

*Ministry of Defence*

## **Synopsis of Causation**

### **Spondylolisthesis (incorporating Spondylolysis and Spondyloptosis)**

Author: Dr Tony Woolfson, Medical Author, Medical Text, Edinburgh  
Validator: Professor Sean P F Hughes, Charing Cross Hospital, London

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## **Disclaimer**

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This synopsis has been completed by medical practitioners. It is based on a literature search at the standard of a textbook of medicine and generalist review articles. It is not intended to be a meta-analysis of the literature on the condition specified.

Every effort has been taken to ensure that the information contained in the synopsis is accurate and consistent with current knowledge and practice and to do this the synopsis has been subject to an external validation process by consultants in a relevant specialty nominated by the Royal Society of Medicine.

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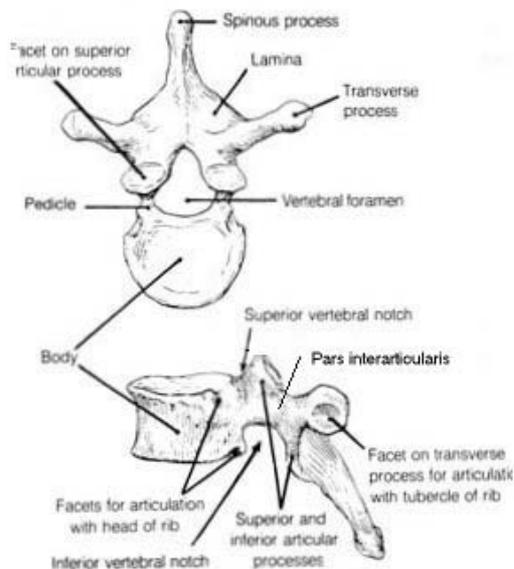
# 1. Definition

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- 1.1. **Spondylolisthesis** is defined as the forward slippage (subluxation) of a vertebra on the one below. The most common sites for this are the 4<sup>th</sup> lumbar vertebra (L4) on the 5<sup>th</sup> (L5), and the 5<sup>th</sup> lumbar vertebra on the sacrum. Spondylolisthesis can occur with or without spondylolysis.
- 1.2. **Spondylolysis** refers to the presence of bony defects in a [pars interarticularis](#) of the [neural arch](#) of a vertebra. These may be [unilateral](#) or [bilateral](#).
- 1.3. **Spondyloptosis** is the most severe form of spondylolisthesis, in which the body of L5 has slipped so far anteriorly that it is lying in front of the sacrum.

**Fig 1. Normal vertebral anatomy**

(Schema to illustrate parts referred to in text)



## 2. Classification

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- 2.1. **Anatomical/aetiological classifications.** Spondylolisthesis may be developmental ([dysplastic](#)) or acquired. The classification by Wiltse, Newman and McNab divides spondylolisthesis into dysplastic, isthmic, degenerative, traumatic and pathological types.<sup>1</sup>

**Table 1. Types of spondylolisthesis (Wiltse, Newman and McNab)<sup>1</sup>**

Type I	Dysplastic		
Type II	Isthmic	a. Lytic	Slip associated with a displaced pars intervertebralis
		b. Elongation	Repeated pars stress fractures have healed with elongation and attenuation. A defect may not be present
		c. Acute fracture	Rare
Type III	Degenerative		
Type IV	Traumatic		
Type V	Pathological		

Although widely accepted, the above classification is confusing because it combines anatomical and aetiological elements.

- 2.2. The classification suggested by Marchetti and Bartolozzi is based on aetiology alone and seems more rational.<sup>2</sup> It may, however, also be confusing in that the lysis which occurs in the neural arch of patients with congenital bony abnormalities is, strictly speaking, acquired. It divides spondylolisthesis into two main groups as follows:

2.2.1. **Developmental.** This is further divided into **high dysplastic** and **low dysplastic**, depending on which set of facets is involved. There are congenital abnormalities of the facets such that the vertebra is not held in place solidly by bony structures, so it may slip forward on upright stance or movement. In either type [lysis](#) may occur as a result of stresses on the bone with movement, and this may lead to elongation of the arch.

2.2.2. **Acquired.** There are four main subdivisions:

- **Traumatic.** Includes acute injuries and stress fractures
- **Post-surgical.** Made up of direct (from excessive removal of both facet joints) and indirect (usually immediately above a spinal fusion) types

- **Pathological.** Divided into local pathology (e.g. malignant) and systemic pathology (e.g. metabolic bone disease, Marfan's syndrome or osteogenesis imperfecta)
- **Degenerative.** Defined as primary (intact bony arch with degeneration in the disc and the [facet joints](#)) and secondary (adjacent to non-surgically fused segments)

2.3. **Radiological classification.** The original Meyerding classification graded the amount of anterior slippage as Grade I (0-25%), Grade II (25-50%), Grade III (50-75%), Grade IV (75-100%) and Grade V (greater than 100%).<sup>3</sup> While this is helpful, particularly with lower grade abnormalities, it fails to take into account other important aspects of displacement, such as slip angle, [sacral inclination](#) and degree of [vertebral wedging](#) (lumbar index), and particularly the [kyphotic](#) component, which plays a major part in narrowing the spinal canal. These displacements and their measurement have been fully described by Boxall and colleagues.<sup>4</sup>

