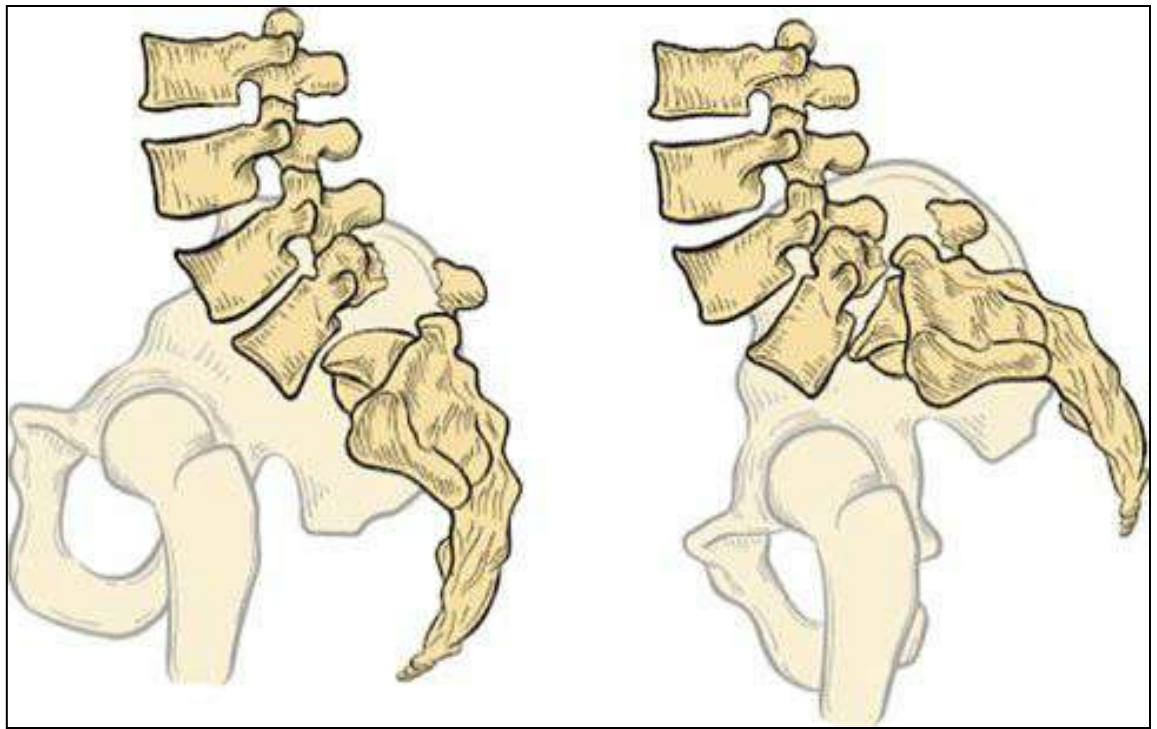
Type 5: Balanced spine

Type 6: Unbalanced spine

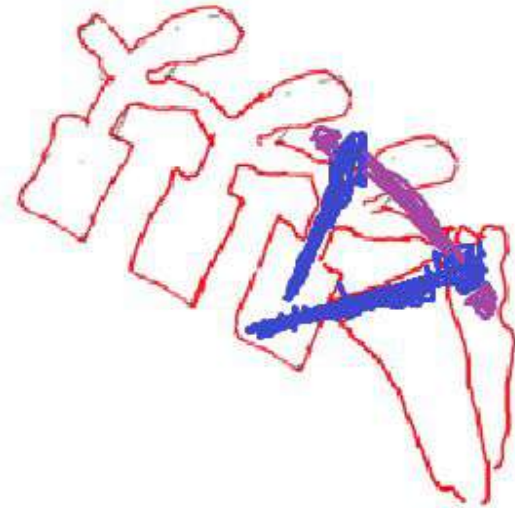
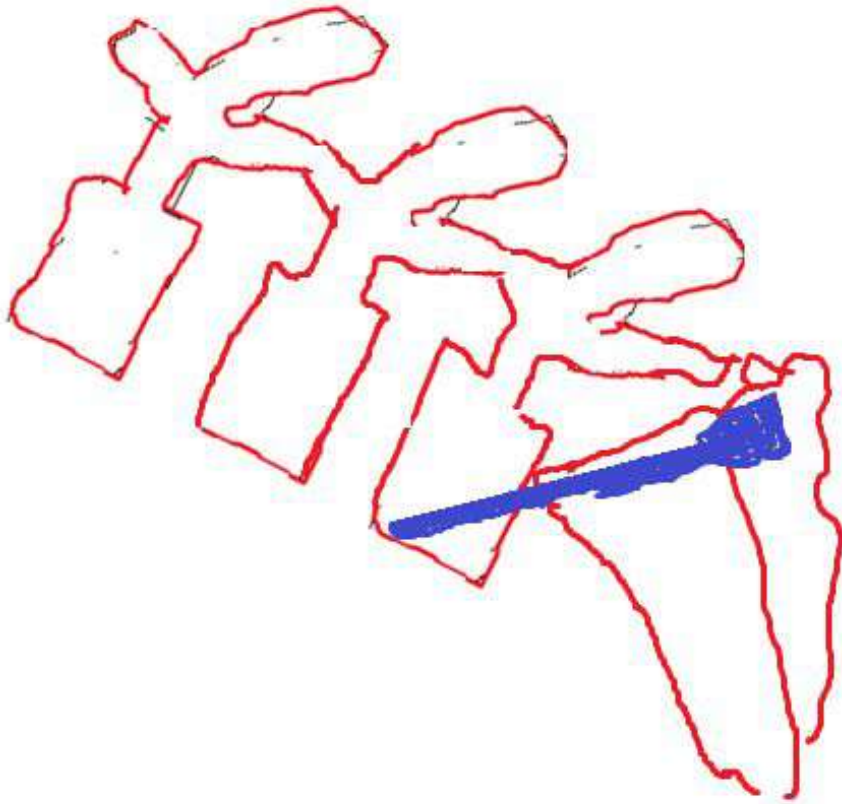








