Adolescent Spondylolysis and Spondylolisthesis

Steven J. Gould, D.C., D.A.C.B.R.
Central Plains Radiologic Services
Cheney, KS.
Purpose

- Review a common but commonly unidentified/overlooked cause of back pain in adolescent athletes
- Treating chiropractors must be able to recognize the presence of this disorder, as spinal manipulative therapy may be contraindicated.

Purpose

- Update of information on this condition:
  - Classification (including a new classification scheme) M. Herman and P. Pizzutillo; Clinical Ortho. And Related Research. No. 434, pp. 46-54.
  - Incidence/Etiology
  - Diagnosis (clinical and imaging)
  - Treatment options
Classification (Wiltse)

Classification of Spondylolisthesis and Spondylolysis

Wiltse, F. C., III. M.D.

The following classification of spondylolysis and spondylolisthesis is a modification of the classification system first proposed by Maggiori in 1931. It is based on the cause of the lesion rather than on the mechanism of separation of the two segments. This classification is valuable in evaluating the true nature of the lesion and planning the type of treatment necessary.

Spondylolisthesis (Wiltse 1976)

- Type I: Dysplastic; Genetic variety of dysplasia of the neural arch
- Type II: Isthmic;
  - IIA: Lytic (spondylolysis) fatigue (stress) fx of pars,
  - IIB: Elongation of pars without separation
  - IIC: Acute pars fx; significant trauma
- Type III: Degenerative; long standing intersegmental instability
- Type IV: Traumatic; acute traumatic fracture of the neural arch, other than the pars
- Type V: Pathologic; generalized or local bone disease

Clinical Orthopedics and Related Research No. 117, June 1976
Classification

- Marchetti-Bartolozzi System
  - Developmental
    - High grade dysplastic
      - With lysis
      - With elongation
    - Low grade dysplastic
      - With lysis
      - With elongation
  - Acquired
    - Traumatic
      - Acute Fx
      - Stress Fx
    - Post-surgery
      - Direct surgery
      - Indirect surgery
  - Pathologic
    - Local pathology
    - Systemic pathology
  - Degenerative
    - Primary
    - Secondary
New Classification System

- Type I - Dysplastic
- Type II – Developmental
- Type III – Traumatic
  - Type III A: Acute
  - Type III B: Chronic
    - Stress Reaction
    - Stress Fracture
    - Spondylolytic defect (nonunion of pars)
- Type IV - Pathologic
Wiltse compared / Herman (new)

- Wiltse
  - Type II: Isthmic;
    - IIA: lytic (spondylolysis) fatigue (stress) fx of pars;
    - IIB: elongation of pars without separation
    - IIC: acute pars fx; significant trauma

- Herman (new)
  - Type II – Developmental
  - Type III – Traumatic
    - Type III A: Acute
    - Type III B: Chronic
      - Stress Reaction
      - Stress Fracture
      - Spondylolytic defect
        (nonunion of pars)

Spondylolistic / Spondylolysis

- Prevalence of spondylolysis varies depending on type and population affected.
  - 1951 study of 4200 cadaver spines showed 4.2% prevalence
    - White men (2.8%), Black men (2.8%), White women (2.3%), Black women (1.1%), Roche
  - 4.4% found in 1st grade children in New York. As the cohort group reached adulthood, incidence raised to 6%. Study also showed that spondylolysis is not present at birth, Fredrickson

Athletic populations

- As high at 47% of young athletes present to sports injury clinic with LBP, Micheli
- Rossi, retrospectively reviewed radiographs of elite athletes in Rome and found 16% prevalence of spondylolysis in athletes in general with higher rates for specific sports.
  - Divers (83%), Weight Lifters (45%), Wrestlers (33%), Gymnasts (38%), high jumpers (24%).
  - Prevalence of spondylolisthesis in these patients was 32%.
Ferguson studied back pain in college football linemen, found 24% had spondylolysis and 8% incidence of spondylolisthesis.

Soler and Calderon; found spondylolysis in 8% of Spanish athletes
- Throwing sports were highest at 27%, followed by artistic gymnastics (17%), and weightlifting (13%).
- Found higher incidence in women.

