## Definition

The term “discosis” encompasses all biomechanical and pathoanatomical changes in the intervertebral disk that are associated with disk degeneration. **Synonyms:** Disk degeneration, degenerative disk disease, chondrosis intervertebralis.

## Classification

There are three stages of discosis (Fig. 6.1):
- the first, or early, stage, in adolescence and young adulthood
- the second stage, in middle age
- and the third stage, in old age.

The **first stage of discosis** begins with regression of the intradiscal vessels between the ages of 2 and 4 years. From this time onward, the disk tissue receives nutrients only by diffusion. In childhood, the disk continues to function adequately as an osmotic system, so that its fibroblasts and chondrocytes are assured a sufficient supply of nutrients. The lower body weight of children and, above all, their relatively high degree of physical activity create favorable biomechanical conditions for the nourishment of the fiber-producing cells of the disk.
the intervertebral disk. As body weight increases, so does the axial load on the disk, particularly in the lower lumbar segments. Furthermore, as children grow into adolescents and adults, their level of physical activity decreases as they become relatively sedentary, first at school and then at work. The fibrous lamellae of the disk, which are no longer adequately nourished and thus no longer able to withstand the strong outward pressure of the central, mobile disk tissue, begin to protrude outward. The earliest disk-related complaints may arise at any time between age 12 and age 20, when intradiscal shifting of disk material suddenly causes stretching or bulging of the posterior longitudinal ligament. In adolescents, this produces the clinical picture of iliolumbar extension stiffness (see Chapter 11).

The second stage of discosis affects adults aged 20–60. The poorly nourished fibroblasts and chondrocytes produce poorer-quality fibers that are no longer able to withstand the expansile pressure of the central, mobile portion of the disk, which, at this time of life, is still intact. The anulus fibrosus develops both radial and circular tears, into which the tissue of the nucleus pulposus protrudes. Entire sequestra composed of tissue from the anulus fibrosus and the cartilaginous end plates can form and then, under asymmetrical axial loading, follow the path of least resistance outward, sometimes beyond the boundary of the intervertebral disk. Disk protrusions and prolapses are the result. As long as the external layers of the anulus fibrosus are intact, it is still possible for the displaced tissue to return to its original position. In a disk prolapse, however, the displaced tissue penetrates the anulus fibrosus and can no longer go back inside the disk. Dorsally or dorsolaterally pointing disk prolapses come into contact with the posterior longitudinal ligament, which derives its sensory nerve supply from the meningeal branch of the spinal nerve. The resulting symptoms consist of locally circumscribed lumbago, chronic discogenic low back pain, and/or root compression syndrome (Fig. 6.2).
Pathoanatomical changes within the disk tissue, including fiber disruption, tissue loss due to prolapse, and dehydration, produce a further manifestation of the second stage of discosis: **segmental instability.** Slackening of the initially tautly elastic disk tissue loosens the mechanical link between adjacent vertebrae, enabling movements of nonphysiological amplitude and direction. This kind of instability may not be directly visible. It can often be detected only with the aid of functional images, e.g., lateral radiographs on forward and backward bending. Degenerative instability also causes slippage (olisthesis) of the vertebrae relative to one another, either ventrally or dorsally (retrolisthesis). Symptoms are produced by impingement on the neural elements in the vertebral canal or the intervertebral foramen. Most therapeutic procedures are undertaken in the second stage of discosis, because it is in this stage that disk displacement and slackening most commonly produce intense local and radicular manifestations.

In the **third stage**, the displacement of central, mobile disk tissue (loosening, protrusion, prolapse) ceases to progress. After age 60, the disk tissue loses water and becomes fibrotic and firm, and therefore less liable to dorsal displacement. Calcification of the ligaments that span the intervertebral space as part of the spondylotic process contributes further to the fixation of the motion segment (**Figs. 6.3, 6.4**). The pathoanatomical changes may appear quite impressive at this stage, but, as their net effect is partial stabilization, the patient is usually spared severe symptoms. This is the so-called “**comfortable rigidity of the aging spine.**” The age distribution curves for disk diseases show that protrusions and prolapses do, indeed, occur in old age, but with a different pattern than in middle age, mainly affecting the upper lumbar segments and producing extradiscal sequestra that are projected craniolaterally. Spondylogenic symptoms after age 60 tend to be caused not by disk pathology per se, but by secondary degenerative changes in the dorsal part of the motion segment. The
nerve root from the dorsal side (Fig. 11.30). Very rarely, hard sequestrated fragments can perforate the ventral dura mater of the lumbar sac and present as an intradural or intrathecal fragment. Such cases have been reported by Roda et al. (1982), Lee (1983), Griss (1984), Kasch (1986), Yildizhan and Okten (1991), McCulloch (1998), and Postacchini (1999).

