

What is spondylolisthesis?

The term spondylolisthesis is derived from the Greek "spondylos," of the vertebrae, and "olisthesis," sliding. Spondylolisthesis is the sliding forward of a vertebral body with its superior articular processes, pedicles, and transverse processes over the vertebra below it, where the vertebral arch with its inferior articular processes remains in its original location. Spondylolisthesis can occur in every vertebral segment of the lumbar spine, though spondylolisthesis of grades 3-4 occur almost exclusively in the 5th lumbar vertebra/1st sacral vertebra segment.

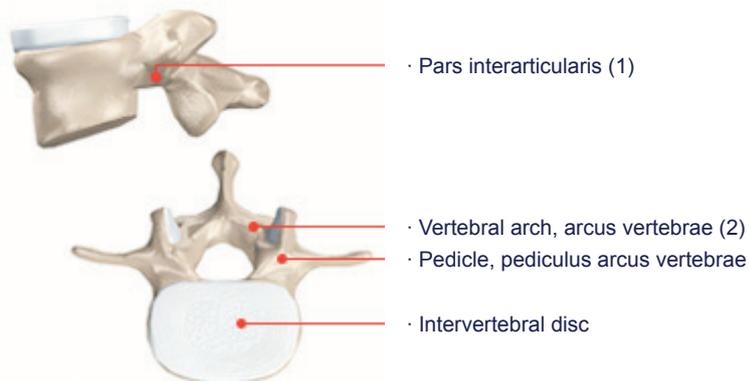
What classifications are used for spondylolisthesis?

Spondylolisthesis is pathogenetically classified in the following subtypes:

Type I: Isthmic-lytic form, with a lesion of the pars interarticularis (1) of the vertebra.

In a "genuine" spondylolisthesis, the sliding of the vertebra is caused by a bony defect of the vertebral arches (2), a spondylolysis, in the pars interarticularis (1) of the vertebra.

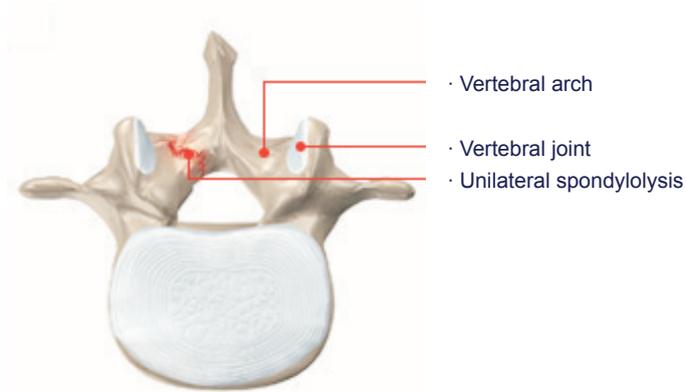
- Vertebra, from side and above



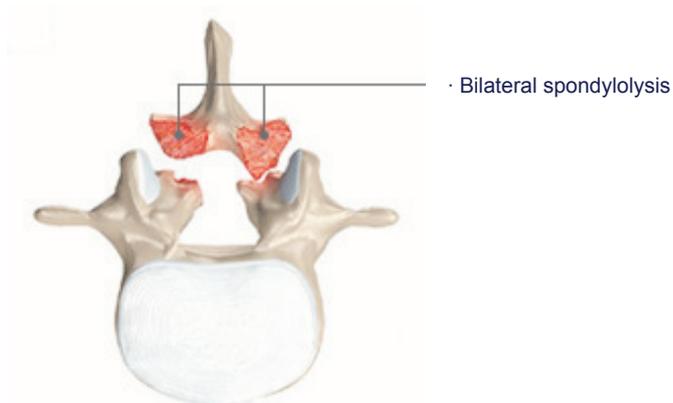
Spondylolysis as a bony interruption in the base of the vertebral arch may be unilateral or bilateral and is also referred to as an interruption of the interarticular portion.

In the presence of a spondylolysis the affected mobile segment loses stability, since the function of the vertebral joints is lost, allowing the vertebral body to slide ventrally (towards the abdomen). The resulting instability means that the forces applied to the region have to be absorbed mainly by the back muscles and intervertebral disc of the affected segment.

