Degenerative Spine Disease

13

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13.1 General Principles

13.1.1 Introduction

Degenerative spinal disease (DSD) is a typical problem of the elderly patient. Against the background of the ongoing demographic change, neuro-, orthopedic-, and spine surgeons are more and more confronted with this topic and the concomitant clinical and economic problems.

Especially in elderly patients, the management of degenerative spinal pathologies is challenging, and "evidence-based" guidelines or treatment recommendations are barely available or lack completely [1, 2].

To illustrate this development, there are some data based on the *Diagnosis-Related Groups* (*DRG*) *system* in Germany, in which degenerative spinal pathologies like stenosis, spondylosis, and disc herniation as the main hospital diagnosis were coded 2005 in 156.333 patients >65 years and 2014 in 254.329 patients [3]. These numbers underline the future importance of this topic in spinal surgery.

In elderly patients diagnosis and therapy are often complicated by age-related problems like concomitant cardiovascular, cerebral, and/or endocrinologic disturbances. Osteoporosis and a decreased physical and mental performance are additional factors which have to be considered when a treatment concept is planned.

With this chapter we want to summarize the pathophysiological mechanisms and to describe diagnostic and therapeutic pathways based on the published scientific data and on our own practical and experimental experiences.

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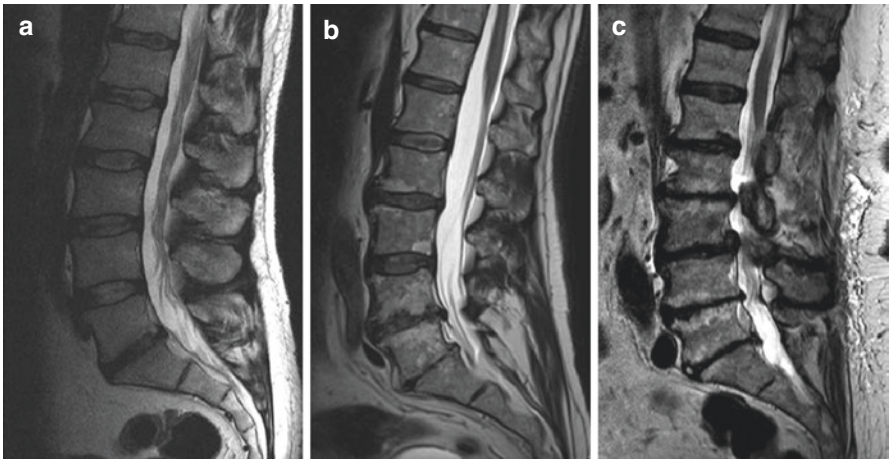

Fig. 13.1 Figure illustrates the physiological aging process of the lumbar spine. A T2-weighted sagittal MRI of an asymptomatic 15-year- (**a**), 50-year- (**b**), and 80-year (**c**)-old patients shows the typical changes like fluid and consecutive height loss of the discs and progressive narrowing and also deformation of the spinal canal

13.1.2 Age-Related Spine Degeneration

More than 75 % of the population in the Western industrialized countries experience back pain at least once during their lifetime. The concomitant temporary disability represents an enormous socioeconomic burden. In this context, one should be aware that there is a difference between normal age-related degenerative changes and "pathological" degeneration, which is associated with neck and back pain. A high percentage of individuals (between 15 and 70 %) with more or less pronounced signs of disc degeneration never experience relevant symptoms.

Degenerating "spondylosis" or spinal osteoarthritis is the most common alteration of the aging spine. This condition seems to be inevitable, with osteophytes (bone spurs) arising circumferentially from the margin of the vertebral body usually accompanied by a height reduction of the associated disc as the typical radiological sign (Fig. 13.1). In the historical context, the term "spondylosis" was created to differ between degenerative changes of the anterior column (vertebral body and intervertebral disc) and those of the facet joints (osteoarthritis). However, up to now it has come clear that age-related changes in the anterior column and aseptic osteoarthritis of the synovial joints have the same origin; they coexist and are closely interrelated.

13.1.2.1 Disc Degeneration

The degenerative changes of the whole spine are finally only a physiological reaction on the ongoing aging process. Already in the early adulthood, degeneration begins with a fluid loss within the discs which lead to a continuous height loss of the spinal segment (Fig. 13.2).

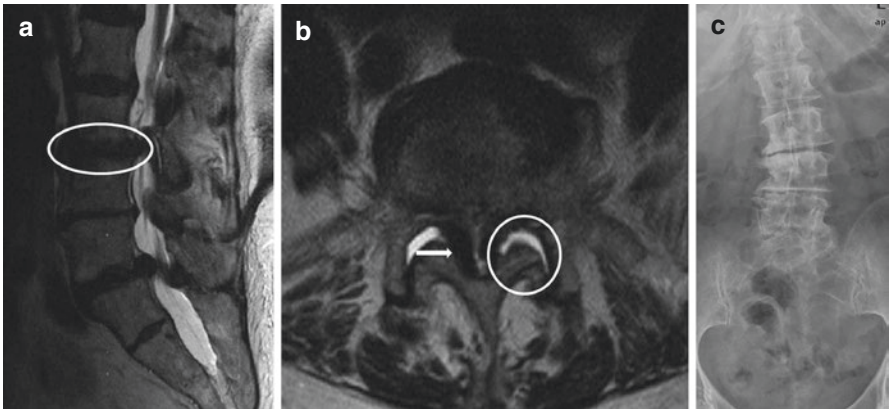

Fig. 13.2 Figure shows the typical radiological features of lumbar spine degeneration with disc bulging (**a**) ligamentum flavum hypertrophy (**b**, *arrow*), facet joint arthrosis (**b**, *circle*), and degenerative scoliosis (**c**)

The "motion segment" or "functional spinal unit" is defined as the spinal disc with the adjacent vertebral body, the facet joints, and the surrounding ligaments.

Concerning the degeneration process, different stages can be defined:

Juvenile disc

- Normal disc height and gel-like appearance (hydration) of the nucleus pulposus.
- Cartilage end plates are thick and resistant.

Adult disc

- Disc height normal, but nucleus pulposus less hydrated.
- Cartilage end plates are thinned.

Degeneration (*early stage*)

- Nucleus pulposus consolidated and filled with fibrous tissue
- Annulus fibrosus and nucleus pulposus not well demarcated yet

Degeneration (*advanced stage*)

- Annulus fibrosus with tears, nucleus with deep clefts
- Sclerosis of the bony end plates

Degeneration (*end stage*)

- Intervertebral disc completely degenerated
- End plates with marked sclerosis

13.1.2.2 End Plates

During the aging process, changes in the end plates become more and more evident, such as:

- Fissure formation
- Fractures
- Horizontal clefts
- Increased vascular penetration
- Calcification and sclerosis

Based on MRI findings and histological correlations, end plate changes have been classified by Modic into three types [4]. During the last years, Modic changes have been extensively used to identify the causes of nonspecific low back pain. In this context, Modic type I changes were associated with unspecific low back pain. Modic changes are very common in the lumbar spine. However, they are also found in the thoracic and cervical spine and they are listed below:

Type I

- Low signal in T1 and high signal in T2-weighted images. These changes are associated with vascularized granulation tissue within the subchondral bone indicating an ongoing active degeneration.

Type II

- High signal in T1- and T2-weighted images indicating a fatty replacement of the adjacent bone marrow.

Type III

- Low signal in T1- and T2-weighted images indicating subchondral bone sclerosis.

13.1.2.3 Facet Joints

The facet joints, also called zygapophyseal joints, are paired synovial articulations between the posterior elements of any adjacent vertebrae. The altered biomechanical situation promotes arthritic changes of these joints and the ligamenta flava (Fig. 13.2). Together with the disc bulging, a successive stenosis of the spinal canal and the lateral recesses results. These pathoanatomical changes occur within the whole spine but with slight regional differences. Spine areas with an increased mobility like the cervical and the lumbar spine are in particular susceptible for progressive degeneration with a predilection of the segments C5/C6 and C6/C7 as well as L4/L5 and L5/S1.

They are an essential part of the posterior column and are classified according to Fujiwara et al. [5]:

Grade 0: normal
Grade 1: moderately compressed with osteophytes

Grade 2: subchondral sclerosis and osteophytes
Grade 3: large osteophytes, no joint gap left

Degenerative changes in the facet joints combined with disc degeneration can lead to a compression of nerve roots in the lateral recess, but also a central 360 °stenosis is possible. Although there is some evidence that disc degeneration usually precedes facet joint osteoarthritis, the grade of disc degeneration does not correlate with that of the facet joint.

13.1.2.4 Vertebral Body

The bony components, namely, the corpus vertebrae, are mainly responsible for the static stability of the spinal column. Aging of the vertebral bodies is generally characterized by a decreased structural strength, mainly due to osteoporosis. Osteoporosis manifests as a general skeletal disorder, whose main feature is the reduced bone mass combined with microarchitectural changes within the bone tissue and a subsequently elevated fracture risk.

