Assessment of Cervical spine surgery in ankylosing spondylitis

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KEYWORDS

Cervical spine surgery, ankylosing spondylitis

Background: Ankylosing spondylitis (AS) is a chronic inflammatory disease primarily affecting the axial skeleton, often leading to significant cervical spine involvement. Progressive spinal inflammation can cause pain, stiffness, and ultimately, severe deformities like kyphosis and subluxation, impacting neurological function and quality of life. Surgical intervention in the cervical spine becomes necessary when conservative management fails to alleviate debilitating symptoms or when neurological compromise arises. This abstract summarizes the complexities and considerations involved in cervical spine surgery for AS patients. Cervical spine surgery in AS presents unique challenges due to the altered bony anatomy, frequent osteoporosis, and the presence of syndesmophytes, which make instrumentation technically demanding. Common indications for surgery include intractable pain, progressive neurological deficit, cervicomedullary compression, and severe deformities causing functional limitations. Preoperative planning is crucial and involves detailed radiological assessment with CT and MRI to evaluate bone quality, the extent of spinal involvement, and the presence of any spinal cord compression. Careful patient selection is paramount, considering factors like age, comorbidities, and disease activity. Surgical goals primarily focus on restoring sagittal and coronal balance, decompressing neural structures, and stabilizing the spine. Various surgical techniques are employed, including posterior osteotomies (e.g., Smith-Petersen, pedicle subtraction), anterior cervical discectomy and fusion (ACDF), and combined anterior-posterior approaches. The choice of technique depends on the specific pathology, the degree of deformity, and surgeon experience. Intraoperative neuromonitoring is essential to minimize the risk of iatrogenic neurological injury. Postoperative management involves appropriate pain control, early mobilization, and bracing to promote fusion. Long-term follow-up is necessary to monitor for complications like implant failure, non-union, and infection. While surgical outcomes are generally favorable in terms of pain relief and functional improvement, patients with AS undergoing cervical spine surgery face a higher risk of complications compared to the general population. Further research is needed to refine surgical techniques, optimize patient selection, and improve long-term outcomes in this challenging patient population. This includes exploring minimally invasive approaches and developing strategies to mitigate the risk of complications.

1. Introduction

Ankylosing spondylitis (AS) is an inflammatory rheumatic disease causing structural cervical spine damage. Microscopic changes include bone fragility [1] due to reduced bone density from persistent systemic inflammation and hypervascularization. Severe cases manifest as "bamboo spine," with intervertebral fusion and kyphosis [2]. Ossification affects the anterior disc space and posterior facet joints. Unlike a normal, mobile cervical spine allowing upright head posture, the AS spine becomes rigid, often with a debilitating flexed neck. Along with potential AS involvement in the hips, sacroiliac joint, and lumbar spine, cervical effects significantly impair quality of life and increase cervical fracture risk.

Cervical spine surgery in AS addresses trauma [3, 4, 5, 6, 7, 8] and corrects chin-on-chestdeformity [2, 9, 10, 11, 12, 13, 14, 15, 16], both technically and strategically challenging.

Similar to the general population, AS patients typically experience traumatic fracture/dislocations in the lower cervical spine (C5-T1). However, these fractures are often more severe [1] and unstable, involving both anterior and posterior elements in a transverse or short oblique pattern, not adhering to the three-column stability criteria [17]. The "broken bamboo spine" acts like a long bone diaphyseal fracture, increasing instability and neurological deterioration risk [18, 19, 20]. Kyphosis compromises sagittal balance, and the hemorrhagic tendency elevates the risk of compressive epidural hematoma and neurological complications [6]. Despite these complexities, AS bone fuses readily.

Managing AS spinal fractures differs significantly from standard cervical fractures. Due to case rarity, guidelines are limited. Key questions include the role of conservative management, optimal fixation (posterior, anterior, or circumferential), ideal reduction (pre- existing kyphosis versus lordosis), and fracture gap healing potential. Posterior cervical subtraction is described for kyphotic deformity correction [10, 11, 12, 15], with limited

discussion on optimal osteotomy level (cervical or lumbar) [2, 9, 13, 15, 16]. Management of trauma cases

Cervical spine trauma incidence is higher in AS due to spinal imbalance, hip/knee involvement, and bone fragility [21]. Patients should use ambulatory aids and avoid chiropractic manipulation. Even low-energy trauma can cause fractures, sometimes seemingly spontaneously, with potentially delayed diagnosis [22]. Any recent neck pain or neurological change in AS patients, even without trauma, necessitates full spinal imaging. Confusion, similar to odontoid fractures, can be the sole presenting symptom.

