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Open-door laminoplasty

What can the unilateral approach offer?

Introductory remarks

Cervical spondylotic myelopathy (CSM) is the main cause of spinal cord dysfunction [3]. The natural course of CSM is often poor. With surgical decompression, a stabilization of cervical myelopathy or even recovery may be possible in the majority of patients. The goals of surgery are to provide effective decompression, maintain or restore cervical lordosis, and to stabilize the cervical spine in case of instability. In multilevel subaxial cervical stenosis, laminoplasty, and laminectomy with fusion are the main treatment options. Recent systematic literature reviews suggest that both procedures have similar effectiveness [1, 4].

Several disadvantages of laminoplasty like increasing neck pain, loss of motion, and secondary cervical kyphosis have been described. This is mainly due to the approach-related muscle trauma. To decrease cervical muscle traumatization, a modified laminoplasty technique using a unilateral approach was first described by Roselli et al. [7].

However, the indication for this less-invasive procedure is limited to patients with lordotic cervical alignment and no or only moderate neck pain. To overcome this limitation, we combined laminoplasty with unilateral lateral-mass (LM) screw fixation using the same less-invasive unilateral approach. In a recent biomechanical study, we could show that unilateral LM screw instrumentation exhibited almost the same degree of primary stabilization as bilateral screw fixation [8].

Surgical principle and objective

The surgical goal is the posterior opening of the subaxial spinal canal to achieve sufficient decompression of the spinal cord by its dorsal shift. In conventional open-door laminoplasty, the neck muscles are dissected on both sides. After a unilateral laminotomy on the opening-side, a monocortical cut is performed on the hinge side to weaken the laminae. The "opening of the door" is stabilized with a mini-plate.

With the unilateral approach, the same opening is achieved with preservation of the muscular ligament complex on one side. In contrast to the traditional technique the laminae on the contralateral (hinge) side are fractured without weakening of the bone. This is accomplished by an elevation of the lamina with a punch and a simultaneous force on the spinous process by the thumb. Usually, the opening is performed from C6 to C3 to allow a sufficient shift of the spinal cord. If necessary, the open-door laminoplasty can be combined with a unilateral LM screw fixation by the same less-invasive approach.

Advantages

- Sufficient decompression of the spinal cord in multilevel subaxial cervical stenosis
- Preservation of the contralateral muscular–ligament complex
- Reduced risk of postoperative kyphosis and neck pain
- Option of unilateral stabilization and fusion by the same approach

Disadvantages

- Demanding technique to achieve the opening of the laminae
- Bilateral foraminotomy is not possible
- Unilateral stabilization with LM screws may not be sufficient in case of instability
- C2 and C7 can only be addressed by undercutting

Indications

- Multilevel subaxial cervical stenosis with myelopathy (**Fig. 1**)
- Lordotic or neutral sagittal profile
- Neck pain and neutral profile require an additional unilateral stabilization

Contraindications

- Kyphotic alignment of the subaxial cervical spine
- Bilateral radiculopathy due to foraminal stenosis
- Segmental instability

Patient information

- Conventional risks of cervical spine surgery
- Postoperative C5 palsy

Fig. 1 ◀ Indications for a unilateral posterior approach in multilevel cervical spondylotic myelopathy (CSM). **a** Image of an 82-year-old man with CSM and no history of neck pain. The T2-weighted sagittal magnetic resonance image (MRI) shows multilevel circumferential stenosis with a lordotic profile of the cervical spine. **b** The postoperative MRI after unilateral laminoplasty shows an excellent decompression with a posterior shift of the spinal cord. **c** Image of a 78-year-old man with CSM and severe neck pain. The T2-weighted sagittal MRI shows multilevel circumferential stenosis with a neutral profile of the cervical spine. **d** The postoperative MRI after unilateral laminoplasty and fusion shows excellent decompression with a minor shift of the spinal cord and a lordotic profile due to the instrumentation. **e** The postoperative biplanar x-ray shows a correct position of the unilateral lateral mass fixation and the laminoplasty plates

- Increased postoperative neck pain
- Loss of motion
- Development of postoperative cervical kyphosis (laminoplasty)
- Implant failure and pseudarthrosis (laminoplasty plus fusion)

Preoperative work-up

- Clinical and neurological work-up (myelopathy versus radiculopathy)
- Imaging: biplanar X-ray, functional X-ray, MRI, reformatted computed tomography (CT) scan

Surgical instruments and implants

- Microscope
- Cervical muscle retractors for the unilateral approach
- High-speed drill (alternatively: small craniotome)
- Thin-footplate punches
- Laminoplasty plates for fixation of the lamina opening
- Posterior cervical screw rod system (for unilateral stabilization)

Anesthesia and positioning

- Video-endoscopic intubation in case of severe cervical myelopathy (◘ **Fig. 2a**)
- General anesthesia; preoperative antibiotic prophylaxis
- Prone "Concorde" positioning with Mayfield clamp (◘ **Fig. 2b**)
  Alternatively: sitting position in very obese patients or patients affected by severe ventilator disturbances
- Technical remark: for laminoplasty the subaxial spine should be placed in a kyphotic posture to obtain better access to the laminae. In case of additional unilateral fusion, it is important to restore the physiological lordosis before rod fixation.

