Back in the Game

Understanding Spondylolysis in the Young Athlete

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Disclosures

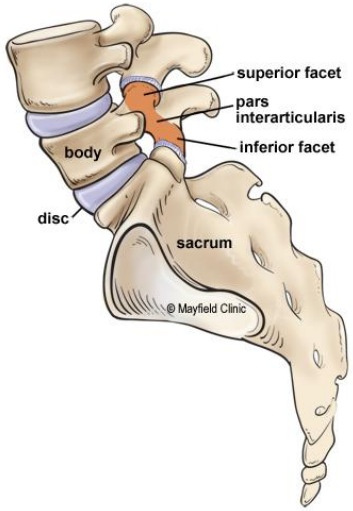
- No financial disclosures or conflicts of interests related directly or indirectly to the subject of this presentation

Goals and Objectives

- 1. Define spondylolysis
- 2. Understand risk factors and biomechanics
- 3. Discuss diagnosis, treatment, and return to play strategies
- 4. Review a real life case

Spine Anatomy

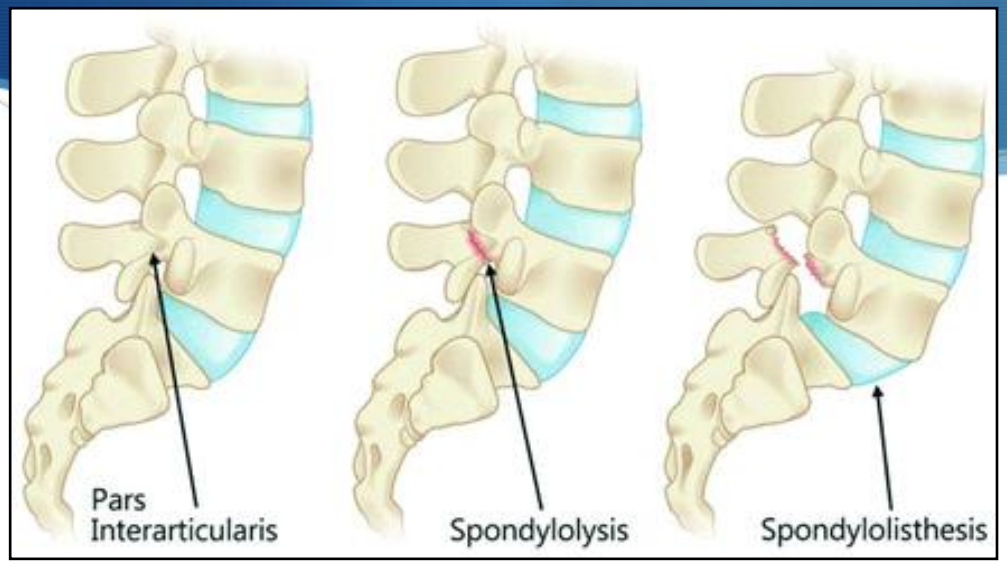
- 33 bones, 3, 5 or 7 different joints, over 100 joints, over 150 fascicles of muscle in the trunk
- Each vertebra has a superior and inferior facet
- Pars Interarticularis = bony bridge connecting the two facets