In situ fixation and fusion



Pre-op 21.07.2009



Post-op



H



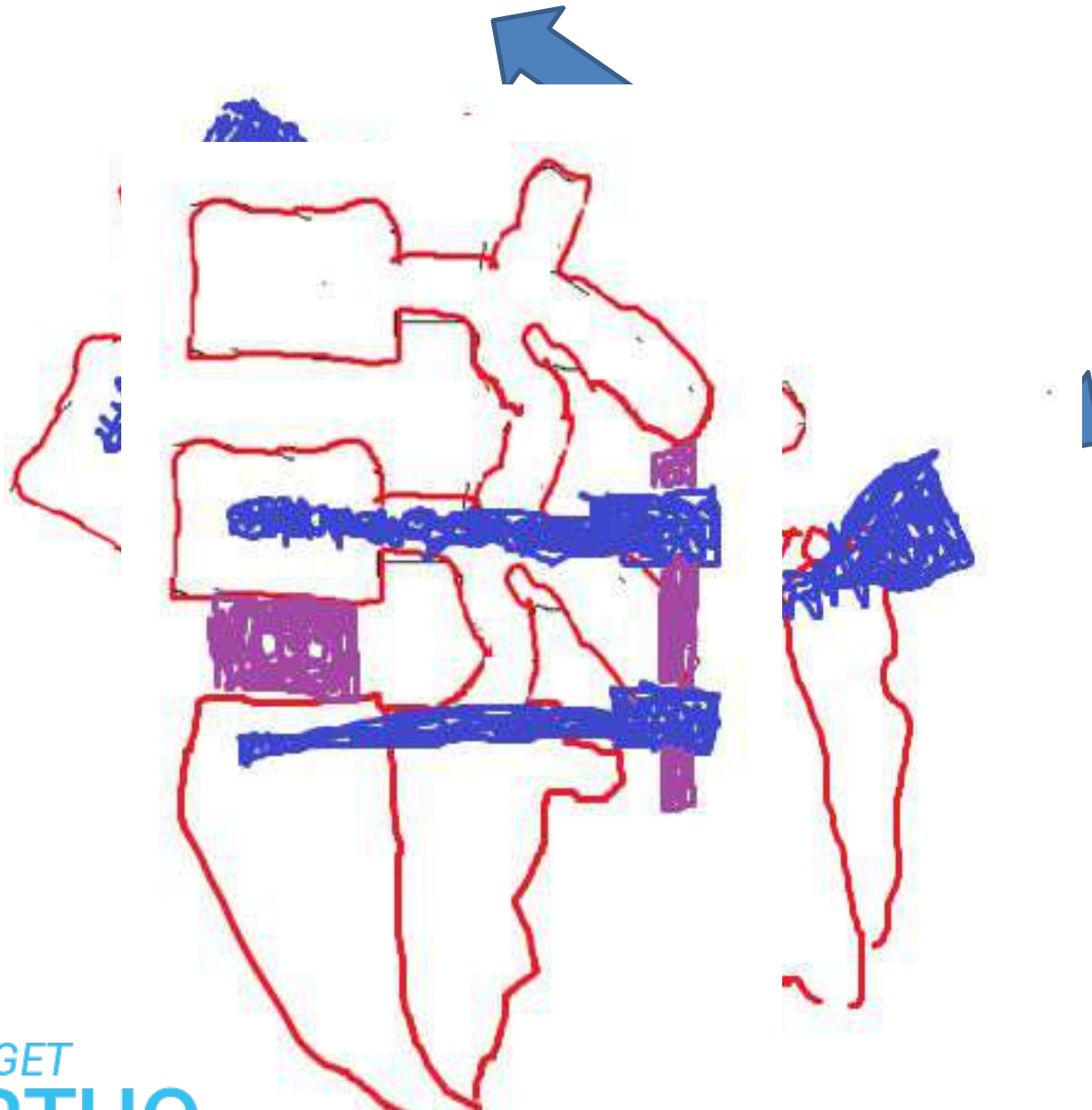