The prevalence of osteoporosis in Western Europe is estimated around 45 % for women and around 20 % for men, respectively, older than 70 years [6].

According to the operational definition of the WHO in 1994, osteoporosis is present if the bone mineral density (BMD) measured by dual X-ray absorptiometry (DXA) bone densitometry at the lumbar spine differs more than –2.5 standard deviations from the mean value of a healthy female between 20 and 29 years. The difference of the BMD values in comparison to this indicated as standard deviations is the so-called *T*-score. This definition can be used for men older than 50 years of age as well.

However, for the daily praxis in spine surgery, *T*-scores play a rather limited role. Of much more relevance are the absolute values of the BMD. These values can be determined by quantitative computed tomography (QCT). In contrast to DXA, the CT calculates the physical density value for each voxel (specified in mg/cc) allowing to asses an absolute value of the bone mineral density. Furthermore, mechanical parameters of the respective bone area are captured better by QCT [7].

In consequence, BMD values from QCT measurements must not be specified as T-scores, nor are they comparable to DXA values. Based on our own experience, implant anchoring (especially pedicle screws, but anterior cervical plates, too) is significantly decreased below a BMD of 100 mg/cc. In these cases an additional augmentation of the respective implant should be considered, or, alternatively, instrumentation should be expanded over multiple segments.

The increased bone fragility can induce osteoporotic fractures which lead to a bulging of the disc into the vertebral body, to kyphotic deformity, and to a loss of the sagittal balance (see below). The end stage is characterized by a so-called fish vertebra (totally collapsed vertebral body with discs bulging into the end plates).

13.1.2.5 Sagittal Balance

The ongoing degeneration comprising vertebral bodies, intervertebral discs, ligaments, and facet joints is the pathophysiological correlate for a secondary degenerative instability of the spine. Multisegmental deformities in the sagittal (kyphosis,

degenerative spondylolisthesis) as well as in the coronal (scoliosis) plane with additional rotatory misalignment are possible (Fig. 13.2). In upright position the following aspects are important for a balanced state:

- Coronal balance
- Sagittal balance
- Sagittal profile
- Muscle tension bending

Coronal balance is defined by a plumb line that does not deviate off the intergluteal groove. Sagittal balance is closely correlated with lumbar and cervical lordosis as well as thoracic kyphosis. A thoracic kyphosis of 20–60° is usually considered as normal [8]. The normal range for cervical lordosis (C2–C7) is 20–60° [9]. In the lumbar spine, the last two segments (L4/L5 and L5/S1) contribute about two thirds of the whole lumbar lordosis (L1–S1). In standing position, a plumb line from the center of C7 should be centered over the first sacral segment [10]. Patients with chronic low back pain and lumbar degenerative disease often present with modifications of the sagittal balance and are mostly featured by anterior sagittal imbalance, loss of lumbar and cervical lordosis, and an increase of pelvic tilt [11]. The spinal muscles must counteract this imbalance and thereby fatigue, possibly resulting in severe pain. The anterior imbalance has a great impact because it increases the risk of progressive thoracic kyphosis.

13.1.3 Clinical Symptoms

Degenerative changes of the spine provoke a lot of different clinical symptoms. But especially in elderly patients, the typical clinical features are often masked by a lot of possible comorbidities. On the other side – as mentioned above – spine degeneration is a physiological phenomenon and not each radiological abnormality has to be treated as a symptomatic degenerative pathology. So only the matching correlation of the clinical and radiological features can be the base for a successful treatment plan.

Two important pathogenetic causes for symptoms in degenerative spine disease have to be mentioned:

- The arthritic changes of the facet joints, together with an optional increased mobility of the segment leading to local pain.
- The degenerative narrowing of the spinal canal compromises the adjacent neural structures with radicular pain and optional neurological deficits reaching from mild sensory disturbances to severe tetraparesis in cases of a cervical myelopathy.

13.1.4 Diagnostics

The diagnostic algorithm for potential degenerative spinal changes is always based on three consecutive columns irrespective from the affected section of the spine:

1. Patients history
2. Clinical examination
3. Radiological procedures

13.1.4.1 Patient's History

An exact and not only spine-related evaluation of the patient's history, especially in elderly patients, is mandatory because only the synopsis of clinical and radiological findings define further diagnostic and therapeutic measures. The initial questionnaire should include pain characteristics (burning, stabbing, movement dependency, etc.), duration and distribution (mono-/poly-/pseudoradicular?), possible neurological (motoric, sensory, vegetative) disturbances, and possible other preexisting comorbidities including cardiovascular, cerebral, and neoplastic pathologies. An osteoporosis is often known.

Special "red flags" which require urgent diagnostics can be ruled out during the first interview; these are:

- Severe neurological deficits including vegetative disturbances, possibly indicating a relevant compression of neural structures
- Fever, progressive pain, and/or immunological deficits, indicating a possible infectious pathology (spondylodiscitis, intraspinal abscess, or empyema)
- Trauma history, suggesting a fracture, sometimes even a sudden onset of the symptoms can be the clinical correlate of a spontaneous osteoporotic fracture
- History of a malignoma, with a spinal tumor or metastasis

In these cases, even when there are no relevant deficits, further diagnostics have to be scheduled within hours or days to not overlook potential spinal cord – or even life-threatening pathologies.

13.1.4.2 Clinical Examination

The following clinical examination has to be performed not only as "symptom-related check" but rather as a complete "whole body examination" focusing on neurological but also on orthopedic and on medical abnormalities. Systemic CNS problems like ischemia, neurodegenerative diseases, normal pressure hydrocephalus, and chronic inflammatory CNS diseases can be causative for the symptoms of the patient. Also cardiovascular pathologies like peripheral arterial disease (PAD) and even myocardial infarction can mimic lumbar or cervical radiculopathy. There is a relevant coincidence of spine degeneration and cox- and gonarthrosis, and an exact examination can reveal the pain causing the problem.

Apart from the body check, a (neuro-)psychological evaluation can be helpful, especially in cases of a planned operative treatment. So a possible psychopathological component of the pain on the one hand and neurocognitive deficits in cases of neurodegenerative diseases on the other hand can be determined. During the last years, the psychological pre- and postinterventional state of the patient has been recognized as an important and even prognostic factor within the treatment concept of degenerative spine disease.

13.1.4.3 Radiological Procedures

In symptomatic patients a targeted radiological examination is necessary. So the causative pathology can be named, additional diagnostic procedures can be scheduled, and, in the end, a treatment concept can be established.

But one always has to bear in mind that the sole radiological detection of degenerative spine changes is not sufficient to indicate specific therapeutic measures. As mentioned before, there has to be always a correlation between clinical symptoms and the radiological findings. Terms like "absolute" or "relative" spinal stenosis only describe the radiological image; they do not reflect the clinical relevance and should be avoided in this context. The diameter of the spinal canal does neither reflect the clinical symptoms nor it even allows a prognostic statement before and after treatment [12].

The most important diagnostic tools are:

- Magnetic resonance tomography (MRI)
- Standard radiographs (flexion/extension/standing)
- Computed tomography (CT)

The gold standard for the detection of degenerative spine changes in the cervical but also in the lumbar area is the magnetic resonance tomography (MRI). The sensitivity concerning lumbar degenerative pathologies is described between 87 and 96 % with a specifity between 75 and 86 % [13]. In the cervical spine, the data are comparable. Routinely, the examination has to be performed as T1- and T2-weighted sequence in sagittal and transversal orientation. Changes of the discs, the bone, the ligaments, and the facet joints are visible as well as abnormalities concerning the regional alignment of the vertebral column in all three orientations. Furthermore, the MRI allows an exact assessment of intra- and sometimes even extraspinal pathologies. It shows the neural structures like spinal cord, cauda equina, and nerve roots and their potential contact to the surrounding structures. In special cases, when a tumor or an infection is suspected, contrast enhanced imaging is necessary.

Nevertheless, the native standard radiograph in two orientations (anterior-posterior and lateral) of the spine still has its place in the diagnostic of degenerative spine disease. In cases of an unclear history, it can rule out fractures or osteolytic changes. Changes in the alignment possibly indicate a relevant instability which can be definitely diagnosed with an X-ray in standing position and/or under flexion/extension. In selected patients films of the whole spinal column can be necessary to assess reactive changes in distant spine sections [13].

The domain of the computed tomography is the delineation of bone. Fractures, osteolysis, and genuine spondylolisthesis can be located exactly, and discoligamental changes ("soft disc") can be distinguished from osteophytes ("hard disc"). In the context of a scheduled surgical intervention, a preoperative depiction of the vertebrae is reasonable, especially when an additional instrumentation is planned.

Against this background the evaluation of the bone density, especially in elderly patients, becomes more and more important. Quantitative computed tomography

(qCT) is a good option to get an exact value of the bone mineral density. According to our experience, a BMD of lower than 100 mg/cc is an indication for an additional cement augmentation or an extension of the instrumentation. A myelography today is only in exceptional cases indicated, e.g., in patients with a ferromagnetic implant or when a mobility-dependent compression of neuro structures especially in the cervical spine are needed.

