



Cervical Myelopathy: Indication and Operative Procedure

6

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6.1 Introduction

The most common cause of spinal cord dysfunction is related to nontraumatic, noninfectious and nononcologic causes such as degenerative disc disease, hypertrophy of the ligamentum flavum, ossification of the posterior longitudinal ligament (OPLL) and progressive kyphosis [1, 2]. Cervical spinal cord dysfunction due to these pathologies is referred to as degenerative cervical myelopathy (DCM) leading to neurological deterioration and reduced quality of life [3, 4]. Treatment options for DCM range from non-surgical conservative approaches to surgical 360° reconstruction procedures of the cervical spine [5]. Optimal treatment requires thorough knowledge of the natural history of the disease, detailed expertise in surgical decision making, experience in anterior and posterior approaches to the cervical spine as well as medical expertise related to intra- and postoperative management of patients with (chronic) spinal cord injury [1, 5]. The following chapter outlines three different cases of DCM focusing on timing of treatment and treatment indication (Case 1), surgical decision making (anterior vs. posterior vs. combined technique, Case 2) and the special pathology of

ossification of posterior longitudinal ligament (OPLL, Case 3). Rationale for surgical treatment derived from typical symptomatology and preoperative imaging/diagnostics is demonstrated. Surgical techniques, approaches and risks are discussed in relation to the pathoanatomical presentation of DCM based on three exemplary cases.

6.2 Case Descriptions

6.2.1 Mild Degenerative Myelopathy C5/6

A 45 year old male patient presented with persistent radicular pain for 3–6 months in the right arm corresponding to the C6 dermatome paralleled by dysesthesia. The patient did not experience changes in gait or fine motor movements of the hands. Furthermore no paresis was detected on physical exam. The patient has not performed specific therapeutic interventions except for pain medication that did not lead to permanent control of the radicular symptoms.

Physical exam: visual analogue scale (VAS) for radicular pain right arm: 6 points; modified Japanese Orthopaedic Association scale (mJOA): 17 points; NURICK scale grade 0 (Fig. 6.1).

Based on these findings the patient presents with a severe spinal canal stenosis and the presence of myelomalacia in MRI, yet without clinical signs of myelopathy. The radicular pain in the

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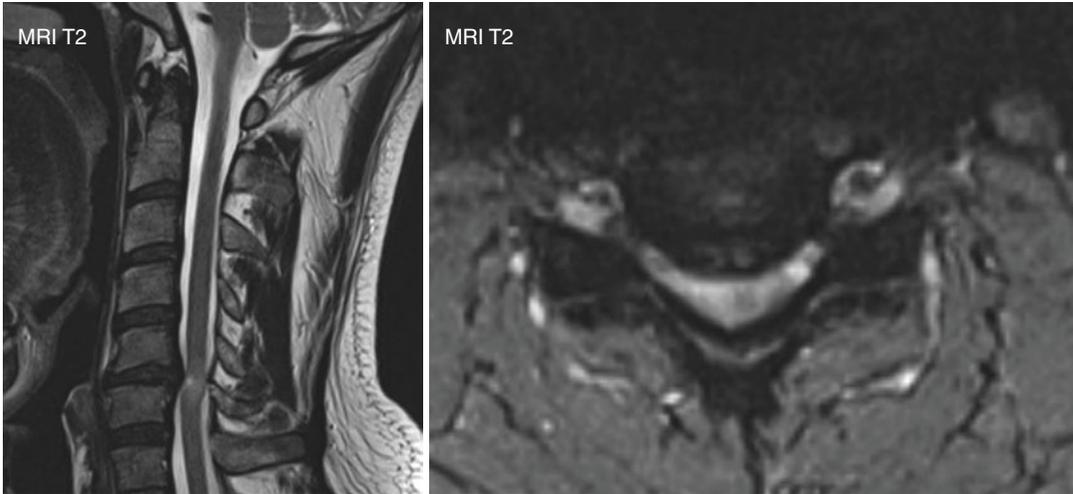