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Open-door laminoplasty. What can the unilateral approach offer?

Abstract

Objective. Multilevel posterior decompression of subaxial cervical spinal canal stenosis through a less-invasive unilateral approach.
Indications. Degenerative cervical myelopathy due to multilevel subaxial spinal canal stenosis.
Contraindications. Cervical kyphosis or instability, bilateral radiculopathy due to foraminal stenosis, involvement of C2 or C7.
Surgical technique. Unilateral subaxial approach with detachment of muscles only on one side. The ipsilateral laminae C6 to C3 are cut at the laminofacet junction and opened up. The loss of resistance is usually due to a greenstick fracture in the proximity of the contralateral laminofacet junction. The opened laminae are fixed with Z-shaped thin titanium plates. If necessary, the laminoplasty can be combined with a unilateral fixation and fusion by the same approach.
Postoperative management. Early mobilization 4–6 h postoperatively. No orthosis necessary.
Results. A total of 131 patients (77 men, mean age 67 years) with a multilevel cervical spondylotic myelopathy (CSM) underwent surgery using a posterior approach. In 52 patients (40%), a unilateral approach was performed (laminoplasty: $n = 30$; laminoplasty/fusion: $n = 22$). In this group, the mean operation time was less compared with two other techniques (unilateral approach: 110 min; laminectomy/fusion: 150 min; 360° approach: 210 min). The postoperative European myelopathy score (EMS) improved from 12.8 to 15.2. The overall complication rate was 17% (unilateral approach: 9%; laminectomy/fusion: 18%; 360° approach: 27%).

Keywords

Cervical spondylotic myelopathy · Surgical decompression · Surgical procedures, operative · Unilateral stabilization · Subaxial cervical spine

Open-door-Laminoplastie. Was kann der unilaterale Zugang bieten?

Zusammenfassung

Operationsziel. Multisegmentale dorsale Dekompression des subaxialen zervikalen Spinalkanals über einen weniger invasiven unilateralen Zugang.
Indikationen. Degenerative zervikale Myelopathie aufgrund einer multisegmentalen subaxialen zervikalen Stenose.
Kontraindikationen. Zervikale Kyphose oder Instabilität, bilaterale Radikulopathie bei Foramenstenose, Notwendigkeit der Laminoplastie der Halswirbel HW 2 und HW 7.
Operationstechnik. Unilateraler subaxialer Zugang mit subperiostaler Ablösung der Muskulatur auf einer Seite. Die ipsilateralen Hemilaminae werden von HW 6 bis HW 3 am Übergang zwischen Bogen und Gelenk durchtrennt und angehoben. Der Widerstandsverlust zur Gegenseite folgt üblicherweise einer Grünholzfraktur im kontralateralen Übergangsbereich von Bogen zu Gelenk. Die angehobenen Halbbögen werden mit Z-förmigen Titanplättchen fixiert. Bei Bedarf kann die Laminoplastie durch eine unilaterale Stabilisierung und Fusion über den gleichen Zugang ergänzt werden.
Weiterbehandlung. Frühe Mobilisierung 4–6 h nach Operation, Nachbehandlung ohne HWS-Orthese.
Ergebnisse. Insgesamt wurden 131 Patienten (77 Männer, Durchschnittsalter 67 Jahre) mit einer degenerativen multisegmentalen zervikalen Myelopathie über einen dorsalen Zugang operiert. Bei 52 Patienten (40 %) kam ein unilateraler Zugang zur Anwendung (Laminoplastie: $n = 30$; Laminoplastie/Fusion: $n = 22$). In dieser Gruppe war die durchschnittliche Operationszeit kürzer als bei den beiden anderen Verfahren (unilateraler Zugang 110 min; Laminektomie/Fusion 150 min; 360°-Zugang 210 min). Der postoperative europäische Myelopathie-Score (EMS) verbesserte sich von 12,8 auf 15,2. Die durchschnittliche Komplikationsrate betrug 17 % (unilateraler Zugang 9 %; Laminektomie/Fusion 18 %; 360°-Zugang 27 %).

Schlüsselwörter

Zervikale spondylogene Myelopathie · Operative Dekompression · Operatives chirurgisches Verfahren · Unilaterale Stabilisierung · Subaxiale Halswirbelsäule

