7 Cervical Posterior Long Construct Stabilization

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7.1 Introduction

The cervical spine has a widest range of motion in comparison to the rest of the spine. As part of the physiological global sagittal alignment it acts as a well-tuned adjustment instrument which sustain the horizontal gaze and supports the mass of the head. Due to this complex task, the cervical spine is particular susceptible to a variety of disorders that inevitably can warrant surgical consideration. Hence, the choice of surgical technique should recognize the importance of cervical sagittal alignment as a significant factor that prevents late complications like pseudarthrosis, adjacent segmental degeneration, pain and neurological deterioration.

The typical example of pathology that very often requires long posterior cervical instrumentation is the fracture/dislocation in ankylosing spondylitis (AS).

AS is a chronic inflammatory disease, causing ossification of the joints and ligaments with auto-fusion and widespread ankylosis, that secondary leads to atrophy of the surrounding muscles and osteoporosis. During this process, patients can develop fixed cervicothoracic deformity that leads to difficulty with forward gaze and social outlook. The global kyphotic sagittal imbalance with anterior displacement center of gravity makes patients with AS very prone toward fall trauma. The rigid, osteoporotic cervical spine in kyphotic position creates long lever arm, which is susceptible to distraction fractures in close relationship to junctional levels, even with a minor trauma. Furthermore, even slight displacement of these fractures can lead to a catastrophic neurologic deficit as they tend to be very unstable, and therefore demand a solid construct that withstand shearing forces across the fracture site similar to fixations technique used for long bone fractures.

The authors describe a case of highly unstable cervical fracture that preferably should be treated with a long posterior cervical screw and rod fixation. The preoperative radiological evaluation provides the reader with visualization of the problem to increase understanding of the clinical implications essential for surgical planning. Furthermore, the applied techniques are explained with highlighting their advantages.

This chapter's objective is to equip the reader in sufficient information to be able to plan long posterior screw and rod fixation in cervical spine in case of complex cervical pathology.

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7.2 Case Description

A 66 y/o male with known AS was admitted to the local hospital after he fell at his home and suffered a low energy cervical trauma. The patient presented with severe pain in cervicothoracic region. The neurological exam according to ASIA score revealed signs of central-cord syndrome with motor weakness (3/5) distally in the upper and proximally in the lower extremities with preservation of sacral function (ASIA D). The initial radiological evaluation with computer tomography revealed a highly unstable, distraction fracture C7/T1: B3 displaced anteriorly (Fig. 7.1a–c) [1]. The left C7 pedicle was intact, however the fracture continued through the right C7 pedicle. Patient was urgently referred to our unit at university hospital, level 1 trauma center. The external immobilization was impossible due to severely advanced global kyphotic deformity. This was also the reason, why the radiological investigations were not completed with the MRI. The status at the admission was unchanged. As a result of this highly unstable fracture with serious risk of displacement, neurological deterioration and threat for free airways, the patient was scheduled for emergency surgery with long posterior cervical fixation bridging across cervicothoracic junction (CTJ). Unfortunately, the intraoperative neuromonitoring was not available in this case.

7.2.1 Surgery

After awake intubation, patient was gently log-rolled to prone position with his head secured in the head holder on the horse-shoe support with a slight traction (3 kg). The effort was made to keep the patient's abdomen completely free, with a support on the table on a padded chest plate and anterior iliac crest pads. After applying padded support to patient's feet, the table was put in reversed Trendelenburg position in order to minimize perioperative bleeding. Due to extreme kyphotic deformity, use of intraoperative fluoroscopy was impossible.

The exposure was carried out from C2 to T3. It was then confirmed, intraoperatively, the presence of subluxation at C7/T1 level. The cervical spine was completely fused. This created two long lever arms displaced against each other. Even slightest attempt on instrumenting cervical spine above the fracture caused eminent thread to further displacement. Moreover, the bone fragment of the right broken pedicle injured dura mater in close relationship to the C8 nerve root with CSF leak.