Fig. 6.1 MRI scan. The MRI scan demonstrates severe cervical spinal canal stenosis in C5/6 with corresponding signs of myelomalacia due to a broad based disc protrusion and bilateral foraminal stenosis

right C6 dermatome may be due to foraminal stenosis and / or to the presence of myelomalacia which may not be differentiated clinically. Results of the mJOA and Nurick scale underline the clinical diagnosis with very low scores. This clinically mild or almost non-present form of myelopathy is in clear contrast to the myelomalacia (T2 hyperintensity) demonstrated in MRI. In these cases, electrophysiological assessment adds important information beyond findings in physical examination (e.g. clinically non-detectable compromise of MEPs or SEPs). Therefore in order to further analyse the patients pathology flexion/extension x-ray of the cervical spine and electrophysiological analysis of somatosensory evoked (SEP) and motor evoked potentials (MEP) was performed. No deficits in SEP and MEP analysis were detected while x-ray imaging did reveal a non-moving segment C5/6. Additional CT imaging verified a soft disc protrusion causing the spinal canal stenosis (Fig. 6.2).

Due to persistent radicular pain and the presence of severe spinal canal stenosis the decision was made to operate the patient using an anterior cervical discectomy and fusion (ACDF) in order to decompress the spinal canal and the foraminal stenosis.

6.2.2 Severe Degenerative Multisegmental Myelopathy

A 44 year old female patient presented with progressive gait ataxia, persistent paresthesia in the left arm and left foot. Especially the gait disturbance has worsened over the last 12 months. The patient had received MRI with the diagnosis of a cervical spinal canal stenosis 4 years ago due to similar but less pronounced symptoms. The indication for surgical decompression was already seen at that time, however the patient declined surgical treatment due to tolerable symptoms and decided for conservative management.

Physical exam: mJOA 10 points, NURICK scale grade 3, VAS 5 points for neck pain (Fig. 6.3).

Additional electrophysiological analysis demonstrated a reduced response in SEPs from the upper extremity verifying spinal cord injury. Consequently surgical treatment was recommended for that patient. Due to cervical kyphosis and the compressive pathology restricted to the disc segment without signs of ossification, the decision was made to perform three-level ACDF in order to decompress the spinal cord and to correct the kyphotic deformity (Fig. 6.4).