## 2.4. Epidemiology

2.4.1. **Developmental** spondylolisthesis (dysplastic, with or without spondylolysis) almost always occurs at the lower end of the lumbar spine, primarily between L5 and the sacrum. Spondylolysis is never present at birth, but results from abnormal stresses on the bone of the neural arch, resulting from failure of the bony structures to maintain vertebral stability. By the age of 5 years, the prevalence is approximately 5%,<sup>5</sup> rising to approximately 7% in adult life.<sup>6,7</sup> Most Grade IV and V spondylolistheses occur during the adolescent growth spurt,<sup>8</sup> or during pregnancy.<sup>9</sup> Spondylolysis can also occur in anatomically normal vertebrae in athletes.

2.4.2. **Acquired** spondylolisthesis with slippages occurring after the age of 20 years tends to be more stable and less symptomatic. **Degenerative** spondylolisthesis occurs later in life, usually after the 5th decade and most commonly at the L4-5 level, and is associated with changes in the [articular facets](#) rather than in the pars interarticularis. There may be compression of the spinal canal, leading to spinal stenosis, but the degree of slippage is normally limited by the intact neural arch. **Traumatic** spondylolisthesis from high impact fracture-dislocation with fracture of the pedicle or posterior arch can occur at any age and always requires immediate surgical stabilisation. **Post-surgically**, spondylolisthesis can occur following removal of the posterior structures, including part or all of both the facet joints. **Pathological** spondylolisthesis is uncommon and symptoms are variable.

### 3. Clinical Features

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- 3.1. **Anatomical deformity.** In patients with spondylolysis only or with little slippage, there is no detectable deformity. With greater degrees of subluxation, spinal deformity becomes increasingly obvious. The pelvis rotates posteriorly, producing lumbar [kyphosis](#). The [gluteal](#) muscles become less prominent and the posterior parts of the iliac crests more protuberant. In patients with spondyloptosis, shortening of the lumbar spine is visible and a skin crease appears across the abdomen.
- 3.2. **Symptoms.** Most patients with spondylolysis are asymptomatic.<sup>10</sup> The association of low back pain with milder grades of spondylolisthesis is not strong, although statistically significant in women, in one study.<sup>11</sup>
- When symptoms occur, they are attributable to muscle contraction and spasm, as the body tries to limit movement around a painful pseudarthrosis of the pars interarticularis, a tear in the [annulus fibrosus](#) of an intervertebral disc, or compressed spinal nerve roots
  - Children and young adults with significant vertebral slippage often complain of pain in the back and in the hamstrings on movement, particularly extension of the back. This is due to chronic contraction of the paraspinal muscles. After months of chronic spasm, fixed [contractures](#) may develop, which limit forward bending and hip flexion. There may be tenderness over a fracture of the pars interarticularis
  - In older people with degenerative disease, episodes of the back “giving way” may occur, possibly associated with [sciatica](#) due to nerve root compression. In severe cases with compression of the spinal canal, there may be bilateral leg symptoms and occasionally problems with bowel and bladder function

## 4. Aetiology

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4.1. **Developmental spondylolisthesis.** There are two basic processes that play a part in developmental spondylolisthesis, **dysplasia** and **traumatic damage**.

4.1.1. **Dysplasia** is associated with a congenital defect in the *hook* or *catch* that normally link the vertebrae.

- The *hook* is made up of the pedicle, pars interarticularis and the inferior articular process of the higher vertebra, and the *catch* is the superior articular process of the one below. Slippage may happen as the weight of the trunk and head bears on the area during upright stance because of deformation or stretching of the ligaments, or the disruption to the intervertebral disc when the *hook* and *catch* no longer function properly
- Various changes may occur, including alterations in shape of the vertebrae, rounding of the front of the superior part of the sacrum, decrease in the inclination of the sacrum (becoming more vertical), and kyphosis of the involved part of the spine
- There is evidence of a genetic predisposition to this type of defect, but no Mendelian pattern has been established

4.1.2. **Repeated trauma** from excessive stresses on the neural arch in patients with congenital bony abnormalities may result in fractures of the pars interarticularis. The bone of the pars is hard, and is vulnerable to fatigue fractures and to difficulties in healing. The result may be non-union, which produces elongation of the neural arch, allowing subluxation of the vertebra. This in turn can lead later in life to increased stresses on the intervertebral disc, with consequent degeneration of the disc and possible disc prolapse. It can also lead to reactive changes in the ligaments surrounding the vertebra.

4.2. **Acquired spondylolisthesis**

4.2.1. **Degenerative spondylolisthesis** results from changes in the intervertebral disc and facet joints, which can occur with ageing. The slippage is usually mild (Grade I) because it is limited by the intact neural arch. There is no evidence that any particular activities such as heavy manual work are associated with spondylolisthesis, although there is a relationship between spondylolisthesis and back pain.