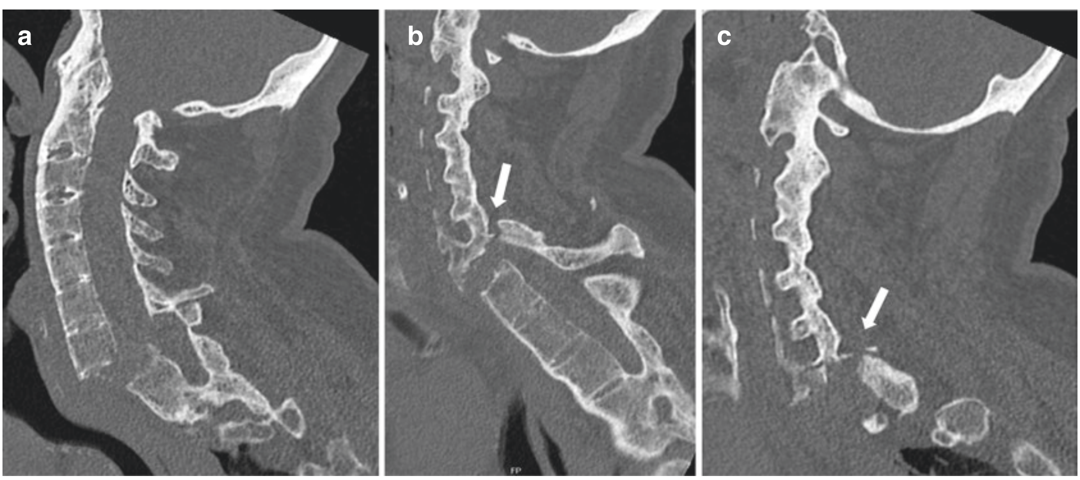

Fig. 7.1 CT scan on admission to primary hospital after the trauma. The CT scan shows an anteriorly displaced, luxated cervical fracture C7/T1: B3 according to AOSpine subaxial cervical spine injury classification fracture [1]. Typical characteristics of AS with "bamboo spine" appearance is clearly visible. Arrows point at three column disruption and fractured right C7 pedicle. (**a**) midline slice, (**b**) left side slice, (**c**) right side slice

Under direct visualization the short segment fixation was carried out on left side between C7 and T1. This maneuver allowed re-alignment of the column. On the right side the C7 pedicle was not suitable for instrumentation. This is the reason, C6 pedicle and T1 were used for another short instrumentation. This completed reposition of the fracture and provided with sufficient segmental stability for further instrumentation at the higher levels (Fig. 7.2). The Magerl technique was then used at C1/C2 vertebrae bilateral since they were already auto-fused. This created a solid cranial bone purchase. Lower subaxial segments were instrumented with use bi-cortical, lateral-mass screw technique. The caudal instrumentation was extended toward T3 due to of very poor bone quality. The four-rods (3.0 mm titanium each) technique was applied to connect and close the construct (Fig. 7.3a, b). The fixation was followed by laminectomy C6-T1 with suturing a dural tear and evacuation of minor intraspinal hematoma. No attempts were taken to correct the

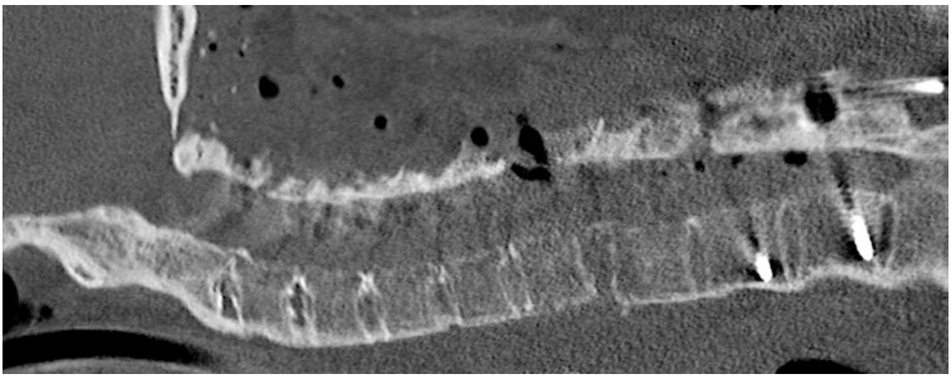

Fig. 7.2 Postoperative CT scan. The postoperative CT confirmed realignment of the cervical column with a long posterior screw and rod fixation crossing CTJ