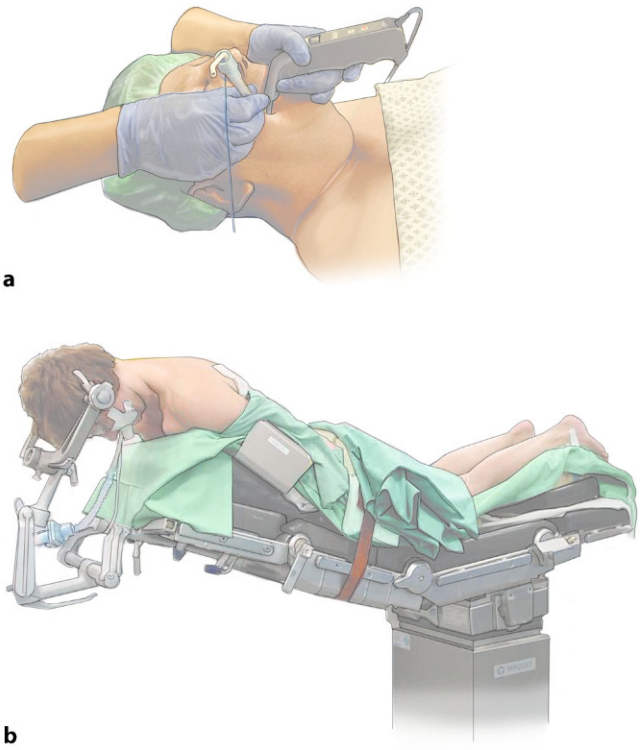

Fig. 2 ◄ Anesthesia and positioning. **a** Video-endoscopic intubation is recommended in patients with severe cervical spondylotic myelopathy (CSM) to avoid reclination of the subaxial cervical spine, which could lead to additional spinal cord compression. **b** "Concorde" positioning: The head is fixed with a Mayfield clamp and the neck plane is above heart level to avoid intensive bleeding during the surgical approach

Surgical technique

(Figs. 3, 4, 5)