Athletic populations
CASE REPORT

Stress fracture of the thoracic spine in an elite rhythmic gymnast: A case report

Suzuki C.J., Toshiko Sakai, Hitomi Haraguchi, Akira Tsuda, Nao Takei, Aiko Nakayama, and Kotaro Sato

Department of Orthopedics, Institute of Medical Science, University of Tokyo, Tokyo, Japan. Department of Orthopedics, National Cerebral and Cardiovascular Center, Osaka, Japan.

Abstract: A 22-year-old female rhythmic gymnast presented with a 1-week history of lower back pain, without trauma. The symptoms were exacerbated by performance of certain movements in the sport, and she was unable to continue training. Spine radiographs were obtained, and a diagnosis of stress fracture of the thoracic spine was confirmed. The gymnast was advised to reduce or stop training and to use a TLSO brace for pain relief. She was able to return to full training after 3 weeks of rehabilitation.

Keywords: Stress fractures, Thoracic spine, Rhythmic gymnastics, Athletes

INTRODUCTION

Stress fractures are common in young competitive athletes and occur more frequently in the lower extremities than in the spine. Risk factors for stress fractures in young athletes include high intensity training, rapid increase in training volume, and poor technique. In the spinal region, stress fractures are more common in the thoracic spine, particularly in the upper thoracic region. They can be due to either mechanical overload or chronic microtrauma.

METHODS

A 22-year-old female rhythmic gymnast presented with a 1-week history of lower back pain, without trauma. Physical examination revealed tenderness over the thoracolumbar junction. Radiographs of the thoracic spine were obtained, showing a stress fracture at T10. The gymnast was advised to reduce or stop training and to use a TLSO brace for pain relief. She was able to return to full training after 3 weeks of rehabilitation.

REFERENCES


Figure 1.

Pain radiographs of the thoracolumbar spine showing no obvious abnormality except mild sclerosis with slight left rotational deformity at T10 (arrow).

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC48965
Athletic populations

- Jackson, studied gymnasts
- found 11% spondylolysis in asymptomatic women
  - 54% of whom had spondylolisthesis.
Lumbar spine MRI in the elite-level female gymnast with low back pain.
Bennet DL, Nassar L, Delano MC

Hypothesis is that MRI will demonstrate the same type of abnormalities in both the symptomatic and asymptomatic gymnasts.

Studied 19 Olympic Level Gymnasts ages 12-20.

RESULTS: Anterior ring apophyseal injuries (9/19) and degenerative disk disease (12/19) were common. Spondylolysis (3/19) and spondylolisthesis (3/19) were found. Focal bone-marrow edema was found in both L3 pedicles in one gymnast.

History and physical exam revealed four gymnasts with current low back pain at the time of imaging. There were findings confined to those athletes with current low back pain: spondylolisthesis, spondylolysis, bilateral pedicle bone-marrow edema, and muscle strain.

CONCLUSIONS: Our initial hypothesis was not confirmed, in that there were findings that were confined to the symptomatic group of elite-level female gymnasts.

Athletic Populations

Elliott reviewed studies of Fast bowlers and found prevalence of spondylolysis to be up to 55%.

Fast Bowlers OR Holy Rollers

WIBC'S SISTERS IN SPIRIT TAKE TO LANES

May 2004
Fast Bowlers

- Studied 10 cricketers, with lower back pain. Dx via x-ray, SPECT, and CT scan.
- 2nd and 3rd CT scans done at 3 months and 12 months after initial.
- Radiographs normal in 8 subjects, 2 had evidence of sclerosis.
- SPECT showed uptake in all subjects. CT showed No Fx in 3, Partial Fx in 3, complete Fx in 2 and old Fx bilaterally in 2.
FAST BOWLERS

- Tx; conservative via physiotherapy modalities, postural correction and specific individually graded flexibility, stabilization, strengthening and cardiovascular programs
- Complete healing was achieved in all subjects at 12 months, exception of 1 that showed near-complete union, with a small area of fibrous union at inferior border.
- 2 old bilateral fractures remained un-united.