- Unilateral spondylolysis, view of vertebra from above

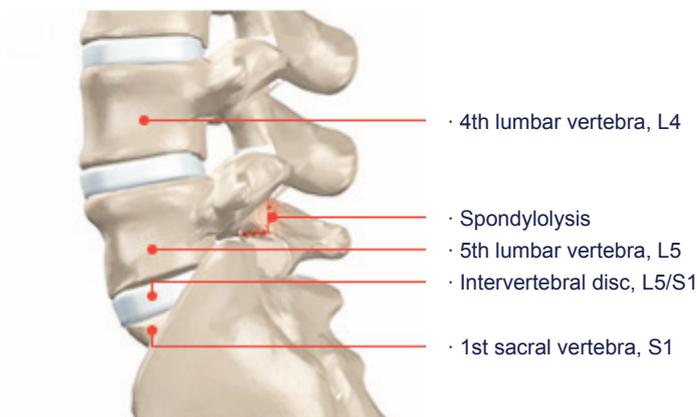


- Bilateral spondylolysis, view of vertebra from above

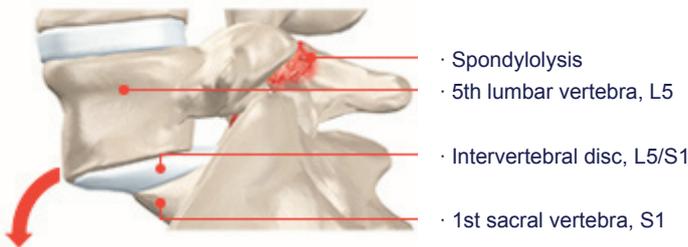


If the pars interarticularis is interrupted on both sides, the 5th lumbar vertebra slides forward over the 1st sacral vertebra. This movement is promoted by the ventrally tipped L5/S1 intervertebral disc.

- Lower lumbar spine, side view, spondylolysis L5



- Lower lumbar spine, side view, the 5th lumbar vertebra slides forward



The isthmic spondylolytic form of vertebral slippage occurs in about 80-85% of cases at the level of the L5/S1 vertebra segment, approximately 15% at the level of segment L4/L5 and, rarely, at the level of L3/L4.

Type II: Isthmic-dysplastic form of spondylolisthesis

As a rule, the dysplastic type occurs only in the 5th lumbar vertebra. This form involves an elongation of the interarticular portion of the slipped vertebra without defect formation within the vertebral arch. If the slippage increases, a secondary interruption of the interarticular portion may also develop. The most noticeable characteristic of this form is, however, the elongation of the interarticular portion as is never manifested in the isthmic-lytic form. It is remarkable that only the dysplastic form of spondylolisthesis can lead to a full-blown spondyloptosis (complete forward dislocation of the slipped vertebra). The isthmic-lytic form never involves a spondyloptosis. The pathomechanism of spondyloptosis is not yet completely understood, though it is clear that increasing slippage in an isthmic-dysplastic spondylolisthesis will necessarily lead to a straightening up of the sacrum with respect to the 5th lumbar vertebra so that the body weight (gravity line) remains centered over the head of the femur. This retroversion of the sacrum in relation to the pelvis frequently results in the grotesque deformation of the lumbosacral transition that is often easily diagnosable based on the clinical picture. A lumbosacral kyphosis can only develop in the isthmic-dysplastic form. Here a kyphotic buckle forms between the 5th lumbar vertebra and the 1st sacral vertebra. This type of kyphotic deformation is never observed in the isthmic-lytic form. Considering this aspect of lumbosacral kyphosis, the isthmic-dysplastic form must also be interpreted as a kyphotic malposition of the spinal column and should receive treatment as such. Type I and type II spondylolisthesis must be viewed differently in both diagnostics and therapy.

Type III: Degenerative form of spondylolisthesis

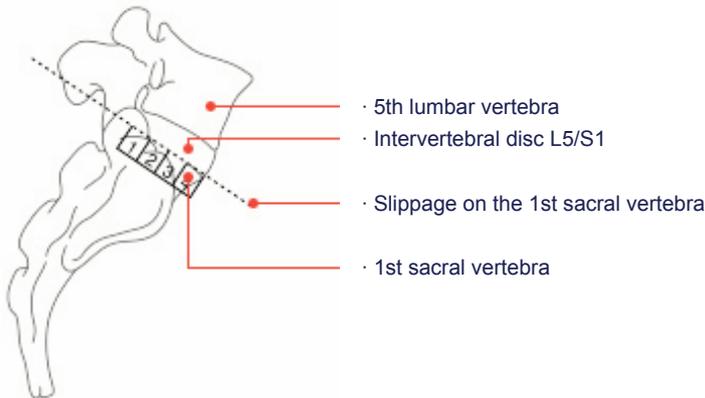
The degenerative form of spondylolisthesis is caused by the wearing down of the vertebral joints and intervertebral disc. This results in a spondylolisthesis without the formation of a defect in the interarticular portion, although the spinal canal is always narrowed in this form. It usually occurs at the level of the 4th lumbar vertebra. There is no spondylolysis in the vertebral arch, which is why this form is also known as "pseudo-spondylolisthesis."