H

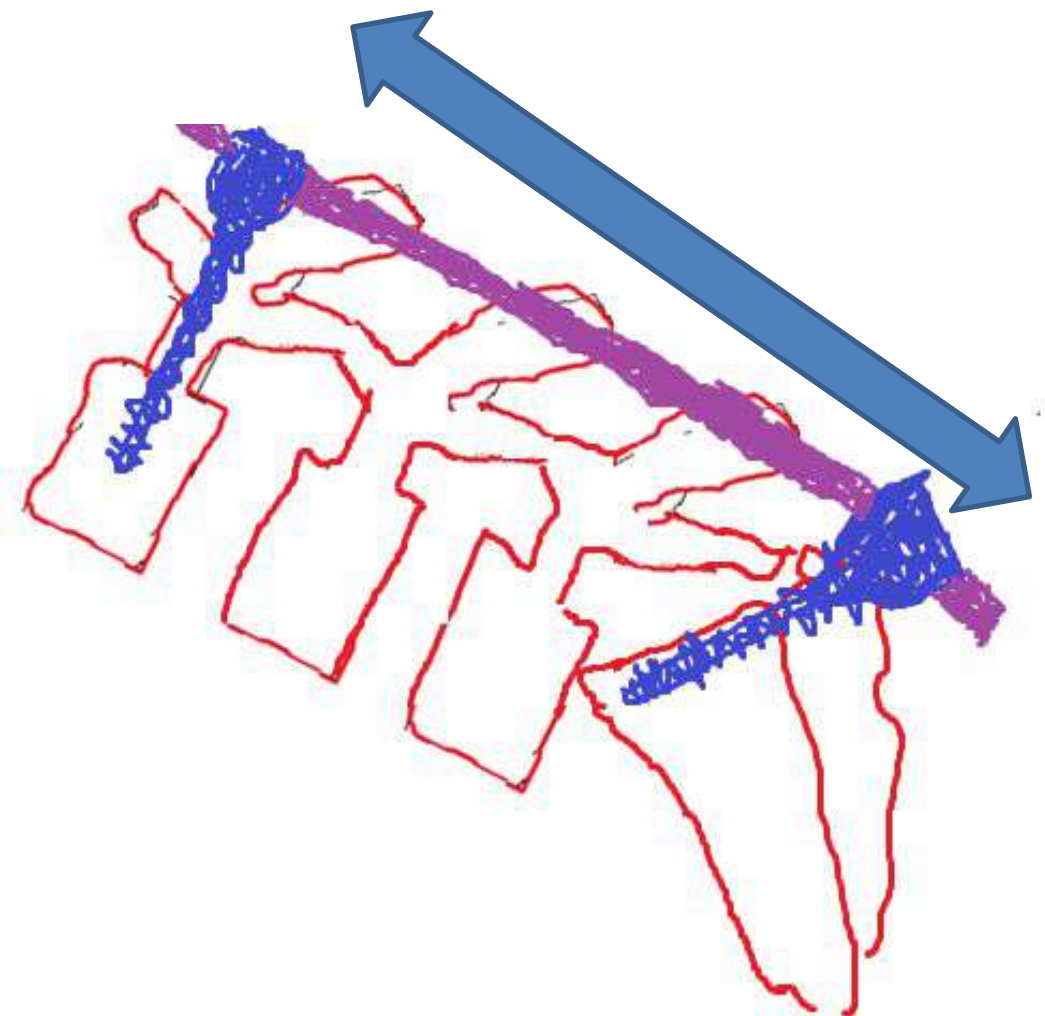


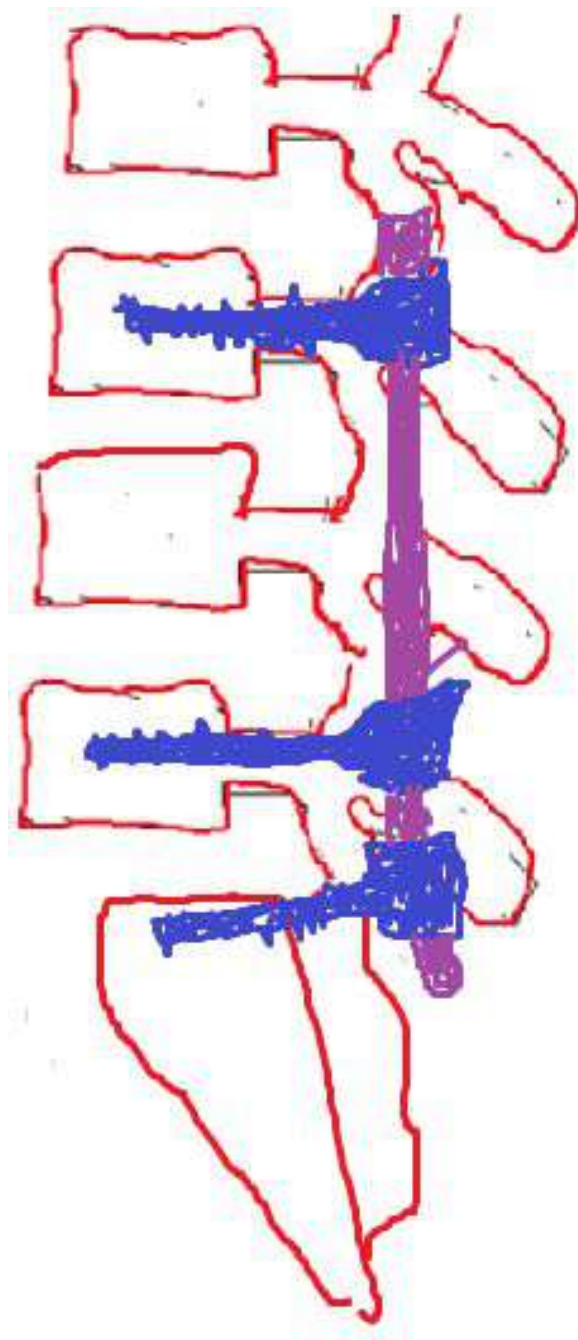
