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Surgical Management of Fractures in Vertebrae with Enclosing Spondylitis- A Systematic Review with Newer Principles of Management

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Abstract

Ankylosing Spondylosis is a type of seronegative arthritis that causes inflammation and eventually fusion of the spine and the spinal joints. Involvement of peripheral joints and extraarticular manifestations. It includes-Ankylosing spondylitis (AS); Diffuse idiopathic skeletal hyperostosis (DISH); End stage spondylosis multiform (EASM); Ossified posterior longitudinal ligament (OPLL). The prevalence ranges from 0.1 to 1 percent of the population, M>F, between15-40 years; 95% share the genetic marker HLA-B27. Numerous bony changes to spine include-Intraosseous bone loss; erosion; sclerosis; fractures; extra osseous squaring; syndesmo and enthesophytes. Incidence of vertebral fracture in patients with AS is 3.5 times higher than in general population, 75% of the fractures occur in the cervical spine followed by the thoracic and lumbar spine. Spinal cord injury is about 11 times higher than the general population. Mean age of fracture is 63.4 years. Treatment is challenging due to kyphosis, osteoporosis, with restrictive lung disease, and medical comorbidities. Treatment goals are to reduce or prevent- inflammation, ankylosis, abnormal posture. The principle is to treat the fracture as long bone osteoporotic diaphyseal fracture. Apart from 360 fracture fixation with long construct, MIS surgery, other fracture managements in AS are deformity correction, laminectomy, laminoplasty, rhizotomy, neuromodulation. Complication rates are high, wound infections up to16%, pulmonary complications up to 63%, mechanical complications up to 23% amongst many are reported. Therefore, an appropriate standardized workup and consideration of specific injury patterns are essential before decision making.

Keywords: Ankylosing Spondylytis; Vertebral fracture; Anteropostero fixation; Wedge osteotomies; Significant complication.

Introduction: Vertebral Fracture in Ankylosing Spondylosis

In AS , the risk of vertebral fracture increases. Diagnosis of vertebral fracture is not easy, although their clinical consequences aggravates in spine deformities (hyperkyphosis) and complications are higher (Geusens). In a study in France VF in AS was found as high as 17%(1). Fractures in AS spine are often the consequences of minor low- energy trauma because of alteration in the bone composition and biomechanical properties. This fractures is mostly unstable and susceptible to displacement and neurological deficit as the supportive ligaments and soft tissue ossify and lose their elasticity behaving like bone. (2,3). Complication rates are high with 51% in AS patients, overall mortality rate within 3 months period being 17.7% in AS patients. 8-13% of patients have multilevel fractures. Incidence of spinal cord injury is 11 times higher than the general population (4), The average age of fracture is 63.4 yrs(5) [Figure1and Figure2].

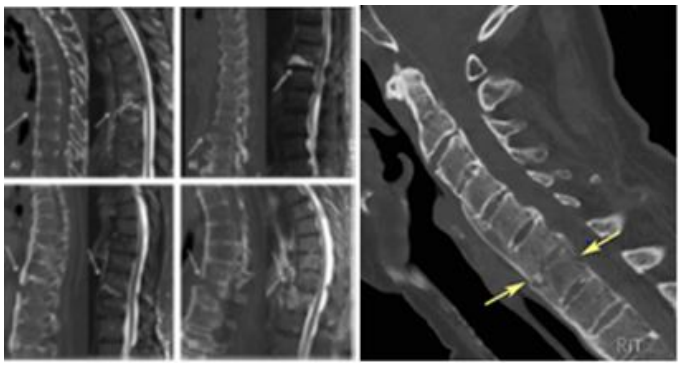

Figure1 & Figure 2: Preoperative Tomography and MRI showing acute vertebral fractures in AS vertebra.

Management of Vertebral Fractures in Ankylosing Spondylytis

The management would be divided into medical and surgical managements. Protected transfers are essential to prevent secondary neurological insult. Conservative methods, including immobilization by a Halo vest and prolonged bedrest in traction or a collar, have been associated with a high rate of complications. With advances in care and surgical technique, there is a rising trend to surgery.

Conservative Treatment

46% of the patients are treated by conservative methods [5]. Conservative approach is chosen either because of high anesthetic risks or following patient's refusal to undergo surgery.

Nonoperative treatment had higher rates of fracture displacement, worsening neurology, and nonunion compared to surgical treatment .[5] Conservative care includes bed rest, roto rest bed, halo vest or cervical collar for cervical fractures.[6] The kyphotic deformity and the abnormal body morphology necessitates the use of customized braces to maintain the natural preinjury contour. Patients should be regularly followed up and observed for any displacement of the fracture.

Surgical Principle

Fractures in an ankylosed spine are analogous to that of long bone diaphyseal fractures, the principles of which mandate multilevel fixation. Although most of the patients can beoperated electively, patients with incomplete neurological deficit and secondary neurological insult should be operated on emergently.