Appropriate initial management is crucial to avoid iatrogenic complications. The fractured ankylotic spine, resembling a long bone fracture, relies on cervical musculature (often atrophied) for stabilization. Maintaining the patient's habitual flexion is critical; enforcing neutral positioning can be harmful. Suspecting AS in patients voluntarily holding their head flexed can prevent errors.

Imaging is challenging due to bone remodeling, kyphosis, and fusion [23], particularly at the cervicothoracic junction [24]. CT is necessary, and MRI may be beneficial. The fracture line often resembles a transverse or short oblique Chance fracture.

2.1. Traction and halo braces

Axial traction can manage confirmed cervical fractures in AS. Traction must align with pre-existing kyphosis, using minimal weight. Neck extension risks neurological complications. Even with proper traction, deterioration is possible due to residual rotational movement. Close monitoring for neurological changes, including altered consciousness, is essential. Traction provides temporary stabilization before surgery or can be transitioned to a halo bracefor non-operative management.

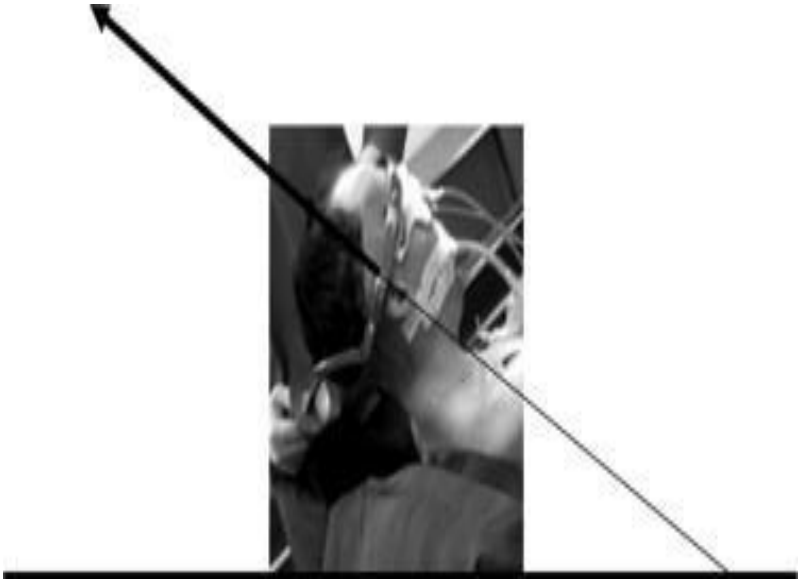

Fig. 1. Axial traction: in the case of ankylosing spondylitis, the direction of the traction has to be considered in the context of the cervical kyphosis.

Debate continues regarding optimal management of fracture/dislocations in AS: external immobilization alone versus surgical fusion followed by external immobilization. While halo brace application alone is considered a standard treatment [25], it carries inherent complications. Although many patients achieve fusion with halo bracing, non-union and neurological deterioration can occur.

Several considerations are crucial for halo brace application: due to cervical kyphosis, custom fitting is often necessary. Connectors between the halo and vest must counteract anterior flexion tendencies. Lateral connectors should not be placed at shoulder level, as this can lead to hyperextension, excessive pin traction, and pin pullout from the skull. Significant complications also include translation and overdistraction at the fracture site. Anterior turnbuckles should be positioned on the anterior vest valve to accommodate kyphosis. A posterior turnbuckle can be added, and in cases of severe kyphosis or planned progressive correction, an additional anterior turnbuckle may be used (Fig. 2). In our experience, having appropriate tools readily available for rapid halo vest removal is crucial in the initial days post-application, should urgent decompression be required for neurological complications like neurogenic cardiovascular or respiratory compromise.