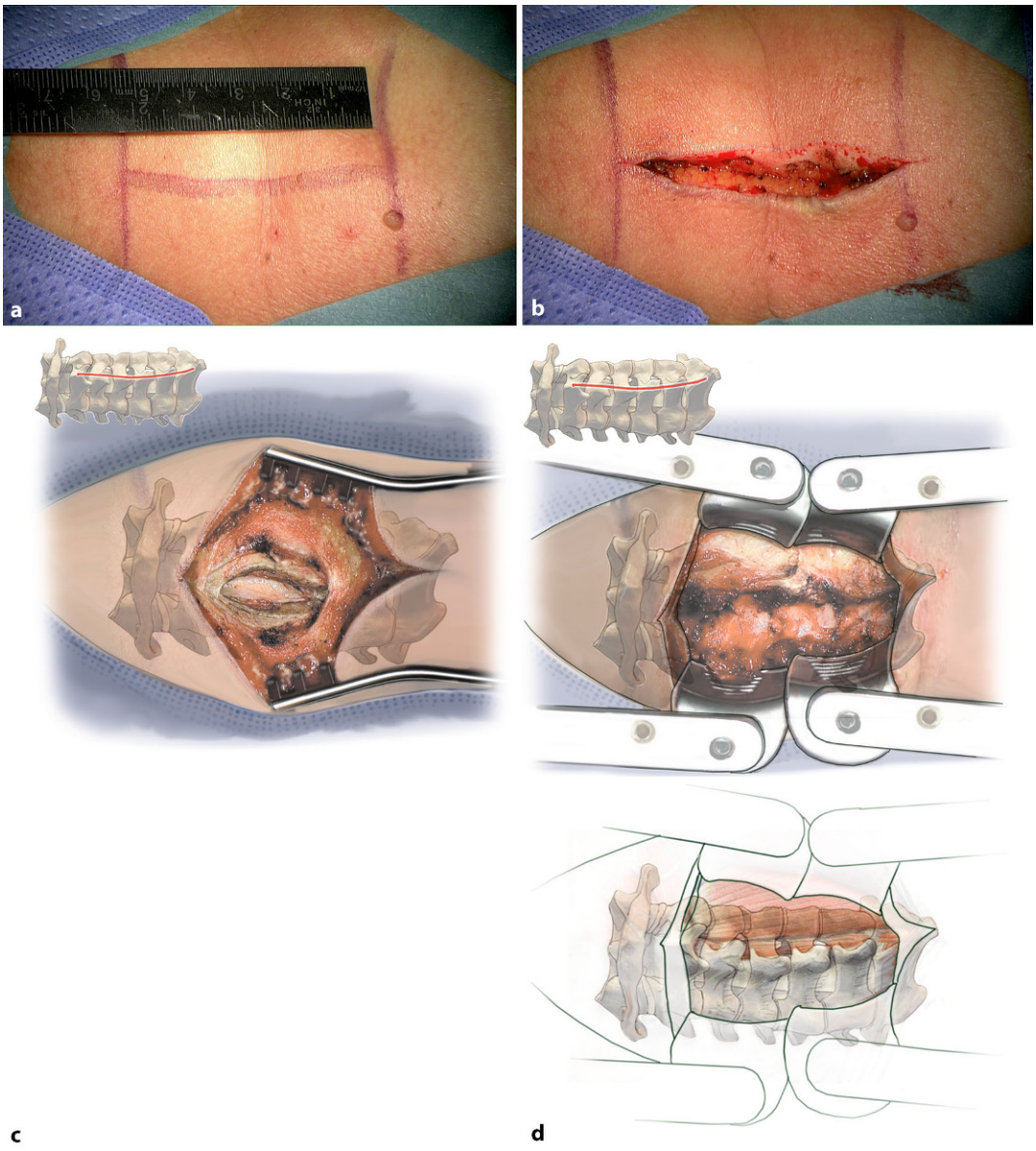

Fig. 3 ◄ **a–d** Unilateral approach of the subaxial cervical spine. The spinous process of C2 and C7 is labeled with lateral fluoroscopy. After a midline skin incision, the superficial fascia is identified and cut through. It is important to stay in the median avascular zone to avoid bleeding and denervation of the neck muscles. After identification of the spinous processes the paraspinal muscles are detached on the opening-side from C3 to C6 to expose the laminae and facet joints. The contralateral muscular–ligament complex is preserved. The approach side should be the side with the main pathology. If there is no difference the decision depends on the handedness of the patient. **a** Labeling of the 5 cm incision (cranial is left). **b** Skin incision from C2 to C6 (the head is on the left side). **c** Midline incision of the superficial fascia and the nuchal ligament. **d** Unilateral dissection of the paraspinal muscles with exposure of the laminae from C3 to C6. Please note that the contralateral muscles are intact