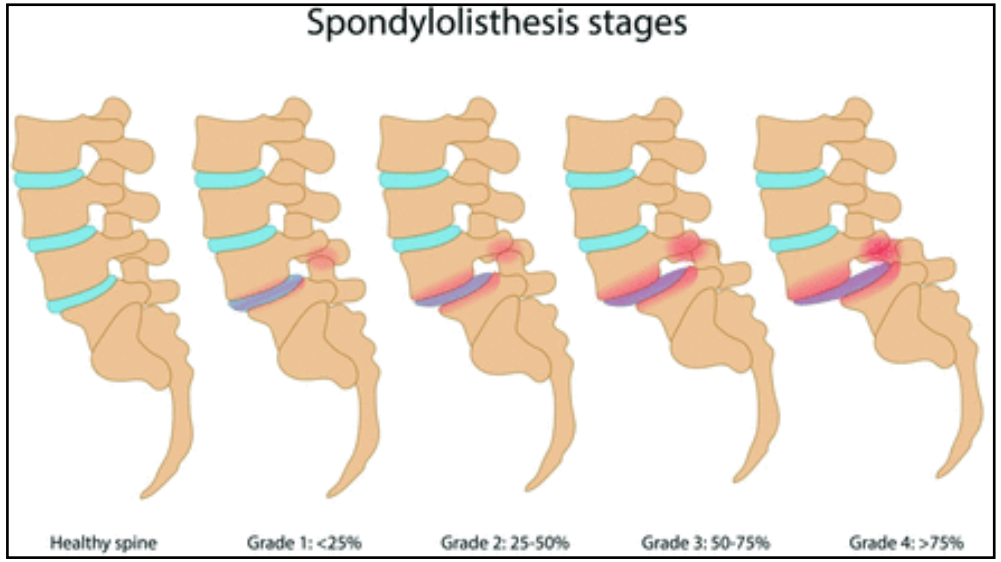


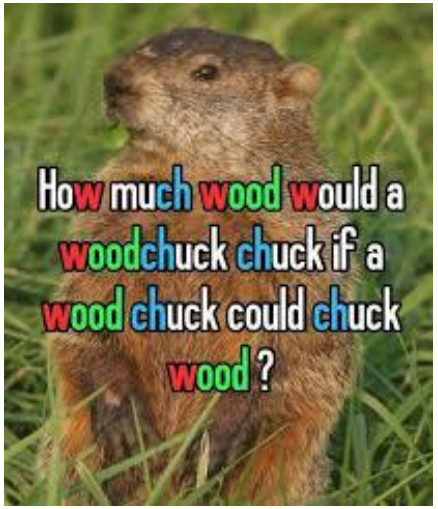
What is Spondylolysis?

- Defect in the pars interarticularis
- Wiltse Classification:
  - **Isthmic:** uni- or bilateral bone stress injury due repetitive loading of the lumbar spine
  - Dysplastic
  - Degenerative
  - Traumatic
  - Pathologic

Spondylolysis vs Spondylolithesis







Epidemiology

- Low back pain is very common in paediatric athletes
  - 50% report some level of back pain
  - Unknown role of early sport specialization
- Prevalence:
  - ~6-10% in the peds/adolescent population
  - 8-47% of young athletes with back pain
  - L5 = 85% to 95% of cases
  - L4 = 5% to 15% of cases
- Most common in sports like gymnastics, rhythmic gymnastics, football, wrestling, weight lifting.
- Adolescents more prone during off-season conditioning

Pathophysiology

Biomechanics of Injury

- Two recognized theories: (1) Biomechanical (2) Genetic
- Biomechanical
  - repetitive movement—> inadequate rest —> microdamage/edema —> inflammatory/osseous healing response
  - Pars = high stress load in extension
  - Pediatric spine anatomic factors:
    - Neural arch weakness
    - Elastic intervertebral discs

Biomechanics of Injury

- 13.5 years of age Peak age velocity/growth spurt
  - Increased incidence of overuse injuries **after** growth spurt
  - Muscle tissue changes **after** limb length/mass changes
    - Greater muscular force needed for same acceleration
- Genetic
  - **Increased incidence in 1st degree relatives**
  - Spina bifida occulta
  - Scoliosis

Risk Factors

- Athletes > Non-athletes
- Female
- High levels of physical activity
- Repetitive lumbar hyperextension and axial rotation
- “High Risk” Sports
- All Athletes with low back pain
  - 47% between 12-18 years old with atraumatic low back pain

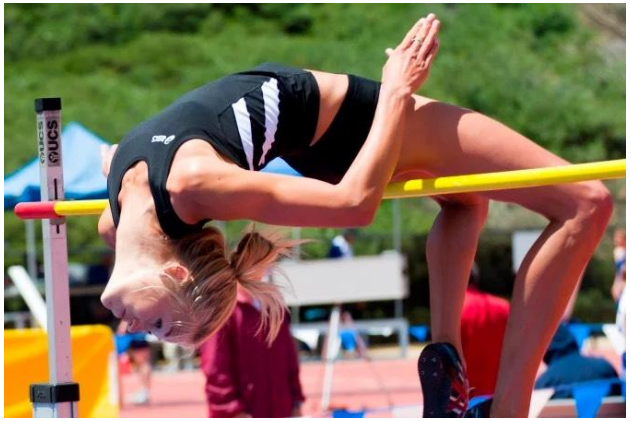
Clinical Presentation and Diagnosis

History of Presenting Illness

- Patient ID: Mean age of 15 years old
- Onset: Atraumatic, gradual (possibly acute)
- Mechanism: Increased activity amount, frequency, or intensity vs. Single overload event
- Location: Unilateral or bilateral
- Aggravating: activity (does not warm up), lumbar extension/rotation
- Alleviating: Rest
- Radiation: Buttocks and/or upper thighs