**Grades of Dislocation**

The classification of disk protrusions and prolapses by grade of dislocation (I–V) is shown in Fig. 11.31. The grade of dislocation, together with the clinical findings, determines the most advisable form of treatment; intradiscal therapy may still be possible, or an open operation may be necessary (Figs. 11.32–11.37).

**Spontaneous Changes of Disk Prolapse**

Once the disk tissue has left its usual environment in the intervertebral space and entered the epidural space, it is subject to new metabolic conditions. It was originally nourished by diffusion through the normal, pressure-related fluid shifts within the disk, but it now lies more or less suddenly in a space surrounded by connective tissue where it is exposed to lymphatic fluid.

When the disk tissue is no longer subject to intradiscal pressure, it takes up fluid, according to the relation
Fig. 11.33  Grade III dislocation. Covered prolapse at the discal level. The prolapsed tissue has completely perforated the anulus fibrosus and is only covered by a thin membrane (the ventral epidural membrane). This membrane can be bluntly perforated, e.g., with a 2 mm dissector. In general, the edge of the lamina will have to be resected for the prolapse to be reached.

Fig. 11.34  Grade III dislocation. Covered prolapse at the supradiscal level. The dislocated disk tissue has emerged from the intervertebral space but is still covered by the ventral epidural membrane. The dislocated disk tissue can be reached only by opening the membrane with a blunt 2 mm dissector. In general, the lower edge of the lamina will have to be resected for the prolapse to be reached. A hemilaminectomy may be necessary.

Fig. 11.35  Grade III dislocation. Covered prolapse at the infradiscal level. The prolapsed tissue is found under the ventral epidural membrane. After blunt opening of this membrane, e.g., with a dissector, the dislocated disk tissue is reached. The submembranous infradiscal prolapse can generally be reached by fenestration at L4/5 and L3/4. At the L5/S1 level, part of the sacral lamina may need to be resected.

Fig. 11.36  Grade IV dislocation. The dislocated disk tissue is found partly inside and partly outside the disk. This situation generally obtains only at the discal level, when the ventral epidural membrane is also perforated at this level. Extensive removal of the dorsal portion of the disk is necessary to prevent recurrent disk herniation.
Treatment of Lumbar Syndromes

Classification of Treatment Methods

The international literature has traditionally classified the methods of treating lumbar syndromes as conservative vs. operative, or as operative vs. nonoperative. This distinction is clearly useful as a demarcation between widely differing techniques, such as heat application and positioning, on the one hand, and open disk surgery on the other. In recent decades, however, new methods of treatment have arisen that occupy a place on the spectrum between conservative management and open surgery and that are designated as "minimally invasive." Because the origin of the pain in lumbar syndromes lies well beneath the surface, e.g., in lumbar root compression syndrome, and because open surgery is therefore impossible except by a relatively difficult surgical approach, many new methods have been developed by which the anterolateral epidural space and the foramino-articular region can be reached with the aid of special needle techniques and endoscopic instruments. The common feature of all minimally invasive measures is a percutaneous approach in which the instruments are introduced without a skin incision (except for a minimal stab wound).

A classification of the various methods of treating degenerative diseases of the lumbar spine is given in Table 11.17. Minimally invasive procedures are listed between conservative and operative methods and are themselves subdivided into paravertebral injections, intradiscal therapy, and endoscopic techniques.

All of the conservative methods of treating disk disease, and some of the minimally invasive ones, leave the osmotic system of the intervertebral disk undisturbed.

Patients with disk protrusions should be treated with all possible methods that preserve the integrity of the disk.

Conservative Treatment

The classic conservative measures include physiotherapy, heat application, positioning, and analgesia. Additional ones are local injections such as trigger point infiltration, intracutaneous injections, and muscle infiltration (superficial needling techniques).

Paravertebral injections are deep needling techniques involving infiltration of the epidural space or the foramino-articular region and are included among minimally invasive methods. These injections require directed needle introduction, often under imaging guidance. Because the target sites for injection are immediately adjacent to the nerve root sleeves and the dural sac, with the possibility of subarachnoid injection, paravertebral injections require circulatory monitoring during the procedure and post-procedural monitoring afterward. The application of medications in the epidural space is done either as a single shot or as a longer-lasting infiltration through a temporarily implanted percutaneous catheter.

Intradiscal techniques use either special needles (e.g., chemonucleolysis) or percutaneously introducible instruments, some of which are inserted under endoscopic guidance.