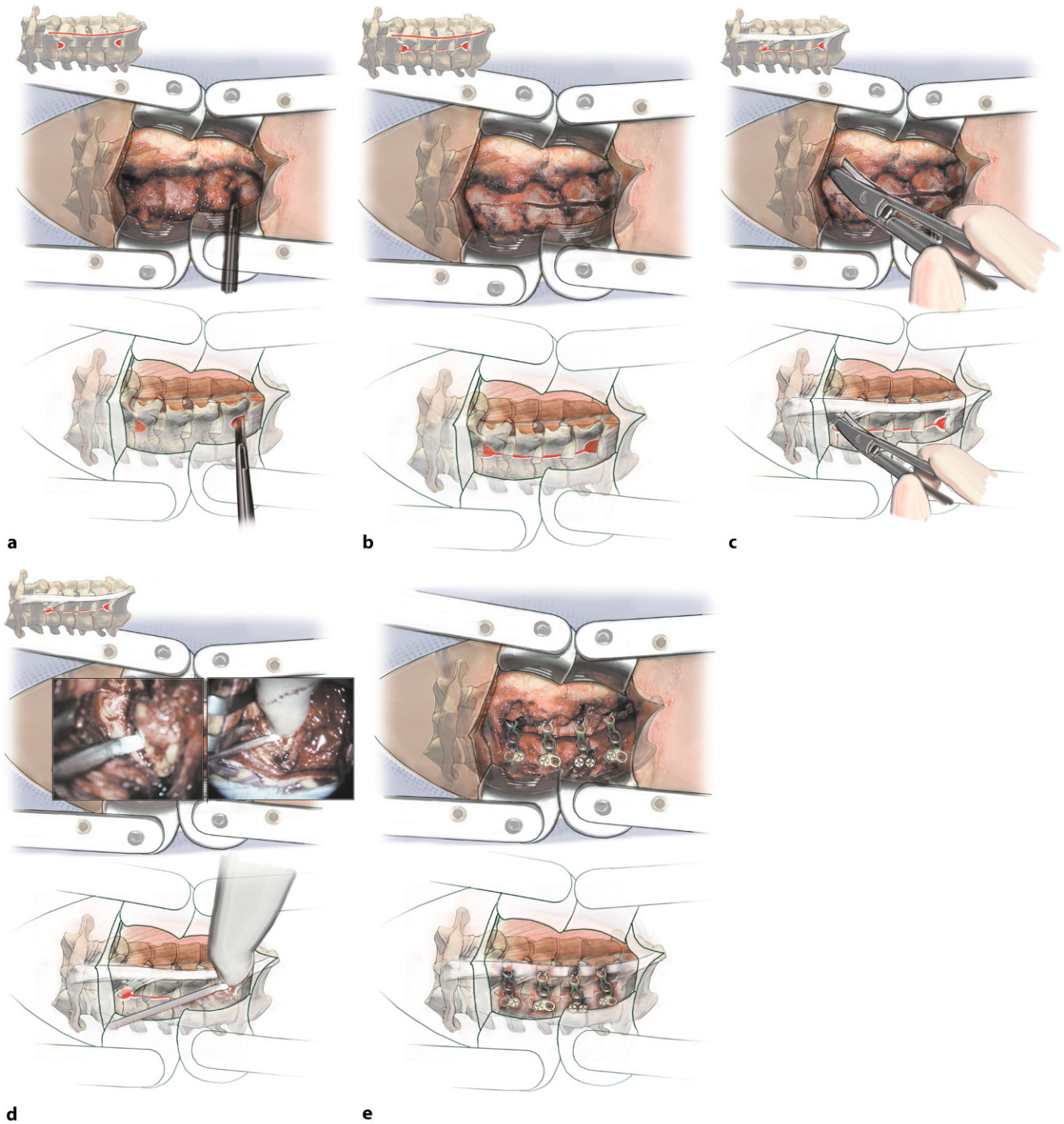

Fig. 4 ▲ **a–h** Unilateral laminoplasty. A small laminotomy is performed with a thin-footplate punch at the lower end of the lamina of C6 and the upper lamina of C3. These are the entry (C6) and exit (C3) points for the small craniotome. The craniotome should start at C6 and cut lamina by lamina at the laminofacet junction. Alternatively, a diamond high-speed drill can be used. The supra- and interspinous ligaments are cut through between C2/C3 and C6/7. Then the contralateral side (hinge-side) of each lamina is fractured at its laminofacet junction. This is accomplished by an elevation of the (opening-side) lamina with a punch and a simultaneous force on the spinous process by the thumb. If the hinge-side lamina does not fracture a contralateral transmuscular approach can be performed to drill off the external cortical bone of the lamina. In case of a spontaneous fusion between C2 and C3, this level can be decompressed in a cross-over technique with the assistance of the microscope. When all segments are mobile, the laminae can be elevated to "open the door". If necessary, the yellow ligament can be resected to achieve an additional decompression. If the stenosis involves the level of C2/3 or C6/7, an undercutting of the lamina of C2 or C7 must be performed. The use of the microscope is strongly recommended for this procedure. Finally, a thin Z-shaped titanium plate is fixed at each level to keep the door open. We do not routinely use an allograft to fill the space between the lamina and the facet. The plate is fixed at the lamina and the lateral mass with one or two screws. For the laminae, we recommend a bicortical screw fixation. **a** Preparation of the entry point at the lamina of C6 with a punch. **b** Lateral laminotomy from C6 to C3

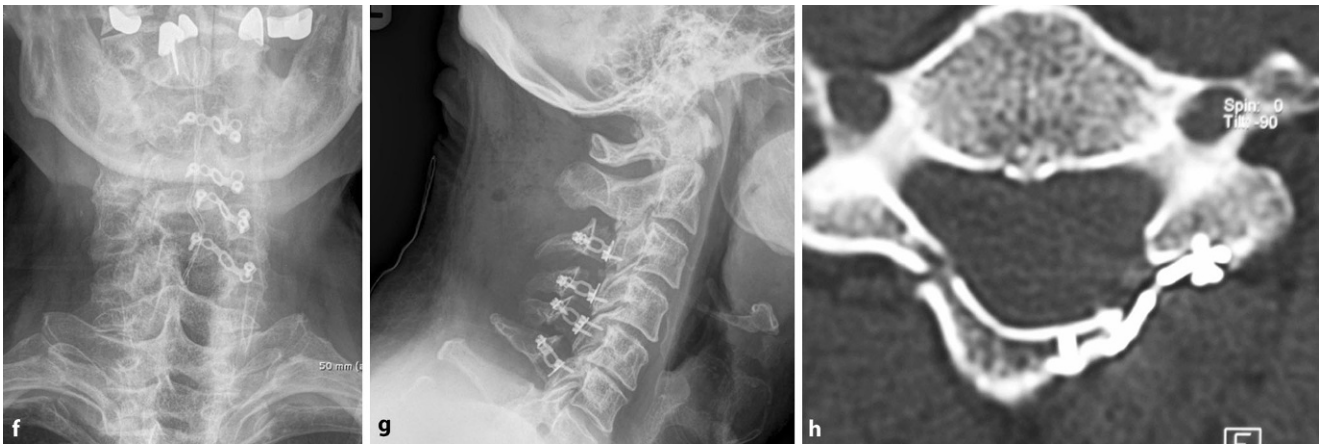

Fig. 4 (continued) ▲ **c** The supra- and interspinous ligaments are cut through with a bipolar scissor at the level of C2/3. **d** Rigid fixation of the lamina with the punch. **e** Elevation of the lamina with a punch and simultaneous force on the spinous process by the thumb starting at the caudal end (C6). **f** The opening of the laminae is stabilized with special plates (Securespan^{TM}Laminoplasty System, Aesculap). **g** Postoperative biplanar X-ray after unilateral laminoplasty from C3 to C6. **h** Postoperative axial computed tomography (CT) scan shows the widening of the spinal canal and the contralateral fracture on the hinge-side