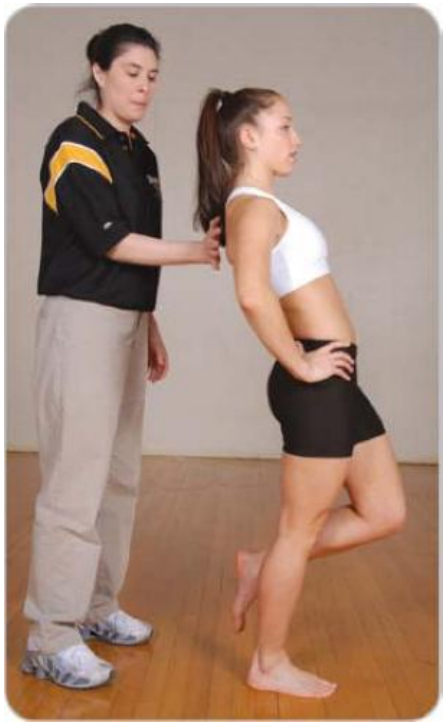
History of Presenting Illness

- Absence of neurological or constitutional symptoms
  - If present, consider alternative diagnosis
- ****Activity History****
  - Frequency and duration of activity
    - Practices, Games, Training Sessions per week
  - Position/Technique
  - Hand/Foot Dominance
  - Other physical activity outside of competitive sport
- REDs Screen
- Family history of low back pain, spondylolysis, autoimmune conditions



Physical Examination

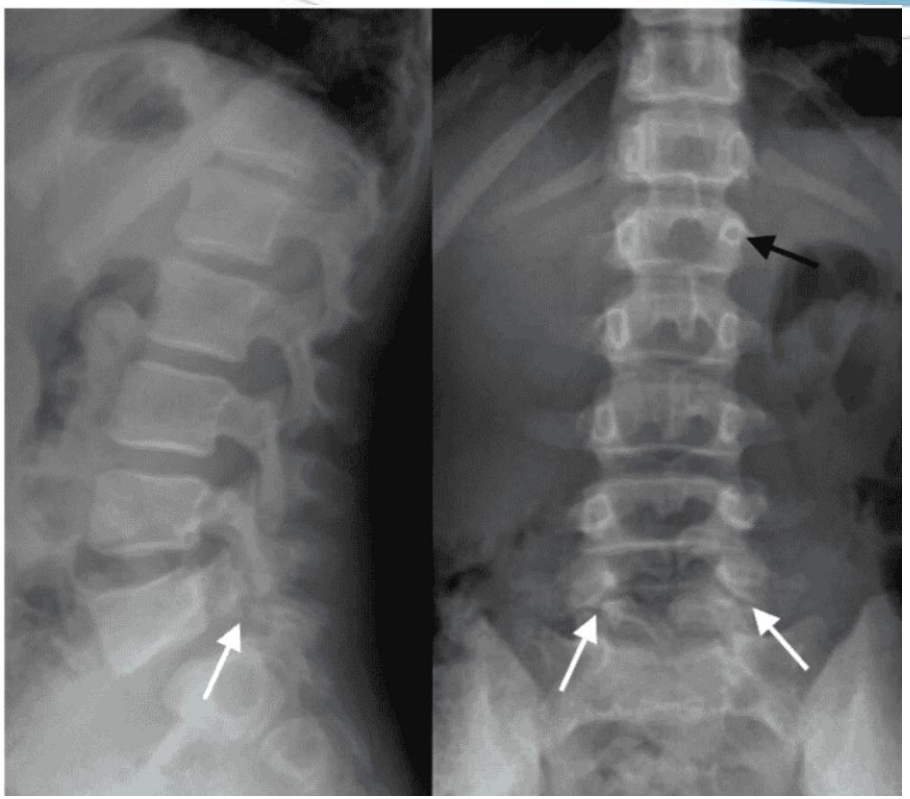
- Inspection: Assess for skin discolouration, dimples, patches, or tufts
- Palpation: Spinous process tenderness +/- paraspinal muscle tenderness
- Range of motion:
  - Reduced and pain with extension, rotation, lateral flexion
  - Repetitive movements
  - Pain w/ extension: 81% sensitive
- Neuro: weakness/decreased sensation in L5 = ?anterolisthesis
- Special Tests:
  - Stork Test: low sensitivity (50-55%) and specificity (17-32%)