Role of Preoperative Traction

Significant fracture malalignment requires a low weight skull traction not exceeding 5–10 lb. The traction direction is chosen to take the preinjury cervicothoracic alignment intoconsideration as hyperextension should be avoided to prevent neurological deterioration.

Positioning

Due to the highly unstable nature of these injuries, patients are at risk for neurological worsening when being intubated. The risks associated with positioning can be minimized by awake fiberoptic intubation and electrodiagnostic monitoring, rigid fixation of the skull with Mayfield clamps or a comparable device.

Anterior vs Posterior vs Circumferential Stabilization

Anterior access is less traumatic, minimizes the risks of displacement during positioning, provides immediate stability and a greater surface area for bony fusion and has less incidence of postoperative infections. However, the biomechanical stability of anterior approach is questionable as osteoporosis frequently seen in these patients preferentially affects the anterior column. Failure rates of initial anterior fixation as high as 50%. The posterior alone approach can restore the alignment of the spine, stabilize the injured segments, and allow broad decompression of neurological elements. Multisegmental posterior fixation with autologous cancellous bone graft offers a biomechanical advantage over anterior fixation and result in decreased morbidity compared with combined anterior-posterior fixation. However, the extensive dissection of muscles required, increased risk of wound infection, and inability to access anterior spinal cord compression. It is unsuitable for cases with anterior fracture gaps. In addition, a fusion of the posterior elements may make localization of the anatomic landmarks difficult which can lead to pedicle fracture, neurodeficit, and vertebral artery injury. The anteroposterior or the circumferential approach is the current treatment of choice in cases with marked three column instability.[7] It is used in approximately 25% of patients with AS and cervical spine fractures. The primary indication of adding an anterior approach to posterior surgery is the presence of a persistent deformity, gap or displacement that is compromising the spinal cord following posterior instrumented reduction. The high morbidity associated with the procedure in the form of long surgical duration, blood loss, and occasional mortality I would recommend a combined approach for unstable fractures (translation, distraction, or angulation) and fractures with anterior gap. Irrespective of the approach used it is important to augment screw purchase by increasing number of fixation points, using larger diameter screws, trying for bicortical purchase, and convergent screws.

Role of Fusion in Asv Fracture

Spinal fusion approaches for vertebral fractures in AS patients depend on the location of the fracture and can include posterior spinal fusion (PSF), anterior-posterior spinal fusion (APSF), and anterior spinal fusion (ASF). With the advent of new instrumentation and techniques, trends in the use of these approaches have changed [Figure3 and Figure4].

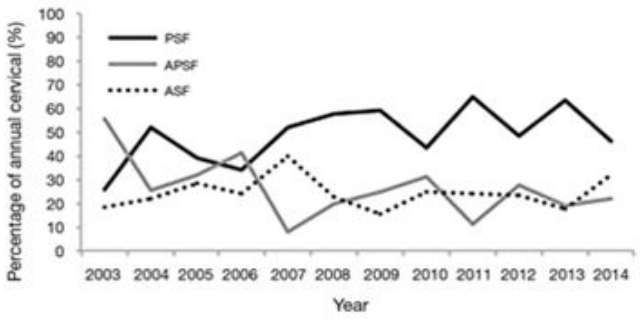

Figure 3: Multicentric data- Departments of Orthopaedic And Spine Surgery, Multicentre trends in cervical fusion from 2003-2014 in cervical spine fracture in AS vertebra. ASF=Anterior spinal fusion; PSF=Posterior Spinal Fusion; APSF=Antero-posterior Spinal Fusion.

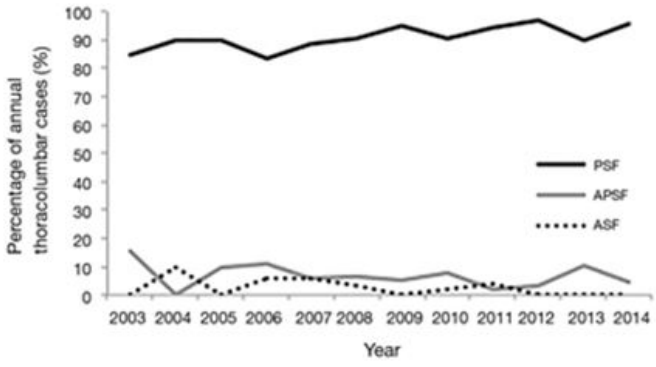

Figure 4: Multicentric Data - Departments of Orthopaedic And Spine Surgery, Multicentre trends in thoracolumbar fracture in AS vertebra.