Bohlmann's Technique

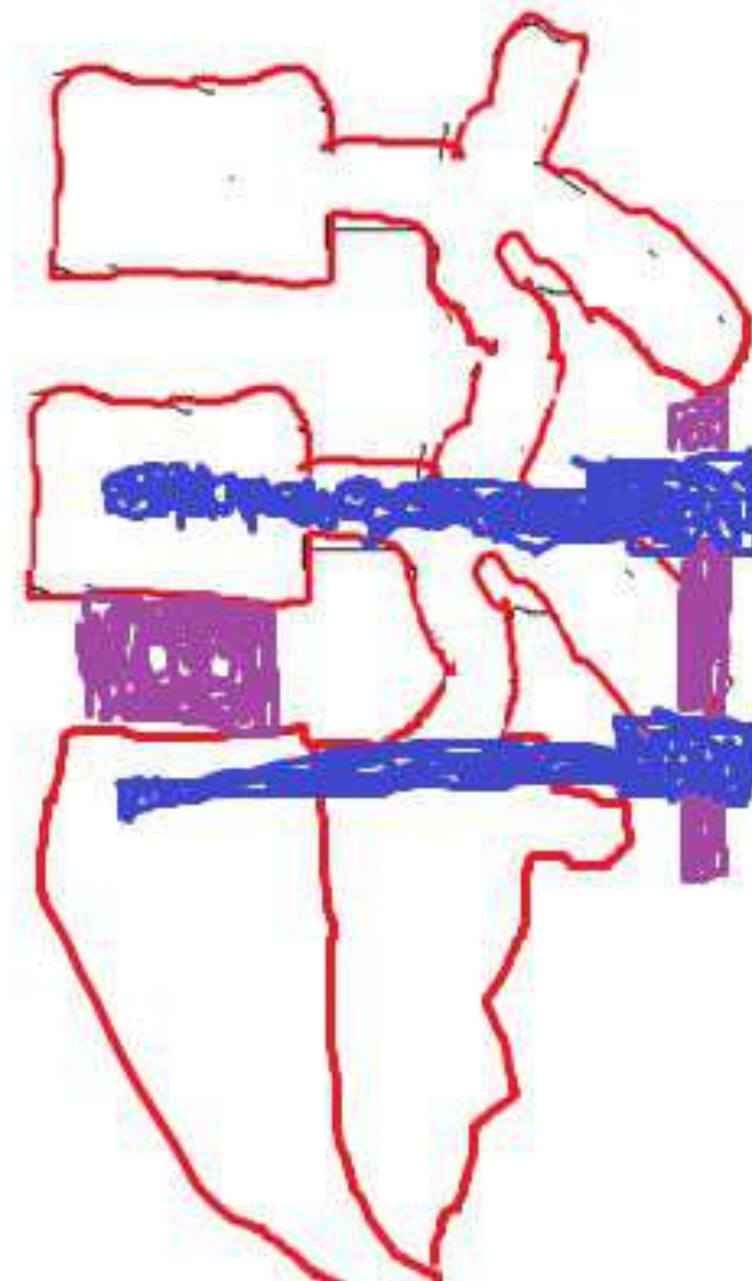


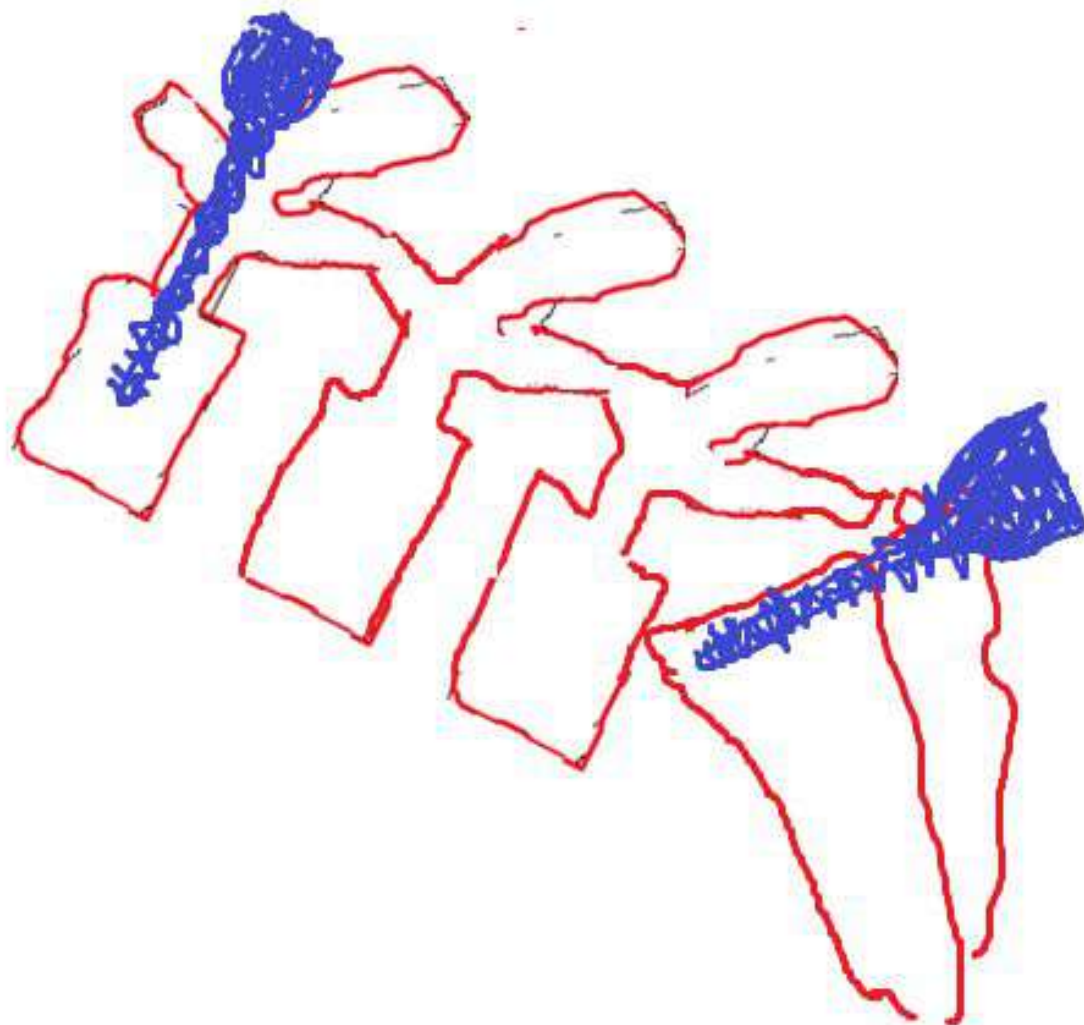