Purely endoscopic operations for the removal of lumbar disk herniations are done either transforaminally, i.e., through the intervertebral foramen, or by the interlaminar route, i.e., through the ligamentum flavum. Open operations are defined as those requiring a skin incision of 3 cm or longer and are subdivided into microscopic decompressive methods with use of an operating microscope and more extensive approaches, with or without use of a microscope. Microsurgery enables precision to within a millimeter in a narrow operative field. Special instruments are needed. The conventional, more extensive approach generally involves a partial or total removal of the lamina (hemilaminectomy or laminectomy). When decompression is extensive and includes a partial or total resection of the intervertebral joint (facetectomy), a fusion operation is usually carried out in the same sitting. Fusion operations are classified as dorsal, ventral, or combined (dorsoventral).

Replacement of the entire disk by a moveable artificial disk is called disk prosthesis surgery.

Stress-reducing Positioning, no Bed Rest

There are no universally valid guidelines for the optimal bodily position for disk-related symptoms in the lumbar region. For every anatomical or functional disturbance in the motion segment, there is an optimal position of the spine in which the pain is less intense than in other positions. This optimal position may be the upright position or the horizontal position, in bed, in practically any conceivable posture, depending on the exact cause of the pain. In general, patients feel best in the supine or lateral decubitus position with the hip and knee joints flexed. For other patients, however, the optimal position
Table 11.17 The treatment of lumbar syndromes

<table>
<thead>
<tr>
<th>Conservative</th>
<th>Minimally invasive</th>
<th>Endoscopic</th>
<th>Surgical</th>
<th>Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Positioning</td>
<td>Manual therapy</td>
<td>Epidural LSPA</td>
<td>Microdiscotomy</td>
<td>Dorsal</td>
</tr>
<tr>
<td>Physiotherapy</td>
<td>Special patient exercises</td>
<td>Facet infiltration</td>
<td>Conventional Laminate</td>
<td>Ventral</td>
</tr>
<tr>
<td>Analgesics Injections</td>
<td>Back training</td>
<td>Percutaneous nucleolyis</td>
<td>Transforaminal</td>
<td>Dorsoventral</td>
</tr>
<tr>
<td>(superficial) Orthoses</td>
<td></td>
<td>Percutaneous nucleotomy</td>
<td>Interlaminar</td>
<td>fusion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percutaneous laser</td>
<td>Intradiscal</td>
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</tr>
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<td></td>
<td></td>
<td>Percutaneous thermotherapy</td>
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</table>

is standing bent forward, supporting the upper body with the arms.

Mechanical stress on the lumbar disks is at a minimum in the so-called step position, i.e., horizontal with flexed hip and knee joints (Fig. 11.95).

All biomechanical factors of the step position lead to a minimization of contact between the disk protrusion and the spinal nerve. When disk tissue is displaced within the disk, but the anulus fibrosus is intact, there is a good chance that conservative management in the step position will result in a return of the displaced tissue to the center of the disk.

A stress-reducing position should only be assumed temporarily, e.g., during or after other therapeutic measures such as heat application, electrotherapy, progressive muscle relaxation, etc.

Prolonged bed rest is counterproductive in lumbar disk disease, even when the patient assumes a stress-reducing position. Many controlled studies (Table 11.18) have shown that patients with lumbago and sciatica have more symptoms after prolonged bed rest than patients in a control group who are allowed to be mobile and continue to go to work (Hagen et al. 2004, Becker et al. 2006).

Return to work is therapeutic (Nordin 2004).

The probability of returning to work decreases very rapidly with increasing duration of sick leave.

Heat Therapy

Patients with lumbar disk disease experience relief with heat in all its forms, whether through local heat application or simply through a warm climate. Cold, on the other hand,provokes symptoms even in the absence of other mechanical influences. The causal mechanism for this has not yet been fully explained. Patients with

Fig. 11.95  Step positioning: a stress-reducing position with the patient lying on their back and the hip and knee joints in flexion. This results in low intradiscal pressure, widening of the Intervertebral foramina, relaxation of the intervertebral joint capsules, flattening of dorsal disk protrusions, widening of the spinal canal, relaxation of the sciatic nerve, and reduction of stress on the sacroiliac joints.
photic lumbar spine at certain points. As Grandjean and Burandt (1962) observed, the desired correction also fails to occur when the individual, as usually happens, does not lean back properly or when the buttocks slide forward on the seat.

**Sitting Back**

The appropriate position for sitting is one that puts the least stress on the disks, ligaments, and muscles.

As only lying down brings about a near-total unloading of all of these elements, individuals who must sit for a long period of time should attempt to sit in positions most closely approximating the lying position. Most individuals meet this requirement unconsciously by sliding forward in the seat while reclining the upper body backward, as long as the sitting surface offers enough room to do so. The final result is the extreme sitting-backward position with the pelvis tilted back (Fig. 14.4b). This position is felt as pleasant at first, because the weight of the upper body is partly supported by the backrest. Nonetheless, if the backrest is high and close to the vertical, lack of lumbar support will lead to the development of a maximal kyphosis, not just of the lumbar spine but also of the cervical spine.