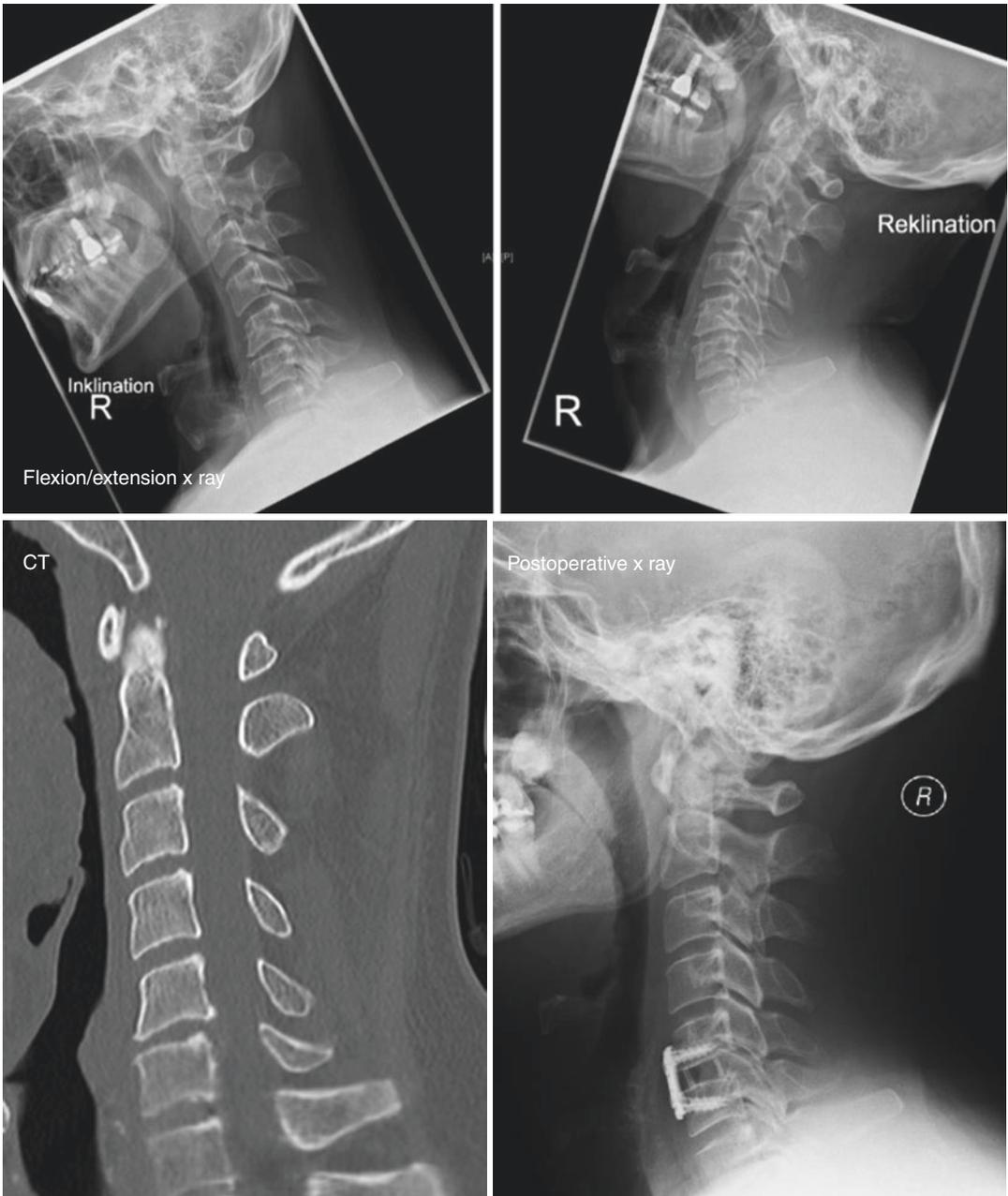


Fig. 6.2 x-ray and CT imaging of the cervical spine. Flexion/extension x-ray of the cervical spine shows a fixed C5/6 segment without signs of instability. CT imag-

ing demonstrates a soft disc protrusion without signs of ossification in C5/6. A postoperative x-ray control verifies a three level discectomy and fusion from C3-6



Fig. 6.3 Preoperative MRI. MRI demonstrates cervical degenerative kyphosis with severe spinal canal stenosis in segments C3/4, C4/5 and C5/6 and associated myelomalacia

6.2.3 Degenerative Myelopathy Due to Ossification of the Posterior Longitudinal Ligament

A 57 year old male patient presented with coordination problems and fine motor dysfunction of both hands especially when eating and manipulating small items. Additionally a gait disturbance has developed over the last 9 months resulting in 2 domestic falls while walking to the bathroom at night without turning the lights on. The patient had received MRI at an external institution demonstrating severe spinal canal stenosis with a maximum extension behind C4 and C5. A less pronounced spinal canal stenosis is shown in C5/6.

Physical exam: mJOA 13 points, NURICK scale grade 2 (Fig. 6.5).

Electrophysiological assessment showed delayed latencies in MEPs from the upper and

lower extremity verifying spinal cord injury. Due to the unusual compressive pathology in MR imaging a CT scan was initiated which verified a broad based OPLL behind the vertebral bodies of C4 and C5. In the presence of OPLL surgical treatment was recommended using a posterior approach with wide laminectomy and posterior instrumentation using spinal navigation for the placement of cervical pedicle screws (Fig. 6.6).

6.3 Discussion of the Cases

6.3.1 Indication Case 1

The patient in case 1 represents a non-myelopathic patient with imaging evidence of cord compression and radiculopathy. Indication for surgical treatment is based upon natural history of the disease, rates of disease progression/myelopathy