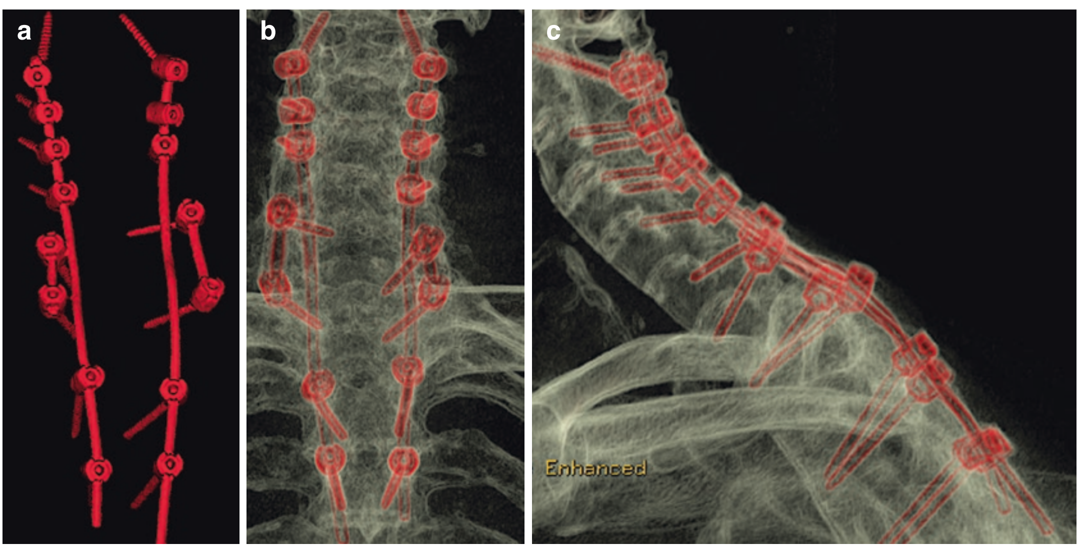

Fig. 7.3 Enhanced images of the construct. The construct consisted of: Magerl screws at most cranial C1/C2 segments bilateral, followed by lateral-mass screws and pedicle screws at levels T2 and T3. Additional two short segment fixations: right C6 pedicle screw to T1 pedicle screw and left C7 pedicle screw to T1 pedicle screw. (**a**) and (**b**) coronal and (**c**) sagittal view

kyphotic deformity because of the risk of further neurological deterioration.

The wound was closed in layers in regular fashion. No drain was used to in order to prevent development of CSF fistula.

Postoperatively patient presented with unchanged neurological status. He was discharged for rehabilitation after a few days at our unit.

7.2.2 Follow-Up

The patient presented a full recovery of his neurological deficit at the 3 months follow-up. He was also pain-free. The following radiological examination at 6 and 12 months showed complete fusion of the segment (Fig. 7.4a, b).

However, due to the global kyphotic deformity, the patient was scheduled for corrective surgery with PSO at the lumbar segments and instrumentation (Figs. 7.5 and 7.6).