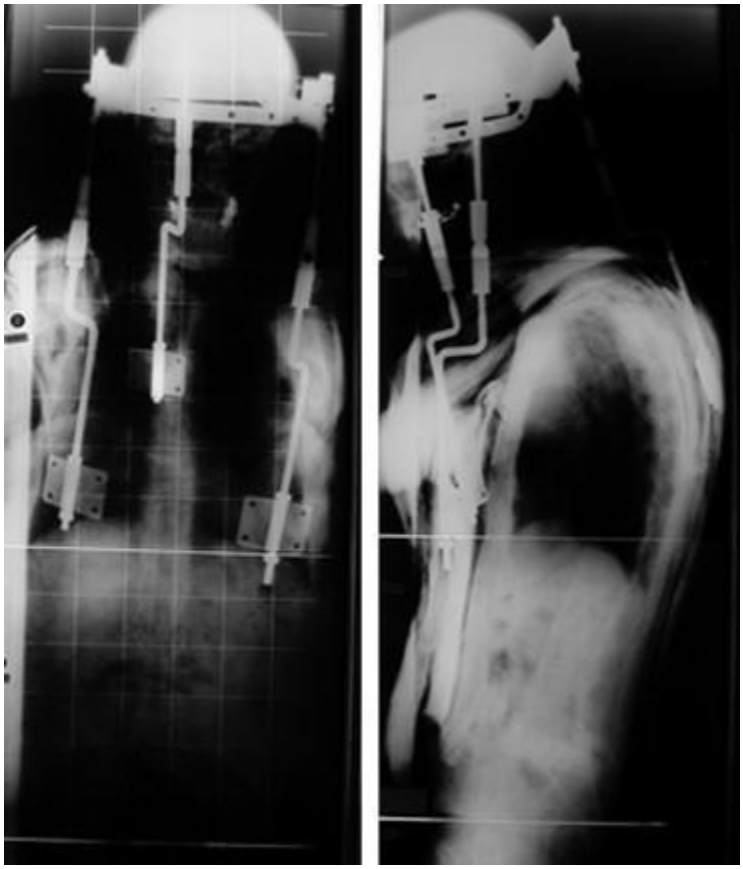

Fig. 2. AP and lateral radiographs of a patient non-operatively treated using a halo vest. Note that the anterior turnbuckles have to rely on the chest because of the kyphosis.

Non-operative treatment complications include significant instability from disrupted anterior and posterior vertebral structures, potentially rendering halo fixation ineffective due to translation and rotational displacements. Detecting this instability radiographically can be difficult, especially in the lower cervical spine, sometimes requiring CT, particularly in severe kyphosis. Assessing fusion after the expected 3-month immobilization period can also be challenging. Pressure ulcers are more common under halo vests in AS patients due to thoracic kyphosis, especially with compromised patient care, poor general condition, and limited compliance with verticalization and brace tolerance. Meticulous padding or custom-fitted vests can mitigate this risk. Cranial pin fixation can also cause complications like infection or pin loosening. However, with proper placement avoiding skin contact, positioning below the ears to minimize pull-out risk, and careful pin monitoring, halo vests remain a viable option.

Pathophysiology of Cervical Spine Involvement in AS: [25]

In AS, the inflammatory process targets the entheses, the sites where ligaments and tendons attach to bone. In the cervical spine, this inflammation can lead to:

Syndesmophytes: Bony growths that bridge adjacent vertebrae, eventually leading to fusion and a characteristic "bamboo spine" appearance on radiographs.

Facet joint ankylosis: Inflammation and subsequent fusion of the facet joints, which contribute to spinal stability and allow for movement.

Atlantoaxial subluxation: Instability between the first two cervical vertebrae (atlas and axis) due to ligamentous laxity and erosions. This can be a serious complication, potentially leading to spinal cord compression.

Fractures: The fused, brittle spine is more susceptible to fractures, even from minor trauma. These fractures often occur at the junction between fused and unfused segments.

Ossification of the posterior longitudinal ligament (OPLL): Thickening and calcification of the posterior longitudinal ligament, which runs along the back of the vertebral bodies. This can compress the spinal cord, leading to myelopathy.

Cervical radiculopathy: Compression of the cervical nerve roots as they exit the spinal canal, causing pain, numbness, and weakness in the arms and hands.

Indications for Cervical Spine Surgery in AS: [25]

Surgical intervention in the cervical spine of AS patients is considered when conservative treatments, such as medication, physiotherapy, and bracing, fail to provide adequate relief. The primary indications for surgery include:

Intractable pain: Severe neck pain that significantly impacts quality of life and does not respond to conservative measures.

Progressive neurological deficit: Evidence of spinal cord compression or nerve root impingement, manifesting as weakness, numbness, tingling, or bowel/bladder dysfunction.

Unstable atlantoaxial subluxation: Significant instability between the atlas and axis, posing a risk of spinal cord injury.

Cervical deformity causing significant functional limitations: Severe kyphosis (forward bending) or subluxation leading to difficulties with eating, swallowing, breathing, or maintaining horizontal gaze.