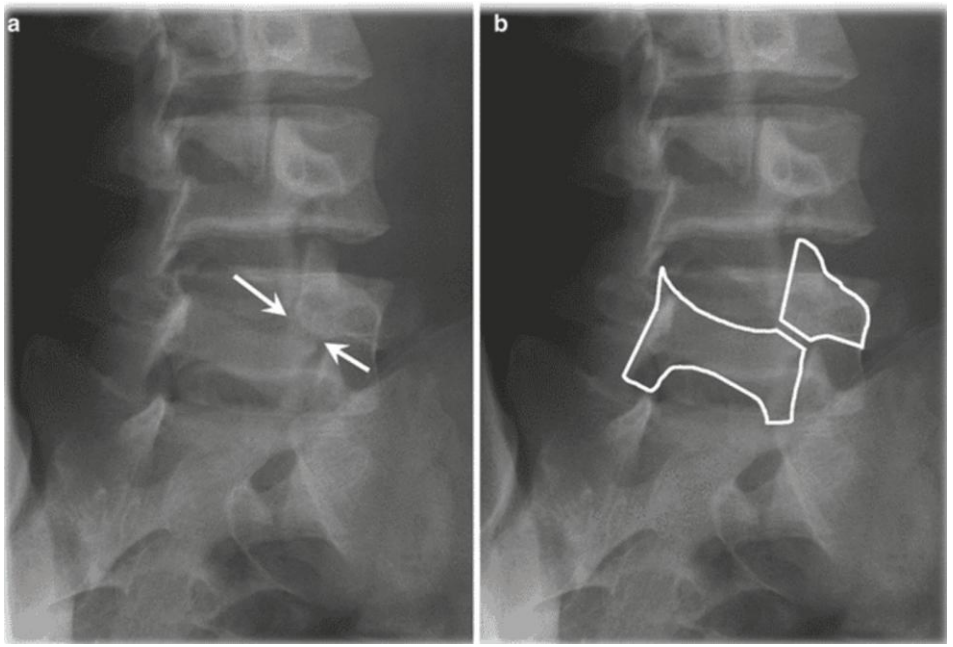


Imaging

- No consensus imaging algorithm or agreed upon first line
- Understand the utility and limitations of each modality
- X-ray:
  - AP, lateral +/- flexion and extension views
  - Do NOT order oblique views
    - No added diagnostic accuracy, increased radiation exposure
  - “Scotty Dog” deformity
  - 52% False Negative compared to MRI
  - Low sensitivity in early stages and regardless may lead to further imaging

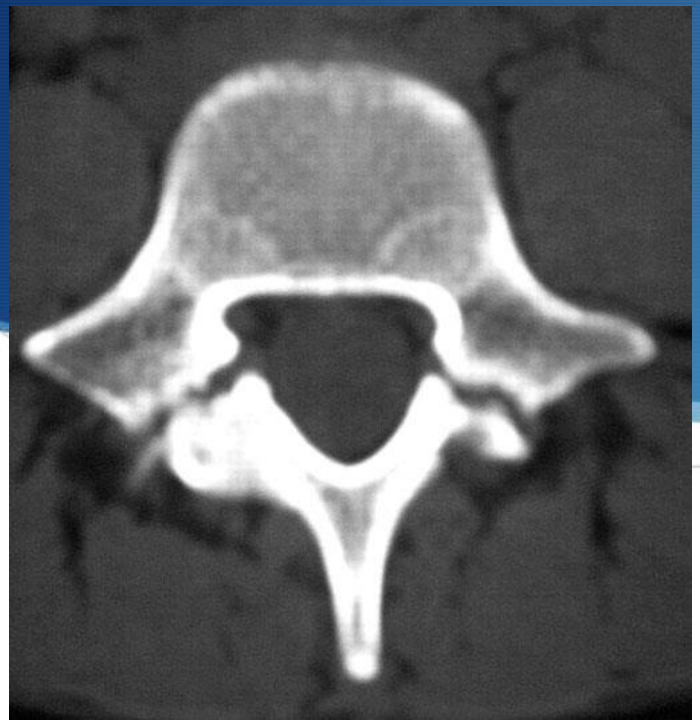
X-Ray





Imaging

- CT Scan
  - Gold standard
  - Best to delineate anatomy of lesion
  - More accurate than XR
  - Better than MRI for direct visualization of pars defect
  - Able to assess healing (sclerosis/bony bridging)
  - Unable to detect early acute stress reactions with only edema
  - Decreased dose CT ideal in adolescent population