How are the extent and severity of spondylolisthesis measured?

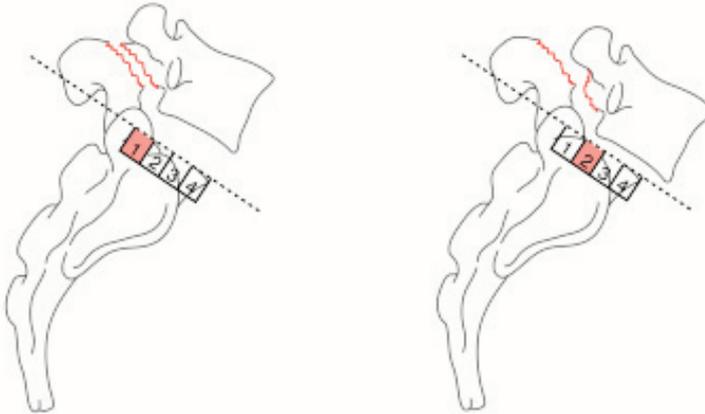
1. Meyerding grading scale

The extent of spondylolisthesis is graded in 4 Meyerding stages by dividing the upper plate of the 1st sacral vertebra into 4 equal parts. The stage of spondylolisthesis is then determined by which of the 4 divisions of the surface of the 1st sacral vertebra the posterior edge of the slipped vertebra projects onto. The length of forward slip of the 5th lumbar vertebral body on the 1st sacral vertebra determines the severity stage from I to IV.

- Normal state of lumbosacral transition (transition 5th lumbar vertebra)

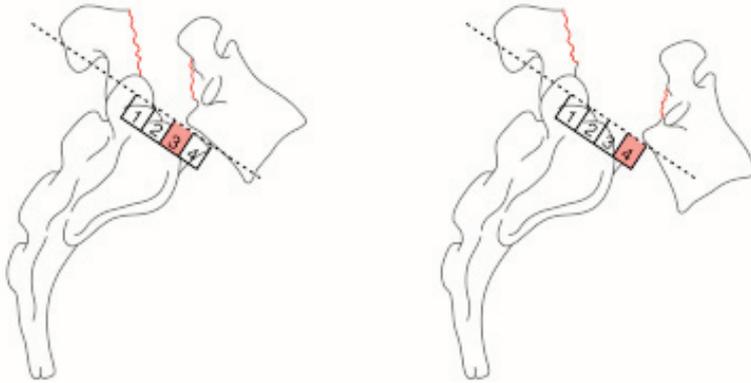


- Meyerding stage 1-2



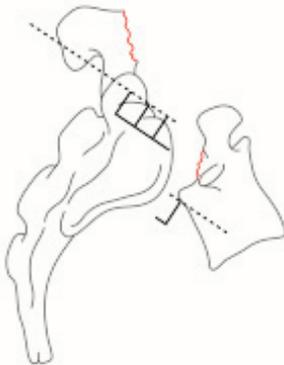
Beginning with Meyerding stage 3, in which the 5th lumbar vertebral body has slipped forward over 50% of the gliding plane on the sacrum, the condition is defined as severe spondylolisthesis.

- Meyerding stage 3-4



The most severe form of is known as spondyloptosis, a condition in which the 5th lumbar vertebra has slipped forward over 100% of the gliding plane and also angled downward off the sacrum.

- Spondyloptosis



2. Measurement of the sliding distance of the slipped vertebra

There are various methods of determining the length of the sliding distance of the slipped vertebra. Taillard, Wiltse and Winter developed measuring methods in which predefined reference lines are superimposed over certain vertebral structures on an x-ray image (e.g. the rear edge of the upper plate of the vertebra) to provide a basis for calculating the percentage of sliding distance.