Fractures with neurological compromise or instability: Fractures that compress the spinal cord or threaten spinal stability.

Types of Cervical Spine Surgery for AS:[25]

The specific surgical procedure chosen depends on the underlying pathology and the patient's individual circumstances. Common surgical approaches include:

Posterior decompression and fusion: This is the most common surgical procedure for cervical myelopathy or radiculopathy caused by OPLL or facet joint hypertrophy. It involves removing the compressive elements from behind the spinal cord and stabilizing the spine with instrumentation and bone grafts to promote fusion.

Anterior cervical discectomy and fusion (ACDF): This procedure is used to treat cervical radiculopathy caused by disc herniation or osteophytes. It involves removing the affected disc and replacing it with a bone graft or artificial disc, followed by fusion. It's less commonly used in AS due to the frequent presence of syndesmophytes and ankylosis.

Atlantoaxial fusion: This procedure is performed to stabilize an unstable atlantoaxial joint. It typically involves placing screws across the joint and securing them with rods or plates, promoting fusion between the atlas and axis.

Osteotomy: This involves surgically cutting the bone to correct severe deformities like kyphosis. It is a complex procedure with higher risks but can significantly improve posture and horizontal gaze. Different types of osteotomies exist, including Smith-Petersen, pedicle subtraction, and vertebral column resection. The choice depends on the degree and location of the deformity.

Laminectomy: Removal of the lamina (the bony arch of the vertebra) to relieve pressure on the spinal cord. This is less commonly used in AS as it can destabilize the already compromised spine.

Pre-operative Evaluation and Planning:

Thorough pre-operative evaluation is crucial for successful cervical spine surgery in AS patients. This includes:

Detailed medical history and physical examination: Assessing the patient's overall health, neurological status, and the severity of their symptoms.

Imaging studies: X-rays, CT scans, and MRI are essential to evaluate the extent of spinal involvement, identify any instability or compression, and plan the surgical approach. Dynamic radiographs are important to assess instability in flexion and extension.

Pulmonary function tests: Assessing lung capacity and function, especially in patients with thoracic spine involvement, as it can affect respiratory function after surgery.

Cardiovascular evaluation: Assessing cardiac function to ensure the patient can tolerate the surgical procedure.

Anesthesia consultation: Discussing the anesthetic plan and addressing any potential airway challenges due to limited neck mobility.

2.2. **Surgical treatment**

Surgery is indicated for neurological deficits clearly attributable to cord or nerve root compression on imaging (Table 1). This involves decompressive laminectomy and fusion. However, cord compression isn't always apparent; instability itself can cause neurological worsening, sometimes observed even with initial halo brace treatment. Surgical fixation allows immediate mobilization and facilitates nursing care. Technical challenges remain due to kyphosis and instability, impacting intubation, prone positioning, and the surgical procedure itself. Postoperative immobilization with a custom-made cervical collar is often necessary due to residual kyphosis, sagittal imbalance, poorbone quality, and high lesion instability.

Table 1
Surgical management of AS cases at the cervical level: bibliography table.

Author	Year	Journal	n	Age	Neurological status	Level	Management	Results	Complications
Taggard and Traynelis [8]	2000	*Spine*	7	60 y.o. (49–83)	3 tetraplegia	3 C5C6 4 C6C7	Posterior approach ± cervical traction preop rib harvesting	100% fusion at 3/4 month	1 deep venous thrombosis 1 upper gastrointestinal hemorrhage 2 pneumoniae 2 deceased
El Masry et al. [4]	2004	*Injury*	1	82 y.o.	Sensory C7 deficit	C6C7	Circumferential single session	Anatomical reduction and fusion 4 years	None
Cornefjord et al. [3]	2005	*Eur Spine J*	19	60 y.o. (32–78)	2 paraplegia 2 motor weakness 4 sensory deficit	5 C5C6 5 C6C7	Posterior fixation	No reoperated for loosening of the instrument or healing pb	1 deep wound infection 2 extensive peroperative bleeding
Mountney et al. [5]	2005	*Eur Spine J*	1	36 y.o.	Hyperflexia	C7	Traction first And anterior approach And posterior fixation 15 days after	Good results at 18 months	None
Payer [6]	2006	*J Clin Neurosci*	4	77 y.o. 70 y.o. 66 y.o. 52 y.o.	C7 motor weakness Tetraplegia Normal Tetraplegia	C6C7 C6C7 C6C7 C6C7	Posterior approach Anterior approach Circumferential two-session Circumferential single session	Partially recover redislocation Stable fixation, 12 months Stable fixation, no neurological recovery	None Reopearted circumferential None None
Shen and Samartzis [7]	2006	*J Trauma*	2	79 y.o. (77–81)	1 tetraplegia	2 C6C7	Posterior approach	Fusion and intact instrumentation at 1 year and 3 month	1 pneumoniae with death at 3 months
Einsiedel et al. [26]	2006	*J Neurosurg*	37	65 y.o. (36–82) Two institutions	9 Frankel A 11 Frankel B 6 Frankel C 10 Frankel D	19 C6C7 6 two-segments	10 anterior approaches 11 circumferential single session 13 circumferential two-session 3 posterior approaches	5 early implant failure with anterior approach	3 deceased (RDS and cerebral ischemia) 3 infections 1 deep venous thrombosis
Kouyoumdjian et al. [27]	2012	*OTSR*	19	61 y.o. (33–64)	10 medular deficit 7 radicular pain	9 C5C6 10 C6C7	13 anterior approaches 3 conservative treatment 2 circumferential 1 posterior	Good for bone healing	5 deceased 1 haematoma drained 2 cases of screw brached out 1 pressure sore on minerva