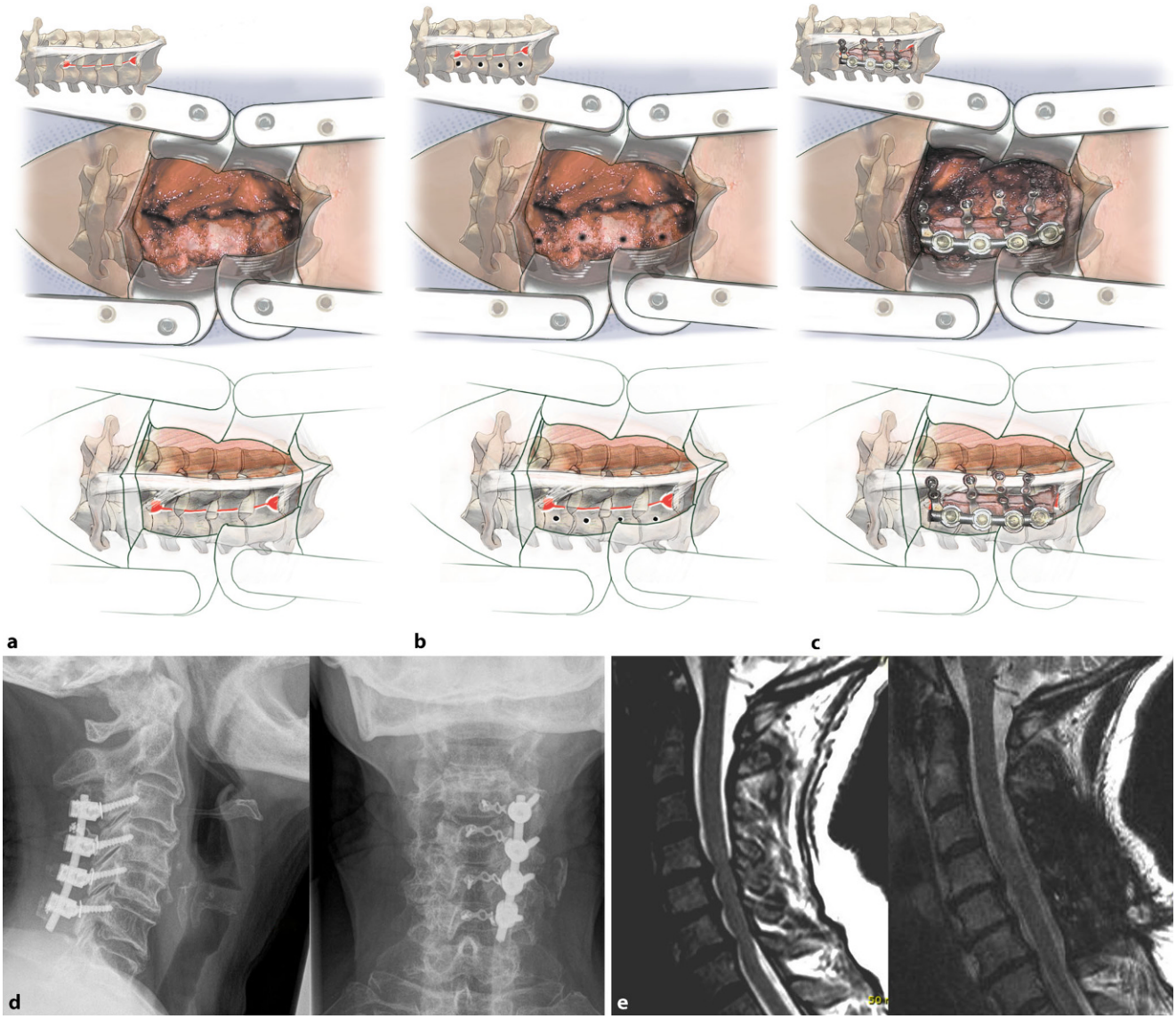

Fig. 5 ▲ **a–e** Unilateral laminoplasty and fusion. An additional stabilization and fusion can be performed by the same unilateral approach. After exposure of the laminae and lateral mass from C3 to C6 a bi-cortical hole is drilled in each lateral mass according to the technique of lateral mass screw fixation described by Magerl [6]. Then the laminoplasty is conducted as described above. The laminoplasty plate has to be fixed with the lateral mass screw, because there is not enough space for more than one screw in the lateral mass. Therefore, a special plate design is necessary. The Z-shaped plate is fixed to the lamina with a bi-cortical screw. The instrumentation is completed with the fixation of the rod. To achieve a better sagittal profile, we recommend to restore lordosis with the Mayfield clamp before final rod fixation. Allograft is placed onto the lateral masses to achieve bony fusion. **a** Exposure of the laminae from C3 to C6, **b** Lateral mass after hole preparation for LM screws, **c** LM screw instrumentation and plate fixation after laminoplasty, **d** Postoperative Bi-planar X-ray after unilateral laminoplasty and LM screw instrumentation from C3 to C6, **e** Pre- and postoperative MRI (T2 sagittal scan) in a case with unilateral laminoplasty and fusion

Wound closure

We do not routinely place a subfascial drainage before wound closure. But it is important to perform a meticulous hemostasis of the epidural space and the muscles. Wound closure is performed in multilayered fashion.