Fast bowlers:

- a. SPECT
- b. no fx on CT
- c. partial fx
- d. union w/ sclerosis 12 mnth followup

Fast Bowlers Cont’d...

- A. sag. Partial fx
- c. significant healing at 3 mnth
- d. x-ray at initial ct show no fx

- 37
- 38
- 39
Etiology

- Repetitive Stress injury of the pars interarticularis.
- Extension/Hyperextension and Extension with Rotation.
Etiology

- **Familial tendency noted.** (Native Alaskans/Eskimos; Frequency approaches 60% in relatives of affected individual.)
- Wynne-Davies and Scott; 19% in first-degree relatives. Isthmic lesions (33%) more commonly associated compared to dysplastic types.
- Fredrickson; similar results and noted spondylolysis not present at birth.

- **Weakness from dysplastic elements.**
  - Spina bifida occulta related to spondylolysis ~ 22-92%. McTimoney and Micheli.
  - Spina Bifida occulta without spondylolysis is about 7%.
  - Gracile, thin pars in dysplastic cases.

Risk Factors for Spondylolysis

- Heredity
- Male sex
- Type of sport
  - Presence of spina bifida occulta is associated
Spondylolysis Stress Fx
Clinical presentation

- Signs and symptoms:
  - Adolescent age range, commonly preadolescent growth spurt.
  - Asymptomatic or Symptomatic, May be discounted as “growing pains”
    - Pain in low back that occasionally radiates to the iliac region, buttocks, or posterior thigh.
  - Repetitive hyperextension and rotational activities.

- Pain with running and/or jumping
- Pain relieved some with rest
- Pain may be of several months duration that changes intensity with activity changes.
- May have single episode that brings patient for care. (over the threshold from annoyance to more severe pain).

- Positive extension test of lumbar spine
- Positive “Stork Test”. Single leg standing with spinal extension (validity in ?)
- Positive “Jump or Hop Test”. Hop in place and land on flat feet or on heels with legs straight to jolt the spine.
Spondylolysis Stress Fx
Clinical presentation

Q: Differentiate stress reaction/fx vs. facet syndrome or mechanical back pain?

A:
- Imaging: Changes in posterior arch
- +/- radiographs
- edema on MRI, but +/- for pars lysis
- increased activity on SPECT
- sclerosis or lysis on CT

The use of the one-legged hyperextension test and magnetic resonance imaging in the diagnosis of active spondylolysis

Lorenzo Masci 1*, John Pike 2, Frank Malara 2, et.al.

- Conclusions: These results suggest that there is a high rate of active spondylolysis in active athletes with low back pain. The one-legged hyperextension test is not useful in detecting active spondylolysis and should not be relied on to exclude the diagnosis.
- Also concluded that MRI less sensitive compared to SPECT w/ CT

Juvenile Spondylolysis: a comparative analysis of CT, SPECT and MRI

- Conclusion: MRI can be used as an effective and reliable first-line image modality for dx of juvenile spondylolysis. However, localized CT is recommended as a supplementary exam in selected cases as a baseline for assessment of healing and evaluation of indeterminate cases.

- 14 pts (mean 12.4 yoa) unspecific activity related back pain >3 wks with normal x-rays.
- Impending spondylolysis dx by typical signal abnormalities were confined to the pars interarticularis without fragmentation.
- Brace for 3 months: MRI signal returned to normal in 6 pts. And signal changes returned to normal in 1 patient at 6 months.

MRI showed promising results in detecting and monitoring the early onset of spondylolysis.

Case: Nic H

- 16 yoa male with recent onset of LBP following running hurdles in track.
- Previous episode of LBP with right iliac crest tenderness during football season (5 mths earlier), resolved with three chiropractic care visits.
- X-rays were obtained due to recurrence of LBP, positive jumping test, positive provocative lumbar extension.

Nic H; 16 yoa athlete
Nic H; 16 yo athlete

LAO and RAO plain film radiographic images
L5 pars irregularity

T1, T2, and STIR para sagittal images
- Low signal L4 and L5 pars on T1
- High signal L4 and L5 pars on T1
- Slight increased signal L4 pars on STIR
Nic H; 16 yoa athlete
- Sequential T2 sagittal images

Nic H; 16 yoa athlete
- Sequential T2 Axial images L5/S1 – L4/L5.