The standard cervical fracture classification system doesn't fully apply to AS patients due to the rigid or fused nature of their cervical spines. A more practical classification, based on therapeutic considerations, distinguishes between transdiscal and transosseous lesions (Fig. 3). Transdiscal lesions occur between the reinforced former endplates, preserving anterior column bone stock and allowing good fragment contact after reduction. Although corpectomy has been reported for a C6-C7 transdiscal fracture [4], posterior fixation alone, with at least two fixation points above and below the level, is generally considered sufficient [3, 7, 8]. While cervical pedicle screws offer the most reliable fixation, they are technically demanding [3]. Lateral mass screws also provide satisfactory results [7, 8]. Importantly, posterior constructs should extend into the thoracic spine if necessary, andlaminar hooks are not recommended due to the risk of spinal hematoma in AS. Anterior fixation alone is

generally discouraged due to insufficient stability [6], although some suggest long anterior plates can provide adequate stability if they minimize moment arm forces, similar to long bone fractures [27].

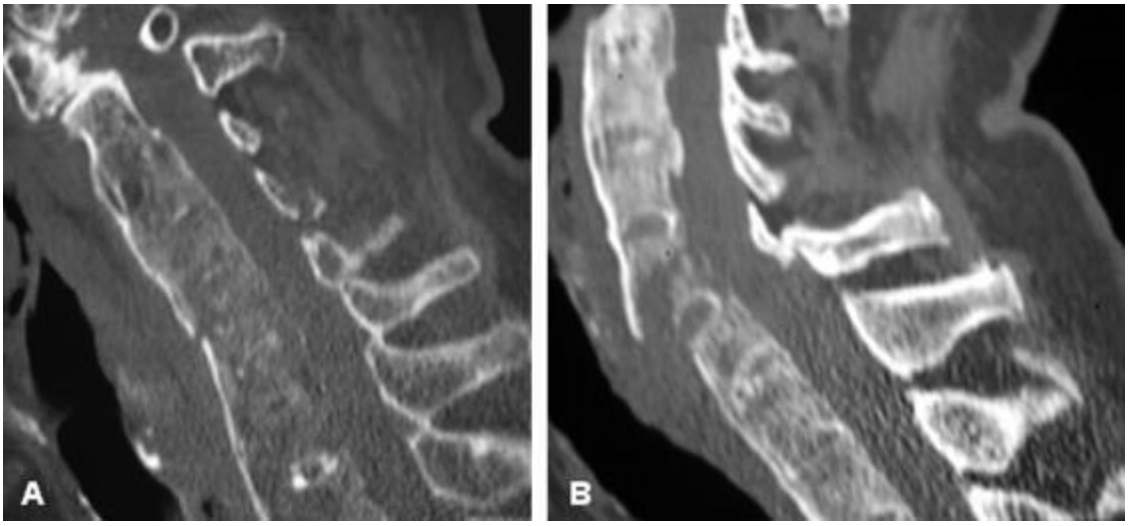

Fig. 3. Imaging classification of the cervical fractures: (A) transdiscal, and (B) transcorporeal. Transcorporeal lesions correspond to the collapse of the cancellous bone and induce a gap after reduction that may require an anterior approach. Transdiscal lesions show no bone defect, and a posterior fixation alone is sufficient.