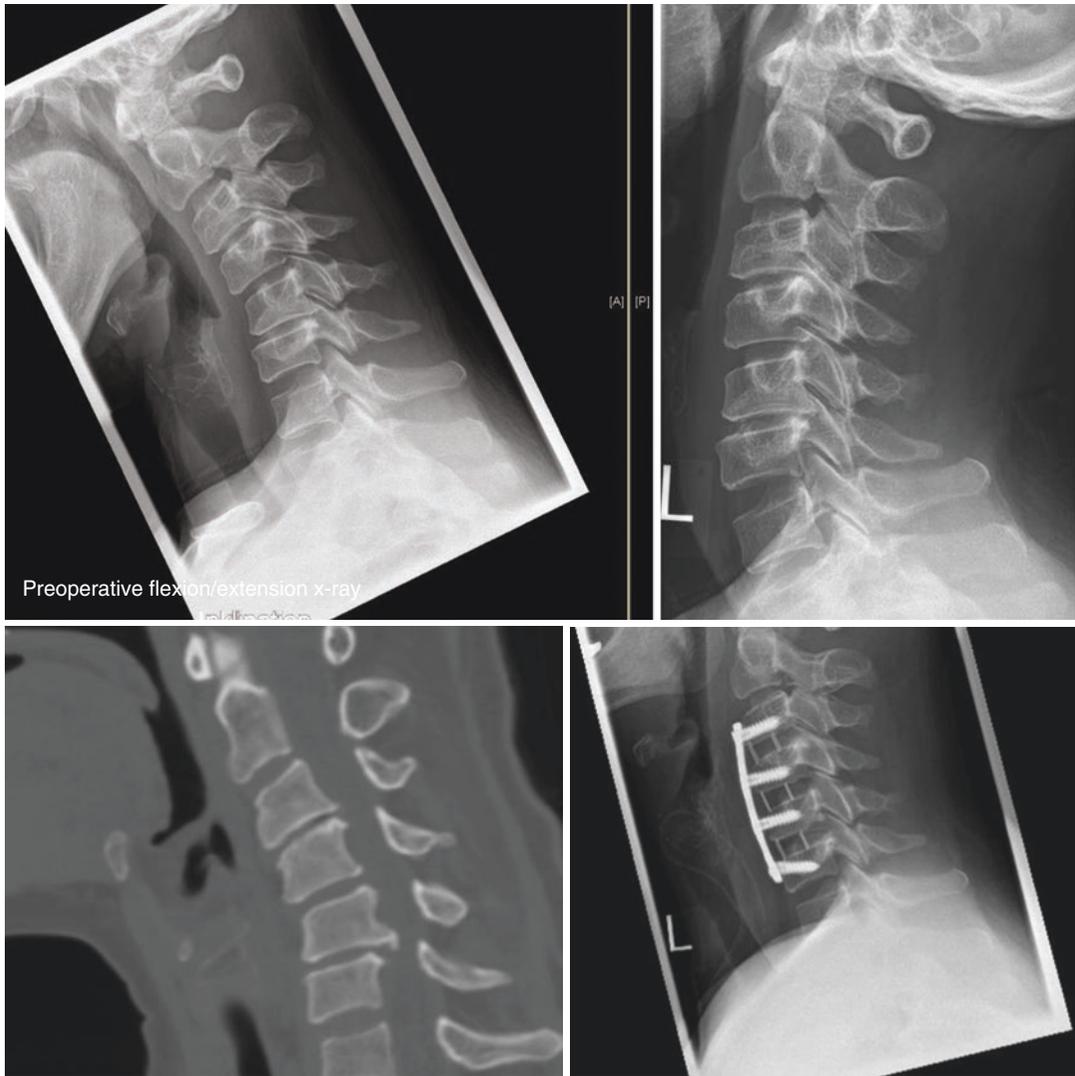


Fig. 6.4 CT and x-ray imaging. CT imaging verifies soft disc protrusions and dorsolateral spondylophytes as cord-compression pathology without signs of ossification. Flexion/extension x-ray demonstrates preserved motion in C2/3 and C6/7 while the degenerated segments are fixed.

No signs of instability are demonstrated. Postoperative X-ray imaging demonstrates ventral discectomy and decompression in segments C3/4, C4/5 and C5/6 with ventral plating from C3-6 and correction of cervical kyphosis

development and risks of operative intervention [1]. Over an observation period of 44 months, 22.6% of patients with imaging evidence of cord compression/cervical spinal canal stenosis develop clinically manifest myelopathy [6]. In the case of OPLL, the rate may rise up to 61.5% of patients developing myelopathy. Presence of radiculopathy and electrophysiological compromise (prolonged SEPs and MEPs, evidence of anterior horn cell lesion) have been identified as distinct and independent risk factors favoring

early myelopathy development within 12 months [6]. Clinical radiculopathy was found in 62.5% of patients which eventually developed myelopathy as compared to only 26.35% of patients without developing myelopathy [6]. Once myelopathic symptoms exist more than 50% of patients worsen at performing activities of daily living over a 10 year period and experience a significantly higher rate for spinal cord injury-related hospitalization [1, 7]. In contrast, non-operative treatment is not well-defined consisting of different treatment