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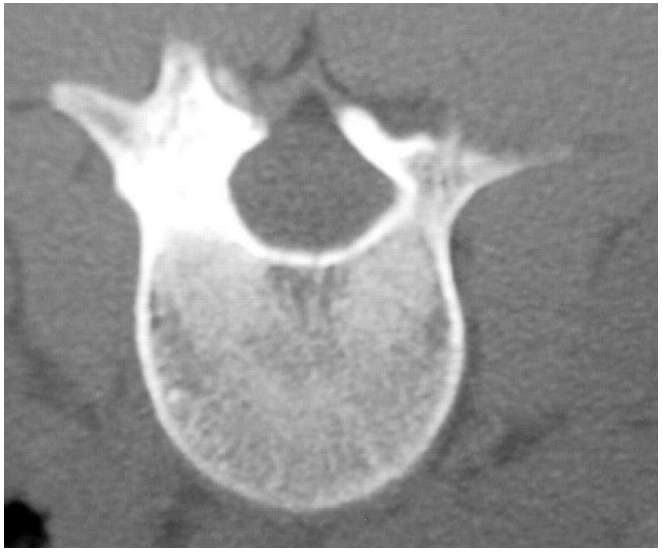
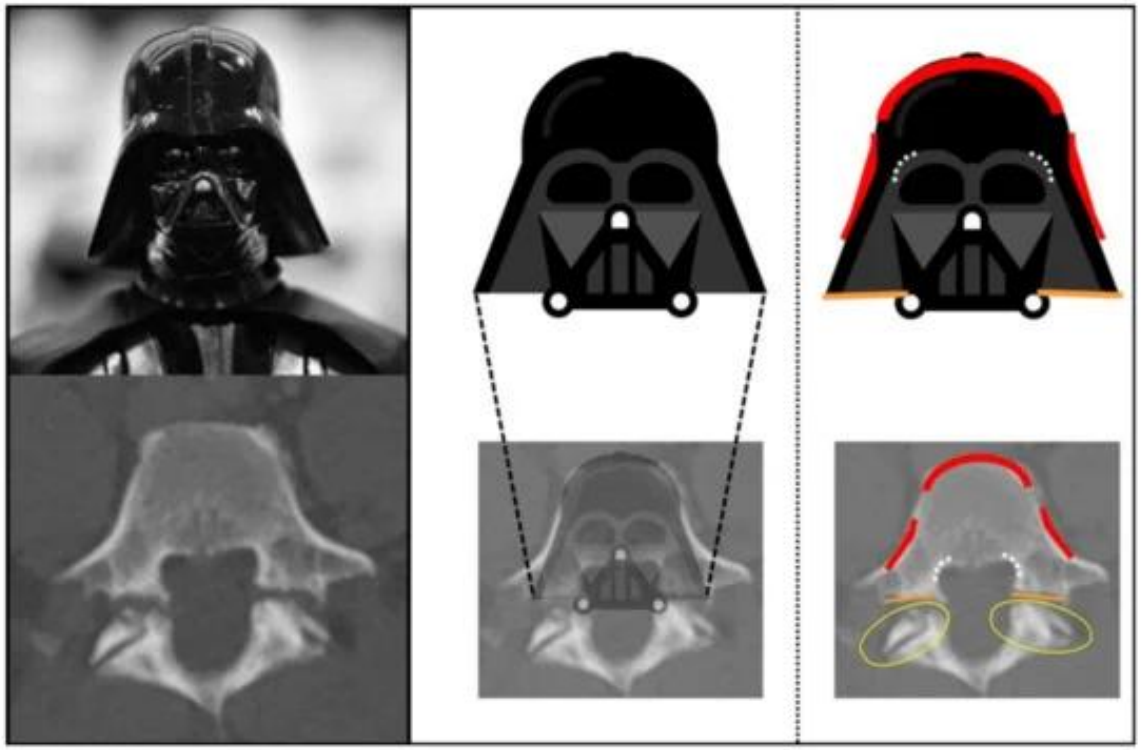


Darth Vader Sign



Imaging

- MRI
  - Imaging modality of choice when XR normal
  - Advantages:
    - Favourable side effect profile (lack of radiation)
    - Identify early bone stress injury
    - Sensitivity 92-98%
    - High Negative Predictive Value: 97%
  - Limitations:
    - Motion artifact in young athlete
    - False negative rate: 40.9% vs. 22.7% for CT

Imaging

Journal of Pediatric Orthopaedics
August 6, 2025 , Volume Publish Ahead of Print

- MRI vs CT

Can MRI Replace CT in the Diagnosis and Staging of Lumbar Spondylolysis in Pediatric Patients? A Validation Study Using MR Bone Imaging

Yutaka Kinoshita, MD, Toshinori Sakai, MD, PhD,* Kosuke Sugiura, MD, PhD,* Takahisa Kurosaki, MD, PhD,† Jiro Kobayashi, RT,† Saori Soeda, MD,* Yasuaki Tamaki, MD, PhD,* Masatoshi Morimoto, MD, PhD,* Hiroaki Manabe, MD, PhD,* Fumitake Tezuka, MD, PhD,* Kazuta Yamashita, MD, PhD,* and Koichi Sairyo, MD, PhD**

