Instructional course lecture: Spondylolysis

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Introduction

Spondylolysis is a defect of the pars interarticularis of the vertebral arch. Its cause is often multifactorial but mostly thought to be as a result of a stress fracture. Most fractures occur at L5 (71%–95%) and L4 (5%–23%).[1]

Key words: spondylolysis, pars fracture, imaging, management

Incidence

The general population incidence is 6%.[1] Most studies have reported ethnic and sex differences.

Skeletal studies: Roche *et al.*[2] found a white male incidence of 6.4%, white women 2.3%, African-American men 2.8% and African-American women 1.1%. Eisenstein[3] looked at South African skeletons and found a general population incidence of 3.5% (white males 3.8%, white women 5.7%, African men 3.5% and African women 2.6%). In contrast, indigenous residents of Greenland were found to have an overall incidence of 54% (men 61.9%, women 48%).[4]

Radiographic studies: Fredrickson *et al.*[5] looked at 500 unselected first-grade children prospectively with plain radiographs and found an incidence of 4.4% spondylolysis at 6 years which increased to 6% in adults. Other studies reviewed large numbers of radiographs (Sonne-Holm *et al.* 4 001 Canadian adults; Amato *et al*. 1 500 plain radiographs) with an incidences of 4.6% and 3.7% respectively.[6,7]

Japanese studies of 2 000 subjects (age 20–92 years) with CT for non-lumbar conditions found lumbar spondylolysis 5.9% and male:female ratio of 2:1.[8]

Other CT studies in unselected populations reported a 5.7–11.5% incidence of spondylolysis.[9,10]

Familial incidence

Most studies suggest a genetic component to spondylolysis.

Fredrickson *et al.*[5] found a 32–34% incidence in family members. Albanese[11] reported on 70 patients and 222 first-degree relatives with a 22% incidence. Other authors reported up to 70% incidence in first-degree relatives.[11-13]

Spondylolisthesis and sport

The association of spondylolysis with sport is well documented. Athletes have a much higher incidence than non-athletes, with certain sports being particularly high risk.

The incidence of spondylolysis was found to be 11% in female gymnasts (Jackson *et al.*[14]) College football players had a 20.7% incidence of spondylolysis (Semon and Spengler).[15]

Akimoto[16] looked at 1 966 unselected adolescents with plain radiography and found 10.3% in athletes and 3.2% in non-athletes.

Ohba[17] found reported on 536 Japanese athletes with lower back pain, with a 32.3% incidence.

Micheli and Wood[18] found 47% of young athletes with lower back pain had lumbar spondylolysis.

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Skeletal and neuromuscular conditions

Spina bifida occulta has an increased incidence most probably due to genetic factors, not mechanical predisposition.

Osteogenesis imperfecta does not seem to have an increased incidence of spondylolysis (5.3%).[19]

Osteopetrosis has been found to have as high as 71.4% incidence of spondylolysis.[20]

Scheuermann's disease has been reported having an incidence of 32–50% possibly due to compensatory lumbar hyperextension.[21,22]

Scoliosis Fisk *et al.*[23] found a 6.2% incidence in 539 patients with idiopathic scoliosis. However Seitsalo *et al.*[22] reported on 190 young patients with an incidence of 44%.

Cerebral palsy: Athetoid cerebral palsy has been associated with a 60% incidence spondylolysis.[24] Takada *et al.*[25] found 48.6% spondylolysis in non-ambulatory cerebral palsied patients.

Lumbar spondylolysis by all accounts appears to be a stress fracture and this was proposed by Wiltse *et al.*[26] in 1975. Supporting the stress fracture theory are findings that it is more common in athletes with repetitive trunk movements, especially repetitive hyperextension and rotation. It is common in patients with involuntary trunk movements such as athetoid cerebral palsy. Radiologically it behaves similarly to a stress fracture in long bones. It is not detected in foetuses, infants and non-ambulatory patients.

The two proposed mechanisms are:

1. Repetitive extension stresses (nutcracker mechanism) with the inferior articular process of the cranial vertebra impacting the pars interarticularis of the caudal vertebra. Biomechanical studies found greatest loading with flexion/extension at L5/S1 and the highest mechanical stresses occurring at the pars interarticularis.[27]
2. Pars failure through a tension mechanism.[28-31]