13.1.4.4 Additional Diagnostics

Additional electrophysiological examinations help to rule out some of the differential diagnosis, e.g., neurodegenerative diseases, inflammatory radiculopathies, nerve compression syndromes, and other mono-/polyneuropathies.

Electromyography and sensory evoked potentials can define the clinical relevant level in cases of a multisegmental spinal stenosis. In the cervical spine, subclinical myelin affection can be determined with the motor evoked potential as the most sensitive and prognosis relevant technique even when clinically evident neurological deficits have not yet occurred [14, 15].

To confirm or to rule out other reasons for the complaints, more technical examinations might be necessary. So in cases of a suspected peripheral arterial occlusive disease, an angiologic assessment with ultrasound evaluation of the ABI (ankle-brachial index) has to follow. Degenerative or traumatic changes in shoulder, hip, or knee – if clinically suspected – require specific radiological examinations.

Laboratory tests can be path breaking in cases of an infection and in autoimmune diseases. When a systemic CNS infection or a chronic inflammatory CNS process seems possible, a spinal tap is indicated.

13.2 Cervical Spine

13.2.1 Cervical Disc Herniation

Cervical disc herniation is the result of an extrusion of the nucleus pulposus through tears in the annulus fibrosus with mechanical irritation of cervical nerve roots or the spinal cord in consequence.

The main causes of disc herniation are age-related changes of the intervertebral disc making the annulus fibrosus susceptible to fissuring and tearing. Cervical radiculopathy due to disc herniation usually occurs during early stages of motion segment degeneration and mainly affects individuals in the fourth and fifth decades of life. Thus, in contrast to younger patients, pure “soft disc protrusions” are rare in elderly patients. If present, they are generally not the only pathology; in fact, they are frequently associated with further degenerative changes. These combined lesions are usually detectable as the so-called hard disc (that means calcified) protrusion in combination with bony spurs at the edges of the vertebral body and osteophytes. Furthermore, there are almost always degenerative changes of the uncovertebral joint with a concomitant uncoforaminal stenosis leading to additional compression of the segmental nerve root. The irritation of the spinal nerve may be pronounced either in

Table 13.1 Table depicts the clinical signs of cervical radiculopathy

Root syndrome	Pain radiation	Reference muscle	Reflex loss
C5	Shoulder, upper arm	Deltoid	–
C6	Radial side of forearm	Biceps, brachioradialis	Biceps, brachioradialis
C7	Whole forearm, mainly second/third finger, chest	Triceps	Triceps
C8	Ulnar side of forearm	Abductor digiti minimi, interossei	Trömner

the dorsal or in the recurrent ramus. The pathophysiology of radiculopathy involves both mechanical deformation and chemical irritation of the nerve roots. This results in a dermatome-associated distribution of the radiating pain.

13.2.1.1 Clinical Symptoms

The clinical symptoms occur for direct compression of the segmental spinal nerve (radicular pain) and the rear longitudinal ligament (dull pain), sometimes even presenting as so-called pseudoradicular pain. This kind of pain can be differentiated from radicular pain insofar, as dermatomal or myotomal allocation is not or only inaccurately possible. In the first line, pseudoradicular pain originates from the joint capsule: It is suspected that degenerative changes of the disc promote a change of the facet joint position so that tension on the joint capsule induces neck pain in consequence. On the other hand, pseudoradicular pain is the result of continuous innervation of the dorsal ramus which provokes muscular pain as well.

In addition to that, the muscle tone of the paraspinal muscles is partly controlled by receptors in the joint capsule resulting in a spontaneous pain in the affected muscles. This pain can be reproduced by pressure on so-called trigger points. In contrast, pressure on the posterior longitudinal ligament by disc protrusion rather leads to dull neck pain, often with a gradual onset. If there is real compression of a segmental spinal nerve, a radicular pain syndrome is the typical result. The pain radiates (into the shoulder, forearm, and chest) with a strict dermatome- and myotome-associated distribution (Table 13.1). The extent of compression correlates to some degree with the pain level. In advanced stages, paresis and atrophy of the depending muscles are possible.

13.2.2 Cervical Spondylotic Myelopathy (CSM)

Narrowing of the spinal canal by a disc herniation or osteophytes can lead to severe neurological deficits because of a direct compromise of the spinal cord resulting in the clinical syndrome of myelopathy. The most common cause for cervical myelopathy in the elderly is cervical spondylosis. Ossification of the posterior longitudinal ligament (OPPL), trauma, or tumors is seen much less frequent as a cause for cervical myelopathy in the elderly.

The pathophysiology of CSM is related to static, dynamic, and vascular factors.

13.2.2.1 Static Factors

The normal sagittal diameter of the subaxial cervical spinal canal varies between 14 and 22 mm. Normally, the spinal cord occupies about three-quarters of the size of the spinal. A narrowing of the spinal canal (static factor) results from cervical spondylosis, disc degeneration, osteophyte formation, and hypertrophy of the facet joints and the yellow ligament. Development of cervical myelopathy is more frequent in patients with a congenitally narrow spinal canal.

13.2.2.2 Dynamic Factors

Flexion and extension of the cervical spine can result in lengthening and consecutive stretching of the spinal cord over vertebral osteophytes, which may lead to a chronic injury of the myelon. Extension of the cervical spine leads to folding of the yellow ligament with dorsal compression of the cord combined with anterior compression due to posterior disc bulging. If disc degeneration in combination with degenerative instability is present, the resulting translative movement may lead to further compression of the spinal cord and consecutive increase of strain and shear forces applied on the cord.

13.2.2.3 Vascular Factors

The corticospinal tract is very vulnerable to ischemia undergoing demyelinization, much more if the spinal canal is narrowed: a compressed spinal cord certainly does not tolerate hypoperfusion. Reversely, a spinal cord with diminished perfusion will not tolerate compression as well.

The following mechanisms of injury to the vascular system of the spinal cord are known:

- Direct compression of the anterior spinal artery
- Torsion and tension of the anterior sulcal arteries with reduced blood flow in the transverse perforating vessels causing ischemia and degeneration of the gray and medial white matter (typically in the early stage of CSM)
- Compression of segmental vessels in the neural foramen
- Interruption of liquor circulation

Apoptosis seems to be the fundamental process in the pathogenesis of CSM [16]. Segmental changes of the comprised segment are presumably the result of neuronal loss due to apoptosis, and the early apoptotic loss of oligodendrocytes is supposed to cause degeneration of the long corticospinal tracts.

13.2.2.4 Clinical Symptoms

The clinical symptoms correlate with the affected region of the cervical spine, but there is no correlation between the extent of compression and the clinical symptoms. In most cases, symptoms are developing slowly. Initial symptoms comprise numb and clumsy hands, compromising fine motor skills (like fastening buttons, sorting coins, etc.), followed by gait ataxia, especially in the dark in the later stages of the disease. Muscle weakness affects primarily the triceps muscle, the little hand muscles, and the proximal

Table 13.2 Nurick grading system [17]

Grading	Signs of myelopathy	Gait	Daily activities/working
0	No	Normal	No limitations
1	Yes	Normal	No limitations
2	Yes	Slight disturbance	No limitations
3	Yes	Significant disturbance	Limitations
4	Yes	Only with support	Not possible
5	Yes	Wheel chair/bedridden	Not possible

hip flexors (iliopsoas muscle). If CSM is ongoing, spastic gait, hyperreflexia, pathological reflexes (Babinski, Gordon, Oppenheimer), and sensory/vibratory deficits are detectable. Bladder and sphincter function may be impaired as well in the chronic stage of a CSM. The Lhermitte sign (pain on sudden head flexion causing electrical sensations along the spine) is positive in only a few patients which rather have an acute stenosis. One always has to keep in mind that multiple comorbidities of elderly patients (diabetes mellitus, chronic kidney disease, polyneuropathy, Parkinson's disease, system atrophies) can mask the initial and often mild symptoms of a CSM.

For observation of the clinical course as well as for scientific reasons, numerous scales have been introduced. The Nurick grading systems is based on gait abnormalities and was introduced in 1972 (Table 13.2).

The Japanese Orthopedic Association proposed a grading system (JOA score) by recording motor function of upper and lower extremities, trunk, and bladder function. The JOA score is widely used in the scientific literature [18]. Furthermore, in Europe the European Myelopathy Score was developed in 1994 [19].

There are some patients with neck pain as the predominant symptom which is part of the so-called spondylotic syndrome. These patients often complain about recurrent episodes of position-dependent neck pain, which is aggravated with motion. Upon request, they report on aggravation in the night and early morning. The neck pain is often accompanied by episodes of vertigo, dizziness, and vegetative symptoms. As well, headaches are a frequent concomitant symptom.

13.2.2.5 Diagnostics

Imaging

Both cervical root compression syndromes as a result of cervical disc herniation and cervical myelopathy are first of all clinical diagnoses. In most cases, an exact history and examination allows the diagnosis of radiculopathy and myelopathy. Root compression syndromes are characterized by the typical referred pain (see above) following dermatomal and myotomal distribution. In contrast to radiculopathy, a myelopathic syndrome generally begins subtly with numb, clumsy, and sometimes painful hands.