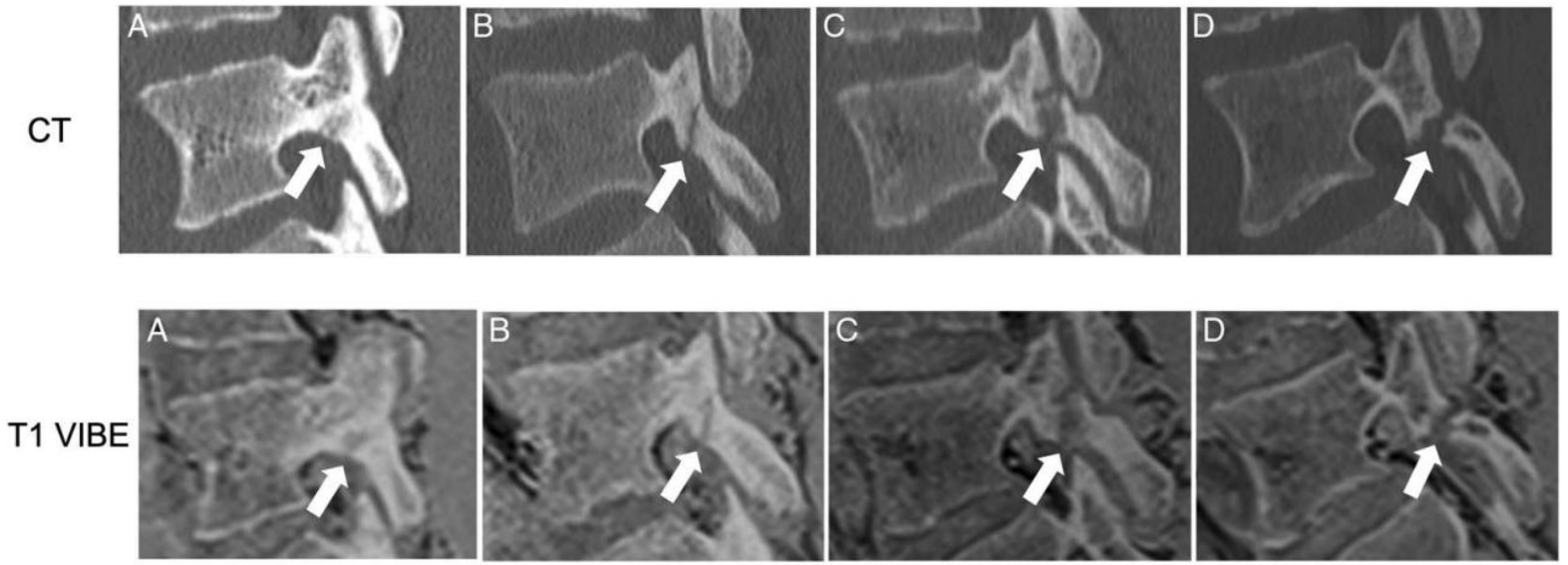


FIGURE 2. T1 VIBE findings for each stage of lumbar spondylolysis. (A) Bone resorption, (B) hairline fracture, (C) complete fracture, (D) gap (white arrows). The fracture line shown in each panel is the same as that in the corresponding panel of Figure 1.

Imaging

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- MRI vs CT

TABLE 2. Distributions of Pars Interarticularis Classified by CT and T1 VIBE Findings

		T1 VIBE findings (n)			
		No fracture (5)	Incomplete (123)	Complete (42)	Gap (20)
CT findings (n)	No fracture (0)	0	0	0	0
	Incomplete (124)	5	117	2	0
	Complete (50)	0	6	37	7
	Gap (16)	0	0	3	13

CT indicates computed tomography; T1 VIBE, T1-weighted volumetric interpolated breath-hold imaging.

TABLE 3. Sensitivity, Specificity, and Accuracy of T1 VIBE in Diagnosing Fractures Compared With CT Scans Including the Intact Pars Articularis

	Sensitivity (%)	Specificity (%)	Accuracy (%)
Incomplete	94	99	99
Complete	74	100	98
Gap	81	99	99
Complete+gap	91	100	99
All fractures	97	100	100

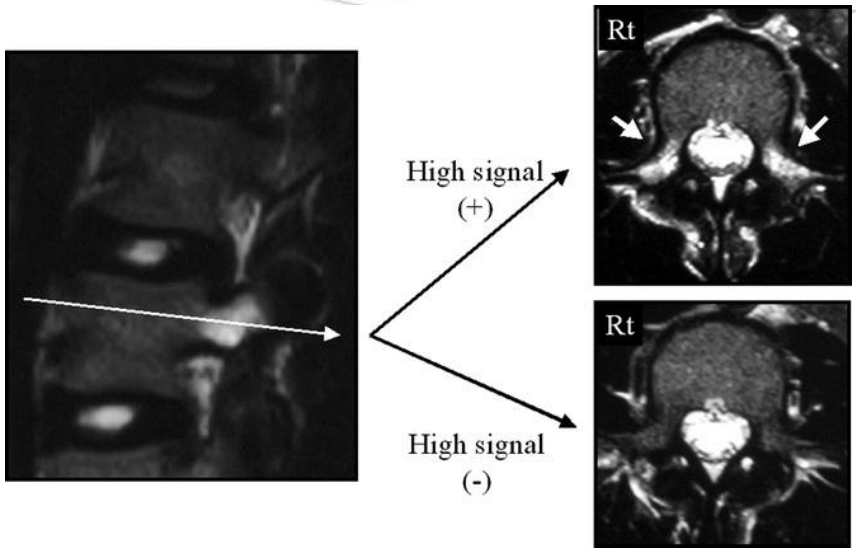
TABLE 4. Sensitivity, Specificity, and Accuracy of T1 VIBE in Staging Fractures Compared With CT Scans Excluding the Intact Pars Articularis

	Sensitivity (%)	Specificity (%)	Accuracy (%)
Incomplete	94	91	93
Complete	74	96	91
Gap	81	96	95
Complete+gap	91	98	96
All fractures	97	100	97