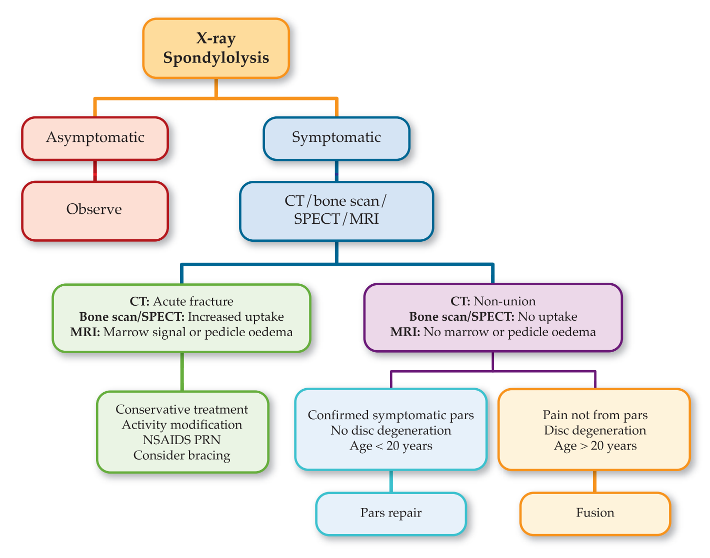
Natural history

Spondylolysis is almost never present at birth. It develops in early school-age years (4.4% incidence) and gradually increases to the adult incidence of 6%.[5] Concerns are that the defect predisposes individuals to the development of lower back pain and progression to spondylolisthesis.

Spondylolisthesis has a benign course. The general incidence of 6% does not change with increasing age from 20–80 years and the overwhelming majority of cases are asymptomatic. There does not appear to be a significant association between the presence of spondylolysis and lower back pain (LBP) in the general non-athletic population.

Athletes with back pain, however, present with an increased incidence of spondylolysis. Micheli and Wood[18] reported 47% spondylolysis in a sports medicine clinic in adolescents compared with 5% of the adult control population. Thus it is in young athletes that painful spondylolysis is particularly a problem.

Algorithm for spondylolysis



Another concern with spondylolysis is the risk of progressive spondylolisthesis. Unilateral pars defects are usually inconsequential. Bilateral pars defects may progress to slip; however, the risk of progression is small in most studies. Only about 4% of pars defects tend to progress to significant slips of more than 20% over several years. The propensity to slip correlates with the adolescent growth spurt and decreases with age over 16 years.[5] Slip progression in child and adolescent athletes has shown similar rates to the general population. Muschik *et al.*[32] reported only one in 86 patients progressing more than 20%, and concluded that there was no increased risk with active sports participation.

Clinical presentation

Most people have radiographic spondylolysis with few or no clinical symptoms. In children the most common identifiable cause of lower back pain is spondylolysis.

Symptoms include lower back pain with or without radiation to the buttocks and posterior thigh. The pain may be exacerbated by spine hyperextension. Often insidious, there may be a history of an acute injury in 40%.

Examination may demonstrate hyperlordosis, localised tenderness, decreased range of lumbar extension and hamstring tightness. The Stork Test is a provocative test combining extension of the lumbar spine with side flexion and rotation, while standing on the leg of the symptomatic side. Neurological examination is usually normal but occasionally the spondylolysis may cause root irritation.

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Imaging

X-rays: Standing AP and lateral views are the usual screening investigations when evaluating lower back pain (*Figure 1*). Oblique films may demonstrate the classic 'Scotty dog neck' which is pathognomonic of a pars fracture with a broken neck or collar. Twenty per cent of pars defects are only shown on oblique films (*Figure 2*).

Bone scan and SPECT: Bone scan and SPECT show increased sensitivity over X-rays; however, their specificity is often low. They do have prognostic value whereby a 'cold scan' of a radiological pars fracture represents a non-union and a positive scan represents active healing or healing potential.

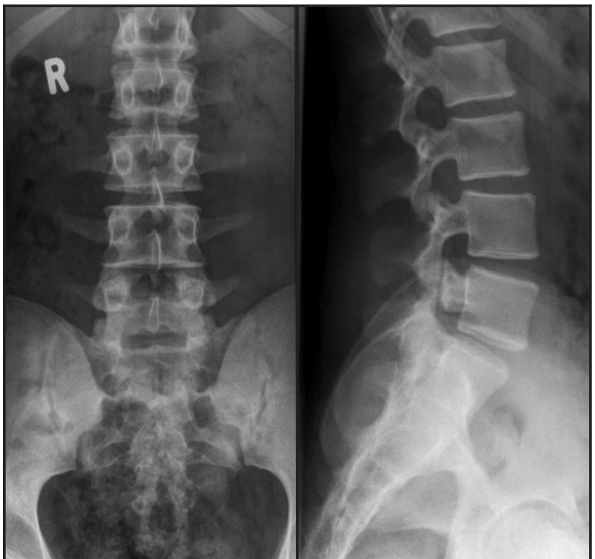

Figure 1. Standing AP and lateral views are the usual screening investigations when evaluating lower back pain

CT scan: CT is significantly more sensitive than plain radiography (*Figure 3*) and provides information about the nature of the defects as well as demonstrating other pathology causing LBP. CT can help differentiate between an acute fracture or a chronic fracture with little healing potential. CT is valuable to assess healing on follow-up scans.

MRI scan: MRI is increasingly used in the diagnosis of lower back pain. Thin slice MRI has been shown to have sensitivity of 57% to 86% and specificity of 81% to 82%. Furthermore MRI has prognostic value with marrow oedema and signal changes in adjacent pedicles representing an acute or sub-acute fracture with healing potential. MRI may also detect a pars stress response before fracture occurs.