Einsiedel et al. [26] reported high historical rates of early implant failure (50%) with single- stage anterior stabilization in AS, leading them to advocate for a one- or two-stage circumferential approach.

Combined anterior and posterior instrumentation is recommended when vertebral body integrity is significantly compromised, particularly with kyphotic deformity at the fracture site. Some authors [4, 26] favor circumferential fusion due to the inelasticity of spinal structures in AS, the involvement of all anterior and posterior elements in AS fractures, poor bone quality, and difficulty identifying anatomical landmarks.Purely posterior fixation/fusion is suitable when the anterior column is well-aligned and lacks significant fracture gaps [4, 6, 8].

Transosseous lesions often involve vertebral body cancellous bone collapse, leading to poor bony contact in extension and increased instability in flexion, translation, and rotation. This raises the question of anterior column reconstruction with cage or bone graft. While large gaps, especially at the cervicothoracic junction, require grafting for stability and fusion [5], smaller anterior gaps may fuse successfully with posterior fixation alone [28], supported by the high fusion rates reported with anterior opening osteotomies in the cervical and lumbar spine [2, 9]. While clear guidelines are lacking, the anterior approach is not routinely necessary for transosseous lesions. Furthermore, anterior access can be challenging due to kyphosis, sometimes requiring partial sternotomy for lower cervicalspine access. Figure 4 provides a proposed algorithm for managing acute cervical lesions in AS.

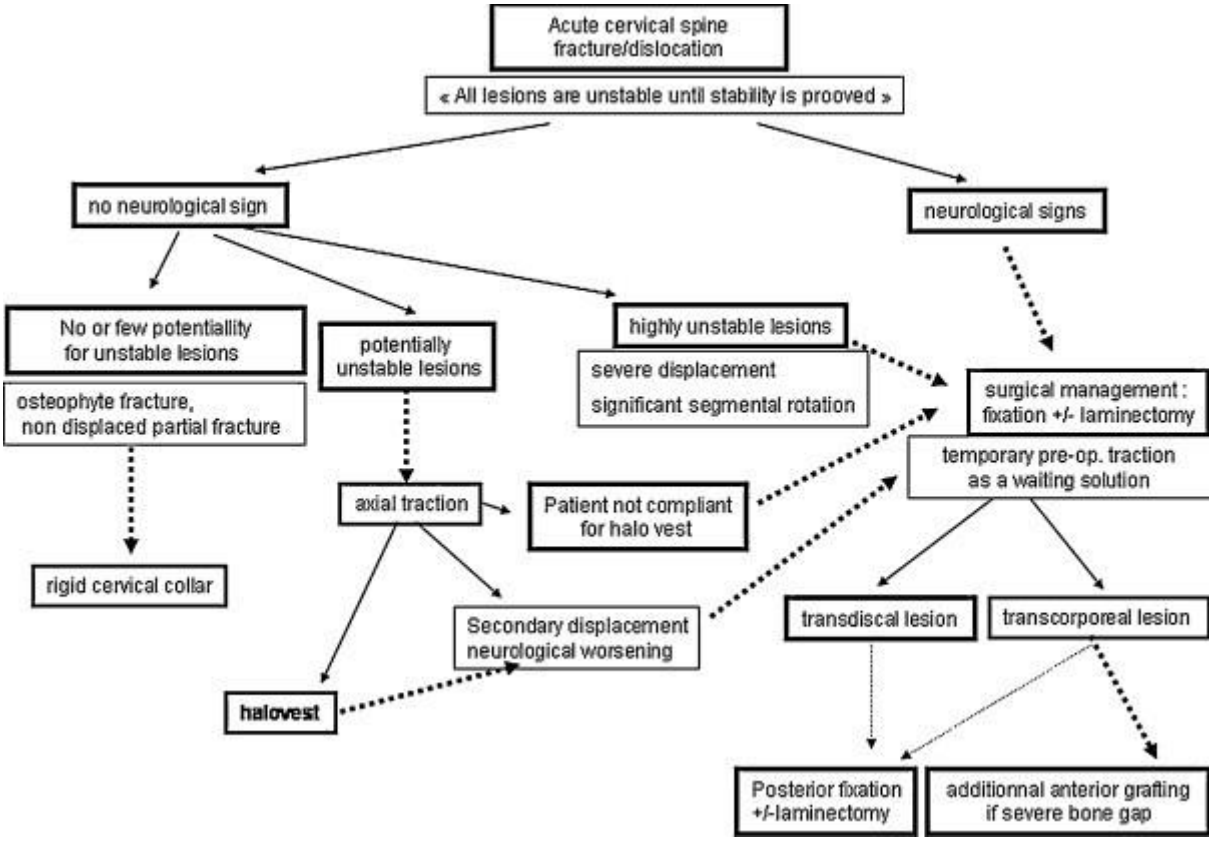

Fig. 4. Algorithm for the management of acute cervical lesions in the case of ankylosing spondylitis.