Imaging studies are helpful but sometimes confusing, because in nearly every patient older than 60 years of age, degenerative changes are detectable.

As earlier mentioned, the MRI has become the gold standard for the visualization of degenerative pathologies of the cervical spine. Image quality is excellent regarding soft tissue contrast and differentiation, whereas there are some limitations regarding bony tissue and bony alterations. Disc herniations are visualized with high sensitivity. The

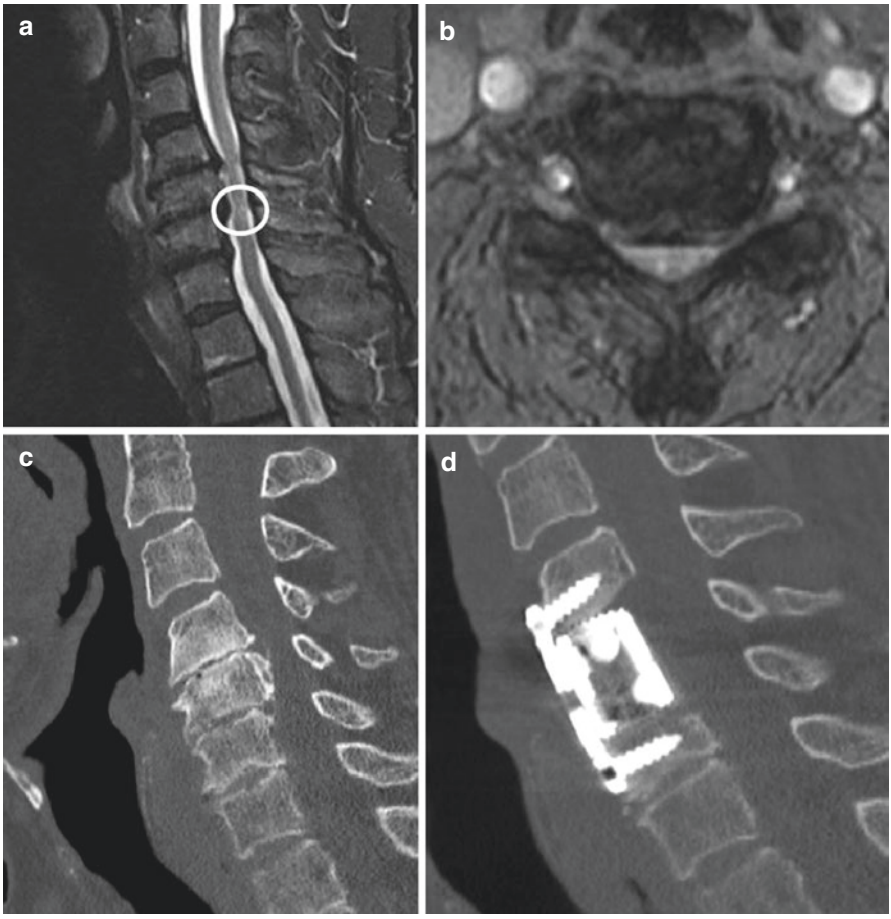

Fig. 13.3 Figure shows the MRI and CT scans of a patient suffering from a cervical spondylotic myelopathy. MRI preoperatively visualizes the narrowing of the spinal canal (**a**, **b**) and even a "radiologic myelopathy" at the level of C5/C6 (*circle*); CT reveals bony changes as the main problem (**c**). Note that the compression originates from ventral. CT after surgery shows the implant in the correct position (**d**)

different sequences can detect the stages of degeneration. In contrast to younger people, the T2- weighted sequences show the herniation mostly as iso- or hypointense because of the advanced degeneration process of the nucleus in elderly. T1- weighted images with contrast enhancement may differentiate between a sequestrated nucleus and scarred changes. If the herniation is subacute, the prolapse sometimes enhances in the periphery. The same also applies for the nerve root. Oblique sequences (90° to the long axis of the foramen) are helpful to visualize the neuroforamen and its content, especially in cases of long-lasting uncoforaminal degeneration processes with nerve root impingement. In patients suffering from myelopathy, the MRI may show the typical signal intensity changes, first and foremost the T2 hyperintensity within the spinal cord, which are sometimes called "radiological myelopathy" (Fig. 13.3). The prognostic significance of these changes remains unclear.

In addition to the MRI, CT scans are helpful especially for the planning of a surgical intervention. Bony changes, facet joint degeneration, uncoforaminal stenosis, and osteophytes are very well detectable. Furthermore, spontaneously fused segments are visualized with sufficient certainty.

In selected patients the CT can be done with additional myelography of the spinal canal. In the pre-MRI era, this imaging modality was the only one to visualize the spinal cord and the nerve roots in relation to the osseous structures of the cervical spine. In the present time, there are only two indications for post-myelography CT: if patients have contraindications for MRI (pacemaker, neurostimulators or other metallic implants etc.) and if additional information from dynamic images (flexion, extension) and its effects to nerve root and spinal cord compression is needed.

Standard radiographs of the cervical spine provide additional information about sagittal alignment, sagittal balance, and bony structures. They can be performed under flexion and extension to get further information about alignment changes and a potentially aggravated spondylolisthesis, but the value of these images remains controversial. The same applies for oblique radiographs to visualize the neural foramen. Normally, these images are of little use, because the CT provides more exact information about bony structures, neural foramen stenosis, and facet joint osteoarthritis.

Neurophysiologic Assessment

If the clinical picture is not clear or there is only little correlation of the clinical and radiological findings, additional electrophysiological assessment may be helpful. The question to be answered by electrophysiological diagnostics is whether a lesion is chronic or acute and which segment is the mostly involved one. Disadvantageous of all electrophysiology are frequent false-positive findings, especially in elderly patients. There is often a subclinical polyneuropathy which interferes with the electrodiagnostics of the cervical roots and the spinal cord.

For cervical root compression syndromes, the electromyography (EMG) of cervical myotomes including neck muscles plays a certain role. Acute root lesions show denervation activity (positive sharp waves, fibrillations) in the dependent muscles. Additionally, sensory nerve conduction studies may prove a preganglionic lesion, if the sensory nerve action potential is reproducible in clinical areas with subjective sensory loss.

For diagnosis of CSM, the EMG is of little relevance. In this context, evoked potentials (somatosensory and motor evoked potentials – SSEP, MEP) may have some importance. Tibial nerve SSEP abnormalities correlate with the extent of spinal cord damage in CSM [20]. In order to obtain a high sensitivity, both somatosensory and motor evoked potentials should be recorded on all limbs with a special attention to segmental cervical and cervico-medullary responses [21].

Differential Diagnosis
The following differential diagnoses have to be taken into account regarding degenerative cervical pathologies with nerve root or spinal cord compression in elderly people:

- Tumors (intradural/extradural)
- Inflammatory disorders
- Coronary heart disease!
- Compression syndromes of peripheral nerves and plexus brachialis
- Rheumatoid arthritis
- Shoulder girdle disorders (impingement syndrome, tendinitis, rotator cuff tear)
- Chronic inflammatory CNS diseases (Lyme disease, multiple sclerosis
- Neurodegenerative diseases

Seldom

Amyotrophic lateral sclerosis
Paraneoplastic
Toxic/metabolic causes
Acute idiopathic transverse myelitis
Vascular pathologies (malformation, cavernoma)
Drug induced
Viral infections

13.2.3 Therapy

13.2.3.1 Nonsurgical Treatment

The treatment decision depends from patient symptoms and his individual psychological strain ("pain is a private problem") as well as on the underlying pathology and on the patient's general condition and comorbidities. Furthermore, the natural history of the disease has to be acknowledged, and the expected outcome of the treatment has to be weighed against its risks and benefits considering the natural history.

As in younger patients, conservative treatment approaches are justified if there is no relevant neurologic deficit or rather no deficit can be expected in the near future. Cervical root compression syndromes often respond very well to a combination of local heat application and oral medication. Heat application leads to local hyperemia and relaxation of neck and shoulder muscles. Oral medication is applied with NSAID as the main column (Fig. 13.7). The use of soft collars in the acute phase is unclear. At least, there is no evidence-based recommendation pro or contra [22]. Local injections may be helpful in the early stage, but there is no even evidence for a long-term benefit neither for lidocaine IM nor for anesthetic nerve blocks including steroids [23, 24].

There is moderate evidence that spinal manipulation and mobilization are superior to general practitioner management concerning short-term pain reduction, but the effect of spinal manipulation is similar compared to high-technology rehabilitative exercises in the short- and long-term follow-up [25, 26].

13.2.3.2 Surgical Treatment

Indication

In the vast majority of degenerative cervical spine pathologies in elderly, a surgical approach is only justified if there has been an appropriate conservative treatment effort [27]. But nevertheless in some cases, an operative treatment, even in elderly people, is indicated. But before considering a surgical treatment, some criteria should be full filled for cervical disc herniation [28]:

- Evidence of nerve root compression because of the herniation.
- Signs and symptoms concordant with the compressed nerve root.
- If there is a progressive motor deficit, indication for surgery is corroborated.