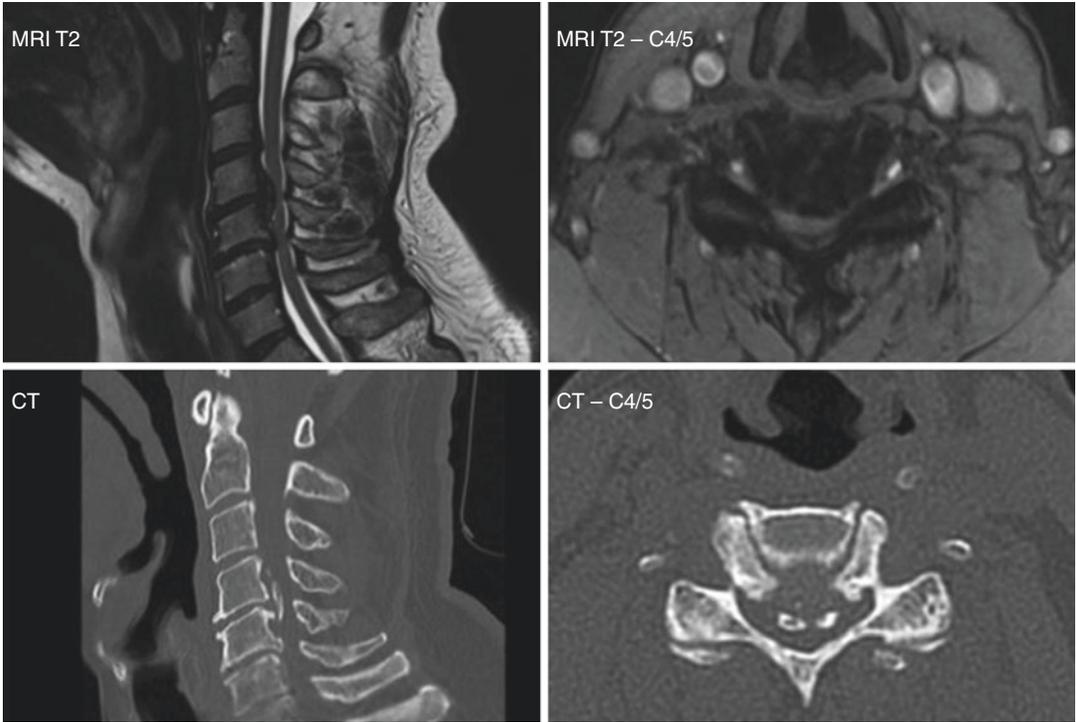


Fig. 6.5 MRI and CT. MRI demonstrates spinal canal stenosis and myelomalacia due to a cord compressing mass behind the vertebral bodies of C4 and C5 extending clearly beyond the disc segment. A moderate spinal canal

stenosis is verified in C5/6 restricted to the disc segment. CT imaging demonstrates a long ossified mass located behind vertebral bodies C4 and C5 (continuous OPLL) leading to severe spinal canal stenosis in axial view

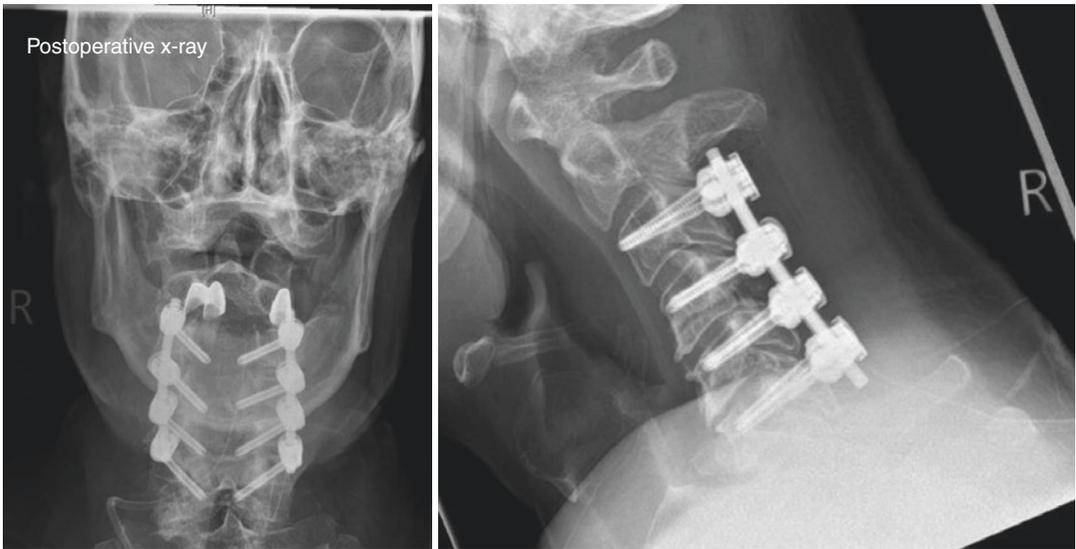


Fig. 6.6 Postoperative X-ray. Postoperative imaging verifies posterior decompression and fusion with cervical pedicle screws