Minimally Invasive Stabilization in Asv Fracture

Minimally Invasive Stabilization, when used on patients with good preoperative neurologic status, can successfully manage spinal fractures in patients with AS and DISH and preserve a favorable postoperative quality of life with limited disability. Minimally invasive approaches are also being utilized more frequently in the treatment of spinal fractures in AS. Minimally

invasive stabilization is an alternative to open reduction given the older age, higher rate of comorbidities, and greater surgical risk of AS patients. In the first case series of ankylosing spinal disorder patients with either AS or diffuse idiopathic skeletal hyperostosis (DISH) being treated with minimally invasive techniques, Krüger *et al.* [8] reported improved patient outcomes with closed reduction and percutaneous dorsal instrumentation (Table 3).

Parameter	Average value (range) or %
Age at surgery	77(52-88)
Male	45%
ASA grade	3
Low impact mechanisam	45%
BMI	34(20,4-44.5)
Number segments incorporated	7(6-10)
Operative time(min)	227(79-449)
Blood loss(ml)	251(25-900)
Post operative LOS (d)	14.4(4-60)
Post operative(ODI)	21.5%(0-34.%)
Post operative EQ-5d Utility Score	0.77(0.60-1.0)
Follow-up time (mo)	28(5-58)

Table 1: Patient reported outcomes in MIS Sacturex for ASV fracture. ASA=American Society of Anasthesiologists. BMI= Body Mass Index. LOS= length of stay. ODI= Oswestry Disability Index. EQ5D= EuroQol 5D.

Osteotomies in Deformity Correction in Asv Fracture

The main indication for surgery across all studies was severe kyphotic deformity in neglected fracture or pseudoarthrosis resulting in the inability to stand upright/lie flat or to look straight ahead. All procedures are performed using primarily pedicle screw instrumentation. Correction of thoracolumbar kyphotic deformities (TLKDs) in this patient population. With regard to options for the surgical treatment of TLKDs, the two best described techniques are the closing wedge osteotomy (CWO) or pedicle subtraction osteotomy and the opening wedge osteotomy (OWO) or a modified Smith–Petersen osteotomy (Figure 5 and Figure 6).[9-12].

Figure 5: Asymmetrical spinal osteotomy consisting of pedicle subtraction and opening wedge osteotomy performed at L3, correcting both coronal and sagittal plan deformity.

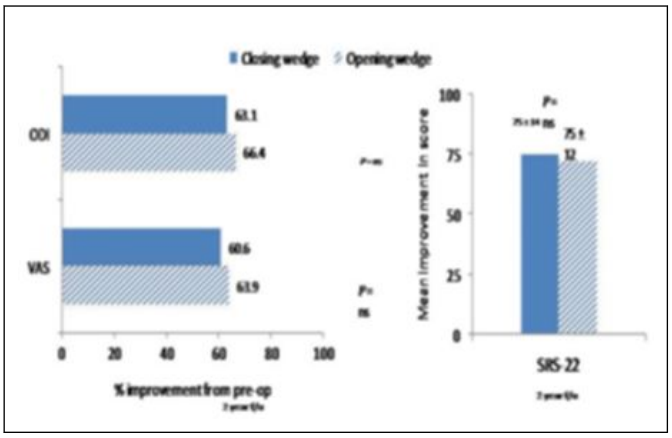

Figure 6: Comparison between Closing vs Opening wedge osteotomy . N=22 2 yrs f.u. Clinical outcomes in pain; ODI; quality of life (Arun et al 2011).

Radiofrequency Rhizotomy

Radiofrequency ablation, also called rhizotomy, is a nonsurgical, minimally invasive procedure that uses heat to reduce or stop the transmission of pain. Radiofrequency waves ablate, or "burn," the nerve that is causing the pain, essentially eliminating the transmission of pain signals to the brain (Figure 7).

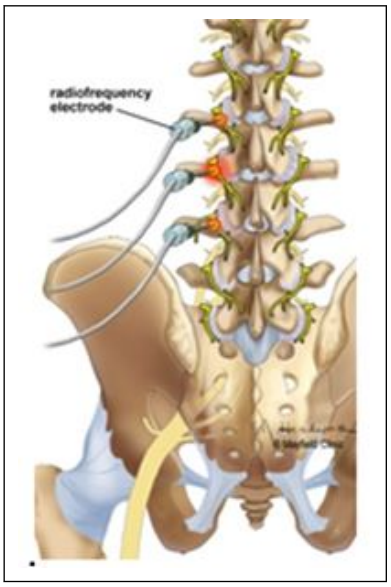

Figure 7: A heating current is passed through an electrode to destroy the medial branch of the sensory nerve to block the transmission of pain signals.

This procedure is most commonly used to treat chronic pain and conditions such as arthritis of the spine (spondylosis) and sacroilitis. It is also used to treat neck, back, knee, pelvic and peripheral nerve pain. The benefits of radiofrequency ablation include: avoiding surgery, immediate pain relief, little to no recovery time, decreased need for pain medication, improved function, and a quicker return to work and other activities.