The stress-reducing sitting position. If, however, the backrest is shaped to correspond to the physiological curvature of the spine, and the head and neck are supported at a more favorable angle, then reclining to 45° results in a sitting posture that takes stress off the spine, ligaments, and muscles. The posture-maintaining work required of the cervical and truncal muscles is minimal in this stress-reducing position (Fig. 14.5). The loading pressure on the intervertebral disk is reduced in all portions of the spine. In the lumbar spine, it is less than 0.3 MPa and approximately equal to the loading pressure in the horizontal position (Nachemson 1974, 1976). Both Andersson et al. (1974) and Wilke (2001) showed that the loading pressure on the lumbar disks diminishes the more the backrest is reclined backward. A parallel lessening of activity in the trunk muscles was demonstrated electromyographically by Hosea and Simon (1984).

In the stress-reducing sitting position, the backrest should not be too soft, and it must have a mild protrusion at the lumbar and cervical levels corresponding to the somewhat flattened lordosis at these levels. As the ankle between the thigh and the truncal axis increases to 135°, lumbar support lessens the backward tilting of the pelvis. The main points of support are now at the thoracolumbar junction and in the craniovertebral region. To give the seated individual a better viewing angle, the head is inclined 10–20° forward in relation to the craniovertebral region. The depth of the seat is adapted to the length of the thighs and its surface is inclined about 10° downward from front to back in order to keep the individual from sliding forward in the seat; a footrest may help achieve the same purpose.

One can use a 45° chair of this type to make the sitting position as much like the horizontal position as possible, not just during leisure hours but also during some types of occupational activity. This stress-reducing position can be obtained almost instantly with some kinds of adjustable easy chairs or TV loungers. It has also been found practical for driving (Krämer et al. 1979, 2005), as the low height of the seat above the floor of standard cars forces the driver to assume a sitting-back-
ward position anyway. Any attempt to bring the spine into an upright position only leads to an even more pronounced lumbar kyphosis.

Guidelines for the sitting-upright position with a vertical spine were published by Akerblom (1948), Schoberth (1962), and Berquet (1984). According to these guidelines, the lumbar region should be firmly supported with a suitable backrest that reaches to the border of the pelvis. Chairs must have armrests so that some of the weight of the upper body can be laterally supported on the elbows at least some of the time, reducing the posture-maintaining work demanded of the shoulder and neck muscles. The proper depth of the seat depends on the length of the thighs, and the seat should be inclined downward about 5° from front to back. Writing desks should be of a height that the lower arms can be freely rested on the desktop without any need to raise the shoulders. The workplace, where many individuals spend a large part of their lives, must be adapted to individual body size, and this is best done with direct trials of the sitting position. Bad fitting of the workplace to the worker leads to the indefinite maintenance of harmful postures.

Sitting and the angle of the lumbar spine, pelvis, and leg. The lumbar spine, pelvis, and leg are a biomechanical system connected by ligaments and muscles. Even without muscle activity, the posture of the spine is affected by the position of the leg: hip extension causes lordosis and hip flexion causes kyphosis of the lumbar spine. Changes of leg position have a stronger effect on lumbar spinal posture if the ligaments of the joint capsules and the lumbar muscles are short and inelastic (Fig. 14.6). The angle of the lumbar spine, pelvis, and leg has been studied by Nentwig, Krämer, and Ullrich (1997) and Schramm et al. (1997).

In the sitting-forward and sitting-upright positions, therefore, the hip joints should be less flexed; the knees should be below the hips. A seat cushion can be used to help maintain this posture; Schneider and Lippert (1961) suggest the use of a cushion together with a forward-tilted seat surface. On the other hand, raising the legs (knees above hips) is necessary to maintain the physiological angle of the lumbar spine, pelvis, and leg in the sitting-backward position (Fig. 14.7).

Dynamic Sitting

The more recent intradiscal pressure measurements of Wilke et al. (1992–2001) have shown a high variability of intradiscal pressure during sitting, depending on position: the values ranged from 0.83 MPa in the sitting-forward position with rounded back to 0.27 MPa in the stress-reducing “relaxed” position. This implies that an alternation of sitting positions can effect an alternation between loading and unloading of the disks, allowing fluid to move in and out of the intervertebral spaces. By temporarily supporting the upper body with armrests (similarly to the parallel bars used in gymnastics), one can even bring the intradiscal pressure down as low as 0.10 MPa. The back school recommendation therefore includes dynamic sitting with alternation of positions and occasional support of the upper body on the armrests.