Upper cervical spine lesions, though less common in AS and often located at C2, require a distinct approach. Given potential instability and poor bone quality, extensive occipitocervical fusion, despite limiting mobility, is generally the safest option. This typically involves posterior autologous bone grafting from the occiput to C2 or C3. Postoperative immobilization with a cervical collar is necessary, and a halo vest may be preferred initially for highly unstable lesions.

Chronic spinal lesions with non-union, often due to missed or delayed diagnoses, present another management scenario. Initial cervical traction assesses reduction potential. If no correction is achieved and neurological status is stable, posterior fixation without laminectomy can be considered, aiming for acceptable sagittal balance. If correction is possible, management mirrors acute lesions. Posterior fixation alone is often sufficient for fusion, provided the construct is long enough and postoperative immobilization is adequate. Anterior surgery is rarely indicated, reserved for severe anterior bone defects or significant imbalance. As with acute cases, kyphosis complicates anterior approaches. In cases of unacceptable, uncorrectable imbalance despite traction, a corrective wedgeosteotomy, despite its risks, may be considered. Figure 5 provides a proposed algorithm for managing chronic cervical lesions.

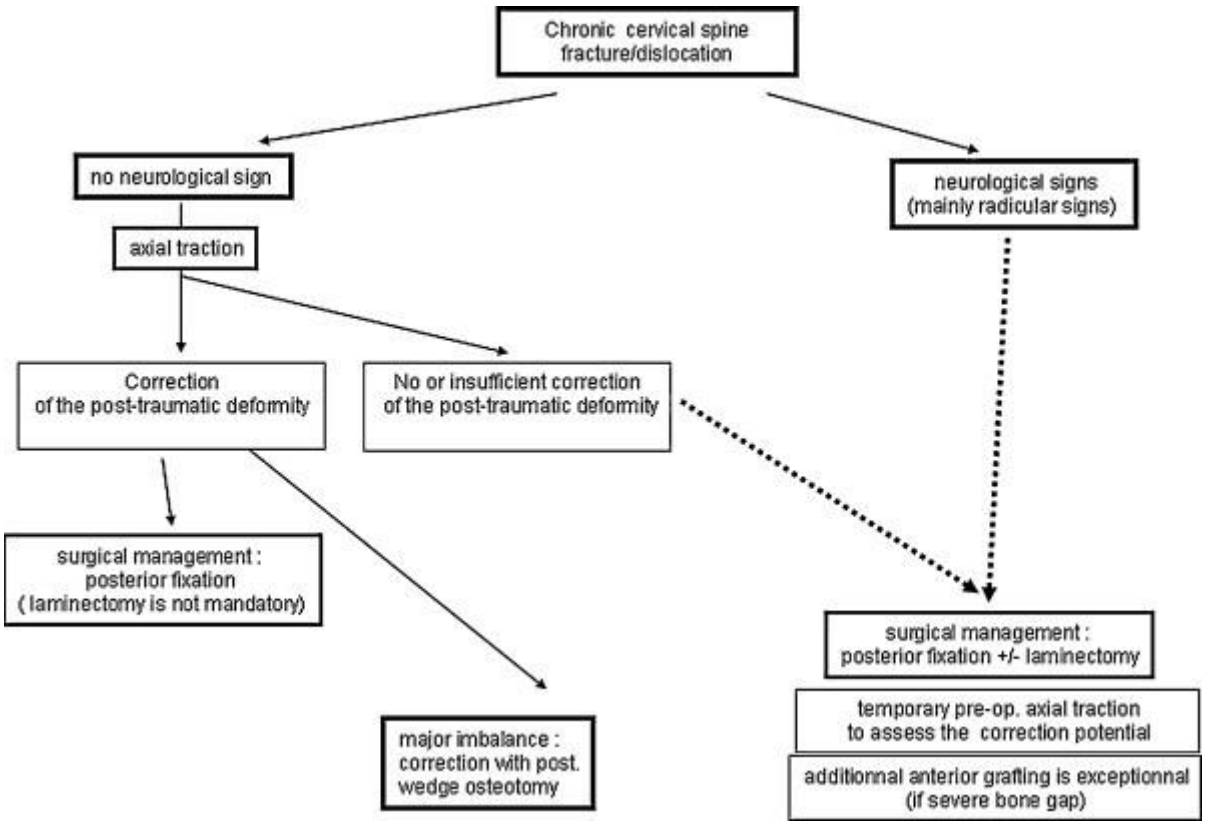

Figure 5: Fig. 6. Algorithm for the management of chronic cervical lesions in the case of ankylosing spondylitis.

Spinal epidural hematoma, a serious complication with increased risk in AS, can occur due to persistent bleeding from fractured cancellous bone within the rigid spinal canal. This raises the question of routine laminectomy with posterior fixation. While laminectomy might facilitate postoperative bleeding drainage, it increases instability and reduces the surface area for bone grafting. Septic complications are also a significant concern due to the unique anatomical features of the skin and soft tissues, often compounded by the patient's debilitated state. The risk is further elevated in patients requiring delayed surgery after initial halo brace treatment due to displacement or neurological worsening. Respiratory complications can also arise due to lung fibrosis and rib ankylosis, impacting postoperative management and surgical strategy.

1. Correction of sagittal deformity

While restoring pre-existing kyphosis is the usual surgical goal, the presence of a fracture allows the opportunity for increasing lordosis [6]. Gradual kyphosis correction is possible with halo vest treatment via progressive anterior distraction using anterior turnbuckles (Fig. 2). However, this requires careful monitoring and adjustment based on patient tolerance and radiological findings. Translation and overdistraction are significant risks duringcorrection, especially above C6, due to potential vertebral artery stretching. Posterior medullary impingement in extension might necessitate concomitant laminectomy, similar to corrective osteotomy. Intraoperative neuromonitoring is essential [13].