In patients suffering from cervical spondylotic myelopathy, one has to bear in mind that the primary goal of every treatment (nonsurgical and surgical) is the prevention of further progression of the disease. Communicating this message to the patient prior to surgery is one of the keys to a successful treatment. If patients are informed about realistic goals, chances, and risks of the planned surgery, disappointment can be avoided from the beginning.

Surgery for CSM is generally indicated if there are:

- Progressive myelopathy or progressive neurologic deficits
- Evidence of spinal cord compression
- Progressive kyphosis in combination with myelopathy

The debate concerning the question, whether anterior or posterior approaches should be chosen for surgical management, is currently ongoing. The controversy on which of the two approaches is appropriate must always be related to the target pathology. That's why it is important to recognize whether the compression originates anterior or posterior from the neural structures. In consequence, the pathology should be treated where it is (Figs. 13.3, 13.4, and 13.5). Thus, an anterior cord or nerve root compression is generally better targeted from an anterior approach (Fig. 13.3) and multisegmental or purely posterior compression from a posterior approach (Fig. 13.5). Furthermore, the following points have to be considered:

- How is the sagittal profile of the cervical spine?
  - If there is a kyphosis, how much kyphosis is present? If present, is the kyphosis fixed or can it be reduced? For fixed or severe kyphosis (>10 ° C2-C7), anterior approaches are advantageous. If posterior approaches are necessary, pedicle screw instrumentation should be considered [29].

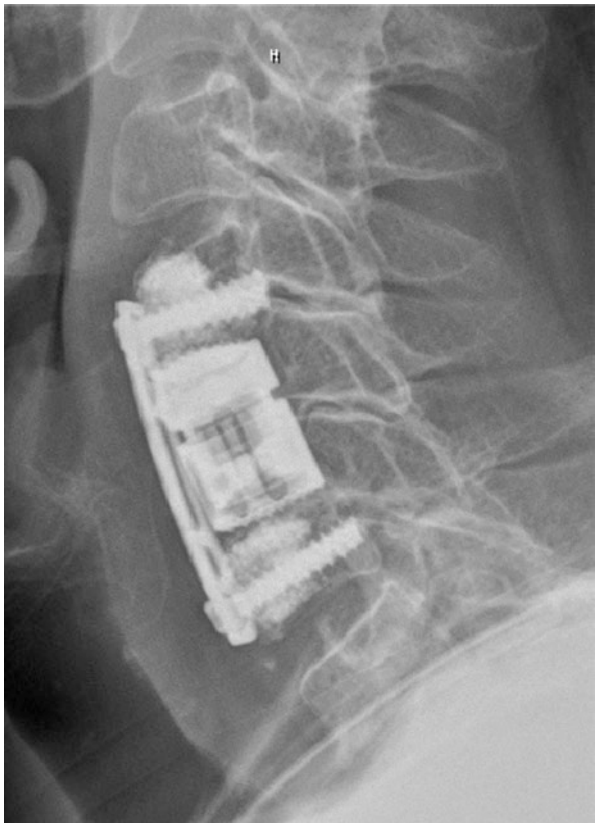

Fig. 13.4 Figure shows cement augmentation of cervical body screw after corpectomy C5 in a patient with a severe osteoporosis

- How is the bone quality (one of the most important questions when dealing with surgical approaches to CSM in elderly!)?
  - If bone quality is not sufficient (generally, if BMD is <100 mg/cc, see page 5) and more than one segment is involved, dorsal procedures (if possible with pedicle screw instrumentation) or circumferential fusion are probably advantageous. If corporectomy and plating is necessary in a patient with reduced bone quality, additional cement augmentation may be considered [30].
- Is there instability?
  - If present (clinical and/or radiological) think about fusion. Non-fusion procedures (like laminoplasty) are contraindicated.
- How many segments are involved?
  - For mono- or bisegmental pathologies, anterior approaches are suitable. If three or more segments are involved, dorsal procedures or circumferential approaches are preferable.

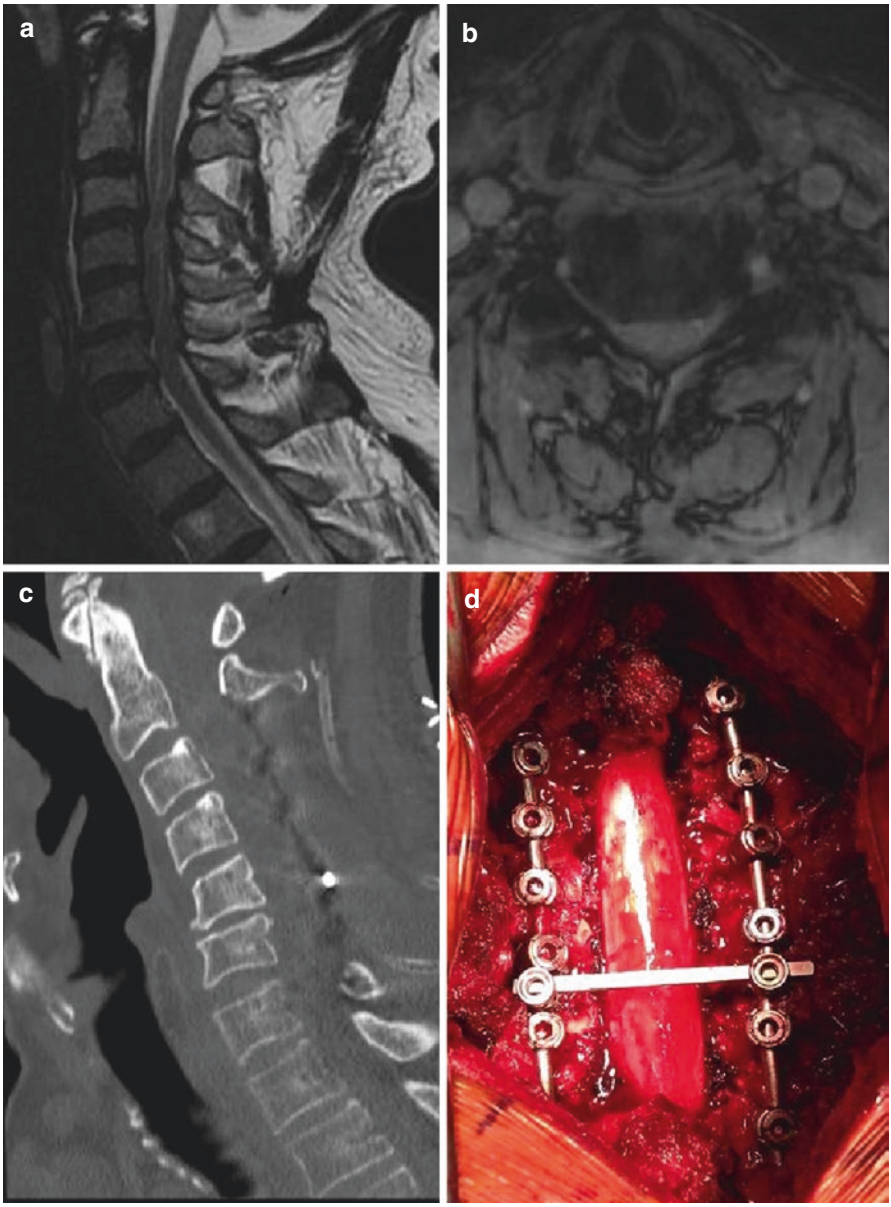

Fig. 13.5 Figure shows the case of a 66-year-old patient suffering from a cervical myelopathy caused by a multilevel cervical degenerative stenosis (**a**, **b**). (**c**) Shows the postoperative CT after multilevel laminectomy; (**d**) shows the intraoperative situation with the decompressed dural sleeve and the instrumentation with massa lateralis screws. Note the slight kyphosis of the cervical spine after the operation (**c**)

Table 13.3 Summarizes advantages and disadvantages of the different surgical approaches to the cervical spine

Ventral procedures		
	Advantage	Disadvantage
Anterior cervical discectomy and fusion (ACDF), if appropriate with additional plating	Decompression directly from anterior Preservation of the vertebral body Easy and safe for simple mono- or bisegmental disc herniations Feasible for multiple segments if bone quality is sufficient	Complex surgery, if multiple stenotic segments are involved; problematic, if marked bony spurs are present High-risk surgery if spinal canal is very narrow Nonunion if multiple segments are involved Hardware failure (plate dislocation, cage subsidence) in case of reduced bone quality
Corpectomy with plating (Figs. 13.3 and 13.4)	Sufficient decompression Restoration of sagittal profile is possible	Complex surgery Considerable nonunion rate Contraindicated if bone quality is bad Long operation time
Dorsal procedures		
Posterior foraminotomy (Frykholm)	Fast Low morbidity	Suitable only for lateral soft disc herniation
Laminectomy	Safe and easy Effective Suitable for multiple segments	Secondary instability (Swan neck deformity) Indirect decompression
Laminectomy with instrumentation (massa lateralis/pedicle screws) and fusion (Fig. 13.5)	Effective Avoidance of secondary deformity Restoration of sagittal profile is possible to some extent	Hardware failure (in particular if massa lateralis screws are used in combination with reduced bone quality) Complex surgery (if pedicle screws are used)
Laminoplasty	Motion preservation (theoretically)	Complex surgery Progressive limitation of cervical range of motion No proof of superiority Neck pain
Combined procedures		
	Effective Appropriate in case of reduced bone quality Best results for severe kyphosis	Complex! Normally two-step surgery Long operation times Enormous strain for patients

13.2.3.3 Surgical Techniques

Several surgical techniques are available to treat degenerative pathologies in the cervical spine, and they are used complementary in the daily clinical practice. First, the initial goal is to decompress the neural structures without causing instability. If instability is present or had been generated by surgery, instrumentation and fusion is indicated. These principles are similar to those of the surgical treatment of younger people (Table 13.3).