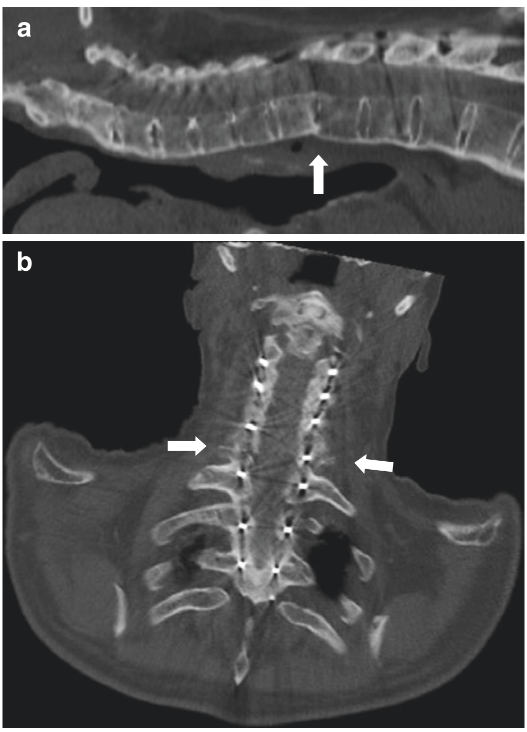

Fig. 7.4 CT scan at 12 months follow-up. This CT scan clearly shows solid, circumferential fusion at the previous broken and dislocated segment C7/T1. Images show: (**a**) sagittal and (**b**) coronal view. There are no signs of hardware failure

Fig. 7.5 Long, standing scoliosis X-ray film. The images show a global kyphotic deformity due to AS. Patient present with chin-on-chest deformity which impairs forward gaze

7.3 Discussion of the Case

7.3.1 Indications

This patient suffered from a minimal trauma to the neck. Complete ankylosis of the spinal column sk. "bamboo spine" creates a long lever arms that makes the fractures in AS patients extremely unstable. Additional kyphosis with almost chin-on-chest deformity makes external immobilization merely impossible. Patients with AS who sustained fracture due to low-energy

Fig. 7.6 Photography of the patient during the last follow-up. The image confirms a severe global spinal kyphotic deformity

trauma tend to deteriorate neurologically and have high morbidity and mortality rate [2, 3]. This advocates an urgent and aggressive surgical treatment. Although, conservative treatment has been described in the literature usually is reserved to non-displaced fractures without deformity [2].

In this case of a severely displaced, highly unstable fracture with a central cord syndrome (ASIA D) the surgical option was mandatory.

The neurophysiologic surveillance with evoked potentials is recommended because of the risk of displacement of the fracture during positioning and surgery.

7.3.2 Choice of Approach

There are three main approaches to cervical spine: anterior, posterior and combined. In general, there is no single gold standard which approach is the optimal one. Each approach has particular advantages and disadvantages thus, the decision is made on case to case basis. However, the access to CTJ, especially in case of distorted anatomy (tumor, displaced fracture, deformity), is very limited due to position of the sternum and close relationship to major vascular elements as well as lungs and structures of mediastinum. The approach, by itself, can theoretically, enhance the surgical morbidity. The CTJ is a complex anatomical region, where very flexible, lordotic cervical spine shifts into to a rigid, kyphotic thoracic spine. Therefore, surgery in cervical spine in close relationship to cervicothoracic junction (CTJ) requires meticulous surgical planning and a surgical approach that addresses these challenges. Moreover, the biomechanical investigation indicates that anterior stabilization can be insufficient to stabilize the CTJ [4].

On opposite to this, posterior stabilization with long construct crossing CTJ, reinforced with T1 or T2 pedicle screws, provides sufficient stabilization even in a case of multi-segmental failure of anterior column [5]. Clinical studies indicate that a risk for revision due to pseudarthrosis and hardware failure seems to be much higher with short posterior cervical fixations, which don’t bridge over CTJ [6, 7].

Posterior instrumented stabilization and fusion is a well-established surgical procedure in cervical spine. It is a valid surgical option for the treatment of a wide variety of cervical pathologies like: cervical spondylotic myelopathy, spinal oncology, fractures, infections and deformities.

Lateral mass fixation is very popular and accepted technique for achieving stabilization and promoting fusion of the subaxial cervical spine [8].