Outside of trauma, chin-on-chest deformity causing loss of horizontal gaze and difficulty breathing/eating are primary indications for cervical extension osteotomy, typically at C7. This location avoids vertebral artery involvement, offers a wider spinal canal, and maximizes the extension lever arm. The C7/T1 facet joint is removed to prevent T1 nerve root impingement. Partial vertebral body decancellation can help control anterior opening, a potentially dangerous step [15]. Neuromonitoring or wake-up tests are crucial for preventing irreversible medullary injury [13]. Lordosis gains of 30-40° are possible, but outcomes are variable, ranging from satisfactory results with good fusion to severe neurological complications and even death.

Chin-brow angle (CBA) measures kyphotic deformity, with 0° indicating normal horizontal gaze. However, CBA reflects whole-spine sagittal balance. Analyzing kyphosis separately at the cervicothoracic, thoracolumbar, and even hip joints is essential. Chin-on-chest (CC) distance measures cervical spine deformity specifically. Normal CC distance differentiates between upper spine kyphosis (requiring cervical osteotomy) and global kyphosis (potentially amenable to lumbar correction) (Fig. 7).

This review (level IV evidence) combines expert opinion and case series. Limitations include the scarcity of literature on cervical spine surgery in AS, with most series being retrospective, small, and incompletely documented. The long inclusion periods reflect case rarity but introduce heterogeneity. Elderly patients and those with severe cord lesions have a poor prognosis, with high mortality despite optimal trauma management [18, 21, 29, 30]. While unanswered questions remain, these cervical lesions are unique. Key takeaways include respecting kyphotic posture during emergency management; carefully monitored halo vest treatment remains an option; fracture classification based on anterior bone gap can guide surgical technique selection; surgical fixation should be long but not always circumferential; and lumbar osteotomy should be considered before cervical osteotomy for kyphosis correction, differentiating CC distance from CBA.

Conclusion

Cervical spine surgery in AS patients is a complex undertaking requiring careful consideration of the risks and benefits. Appropriate patient selection, meticulous surgical planning, and comprehensive post-operative care are crucial for successful outcomes. While surgery can significantly improve pain, function, and quality of life for individuals with debilitating cervical spine involvement, it's important to recognize the potential complications and the need for long-term follow-up. Ongoing research continues to refine surgical techniques and improve outcomes for AS patients requiring cervical spine surgery

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