Reduction of High Grade Spondylolisthesis



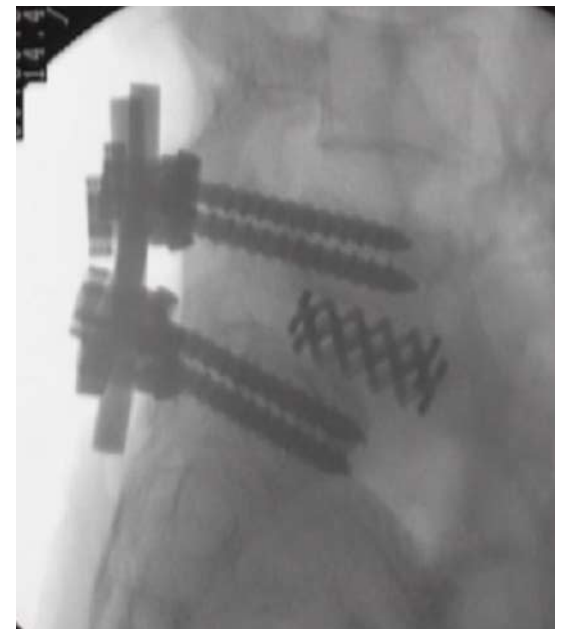
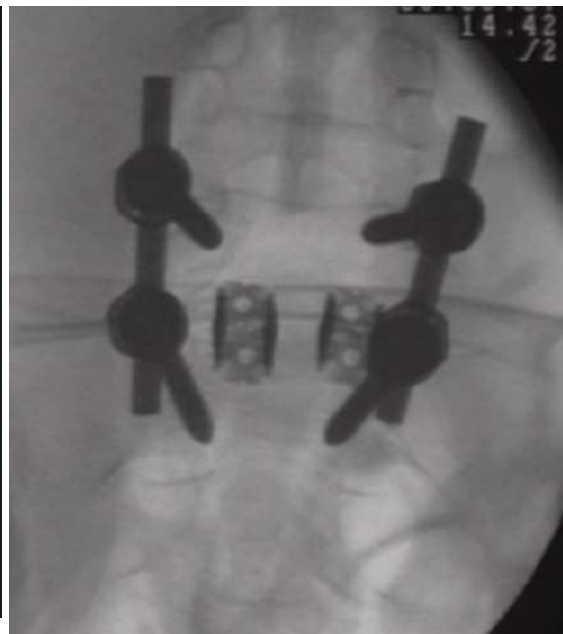
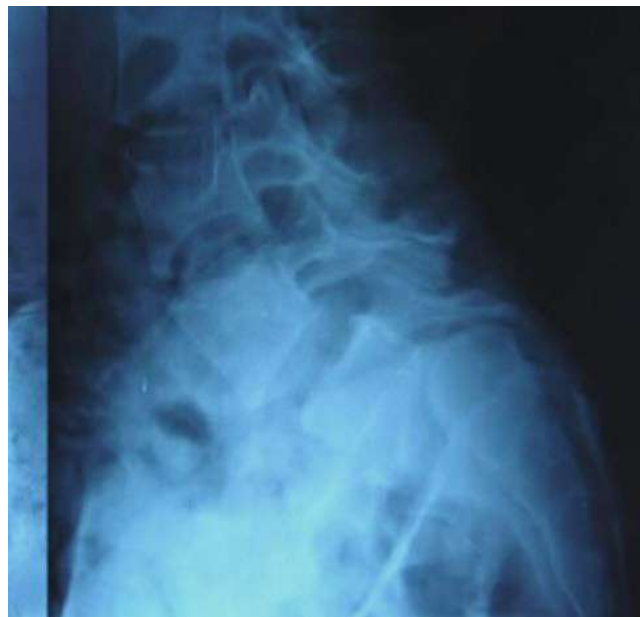