4.2.2. **Traumatic spondylolisthesis.** **Direct severe trauma** may cause fracture dislocations. Trauma from frequent rapid marked flexion and extension of the spine in young people may cause **stress fractures** in a (normal) pars interarticularis, which may fail to heal properly if the activity continues.

- This type of damage to the neural arch is seen in athletes who train and compete regularly, usually those whose sport involves repeated extension of the spine (pole vaulting, gymnastics, wrestling, diving, fast bowling in cricket, and football). Back pain is more common in those with radiological

abnormalities than in those without.<sup>12</sup>

- Back pain is probably more common with occupations involving heavy manual lifting, although this has not been conclusively proven.<sup>13</sup> There is no evidence linking spondylolisthesis with heavy lifting of any type
- Carrying a rucksack produces a vertical load on the spine and is unlikely to lead to spondylolisthesis
- Parachuting causes severe acute stresses on the spine, and radiological changes are relatively common. In one study of army parachuting instructors, spondylolysis was found in 14% and spondylolisthesis in 3%.<sup>14</sup> There was no correlation in this study between the severity of the radiological changes and the presence or severity of back pain, so it is difficult to relate parachuting causally to symptoms

4.2.3. **Post-surgical spondylolisthesis.** Surgical laminectomy with removal of or damage to both facet joints can result in instability and subluxation. This is an inherent risk of the procedure.

4.2.4. **Pathological spondylolisthesis. Systemic** (e.g. metabolic bone disease) or **local** (e.g. metastatic cancerous deposits) pathological changes in the skeleton predispose to pathological fractures in the neural arch.

## 5. Prognosis

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- 5.1. The vast majority of patients with radiographic evidence of spondylolysis have no symptoms, and do not progress to a point where vertebral slippage occurs.<sup>15</sup>
  - In 90% of adolescents with spondylolysis and spondylolisthesis who present at the time of the slippage, the only prognostic factor for clinically significant progression is the amount of subluxation at presentation<sup>16</sup>
  - It is probable that once sufficient damage has occurred to the neural arch, ligaments or intervertebral disc, slippage will occur and may well progress
- 5.2. Acquired spondylolisthesis developing in early adult life tends to remain stable.<sup>17</sup> In athletes with stress fractures of the pars interarticularis, continuing activity has little effect on healing or progression<sup>18</sup> although in more severe cases, rest and even immobilisation may be required so that healing can proceed.
- 5.3. Degenerative spondylolisthesis in later life tends to be relatively stable because of the intact neural arch, but spinal canal compression can occur. The orientation of the facet joints may have some influence on prognosis. With post-surgical and pathological spondylolisthesis, each case needs to be evaluated according to the anatomical abnormality and to the nature and severity of the symptoms.

## 6. Summary

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- 6.1. Spondylolysis and spondylolisthesis of developmental origin are found in approximately 5% of children and 7% of young adults. These result from non-union of stress fractures of the pars interarticularis of the vertebral arch resulting from abnormal stresses on the vertebrae. The neural arch can become angled or elongated.
- 6.2. Most patients have no symptoms and their condition remains stable. Those with more severe abnormalities may progress and require further investigation and sometimes surgical treatment in the form of bony fusion.
- 6.3. There are a number of causes of acquired spondylolisthesis which occur in adult life. These are usually also stable in nature. Athletes may sustain stress fractures of the neural arch without displacement, which may or may not prevent continuing activity. Degenerative changes in the intervertebral discs and ligaments are very common and occur later in life. They may be partly related to occupation. Although the degree of displacement is limited by the intact neural arch, some patients develop nerve root or spinal canal compression.
- 6.4. High-energy trauma can cause spondylolisthesis as a result of fracture-dislocation of the vertebrae. Surgical stabilisation is always required, since the spine is inherently unstable.
- 6.5. Post-surgical and pathological spondylolisthesis need to be evaluated on an individual basis.

## **7. Related synopses**

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Low Back Pain

Spondylosis

## 8. Glossary

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annulus fibrosus	The ring of fibrous tissue forming the circumference of an intervertebral disc.
bilateral	Occurring on both sides.
bony arch	See neural arch.
contracture	Shortening of muscles or tendons resulting in abnormal posture.
dysplastic	With abnormal growth or development.
facet joint	Joints between two adjacent vertebrae (superior and inferior on each side).
gluteal	Referring to the buttocks.
kyphosis	Increased posterior convexity of the spine when viewed from the side. Hence: <i>kyphotic</i> .
lysis	Destruction. Refers specifically here to fractures of the bone of the neural arch.
neural arch	The part of a vertebra extending from each side of the body, surrounding the spinal canal and meeting to form the spine of the vertebra.
pars interarticularis	The part of the neural arch of a vertebra lying between the superior and inferior articular processes.
sacral inclination	Angle of the sacrum in relation to the vertical.
sciatica	Pain in the distribution of the sciatic nerve, radiating over the buttock and down the leg, associated with compression or irritation of the spinal nerve roots.
unilateral	Occurring on one side only.
vertebral wedging	Collapse of the front part of the body of a vertebra resulting in a wedge shaped appearance when viewed from the side.

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