3. Determining the slip angle

There are various methods for calculating the slip angle, i.e. the degree of tilt between the 1st sacral vertebra and the slipped 5th lumbar vertebra. In these methods, reference lines are superimposed on x-rays of the structures of the 5th lumbar vertebra and 1st sacral vertebra (base or upper plates, ventral or dorsal edges of the vertebra), and used to calculate the slip angle.

4. Determination of the lordotic angle of the lumbar spine

The farther the 5th lumbar vertebra angles forward, the greater the tendency of the spinal column to compensate the spinal column statics by increasing lordosis or hollow back in the lumbar spine (hyperlordosis) becomes.

5. Angle of inclination of the sacrum

The angle of inclination of the sacrum is calculated using an x-ray image of the lumbar spine taken from the side with the patient standing, with the sacrum angle along the vertical axis. This angle is significant in spondylolisthesis, since compensatory lumbar lordosis increases with the severity of spondylolisthesis, further straightening up the sacrum and thus reducing the angle of inclination.

What diagnostic procedures are carried out?

Clinical examination:

- Medical history
 - Family history of such conditions?
 - Physical activity?
- Inspection
 - Stepped vertebrae:

The more pronounced a spondylolisthesis is, the more visible and palpable the step between the spinous process of the slipped vertebra and the vertebra beneath becomes.
 - Hyperlordosis (“hollow back”): In advanced spondylolisthesis beginning at the Meyerding slippage stages II-III, increased kyphosing of the 5th lumbar vertebral body in relation to the 1st sacral vertebra occurs, since the 5th lumbar vertebra is no longer supported at the front (ventrally) and continues to slip forward. This kyphosis of L5 must then be compensated by a hyperlordosis of the lumbar spine to facilitate an upright gait.
 - Occurrence of a scoliosis: A reflective change in posture to relieve symptoms of nerve root compression in spondylolisthesis may in rare cases result in scoliotic malposture. In pronounced spondylolisthesis, the combination of slippage and rotation of the slipped vertebra may result in a structural scoliosis.
- Palpation
 - Palpable steps between the spinous processes?
 - Do percussion, pressure, and shaking cause pain in the affected area?
 - Paravertebral myogeloses (abnormal hardening) of the lumbar back muscles visible?
 - Pelvic position?
- Functional and pain tests
 - Neurological examination to test sensibility, sensomotor functions, and reflexes to exclude contributory nerve compression (Lasègue’s sign, Bragard’s sign, far-out syndrome).
 - Mobility of the lumbar spine (Schober’s sign)
 - Does compression of the spinal column cause pain?
 - Support reflex: Straightening up the body from a hunched over position is very painful, and only possible if the arms are supported on the thighs.
- Instrumental diagnostics
 - X-rays of the lumbar spine in 2 planes with inclined images:

A conventional sagittal image clearly shows the degree of spondylolisthesis. The additional inclined images frequently show the spondylolysis more clearly (dog collar phenomenon). In the AP image, an additional scoliosis is also in evidence. With pronounced lordosing of the lumbar spine, the 5th lumbar vertebra has the appearance of a reversed tricorn hat.

- Functional images of the lumbar spine in maximum reclinatioin (bending backward) and inclination (bending forward) reveal any manifest instabilities in the affected vertebral segments.
- Computer tomography (CT)
The manifest spondylolysis is clearly revealed by CT, but other structures such as soft tissues, intervertebral discs, nerves, and muscles are shown much more advantageously by magnetic resonance tomography.
- Magnetic resonance tomography (MRT, MRI)
MRT allows for very good assessment of changes in the nerve roots, spinal canal, and intervertebral discs.
- Myelography
X-ray imaging of the spinal canal using a contrast agent can provide further information concerning a possible stenosis of the spinal canal or compression of a nerve at the roots, items that cannot be assessed with any degree of certainty from MRT images.
- Skeletal scintigraphy
If the above-mentioned tests provide no evidence of spondylolysis, skeletal scintigraphy can reveal an early stage of imminent or manifest spondylolysis by means of enrichment of the contrast agent indicator in the pars interarticularis of the vertebral body.

What are the symptoms?

Many patients remain asymptomatic despite radiological evidence of a spondylolysis or spondylolisthesis. Most symptoms are nonspecific and may occur in other spinal diseases as well, e.g. in degenerative changes of intervertebral discs and vertebral bodies.