algorithms including bed rest, cervical traction, cervical immobilization, thermal therapy, physical therapy and/or non-steroidal anti-inflammatory drugs [1, 3]. In the lack of clear evidence-based data, non-surgical treatment does not lead to a significant recovery of myelopathic patients with the exception for a specific subgroup of patients suffering from soft disc herniation and dynamic myelopathic symptoms [1]. Additionally, 23–54% of patients under non-surgical treatment eventually undergo surgical decompression due to conservative treatment failure [1, 8]. In contrast, the cumulative risk for complications after surgical treatment is low (overall complication rate 14.1%) with major complications ranging from 0.3% to 3.3% [1]. Based on these data, current treatment guidelines recommend either surgical treatment or a trial of structured non-operative treatment in non-myelopathic patients with imaging evidence of spinal cord compression and a relevant risk profile for developing myelopathic symptoms [1]. A shared decision making process between the treating physician and the patient must be performed as the use of prophylactic surgery is likely costly and of limited benefit. Nevertheless, a structured conservative treatment protocol may be challenging beyond practicability of every day life. Yoshimatsu et al. proposed a conservative treatment protocol of cervical traction of 4 h per day for 3 months paralleled by immobilization of the cervical spine, exercise therapy, drug and thermal therapy [9]. Furthermore, if patients experience neurological deterioration during conservative treatment they should be advised to surgical treatment because a longer duration of myelopathic symptoms and a higher severity of symptoms reduce the patients' chances to recover to a non-myelopathic neurological state [1]. In case 1, the indication for surgical intervention was seen due to the patients risk profile for developing myelopathic symptoms and the long-standing severe radiculopathy that significantly reduced the patients quality of life.

6.3.2 Choice of Approach

DCM may be caused by compression of the spinal cord from either anteriorly located, posteriorly

located or a combined localization of degenerative pathologies. Consequently both anterior and posterior approaches are available for the treatment of DCM. Following evidence based data, surgical decompression strategies utilizing both approaches have been demonstrated to effectively treat DCM [10]. Due to the scientific equipoise concerning the superiority of both approaches current treatment guidelines recommend an individualized approach when treating patients with CSM accounting for pathoanatomical variations (ventral vs. dorsal, focal vs. diffuse, sagittal, dynamic instability) [5]. The usual recommendation points out that if the compression occurs from anterior a ventral approach should be performed, if it occurs from posterior a dorsal approach represents the strategy of choice. In case 1 we chose an anterior approach due to the fact that a broad based soft disc protrusion led to an anterior compression of the spinal cord and the neuroforamina. Decompression of the neuroforamina is more easily achieved via an anterior approach compared to a posterior approach. Moreover, the compressive pathology is restricted to the level of the cervical disc, which can be completely addressed by anterior discectomy and fusion (ACDF) and the segment shows a slight kyphotic alignment, which is better corrected by an anterior approach. Additionally, the risk profile for postoperative neck pain favours an anterior approach [5]. The risk for laryngeal nerve palsy and major complications like vessel injury, esophageal injury and tracheal injury is very low (<2%) [11]. The rate of transient postoperative dysphagia lies around 6% [12].

6.3.3 Accordance with the Literature Guidelines

The current guidelines for the treatment of cervical myelopathy were the basis for the presented cases and the discussion of indication and approach.

Level of Evidence: C

The level of evidence available to date is low by only consisting of metaanalysis based upon retrospective series, cohort studies and few prospective studies.