13.3 Lumbar Spine

13.3.1 Lumbar Disc Herniation

Isolated lumbar disc herniation is a rather rare entity in elderly patients; in fact it's often part of a multisegmental degeneration process leading to lumbar spinal stenos (see below). Nevertheless, it has to be mentioned as a possible cause of radicular symptoms considering that, even in cases of multisegmental stenosis, the treatment of a concomitant sequestrated disc herniation might be more successful than a multilevel fusion and decompression procedure.

Depending from the site of herniation, different symptoms can occur. One can differ between medial, mediolateral, and lateral pulposus prolapses with the spinal canal including the dural sleeve and the nerve roots as the leading structures. Furthermore, an up – and downward – sequestration is possible. These anatomical specialties define the complaints of the patient and have to be considered when assessing the symptoms of the patients.

13.3.1.1 Clinical Symptoms

The typical symptom of a lumbar disc herniation is the radicular "sciatic" pain possibly combined with sensory or motor disturbances. Like in the cervical spine, the distribution of pain and possible neurological deficits can define the affected nerve root (Table 13.4).

Table 13.4 Illustrates the clinical signs of lumbar nerve root compression

Root syndrome	Pain radiation	Reference muscle	Reflex loss
L3	Medial thigh	Iliopsoas, thigh adductors	Adductor
L4	Ventral thigh, medial lower leg, medial ankle	Quadriceps femoris	Patellar
L5	Lateral leg, lateral ankle, back of the foot, first toe	Extensor hallucis longus, gluteus medius	Tibialis posterior
S1	Back of the leg, heel, lateral foot last toe	Gastrocnemius	Achilles

In correlation with the different possible pathoanatomy of the disc herniation, one can state out a clinical, pathoanatomical combination: so medial and mediolateral extrusions normally affect the lower nerve root in cases of downward (caudal) sequestration; in cases of an upward (cranial) sequestration, the upper nerve root is affected. Patients with a lateral/extraforaminal disc herniation also suffer from symptoms of the upper nerve root. For example, a mediolateral disc herniation L4/L5 upward sequestration provokes an L4 radiculopathy, while the same location but with downward sequestration leads to an L5 clinic. An extraforaminal herniation leads to an L4 radiculopathy as well.

Typically, the symptoms aggravate during coughing, sneezing, and pressing.

13.3.2 Lumbar Spinal Stenosis

The more frequent problem in elderly patients, compared to isolated disc herniation, is the uni- and multilevel lumbar spinal stenosis. As mentioned above the ongoing degeneration leads to a multilevel narrowing of the spinal canal and a possible misalignment of the whole spinal column.

13.3.2.1 Clinical Symptoms

The typical symptoms of the degenerative lumbar spinal stenosis in the elderly are the radicular pain and more often the so-called spinal claudication.

Spinal claudication comprises a symptom complex including back and (pseudo-) radicular pain into the lower extremities. Typically, the complaints aggravate during standing and walking leading to a progressive reduction of the walking distance. Flexing the spine with widening of the spinal canal allows a clinical differentiation from peripheral artery disease (PAD). Patients suffering from spinal claudication tolerate uphill walking better than downhill walking, and bicycle riding is better possible than walking. This is in contrast to patients with a PAD whose complaints will often aggravate even when they ride a bicycle.

Concerning the exact anamnesis and the diagnostic tools, we refer to the chapter above.

13.3.3 Differential Diagnosis

As mentioned above the spectrum of clinical symptoms in elderly patients suffering from lumbar degenerative spinal changes is manifold, and the list of possible differential diagnosis is long. On the other side, an exact anamnesis and an extensive clinical examination can rule out a lot of possible pitfalls. So the personal contact and the personal examination are mandatory and of particular interest.

Possible differential diagnoses are:

- Vascular claudication
- Cox-/gonarthrosis

- Psychological disorders
- Cervical/thoracic degenerative disc disease
- Metabolic or inflammatory neuropathies
- Osteoporotic vertebral fractures

Seldom

Spinal infections/tumors
Myelopathy
Cerebrovascular or cerebrospinal lesions
Spinal dysplasias
Myopathy
Chronic inflammatory CNS diseases (Lyme disease, multiple sclerosis, etc.)
Bone necrosis of the femoral head
Hip fracture
Retroperitoneal/pelvic processes with affection of the lumbosacral plexus
Thrombosis
Aortic aneurysms

Against this background one has to consider that the possible differential diagnosis can occur even together with the lumbar problem. So an additional vascular occlusive disease is described in up to 26 % of the patients with comparable data concerning a coxarthrosis. Osteopenia and osteoporosis are reported in up to 100 % of the patients [31–33].

Nevertheless, the typical symptoms of degenerative spine disease are obvious in elderly patients as well, and a competent treatment in these cases is mandatory to prevent immobilization-caused complications which might lead to severe and sometimes life-threatening complications (e.g., thrombosis, pneumonia).

13.3.4 Therapy

Only the symptomatic patient has to be treated! In the lumbar spine, an abnormal radiological picture is not an indication neither for a conservative nor for a surgical intervention.

When the complaints of the patients require a treatment, different therapeutic options have to be considered. The therapeutic spectrum reaches from pain medication “on demand” to extensive dorsoventral operations. There are only a few valid studies with respect to this, but during the last year, the first data focusing on elderly patients were published [34]. But still there are no overall accepted guidelines or standards, and the management has to remain an individually based one, bearing in mind the problems of the elderly patients.

In general, a conservative treatment is considered in patients with mild complaints and/or severe comorbidities hindering a surgical approach.

After reviewing the data, a marginal evidence for the surgical versus the conservative management can be stated out [35–38] including one analysis study considering

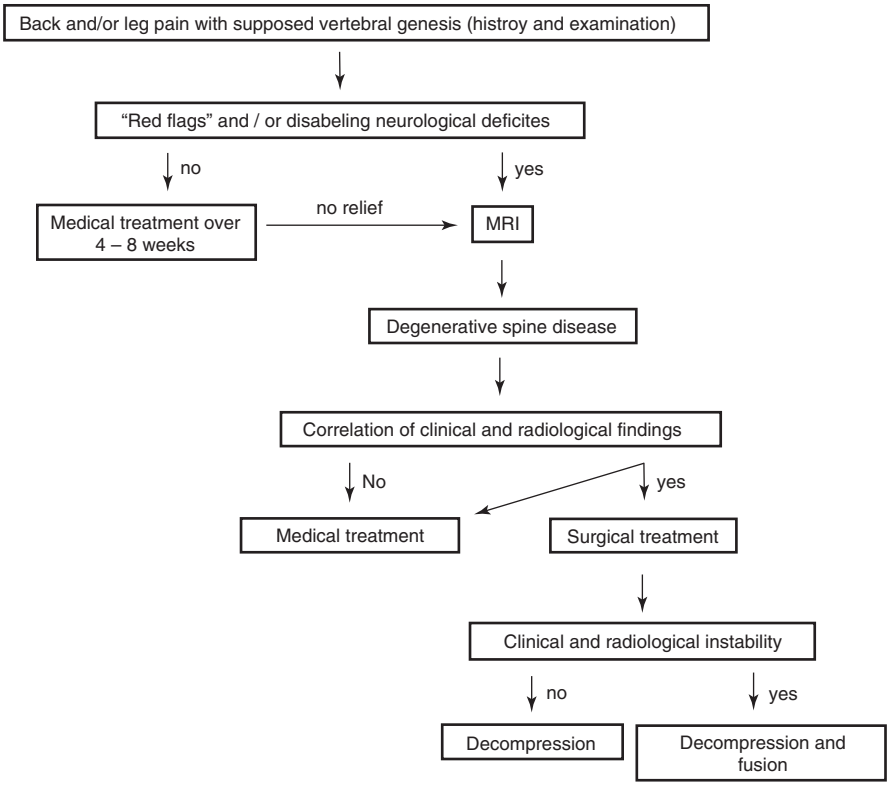

Fig. 13.6 Figure summarizes the diagnostic and therapeutic algorithm for lumbar degenerative spine disease

only elderly people [34]. Nevertheless, different surgical techniques (decompression/fusion/interspinous devices, etc.) and a different follow-up make an objective assessment difficult, and the correct treatment are still under discussion [39].