Cervical pedicle screws technique remains controversial because of the potential risk of injuring vertebral arteries. However, cervical pedicle screws have twice as high pull-out resistance and can be particular useful for three column reconstruction, especially in case of cervical deformity or poor bone quality [9, 10]. This can be especially important in case of AS because of high rate of osteoporosis and high instability.

There are several technical issues to be addressed when planning for a long posterior cervical instrumentation:

- most often the CTJ is impossible to visualize with the side fluoroscopy
- surgeon should be familiar with cervical and thoracic junctional anatomy and be experienced in both lateral mass and thoracic pedicle screw instrumentation techniques
- in case of osteoporosis and ankylosis, most cranial instrumentation can be extended as high as to C1 in order to provide the high pull-out resistance
- the rule of thumb is that in case of AS the instrumentation should be extended minimal to 3 segments above and 3 segments below the fracture [3]
- in case of close relationship to CTJ, the instrumentation should always bridge across the junction (especially in case of AS)
- use of the image guidance is advocated especially when planning CTJ instrumentation and/or use of cervical pedicle screw technique [11]
- use of continuous intraoperative neurophysiological surveillance should be mandatory if available

Whether the instrumentation should cross the CTJ can be questioned since there are available studies demonstrating good results with constructs ending at C6 and C7 [12]. Nevertheless, the authors personal opinion is that thoracic instrumentation at T1 and T2 levels does not considerable prolong surgery but creates a solid foundation of the construct and protects the caudal anchorage. Therefore, we suggest that long posterior cervical fixation should not be stopped at CTJ and must always be considered as a valid option if there is a doubt regarding bone quality and instability.

7.3.3 Accordance with the Literature Guidelines

Unfortunately, there is insufficient power of evidence in the current literature to draw conclusions regarding use of long vs short posterior cervical fixations and the most caudal point of anchoring. Therefore, we cannot apply any general guidelines based on these data. However, there is informal agreement on indication for use of long cervical posterior instrumentation as well as the use of this surgical approach in close relation to CTJ.

Level of Evidence: C
Most available studies regarding this matter are larger retrospective single center cohorts and biomechanical cadaver studies. Publication by Truumees et al. [12] is the only cited retrospective multicenter study.

7.4 Conclusions and Take-Home Message

Although use of long posterior cervical fixation can be debatable, it is relatively straightforward technique and can be applied to the various spinal pathologies. It offers a strong and solid fixation but in the same time can be combined with other techniques like: laminectomy, foraminotomy and even osteotomy for corrective purposes.

Common consensus is that anterior column failure should be managed from anterior approach and complete disruption of the cervical column from 360° combined anterior and posterior approach. This can prolong surgical time and enhance surgical trauma. We advocate using only long posterior cervical fixation, which is sufficient to support and protect the cervical column especially when cervical pedicle and upper thoracic pedicle screw fixation has been used.

Pearls

- preoperative investigation with CT scan and MR images, including upper thoracic levels are mandatory
- long posterior cervical fixation constructs can be used as a posterior-only strategy even with multi-segmental failure of the anterior column
- in case of complete disruption of the spinal column at least 3 segments above and below should be instrumented
- CTJ should be crossed with instrumentation on the T1 and T2 pedicles if the pathology is close or embodies the junction
- image guided surgery should be used for cervical pedicle screws at least

Editorial Comment

The author has chosen a non-degenerative case to illustrate the technical principles and especially the potential of such constructs, which can obviously be applied to every other pathology as well. The development of these stable screw-rod constructs enabled surgeons to treat almost every cervical instabilty with a very high reliability regarding strength of instrumentation and versatilty in reducing complex 3D deformities while avoiding the need for any form of postoperative bracing. When cervical pedicle screws are applied the biomechanical properties allow for a posterior only strategy even in severe multicolumn instabilities. The use of navigation is highly recommended for this (see Chap. 18).

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