6.3.4 Indication Case 2

The patient in case 2 presents clinical symptoms of severe DCM in response to a three segmental compression of the spinal cord at the disc level as a result of a progressive degenerative process leading to kyphotic deformity of the cervical spine. There is strong recommendation for surgical treatment for patients suffering from severe myelopathy as defined by an mJOA score of 0–11 [1]. Surgical treatment has been shown to significantly improve patients symptoms assessed by JOA, mJOA, Neck Disability Index, VAS and Nurick scores over a follow-up period of up to 36 months [1]. The overall risk profile for surgical treatment is very favorable with 14.1% [1]. Based on the fact that myelopathic patients have a high risk for symptom progression (more than 50% of patients demonstrate a decline in symptoms over 10 years) and a decline in daily living activities paralleled by a high risk for spinal cord injury related hospitalization, surgical treatment may be regarded to be cost-effective for the health care system [1]. Special considerations have to be addressed when counseling patients about the effects of surgery in the presence of severe myelopathy: (1) the duration of symptoms negatively correlates with the odds to recover to a non-myelopathic neurological state (mJOA >16) following surgery [13, 14]; (2) the odds to achieve a postoperative mJOA score >16 decline by 22% if the symptoms persist from a short to a long term duration (statistically every 3 months) [13, 15]; (3) clinical improvement compared to baseline level is greater in patients with severe DCM as compared to patients with mild DCM, however the minimal clinically important difference is greater in patients with severe DCM as compared to patients with mild DCM [1, 4].

This means that patients with severe myelopathic symptoms need to massively improve after surgery to experience a minimal clinically important difference (MCID) as compared to the preoperative state because their baseline level of symptoms is very low. This may be the result of long lasting myelon compression resulting in

partially irreversible spinal cord injury. Patients suffering from mild myelopathic symptoms need small improvements to experience a MCID. The overall chances to achieve a clinically relevant benefit improve with a shorter duration of symptoms and a milder form of DCM. Therefore, surgery should be considered in a timely fashion and before symptoms progress to a severe form of the disease.

6.3.5 Choice of Approach

The patient demonstrates severe spinal cord compression with signs of myelomalacia in MRI on the disc level (C3/4, C4/5 and C5/6) with a regular width of the spinal canal behind the vertebral bodies (multisegmental, focal stenosis). Moreover, there is evidence of kyphotic deformity of the cervical spine with remaining mobility in flexion/extension in the adjacent segments. These two factors favor an anterior approach in order to decompress the spinal cord and to correct the deformity while maintaining posterior structures, which may be beneficial for the development of postoperative neck pain and muscle atrophy. A posterior approach has the advantage of a superior widening of the spinal canal (especially behind the vertebral bodies; useful for diffuse multisegmental stenosis), yet suffers from reduced efficacy to correct the sagittal alignment and the higher rate of postoperative neck pain [5]. In this patient, widening of the spinal canal behind the vertebral bodies of less importance as the spinal cord compression is restricted to the disc level. Multisegmental anterior discectomies with plating have been shown to be superior in improvement of clinical outcomes and correction of the sagittal alignment compared to ventral corpectomies or hybrid discectomy-corpectomy strategies while maintaining a lower risk profile for postoperative C5 palsies (1–5%) and a comparative risk profile for postoperative dysphagia (<20%), infection (1–2%) and nonunion (1–18%) [16]. Consequently, we chose a three level discectomy strategy with ventral plating to decompress the spinal cord and to restore the sagittal profile.

6.3.6 Accordance with the Literature Guidelines

The current guideline for the treatment of cervical myelopathy were the basis for the presented cases and the discussion of indication and approach.

Level of Evidence: C

The level of evidence available to date is low by only consisting of metaanalysis based upon retrospective series, cohort studies and few prospective studies.

6.3.7 Indication Case 3

The patient in case 3 shows signs of moderate DCM in response to an OPLL induced compression of the spinal chord. MRI demonstrates a spinal canal stenosis which extends beyond the disc level of C4/C5. CT imaging demonstrates hallmarks of a continuous OPLL from C4 to C5. Following current treatment guidelines, surgical decompression is recommended for the treatment of mild DCM [1]. The rationale for this indication is summarized in Cases 1 and 2. Despite the fact the OPLL represents a special cause of DCM, surgical treatment has proved to be equally effective in OPLL patients similar to patients suffering from other forms of DCM [17]. However, it must be mentioned that surgical decompression of OPLL may be associated with an increased complication risk of 21.8% [1, 17, 18]. CSF leaks, C5 palsies and implant failure are among the most frequent complications following surgical decompression for OPLL [18]. In contrast, non-melopathic OPLL-patients should not receive prophylactic surgery [18]. The risk to develop myelopathy in response to OPLL is quite low with >70% of asymptomatic OPLL patients remaining without myelopathic symptoms over an observation period of 30 years [18]. The most important risk factor for potential development of myelopathy was spinal canal stenosis due to OPLL of >60% [18]. In these cases, surgical decompression is also recommended as 100% of patients with a spinal canal stenosis of more than 60% caused by the OPLL develop myelopathy [18].