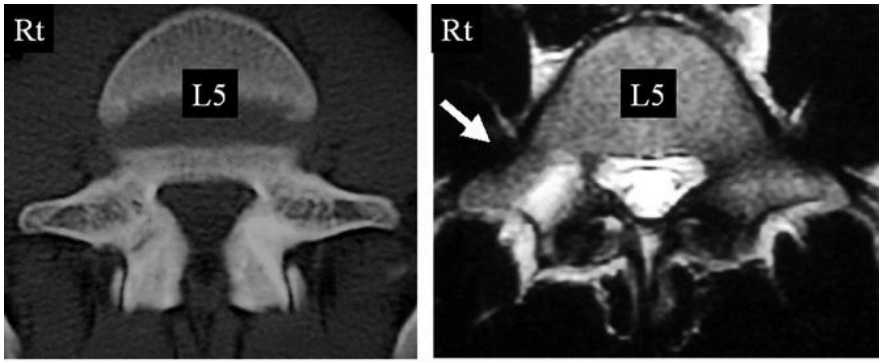
Imaging

- MRI
  - More accurate prognosis
    - Cortical edema (high signal change) in pedicle adjacent to pars = positive predictor of bony healing
    - HSC positive has higher rate of healing than HSC negative
  - Detect concurrent pathology

MR Imaging



An axial slice MR image through the pedicle. Note the difference between the high signal positive and negative images.



A case of right unilateral spondylolysis at the very early stage. Note the high signal change of the right pedicle on T2-weighted MR image.

Treatment and Management

Initial Management

- Goals:
  - Promote healing, Diminish pain, and Prevent progression
- Activity modification
- Avoid aggravating movements x 6 weeks
- Positive Predictors:
  - Unilateral, Early Stage, Lumbar level other than L5
- Negative Predictors:
  - Bilateral, complete fracture, chronic injuries

Pharmacotherapy

- Analgesia (NSAIDs, Acetaminophen)
- Interventions:
  - Pars vs Facet Joint corticosteroid injections vs RFA
- Teriparatide in professional athletes
  - Fast recovery in osteoporotic fractures but has not specifically been shown to improve spondylolysis healing
- Vitamin D supplementation

Rehabilitation

- Physiotherapy
  - Neuromuscular control targeting muscle imbalances
  - Core strengthening (TA / multifidus)
  - May lower rate of re-fracture
  - Duration: ~2 to 4 months
  - Immediate and early PT = 2 months faster recovery w/o inc AE

Rehabilitation

- Bracing
  - Controversial
  - Multiple Options: thoracic-lumbar-sacral orthosis (TLSO), lumbar-sacral orthosis (LSO), Boston Overlap Brace (BOB), and non-rigid braces
  - Duration: 1 to 16 months
  - Boston Overlap Brace Study (2002)
    - BOB + Physiotherapy = 80% RTS in 4-6 weeks
    - Successful RTP at 1 year: 89% with vs. 86% without
    - Conclusion: no affect on clinical outcome
  - Benefits: from activity restriction, not brace itself
  - Indications: Noncompliance, early defect, bilateral, timely return required

Bracing

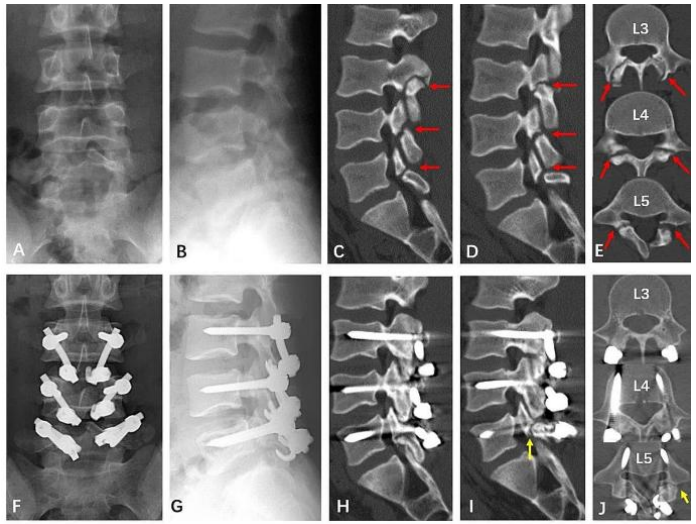
TLSO

LSO

BOB

Advanced Interventions

- Bone Stimulator (LIPUS)
  - Arima et al. 2017 - Increased bony union from 10% to 67% in those with HSC
  - Tsukada et al. 2019 - Reduced RTS time by 72% (mean 61 vs 167 days)
  - Large studies needed
- Surgery in 5% of athletes
  - Indications:
    - Debilitation pain > 6-12 months
    - Neuro deficits
    - Worsening symptomatic spondylolisthesis
  - Better clinical outcomes: unilateral and younger age
  - Direct repair vs fusion