Nic H; 16 yoa athlete
- T1 Axial MRI; spondylolysis
Nic H; 16 yoa athlete

Axial T2 MRI: L5 spondylolysis
Increased T2 signal at pedicles, low on T1, consistent with edema

Nic H; PA and AP Bone Scan Images
- Negative for pars uptake

Nic H; RPO and LPO
Nic H.
State qualifier for hurdles in high school track.
Tx recommendations for rest, not taken well.
Rested about 1.5 wks and returned to running, finished season, summer off.
Walk on football play two years later at Washburn University, Topeka Ks.

Dr. Stovak patient
- Athlete referred to sports medicine specialist from family practitioner with LBP and pain on extension

T1 and T2 sagittal MRI images
Dr. Stovak Patient

- MRI reported as “normal study”
- Spect images
- MRI low T1 and High T2 at left pedicle and pars interarticularis, L5.
- Spect images hot at left pedicle, L5.

SPECT study performed at Wesley Hospital:

Dr. Stovak/Lieu Patient #2
Dr. Stovak/Lieu Patient #2

- **T1, T2, IR**
  - Right side

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**Axial images above and below L5 pars**

- Order Axial slices as “stacked” or contiguous to ensure inclusion the pedicle and pars regions.

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**SPECT Exam**

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Bone scan - 2 dimensional
- SPECT is more sensitive due to removal of overlying anatomy.

- Bone window CT
  - L5 left pars defect

- Questionable defect at left pars of L5
Plain film radiography

- AP and Lateral projections are minimum study.
- Optional projections include oblique projections and tilt up lumbosacral spot projection will yield higher sensitivity to find pars defects.
- Approx. 20% of pars defects noted on plain film are seen on oblique projections only. (Standard, Herring, Evidence Based Sports Med, 2003)
- "Absence of this finding (break in Scotty Dog neck) cannot rule out spondylolysis as it (lumbar oblique projection) detects the pars lesion in only 32% of cases (Saifuddin, White, Tucker, Taylor. Orientation of lumbar pars defects. JBJS 1998.

Pathogenesis of sports-related spondylolisthesis in adolescents: radiographic and MRI study.

- Why slippage advances?
  - Factors may include: age, sex, initial degree of slippage, angle of slippage, rounded S-1, lumbosacral spina bifida.
  - Slippage progress more frequently during adolescent growth spurt.
  - Controversy as to importance of L5 wedging and sacral rounding.
Pathogenesis of sports-related spondylolisthesis in adolescents: radiographic and MRI study.

- Wedging of L5 vert. Body and rounding of the sacrum progressed as the slippage developed. These changes did not occur in non-slip patient group. Therefore, the deformities are secondary to slippage.

Radionuclide Bone Scan/SPECT

- Standard two dimensional radionuclide bone scan is not adequate. With availability of Single Photon Emission Computed Tomography (SPECT), SPECT should be included with the nuclear scan.
- SPECT has higher sensitivity and specificity than standard bone scan, due to planar imaging that separates overlying structures.

MRI

- Early study by Saifudde and Burnett reported admittedly poor results with MRI.
  - Study used TR=500 msec, TE=20 msec. Sino slices with 1 mm interp. interval were assessed upon the sagittal images and were unable to visualize the pars in 26.5% of cases.
- Thick slices and wide interspace intervals were identified as factors that could be modified to decrease the number of false positives. (reported in McTimoney and Micheli. Current Evaluation and Management of Spondylolysis and Spondylolisthesis, Current Sports Med. Reports, 2003).
Udeshi and Reeves:

- Used 3-mm thick slices T1 axials with 3-mm interimage gap. Achieved 98.2% accuracy in assessing the pars on T1 and 93% accuracy on T2 weighted images.
- 4% rate of abnormal findings for the pars in both the T1 and T2 data sets.

They emphasized that the aim of the study was to assess adequacy of visualization of the pars by MRI, not sensitivity/specificity of MRI for DX of spondylolysis.