Postoperative management

- Immediate postoperative mobilization
- Postoperative imaging: biplanar X-ray
- No collar required
- Neurological rehabilitation should start after wound healing
- Follow-up examination three months after surgery

Errors, hazards and complications

- A rigid lamina may require a contralateral transmuscular approach for drilling of the external cortical bone

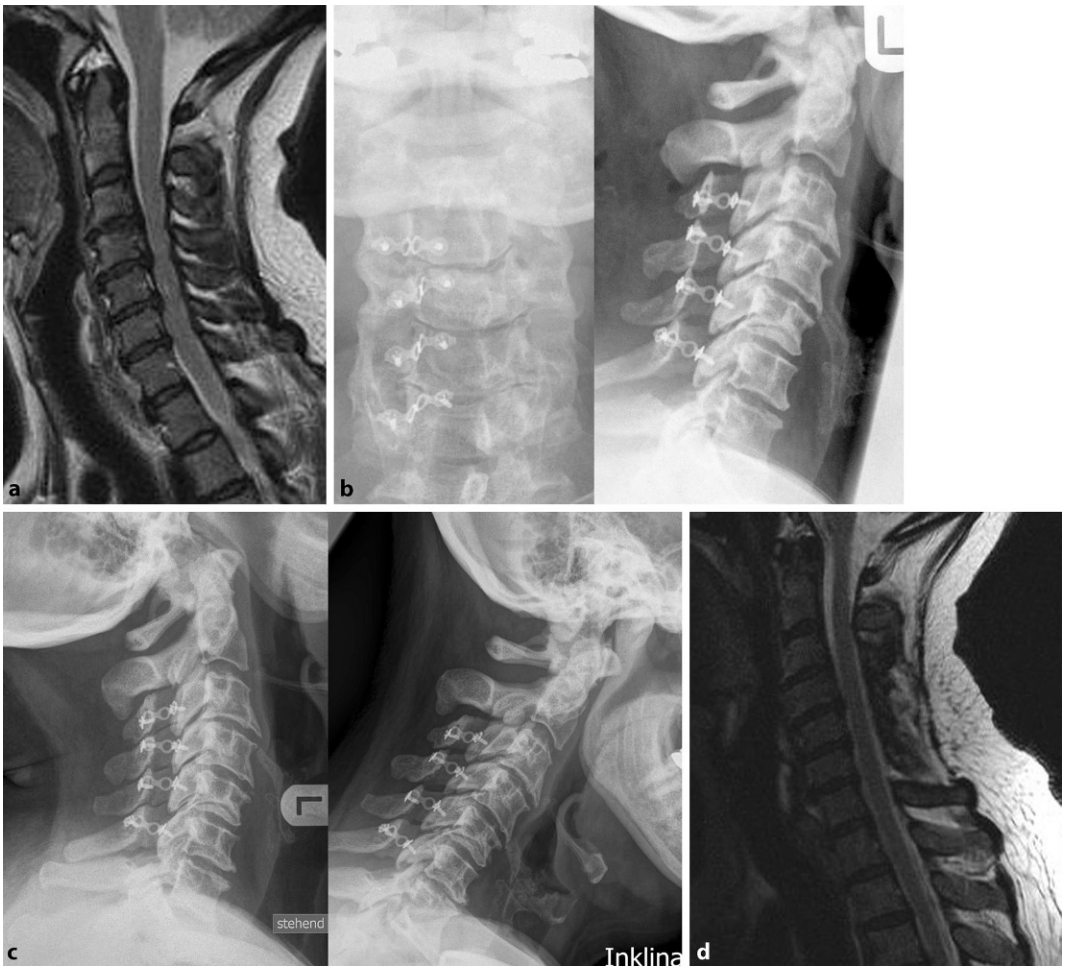

Fig. 6 ◄ Case report of long-term outcome after unilateral laminoplasty. **a** Preoperative magnetic resonance image (MRI) of 51-year-old woman with multilevel cervical spondylotic myelopathy (CSM; European myelopathy score, EMS = 13). **b** Postoperative biplanar X-ray. **c** The 5-year follow-up: long-term improvement of CSM (EMS = 17); Functional X-rays demonstrate excellent mobility after unilateral laminoplasty. **d** The 5-year follow-up: MRI (T2 sagittal scan) shows widening of the spinal canal

- Avoid excessive epidural bipolar coagulation
- Postoperative epidural hematoma may require early revision

Results

Between 2012 and 2016, we have operated on 131 patients (77 men, mean age 67 years) with a multilevel CSM by a posterior approach. Severity of cervical myelopathy was scored by the European myelopathy score (EMS) [2]. The mean preoperative EMS was 12.3 (range 8–17). The decision on the surgical strategy was made by using a specific diagnostic algorithm (CSM-7 Letter Code). The following surgical procedures were performed: (1) Laminectomy and posterior fusion ($n = 49$); (2) 360° approach with ACDF(anterior cervical discectomy and fusion)/ACCF(anterior cervical corpectomy and fusion) and posterior fusion ($n = 30$); (3) Unilateral laminoplasty ($n = 30$); (4) Unilateral laminoplasty and fusion ($n = 22$).

A total of 52 patients (40%) underwent a unilateral approach (30 men, mean age 69 years). In this subgroup, the preoperative EMS was 12.8. The mean operation time was 110 min, which was less than in the laminectomy/fusion (150 min) or the 360° approach group (210 min). The mean length of hospital stay was 8.8 days for the unilateral approach and thereby shorter than for the other two groups (laminectomy/fusion 12.1 days; 360° approach 10.5 days). The postoperative EMS improved from 12.8 to 15.2. Comprehensive clinical and radiological outcome data are currently investigated in a prospective cohort study.