Return to Play

Return to Play

- No consensus optimal treatment algorithm
- Prognosis: mean 4.3 months, 67-96% return to pre injury level of pain
- Image, Time, or Symptom based RTP Criteria
  - Image: Bone healing **not** associated with RTP
    - 3 month healing based on HSC
      - 64% **with** and 27% **without** pedicle edema
  - Time: Varies (2-6 months)
  - Symptom: Pain free on exam and all activity
- Defined period of rest → pain free at rest and activity → gradual return to activity → immediate cessation of activity if pain returns

Literature

ELSEVIER

The Spine Journal

Volume 22, Issue 10, October 2022, Pages 1628-1633

Clinical Study

Management of lumbar spondylolysis in the adolescent athlete: a review of over 200 cases

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- Management
  - Cessation of all sport
  - TLSO 23 hrs/day x 3 months
  - External bone stimulator
  - After brace removal
    - Follow up CT assess bone healing
    - physiotherapy x 6 weeks (core strengthening)
  - Follow up to assess response
    - Corticosteroid injection offered if severe sx + edema on MRI

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Table 1. Patient demographic and injury characteristics

Parameter	*N* (%)
Gender	
Male	139 (69.2)
Female	62 (30.8)
Laterality of spondylolysis	
Left	50 (24.9)
Right	38 (18.9)
Bilateral	109 (54.2)
Unknown	4 (2.0)
Level of spondylolysis	
L1	0 (0)
L2	3 (1.5)
L3	12 (6.0)
L4	43 (21.4)
L5	150 (74.6)
L4 and L5	12 (6.0)
Unknown	5 (2.5)

- Results
  - 98% RTS, 1 surgery
  - Orthosis vs Activity restriction?
  - Higher degree of bone healing with bone stim, ?clinically relevant
  - Treatment algorithm costly
    - Could treat without MRI, without bone stim, without follow up CT and achieve similar outcomes
  - No control group

Case Study

CASE Study

- 16F, RHD, high level hockey player, D1 Commit
- 3 month h/o intermittent LBP
- 1 month ago fell hard into the boards and developed back pain and “seizing” on right side
- Describes low level aching sometimes sharp pain prior to fall
- Back pain 1 yr prior
- Agg: ext > flex, rotation + ext
- No red flags/cauda equina sx
- Menarche at 15 (10 months ago)
  - 3 total periods
  - No restrictive eating habits
- Activity
  - Practice 2-3x/wk (1.5hr)
  - Game 2-3x/wk
  - Lift 1x/wk
  - Field hockey in the fall at school
  - T&F: triple jump, 200m, high jump

CASE Study

- XR
  - 1 year ago: normal
  - 2 wks ago CCMSU: L4-5 spondyloylsis defect and mild anterior lithesis. SIJ: possible sacroiliitis
  - 2 wks ago HSC: Grade 1 anterolithesis on L4/5 with pars defect L4
- Exam:
  - Severely reduced ROM in all directions due to pain
  - Pain with extension (~10 deg), extension + rotation, forward flexion
  - Tender to palpation of the left > right SIJ
- Plan:
  - No back bending. No skating. No high impact activity.
  - Physiotherapy for core strengthening
  - Vitamin D supplementation
  - Follow up after MRI (pending)

CASE Study

- 1 month follow up
  - MRI: mild early DDD at L4/5, L5/S1
  - Seen by another MD - told mech LBP, progress AAT
  - Inflammatory Bloodwork completed, normal
  - Exam unchanged with ++ pain on extension
  - 2nd MRI Consultation: bilateral pars defect at L4 with Grade 1 spondylolisthesis
- Plan:
  - Continue to rehab within pain free ROM
  - Skate without pain, progress as tolerated
- Progression: fu q1-2months, 6 months full RTP

Conclusion

Conclusion

- Spondylolysis is very common in the adolescent population.
- Importance of early diagnosis and intervention
- Take a detailed history
- Multi-disciplinary approach to treatment
- Time + Symptom based RTP
- Prevention as the best long-term strategy
- Future questions:
  - Role for Bone Stimulator?
  - Are we over calling these? Spondylolysis vs Pattern 2 LBP
  - Best treatment algorithm?

There is mild facet joint arthrosis affecting the mid-to-lower lumbar spine and sacrum, particularly markedly affecting L4-5, L5-S1 and S1-2. Incidental 11 mm synovial cyst projecting posteriorly into the paraspinal soft tissues from right L5-S1 facet joint, not causing neural compression.

IMPRESSION:
–No significant spinal canal stenosis or foraminal narrowing.
–Multilevel mild facet joint arthrosis, affecting the mid/lower lumbar spine, most markedly affecting L4-5, L5-S1 and S1-

References

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THANK YOU

QUESTIONS?

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