- Lower back pain radiating into the buttocks and legs
- Compression pain of the spinal column
- Pressure pain of the spinous process of the 5th lumbar vertebra
- Increased lordosis or hollow back (hyperlordosis)

Additional symptoms that may occur in cases of severe spondylolisthesis classified as Meyerding stages 3-4:

- A palpable, visible step at the level of the slipped vertebra, where the sacrum clearly sticks out toward the back
- Neurological dysfunctions
- Reflective or structural scoliosis
- Knees must be bent for patient to stand upright
- Almost complete loss of the ability to bend the hips due to shortened extensor muscles of the hip

How is spondylolisthesis treated?**Therapeutic objectives:**

- Improvement of quality of life by reducing or eliminating pain
- Prevention of progression of the vertebral slippage
- Elimination of existing neurological symptoms

Spondylolisthesis responds to conservative treatment in most cases.

Conservative treatment includes:

- Consulting with the patient and providing information about the disease
 - Explanation of the importance of weight reduction as needed
 - Job consultation should patient need to change jobs
 - Adaptation of physical exertion as necessary for activities on the job and exercise.
- Pharmaceutical therapy with
 - Analgesics
 - Antiphlogistics
 - Muscle relaxants
 - Local infiltrations
- Physiotherapy

To improve the stabilization of the affected vertebral segments, strong back and abdominal muscles must be built up. This can be achieved by means of isometric training and by exercises to strengthen the back muscles accordingly.
- Massages, heat applications and electrotherapy may have additional favorable effects on pain.
- Orthopedic technology aids
 - Brace therapy (delordosing/stabilizing trunk orthotic devices)
 - Orthopedic shoes

Surgical therapy

Indications:

- Intensive suffering from strong pains despite adequate conservative therapy and adaptation of living and working conditions
- Occurrence of neurological defects
- Worsening spondylolisthesis

Objectives of surgical therapy:

- Stabilization of the mobile segment (spondylodesis) with restoration of physiological intervertebral space height
- Elimination of neurological symptoms as needed (by means of repositioning and/or decompression)
- Pain reduction
- Improvement of spinal column statics

A number of different surgical methods are available for the treatment of spondylolisthesis. Here it is necessary to differentiate between type I and type II:

Type I: Isthmic-lytic form:

A. Screw fixation and direct bone material repair of the spondylolysis

This operation can be carried out in cases in which lytic spondylolisthesis is recognized at an early stage. Studies show an expected rate of about 50 to 60% for the successful healing of the defect. This operation is only possible if there is little or no slippage and in particular if no damage has been done to the intervertebral disc (MRT).

B.

If the process of slippage worsens, increasing degenerative damage to the intervertebral disc (overload), repositioning spondylodesis is then indicated.

Repositioning spondylodesis can be carried out using both the TLIF or ALIF methods. Dorsal instrumentation and dorsolateral fusion alone seem insufficient to us, since the pseudoarthrosis rate is much higher after such procedures.

Type II: isthmic-dysplastic form

The range of surgical indication is much wider with this form than with the isthmic-lytic form. In contrast to the isthmic-lytic form, the isthmic-dysplastic form can in many cases cause considerable suffering even in early childhood (beginning at age 3 or 4), which may then require surgical intervention. By the same token, surgery is clearly indicated if progression is observed in the isthmic-dysplastic form.

We know cases involving progression often reach the full-blown clinical stage called spondyloptosis and that this can be a source of severe problems. In our view, surgical repositioning and fusion of L5/S1 should be done even in early childhood in the presence of even mild progression or symptoms, in view of the fact that repositioning is fairly easy to accomplish in children.

Starting at age 12 or 13, in the presence of pronounced lumbosacral kyphoses, repositioning surgery is much more difficult and, above all, it is associated with a much higher rate of neurological complications (paralysis of the L5 nerve).

In general, 3 different surgical options are available:

1. Sole dorsal repositioning spondylodesis with temporary or permanent instrumentation of L4
2. Combined ventrodorsal repositioning, also with instrumentation of L4
3. Corporectomy of L5 and fusion of L4 in relation to S1 (Gaines procedure)

The most important objective of this operation is not only the repositioning of L5 in relation to S1, but also the elimination of the lumbosacral kyphosis and of pelvic retroversion. This can only be done in childhood or early adolescence. Such results are hardly feasible in adults, or at best involve a much more complicated procedure.