MRI protocol for Spondylolysis

- Standard protocol at some imaging centers includes only:
  - T1 and T2 sagittal images
  - T2 axial images through the disc spaces

- Must include consecutive (stacked) axial T2 slices to visualize the pars interarticularis and the pedicles. Otherwise spondylolysis is not shown on axial exam.
- Inversion Recovery sagittal images are useful for sensitive evaluation of marrow edema.

MRI Grading System

- Stress Reactions of the Lumbar Pars Interarticularis. The Development of a New Classification system.
  - Show PDF file of Spine article.
MRI Grading System


MRI Grading System

- 3-mm slices, 0.5-1.0-mm inter-image gap
- Pts. with sports related back pain.
- Working DX of spondylolysis.
- Grading system applied
  - Grade = 0 = normal, no signal abnormalities
  - Grade = 1 = T2 signal changes consistent with edema, but no lysis. (with or without pedicle and/or facet signal changes)
  - Grade = 2 = T2 signal abnormalities and thinning, fragmentation, irregularity of the pars visible on T1 and/or T2 weighted images.

MRI Grading System

- Grade = 3 = Visible complete unilateral or bilateral spondylolysis and associated T2 abnormal signal.
- Grade = 4 = Cases of complete spondylolysis without abnormal T2 signal. Representing old, ununited fractures of the pars.
- Normal pars interarticulars above or below the abnormal level as an internal control.
- Study looked at 55 subjects with sports related back pain, 28 females and 27 males. Primarily gymnastics and baseball activities.
MRI predictive of healing

- Japanese study: 32 pts with suspected spondylolysis (27 male, 5 female, 10-17 age range)
- CT and MRI done.
  - CT categorized into four stages:
    o Very early (Faint partial hairline fx, unclear)
    o Early (obvious defect)
    o Progressive (larger fx without sclerotic mar.)
    o Terminal (fragmentation, sclerosis, pseudarth)
  - “All eight very early defects and 17 early defects showed high signal in the pedicle. Even unclear defects on CT, clearly indicated abnormal findings on MRI.”
  - Half of 16 progressive defects and none of the terminal defects showed high signal at the pedicle.

MRI predictive of healing

- Japanese study; cont’d…
  - Tx: activity modification and soft corset
  - All very early defects, 82% of early stage, and 25% of progressive defects demonstrated bony healing. None of the terminal defects healed.


- 37 ped. Pts with spondylolysis
- 68 defects examined, staged and recorded on CT
- High Signal Changes (HSC) on MRI compared with CT stages.
Sairyo K, Katoh S, Takata Y., et al

16 pts tx conserv. 15 boys / 1 girl at least 3 months

Results:

CT staging: 8 very early, 24 late-early, 16 progressive, and 20 terminal.

All very early and late early showed HSC on T2 MRI.

50% of progressive showed HSC on MRI

0 of terminal showed HSC on MRI

TX: 16 pts with 29 defects >> 19 had HSC and 15 showed bony healing (79%).

None of the 10 negative HSC defects showed healing.

Current Standard of Care

- Plain radiographs; evaluate for obvious defects in pars
- SPECT bone scan; to evaluate for “active” spondylolysis
- lysis or stress reaction in nonfractured pars.
- Computed tomography; to evaluate status of pars. No fx, acute fx, fx with sclerosis, or fx without sclerosis.
- MRI; for questionable exams. Evaluate disc changes, and signal changes in posterior elements.

Imaging cont’d…

- Dr. Gould opinion;
- MRI is becoming and will become the gold standard for imaging the pars interarticularis stress fx/ stress response question.
- No radiation. Reliable follow-up exam.
- Prediction of healing by pedicle signal changes.
Spondylolisthesis Treatment (Wiltse)

These are different patients than the athlete with spondylolysis

- 1. Up to 25% slip in an asymptomatic child; observe with standing radiograph initially every 6 months until age 15, then annually until end of growth; no limitation of activity, but should avoid occupations involving heavy labor
- 2. Between 25%-50% slip in an asymptomatic child: same as #1, avoid contact sports or sports with lumbar extension.