The perioperative complication rate in the unilateral group was 9% (5/52), which was less than in laminectomy/fusion (9/49 = 18%) group or in the 360° approach cohort (8/30 = 27%). The main complications overall were C5 palsy ($n = 6$), wound infections ($n = 4$), and dural tears ($n = 3$). So far, we have seen no implant failures in the unilateral fusion group (◘ **Fig. 6**).

There are few data in the literature regarding the outcome after a unilateral approach for cervical laminoplasty. In 2000, Roselli et al. [7] reported the results of 33 patients with CSM treated by unilateral laminoplasty. There was no control group. The Japanese Orthopedic Association (JOA) myelopathy score improved from 9.8 to 11.6. Postoperatively, cervical spine range of motion was maintained at approximately 80%, and no instability or kyphotic deformity was observed on lateral flexion–extension cervical x-ray films 6 months after surgery.

Lin et al. [5] reviewed 90 CSM patients with open-door laminoplasty with respect to the postoperative cervical sagittal balance. In all, 53 patients underwent laminoplasty with unilateral preservation

of the muscular–ligament complex while 37 patients were operated by traditional open-door laminoplasty. Sagittal balance, cervical curvature, range of motion (ROM), and JOA score were compared. There were no differences in the JOA improvement rate. Open-door laminoplasty significantly affected postoperative cervical sagittal balance, with the cervical spine appearing to tilt forward (increased C2–C7 sagittal vertical axis). This was less in the unilateral technique with preservation of the contralateral muscular–ligament complex.

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Compliance with ethical guidelines

Conflict of interest. L. Papavero is a consultant for Medicon e. G., Tuttlingen, Germany. R. Kothe and G. Schmeiser declare that they have no competing interests.

This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Bartels RHMA, van Tulder MW, Moojen WA et al (2015) Laminoplasty and laminectomy for cervical spondylotic myelopathy: a systematic review. Eur Spine J 24:S160–S167
2. Herdmann J, Linzbach M, Krzan M et al (1994) The European myelopathy score. In: Baucher BL, Brock M, Klinger M (eds) Advances in neurosurgery. Springer, Berlin, pp 266–268
3. Karadimas SK, Erwin WM, Ely CG et al (2013) Pathophysiology and natural history of cervical spondylotic myelopathy. Spine 38:S21–S36
4. Lee CH, Lee J, Kang JD et al (2015) Laminoplasty versus laminectomy and fusion for multilevel cervical myelopathy: a meta-analysis of clinical and radiological outcomes. J Neurosurg Spine 22:589–595
5. Lin S, Zhou F, Sun Y et al (2015) The severity of operative invasion to the posterior muscular-ligament complex influences cervical sagittal balance after open-door laminoplasty. Eur Spine J 24:127–135
6. Magerl F, Grob D, Seemann PS (1987) Stable dorsal fusion of the cervical spine (C2-T1) using hook plates. In: Kehr P, Weidner A (eds) Cervical Spine I. Springer, New York, Wien, pp 217–221
7. Roselli R, Pompucci A, Formica F et al (2000) Open-door laminoplasty for cervical stenotic myelopathy: surgical technique and neurophysiological monitoring. J Neurosurg 92:38–43
8. Schmeiser G, Schilling C, Grupp TM et al (2015) Unilateral laminoplasty with lateral mass screw fixation for less invasive decompression of the cervical spine: a biomechanical investigation. Eur Spine J 24:2781–2787

Buchbesprechung

B. Jenny

Projektmanagement

Das Wissen für eine erfolgreiche Karriere

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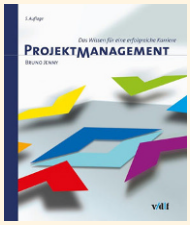

Die Einordnung von Aufgaben in Projekte ist ein Grundpfeiler moderner Unternehmen aller Branchen. Doch solche Projekte stehen und fallen mit der Kompetenz der Projektleitung. Um also einen Projekterfolg zu garantieren, bedarf es eines fachkundigen, durchorganisierten Projektmanagements. *Projektmanagement – Das Wissen für eine erfolgreiche Karriere* des schweizer Unternehmensberaters, Dozenten und Prüfungsexperten Bruno Jenny veranschaulicht in verständlicher und gut strukturierter Weise, wie sich ein Managementsystem optimieren lässt. Jenny zeigt beispielsweise den Mehrwert eines psychologisch ausgerichteten Change Managements im Vergleich zur konventionellen Projektabwicklung auf und demonstriert zudem, warum die optimale Interaktion der einzelnen Projektelemente unerlässlich ist. Anhand von einleuchtenden Lernzielen, Aufgaben, Musterlösungen und vielen Grafiken lehrt es den Leser das vielschichtige moderne Projektmanagement.

D.A. Groneberg (Frankfurt am Main)