Non-operative treatment

The mainstay of conservative management is activity restriction. Non-steroidal anti-inflammatories are used for analgesia as required. The pain-producing sporting activities need to be restricted and active competition stopped for 4–12 weeks.[33-35] Athletes need to be pain-free with full range of spinal motion before returning to active competition.

Bracing is controversial and no consensus exists. There are multiple bracing regimens available with rigid and non-rigid braces. It is possible that bracing simply enforces rest rather than providing structural stability. Brace compliance is also problematic. Rest and activity restriction are more important than bracing in the conservative management of spondylolysis.[36]

Bone stimulators have been used in some studies but further trials are needed to evaluate them.

The mainstay of conservative management is activity restriction

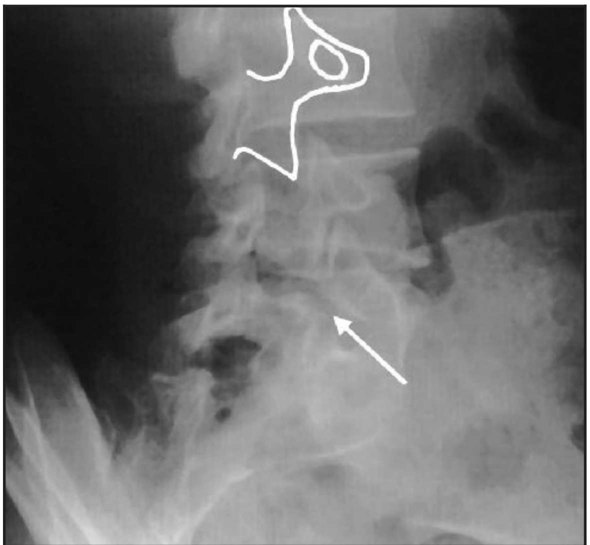

Figure 2. 'Scotty dog' as seen on oblique films

Figure 3. CT scan of pars defect

Figure 4. Bucks screws

Figure 5. Pars repair with pedicle screw and sublaminar hook

Bracing is controversial and no consensus exists

Outcomes

About 75% to 100% of acute lesions heal. L5 lesions are the least likely to heal. All unilateral acute lesions heal and up to 50% of bilateral acute lesions heal. Chronic pars defects remain as a non-union.

Most patients do well on conservative treatment and more than 90% return to their previous activity levels. It is debatable whether radiological evidence of union is required as most non-unions are asymptomatic.[37]

Operative treatment

Surgery is indicated with failed conservative treatment after 9–12 months. The standard operation which has been extensively reported with good-to-excellent long-term results is the L5–S1 posterior uninstrumented fusion with posterior iliac crest bone graft.[38-40] This does however sacrifice motion segments in young patients who are often sportspeople.

Fixation

Pars fixation has the theoretical advantages of motion segment preservation and adjacent level protection.

For spondylolysis repair, the pain should be isolated to the lysis which can be confirmed with local anaesthetic injections. A degenerate disc, more than 3 mm spondylolisthesis or patient age over 20 years are relative contraindications to pars repair.

Numerous techniques exist, including interfragmentary fixation, tension band constructs, pedicle screws and hooks. None has any clear advantages in outcomes and choosing a technique is a matter of personal preference, technical ease of hardware placement and lowest risk of complications. Buck screw technique is popular (*Figure 4*) but when there are deficient posterior elements a pedicle screw-sublaminar hook construct (*Figure 5*) may be employed. More importantly, a thorough debridement of the fibrous defect and bone grafting is required.

Post-operative bracing for six weeks helps restrict activity to allow union. Pars repair has shown 84% return to sports activity after 5–12 months.[41]

Important points:

- Spondylolysis is a common condition and the majority of cases are asymptomatic.
- It is caused by repetitive micro-trauma in the growing spine.
- In symptomatic spondylolysis, rest and activity modification are usually successful.
- A chronic symptomatic spondylolysis may be directly fixed if the patient is young and there is no secondary disc degeneration.

Fusion

When there are relative contraindications to pars repair, posterior fusion is the gold standard.

In-situ posterolateral arthrodesis via the Wiltse muscle-splitting approach has yielded good-to-excellent results in up to 75% to 100% of cases.

The advantage of instrumented fusion in spondylolysis is unclear. There are no studies showing an advantage for instrumented fusions in this young patient group. Instrumentation is generally less necessary in the paediatric population for spondylolysis since they have higher fusion rates and the spine is inherently stable. There may be a role for instrumentation in the older patient especially if a decompression is indicated. Instrumentation may prevent the need for post-operative immobilisation and bracing. The choice of approach and instrumentation remains the surgeon's choice; in general posterior pedicle screw fixation should be adequate.

When considering fixation vs fusion, it is worth considering the findings of Schlenzka *et al.*,[42] who found no advantage of repair over segmental fusion after 15 years.

Post-operative activity restriction is for three months with return to contact sport after one year when there is full pain-free range of motion.

Outcomes

The functional return to pre-morbid sporting level is not known. Most athletes will return to some level of sporting activity and 20% of patients do not return to full contact sport.[43,44]

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