Treatment

- 3. Less than 50% in a symptomatic child; non-operative therapy including physical therapy brace, and activity modification, in addition to recommendations of #2.
- More than 50% slip in a growing child with or without symptoms should be treated surgically. (McTimoney, and Micheli, current sports med. Reports 2003)

Treatment of spondylolysis

- Primary goal of treatment is to achieve a stable, pain free union of the fracture.
- Bony union is preferred. However, some authors have deemed acceptable, a stable, pain free fibrous union.
- D’Heercourt, et al Spondylolysis; returning the athlete to sports participation with brace tx.
- Tx 73 adolescent athletes with Boston overlap brace.
- Returned to activity at 4-6 weeks.
- 80% good to excellent clinical outcome.
Treatment of spondylolysis

- Pain: refrain from activities that provoke pain for 4-6 weeks.
- Activity modification; eliminate hyperextension.
- Physical therapy; hamstring flexibility and deep abdominal muscles with coactivation of the multifidus proximal to the defect.

- Bracing: If no progress from initial program or pain worsens, then bracing with thoracolumbosacral orthoses.
- Immediate vs. delayed bracing controversial
- Brace no more than 6 months
- If no union and still symptomatic; surgery may be option.

“Warm and form” brace used by Sport Med. Fellows at KU med.
Treatment/ Gould’s thoughts

- Tx and return to play decisions are on a case-by-case basis.
- Tx may depend on the stage of the pars lesion at diagnosis. Patients with only edema reaction on MRI or SPECT and no defect, then may respond to activity limitation better than those with a frank defect in the pars.
- Those with no edema signal on MRI or uptake on SPECT are not likely to unite and bracing may not be warranted, unless at risk for spondylolisthesis (slippage) progression.

Core Rehab: Bird Dogs

- Active paraspinal myo (multifidi) in quadrants (right upper and left lower) (shown), then alternate.
- Bird dogs are less stressful than the prone-two arm “super-man”, because the “Bird-Dog” lessens the compressive forces to the spine. (MacGill).

Bird Dog
Core Rehab: Planks

- Beginner: Knees and forearms

More advanced: forearms and toes

- Plank type exercises force the contracture of the “muscular girdle” of the abdomen without compressing the spine.
- Side planks contract the internal oblique abdominal muscles to better advantage.
- Transverse abdominous and rectus abdominous muscles are contracted with the standard plank position.
- All the plank postures work the deep spinal muscles.
- Side Plank – internal obl.
- Curl-up – Rectus Abd.

Cat-camel - warm up exercise.
Runner with LBP -- 54 yoa

T2 weighted images

T1 weighted, parasagittal images.
Edema signal with HSC in posterior elements
- Modic type I marrow changes with facet arthrosis vs. Edema from stress fracture.
- Edema in bone indicating stresses leading to fracture. Different stress mechanism vs. adolescent athlete.
- There is evidence of pars rupture as a result of advancing facet arthrosis with degenerative spondylolisthesis.
LBP  male age 13
- Increased T2 signal in Left L5 pars
- Decreased T1 signal in Left L5 pars

Pedicle / pars edema left at L5
- T2 axial image
L5 pedicle edema bilaterally (left shown)

Volleyball player: 14 year old female.

L5 pedicle edema bilaterally (right shown)

Facet sclerotic changes in a 14 yr. Old?
Axial cuts only at disc levels.
No inversion recovery images.
LBP Male age 13

- Large Anterior Inf. Schmorl’s Node at L1 and anterior superior nodes at L2 and L3

54 yoa male

- Mid sagittal T2 grade one spondylolisthesis L5 on S1
- Parasagittal T1 and T2; spondylolysis
- T12 hemangioma with increased signal on T1 and T2.

54 yoa male

- No edema at pars on T2 image
- Spondylolysis is long standing
Summary

- Stress reaction/fracture of the pars and posterior elements is a common condition in adolescents.
- Treatment with CMT is not indicated in the “Active” phase when MRI shows edema. Chiropractors must keep this diagnosis in the forefront when working with adolescent patients with back pain.