A clear indication for a surgical treatment are disabling neurological deficits (paresis/paralysis). In cases of severe deficits or especially vegetative disturbances, the indication for surgery has to be scheduled eventually as emergency.

When there are no neurological deficits and pain is the "only" symptom, the treatment concept is a more individual one, based on the constriction of live quality and the psychological strain of the individual patient. An objectification of the indication for surgery in these patients is difficult. The walking distance as a parameter might help. Some pain-, quality of life-, and spine-related scoring systems like short form 36 (SF-36) [40], Oswestry Disability Index [41], and the visual analog scale can be useful as well; anyway, these parameters have to be recorded during the follow-up to have objective and reproducible parameters even for post hoc and scientific analysis of the treatment strategy.

Especially when a surgical treatment is considered, a strict correlation between clinical symptoms and radiological findings is mandatory!

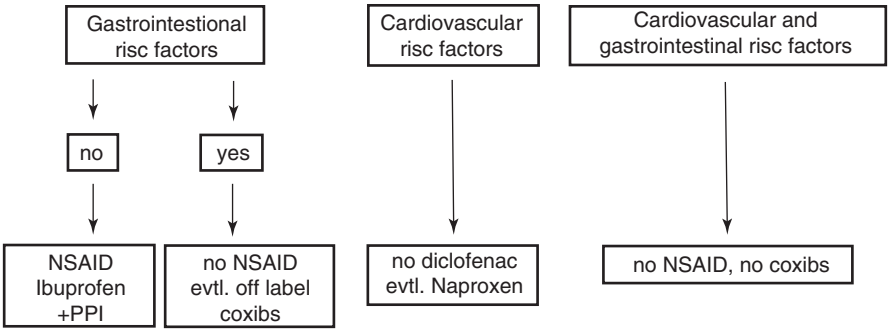

Fig. 13.7 Figure illustrates the actual, personal recommendations for the use of NSAID (Modified according to [43])

A relevant neuroforaminal stenosis, a short history of complaints, predominant leg pain, and neurological deficits are described as predictors for a positive outcome. Nonsmokers also seem to benefit more from an operation, so that it is recommended by some spine surgeons to cease the nicotine consummation before surgery [42].

When planning a surgical intervention, one has always to consider possible comorbidities like cardio- and cerebrovascular problems. Endocrinologic disorders like diabetes mellitus can, e.g., promote severe infections.

The possible complication profile of the planned surgical intervention has always to be weighed against the possible clinical benefit. This has to be communicated with the patient who often has an unrealistic expectation concerning the prognosis of the intervention.

The diagnostic and treatment algorithm is summarized in Fig. 13.6.

13.3.4.1 Nonsurgical Treatment

The conservative treatment concepts are based on the supposed painful pathophysiological mechanisms including an aseptic inflammation and reactive muscular disorders. It comprises medical and physiotherapeutic measures which in the majority of the cases indeed have a reproducible pain-alleviating effect sometime lasting for a long time. Unfortunately, robust evidence-based guidelines are lacking again.

The most popular analgesic substances are nonsteroidal anti-inflammatory drugs (NSAID) which are the basis of a medical analgesic therapy. But especially in elderly people, one has to consider the cardiovascular and gastrointestinal situation.

The most established agents like ibuprofen and naproxen (and aspirin, too) are available on the counter in most countries, but there is still a remarkable risk for gastrointestinal and also cardiac side effects. Actually naproxen is considered to be the at least harmful product with respect to cardiovascular side effects (Fig. 13.7). Proton pump inhibitors (PPI) are mandatory in these patients [43].

COX-2 inhibitors (coxibs) as "off label" option even influence the cardiovascular system. So, coronary artery and cerebrovascular diseases are contraindications as well. These facts often hinder a sufficient analgesic treatment. On the other side, the use of corticosteroids or stronger analgesics including metamizole or opioids,

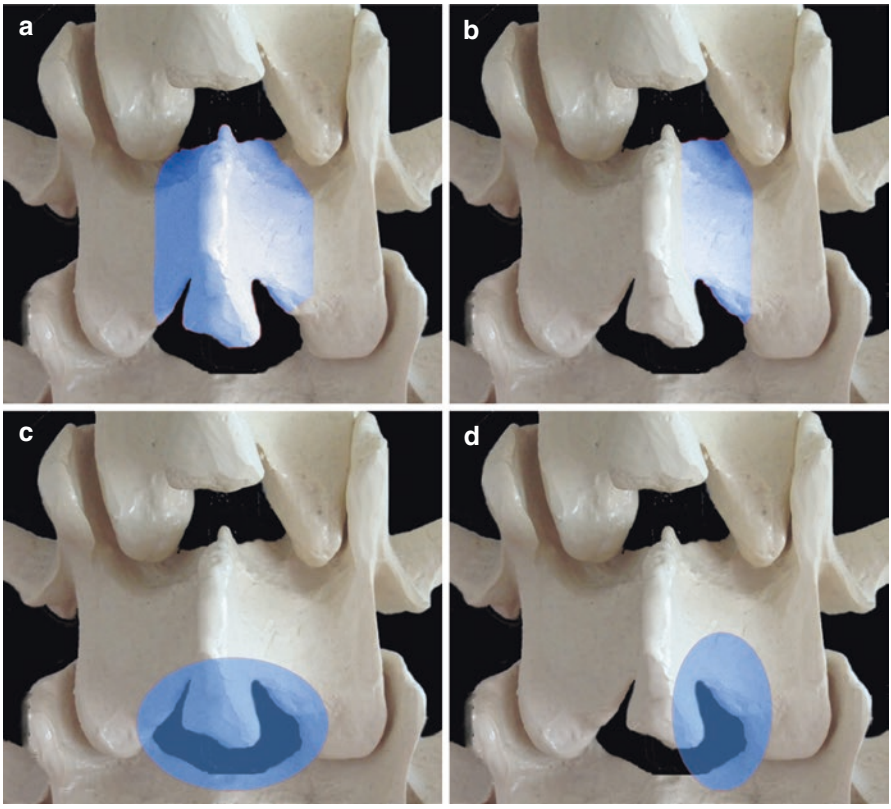

Fig. 13.8 Figure illustrates the possible techniques of spinal canal decompression with laminectomy (**a**), hemilaminectomy (**b**), interlaminar fenestration with undercutting (**c**), interlaminar fenestration (**d**)

antidepressive drugs, and other central-acting drugs like pregabalin and gabapentin as analogues of ɣ-aminobutyric acid is under critical discussion [37, 44, 45].

Local injections including facet joint infiltration, epidural local anesthesia, and/or steroid injections may help in some cases, but up to now, there are not enough data to demonstrate a reproducible long-term pain-reducing effect [46–48].

The most important column in the conservative management of degenerative spine disease, especially in elderly patients, remains the physiotherapeutic treatment. The possible measures include muscle-relaxing techniques like massages and local heat application in the acute stadium and a consequent outpatient-based physiotherapeutic guidance to strengthen the thoracolumbar muscle bending so that the patient regains and particularly preserves his motility [43].

Taken together, the conservative treatment of disabling low back pain in elderly pain is challenging with an interdisciplinary approach including spine surgeon, general practitioner, pain therapist, and physiotherapist required.