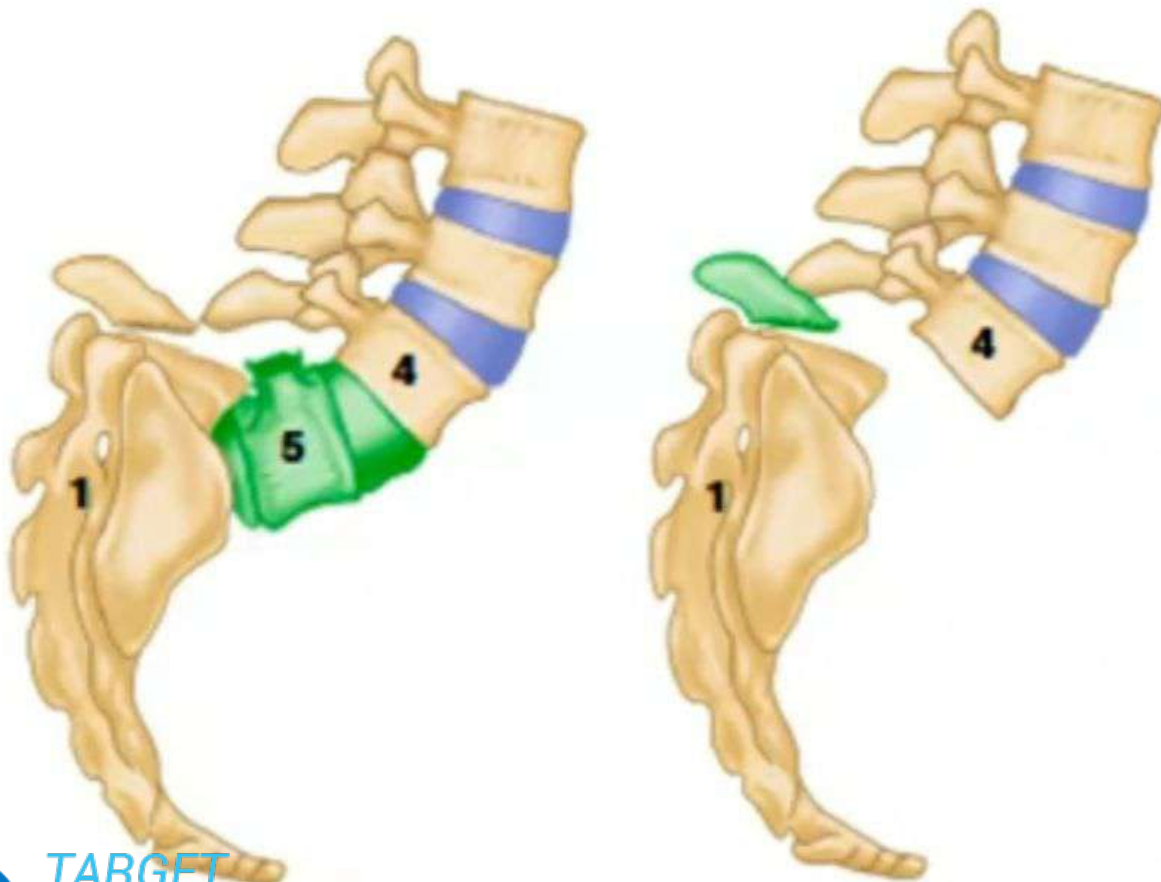








Gaines Procedure



Pars repair - Techniques

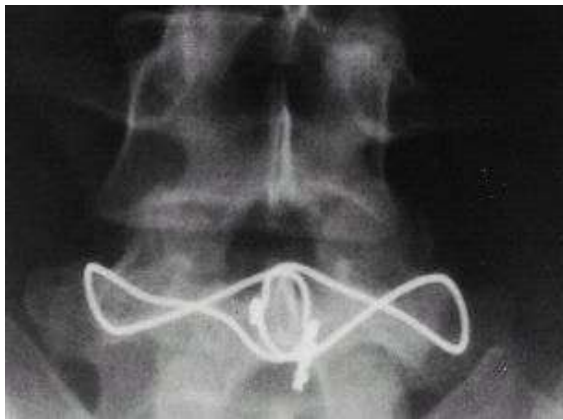
- **Kimura (1968):**

- First described pars repair.
- Cancellous bone grafts + Cast.

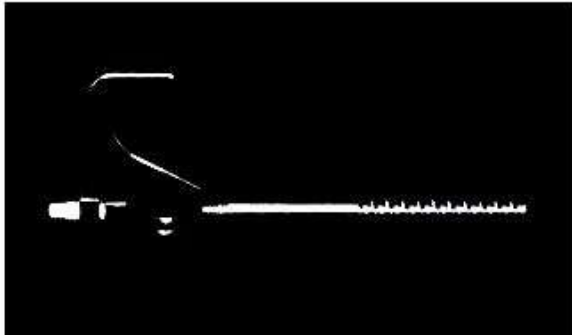


- **Buck (1970):**

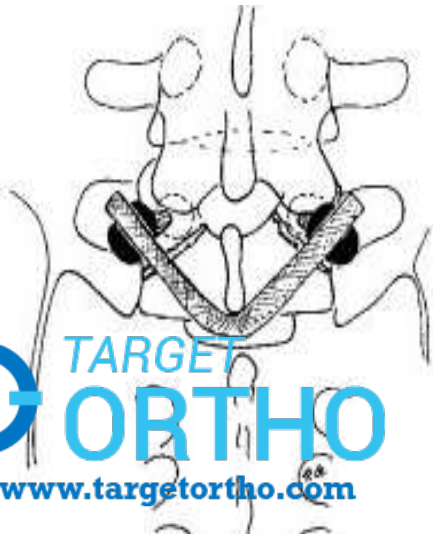
- Screw fixation + bone grafting.



- **Nicol and Scott (1986):**
 - Tension band wire.

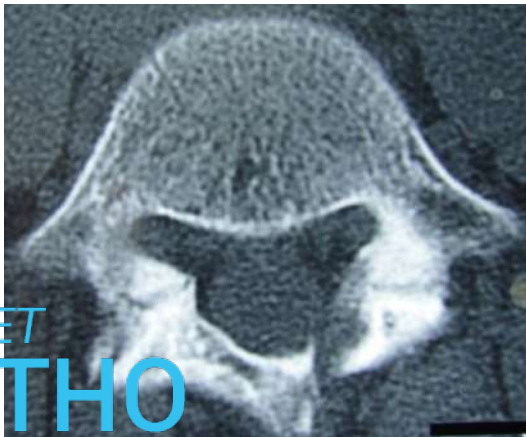


- **Morscher (1984):**
 - Hook screw.



- **Phillipe Gillet (1999):**
 - V shaped rod-screw construct.

Bilateral Spondylolysis



Conclusion

- Instrumented posterolateral fusion remains the gold standard
- MIS TLIF has a definitive advantage in low grade lythesis.
- Understanding pelvic incidence is crucial for understanding sagittal balance

- Thank you