6.3.8 Choice of Approach

The patient in Case 3 demonstrates severe spinal cord compression with signs of myelomalacia in MRI due to compression from a continuous OPLL. In order to achieve adequate decompression a posterior approach was chosen to release the myelon. Currently both anterior and posterior approaches have to be considered equally effective to treat OPLL induced DCM even though there seems to be a higher complication profile for anterior approaches [5, 17, 18]. CSF leaks, implant failure and dysphagia/hoarseness are associated with anterior approaches despite the fact that the anterior floating decompression technique is applied [18]. Usually multilevel corpectomies have to be performed to treat OPLL which predisposes to implant failure and non-union [18]. In contrast, posterior approaches are associated with a lower risk profile for CSF leak, yet they represent indirect decompression strategies with a higher risk for C5 palsies and axial neck pain [18]. Different posterior techniques are available like laminoplasty, laminectomy and laminectomy/fusion. Today, laminectomy is usually not recommended due to the risk of postoperative deformities [18]. Laminoplasty is described as a useful strategy to treat OPLL induced DCM, yet laminoplasty is associated with increased rate of postoperative neck pain and almost 70% of patients that received laminoplasty demonstrate signs of OPLL progression [19, 20]. Laminectomy and fusion is mostly associated with an increased rate of nerve root affections, yet it currently represents a useful tool to decompress the spinal cord with a low complication profile [18, 20]. In order to decide about the optimal approach the K-line may be used to differentiate K-line positive from K-line negative OPLL patients [18]. The K-line on the lateral radiographs connects the midpoints of the spinal canal at C2 and C7. In K-line positive cases, the OPLL is ventral to the line (recommendation posterior approach) and in K-line-negative cases, the OPLL is dorsal to the line (optional anterior or posterior approach) [18]. In cases of multisegmental anterior corpectomies (2 levels and more) an additional posterior instrumentation should be considered to reduce the risk of non-

union and implant failure [18]. For posterior approaches decompression of the adjacent segments above and below the OPLL is recommended to avoid kinking of the myelon after dorsal decompression [18].

In our institution OPLL patients are usually treated by multisegmental posterior decompression and fusion except for patients with severe kyphotic deformity that require additional correction of cervical kyphosis. Consequently, the patient in Case 3 demonstrates adequate cervical lordosis with a K-line positive OPLL which was treated by posterior decompression and fusion.

6.3.9 Accordance with the Literature Guidelines

The current guideline for the treatment of cervical myelopathy were the basis for the presented cases and the discussion of indication and approach.

Level of Evidence: C

The level of evidence available to date is low by only consisting of metaanalysis based upon retrospective series, cohort studies and few prospective studies.

6.4 Conclusions and Take Home Message

Patients with DCM should be treated at an early time point before the symptoms progress and the chances of recovery to a non-myelopathic state decline. Treatment of choice is surgical decompression either from an anterior or posterior approach depending on the patients pathoanatomical characteristics. Non-myelopathic patients with imaging signs of spinal cord compression may also receive surgical treatment if risk factors for the development of myelopathy exist. In OPLL patients, the same rationale for surgical treatment as for the other forms of DCM exist. However OPLL patients may experience a higher complication profile as patients with other causes of DCM.

Pearls

- DCM represents a major cause of spinal cord injury and leads to severe impairment of daily living activities due to neurological deficits if left untreated
- Surgical decompression represents an effective and cost-efficient treatment for DCM
- Anterior and posterior approaches for spinal decompression are equally effective and therefore pathoanatomical characteristics of the patient decide about individualized surgical strategies
- OPLL represents a special cause of DCM with a high rate of spinal cord injury related hospitalizations and a severe neurological decline if myelopathic symptoms exist requiring surgical decompression as treatment of choice

Editorial Comment

This is an excellent chapter on a very important topic. There is no level 1 evidence for timing or surgical technique in patients with CM, the most common treatable cause of chronic spinal cord injury. Since it will take a very long time -if at all- to accumulate better evidence, we encourage the readers to digest the authors' reasoning and line of arguments very closely, because they constitute the standard of care today.

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