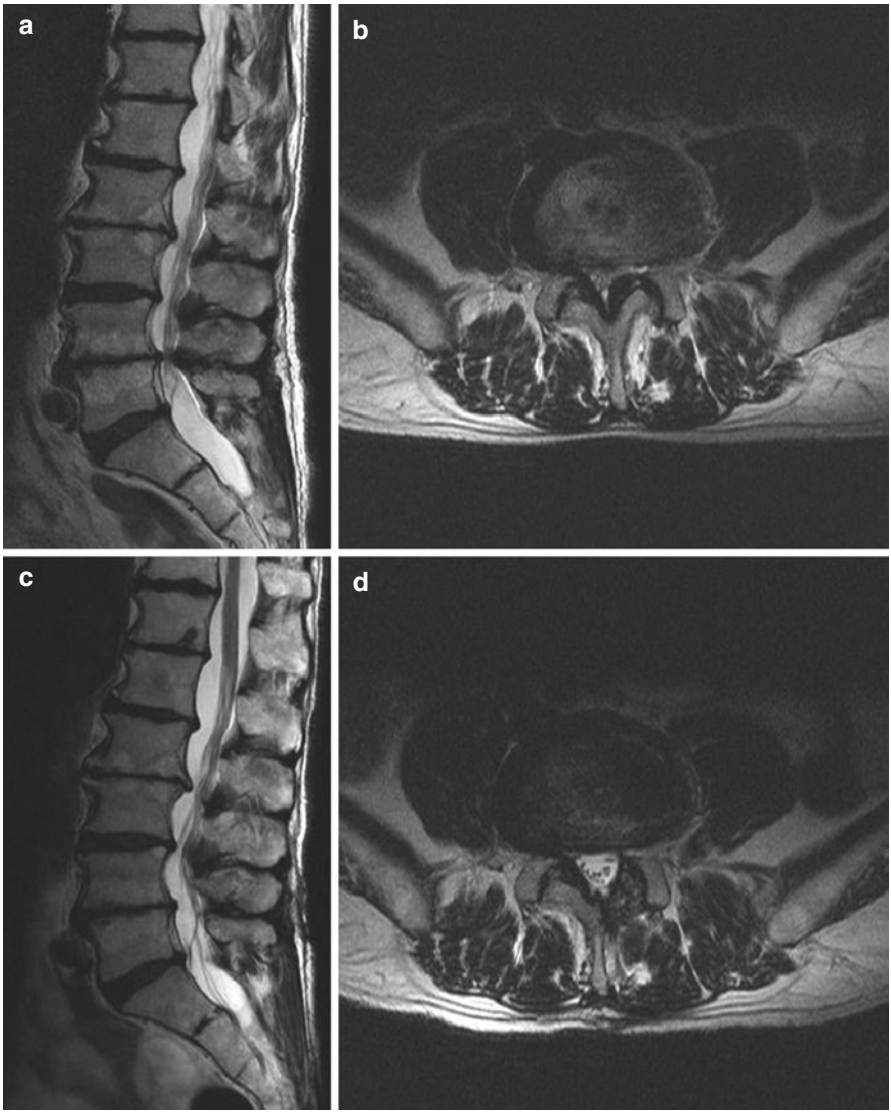

Fig. 13.9 This is an example for a sole decompression procedure (interlaminar fenestration) at the level L4/L5 on the left side in a patient suffering from one-sided sciatic pain. Presented are the pre- (**a**, **b**) and postoperative (**c**, **d**) MRI pictures

13.3.4.2 Surgical Treatment

Concerning the operative treatment of lumbar degenerative spine disease, the surgeon should always keep in mind the maxim "*as extensive as necessary, as minimal as poss*ible."

Decompression

As mentioned above the operative treatment aims in the first line on the decompression of the neural structures mean the dural sleeve and the adjacent nerve roots. In cases of a relevant instability, an additional fusion can be necessary (see below)

Possible techniques for decompression at lumbar levels are laminectomy, hemilaminectomy, and uni- or bilateral interlaminar fenestration, sometimes with undercutting to the contralateral side (Fig. 13.8). Laminectomy leads to a loss of the dorsal bending so that by now it's considered a destabilizing procedure which nowadays should be avoided. On the other side, hemilaminectomy and interlaminar fenestration allow a wide decompression with preservation of the relevant structures like facet joints and interspinous ligaments (Fig. 13.9).

The complication rate of a sole decompression at the lumbar spine is considerable. There are prospective data focusing on elderly patients describing complications in 18 % of the procedures. The most striking problems were dural leaks (9 %) but without clinical relevance and deep wound infections [39, 49]. Cardiovascular comorbidities can lead to additional pre-, peri-, and postoperative complications, so possible operative procedures require a clear indication and a strict anesthesiologic and cardiologic evaluation, before surgery is scheduled.

Another problem is sometimes an insufficient decompression leaving a clinical relevant remnant stenosis. The reoperation rate after decompression is reported with 11 % after 10 years [50].

Instrumentation and Fusion

An additive instrumentation together with fusion procedures is an established measure within the treatment spectrum of degenerative lumbar spine diseases. But unfortunately there are up to now no overall accepted guidelines which clearly define the indication for such a more extensive procedure. An abundance of available devices has lead to a more and more uncritical and not scientifically based use of screws, rods, cages, hooks, and so on.

Nevertheless, there is a good evidence for an additional fusion in cases of a genuine spondylolisthesis. In all other cases, an additional fusion in elderly and often polymorbid patients is barely scientifically underlined.

Furthermore, most spine surgeons go together that in case of a clinically and radiographically evident instability, a fusion procedure is also indicated. Painful degenerative scoliosis, translational instabilities, and even the degenerative olisthesis are examples for that. Another indication for an additional fusion is a manifest instability after decompression procedures.

The most popular technique is the instrumented intercorporal fusion which can be performed as ALIF (anterior lumbar interbody fusion), PLIF (posterior lumbar interbody fusion), or TLIF (transforaminal lumbar interbody fusion). Intraoperative distraction and the possibility of extended bony decompression within the fused levels lead to a relief of the nerval structures without a potential loss of stability.

On the other side, one has to consider the possible complication of an additional fusion procedure. Compared to simple decompression, there is a relevant increased operation time with an increased blood loss which might be problematic especially

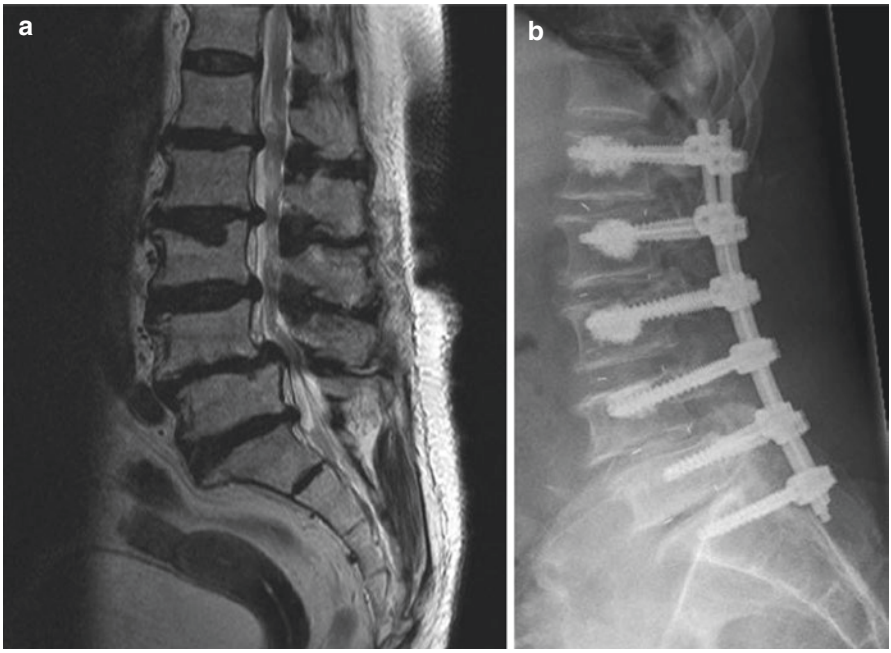

Fig. 13.10 Figure shows an MRI of a 69-year-old woman suffering from a severe bilateral lumbosciatic pain syndrome. She was unable to walk. MRI (**a**) revealed a multilevel spinal stenosis including a degenerative olisthesis at L4/L5. Surgical treatment comprised multilevel decompression and cement-augmented posterior lumbar interbody fusion

in cases of relevant comorbidities. The rate of medical problems and wound healing problems is higher in older patients. The bad bone quality represents always a problem which is sometimes hard to handle. A preoperative quantification of the bone mineral density is mandatory, and in cases of a manifest osteoporosis with a BMD <100 mg/cc, an additional augmentation of the instrumentation has to be considered (Fig. 13.10). The problem of adjacent level degeneration including adjacent level fractures is still not completely understood.

Interspinous and Dynamic Devices

In contrast to the complete immobilization of a fused segment with the possible adjacent level degeneration, there are some new devices which have been developed under the presumption that abnormal motion induces pain. So preservation of the "normal" motion range was the first-line objective. Dynamic fixation systems and interspinous devices have been developed allowing a decompression on the one side and a motion-preserving (partial) fixation on the other. These devices should reduce the intradiscal pressure, they should release the facet joints, and they should widen the spinal canal and neuroforamina by distraction. The significance of these techniques has not yet been defined completely. Up to now the clinical benefit seems to

be comparable with decompression procedures but with an elevated risk of complications including fractures and material dislocation [51, 52].

13.3.5 Prognosis

Despite the up to now moderate evidence for an operative treatment of degenerative lumbar spine diseases, one has to consider that there is an reoperation rate of up to 15 % [50, 53–55] during follow-up for "complications" like recurrent disc herniation, restenosis, and adjacent level degeneration.

During the last years, we learned from a lot of high-quality studies that extent of the stenosis and different operative technique is of less importance compared to the psychological state and the expectations of the patient [56–58]. This has to be considered when planning a surgical therapy. The patient has to be informed honestly about the possible results of the operation – surgery targets to the correction of an unstable spine or on the decompression of neural structures and not on a reversal or a cure of the degeneration process! So local pain in this context is still realistic even after an operative treatment, a fortiori in cases of a multilevel disease. So, in conclusion, diagnosis and treatment of degenerative lumbar spine disease require – especially in elderly people – a multidisciplinary approach of course considering pathoanatomical and pathophysiological specialties but even more the psychological situation including pain sensation and the expectations of the individual patients. Only when all this goes together, an acceptable result for all involved parties can be achieved.

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