The technique for nerve ablation is similar to that used for diagnostic blocks. With the aid of a fluoroscope (a special x-ray), the doctor directs a thin hollow needle into the region responsible for the pain. Fluoroscopy allows the doctor to watch the needle in real-time on the fluoroscope monitor to make sure that the needle goes to the desired location. Contrast may be injected to confirm correct needle location. Some discomfort occurs, but patients typically feel more pressure than pain.

Outcome Measures

Operative characteristics that were evaluated included surgical approach (PSF, APSF, and ASF). Major in-hospital complications,potentially long-term sequelae, neurological, cervical-spine related, pulmonary, cardiac, thromboembolic, renal, infectious, implant-related, and incidental durotomies. We also evaluated in-patient mortality rates and the use of blood transfusions.

In the cervical group, all three approaches were more popular in hospitals located in the Southern part of our country: 41.7% of PSF, 41.2% of APSF, and 46.8% of ASF surgeries. In the thoracolumbar group, most of the PSF (35.8%) and APSF (57.1%) surgeries were performed in the South while most (42.9%) of the ASF surgeries were performed in the west.

Statistical Methods

The associations between surgical approach and complications, patient sex, patient, race, and hospital characterizations were analyzed using Pearson chi-squared tests. Analysis of variance model was used in the comparison of age, length of stay, and total hospitalization costs between the three surgical approaches. Significance was set at $P<0.05$. All calculations were performed using SPSS (SPSS Inc. ver 22.0).

Result

The number of spinal fusion surgeries performed in AS patients who experienced fractures increased significantly ($P<0.01$) over the study period. The proportion of cervical fractures receiving fusions stayed consistent. However, there was a shift in the surgical approaches for cervical fractures. The number of PSF surgeries in cervical fractures increased 4.0-fold and the number of ASF surgeries increased 3.8-fold. While APSF was most popular in 2003 (55.6%), it was least popular in 2014 (21.7%). The proportion of thoracolumbar fractures receiving fusions increased significantly ($P<0.01$) from 2003 to 2014. Moreover, the percentage of PSF surgeries with thoracolumbar fractures increased significantly ($P=0.01$), with PSF accounting for 84.6% of the surgeries in 2003 and 95.7% in 2014 [Figure 3 and Figure 4].

Complications

Compared to the healthy general population, the morbidity of spine fracture in AS is 3.5 times higher.[13] The most frequent cause of death both in the acute phase and at later follow up is respiratory complication such as pneumonia. Associated visceral injuries and rare intrathoracic complications including tracheal rupture and aortic laceration or dissection in thoracolumbar injuries have been cited in the literature. Loss of reduction, nonunion and neurological deterioration have been reported after nonoperative treatment, which often leads to secondary surgery.[14] With regard to the surgical treatment,wound

infections up to 16%, pulmonary complications up to 63%, and mechanical complications up to 23% are described.[15] Therefore, an appropriate standardized workup before decision making [Table1 and 2]. In AS patients, cervical fractures are observed more frequently than thoracolumbar fractures. In an analysis of published case series, Westerveld *et al.* note that 77.5% of fractures were located in the subaxial cervical spine (15). Surgically treated patients provided solid fusion and neurological improvement in contrast to non-operatively treated patients who often presented with pseudarthrosis and progressive neurologic deficits. For thoracolumbar fractures, PSF of at least three levels above and below the fracture are recommended by several authors (16,17).Minimally invasive approaches are also being utilized more frequently in the treatment of spinal fractures in AS. Minimally invasive stabilization is an alternative to open reduction given the older age, higher rate of comorbidities, and greater surgical risk of AS patients. In the first case series of ankylosing spinal disorder patients with either AS or diffuse idiopathic skeletal hyperostosis (DISH) being treated with minimally invasive techniques, Krüger *et al.* (18) reported improved patient outcomes with closed reduction and percutaneous dorsal instrumentation. The authors argue that the benefits of the percutaneous approach, including reduced intraoperative complications and operating times, are very advantageous considering the patient cohort. The increased popularity of surgical treatment for thoracolumbar fractures especially posterior long segments with pedicle screw constructs are preferred and provide favorable outcomes (19) Thus, for the cervical spine, the location and presence of deformity need to be carefully considered when choosing a treatment option. Werner *et al.* (20) recommend that PSF or APSF should be used because ASF is associated with higher failure rates. However, results indicate that ASF is still relatively popular. While APSF (55.6%) was most frequently used in 2003, PSF (46.7%) and ASF (31.7%) were more popular in 2014. A higher prevalence of pulmonary disease is often seen in AS patients due to restrictive ankylosis of the thoracic cage (21,22). Extra-articular involvement of the lungs can be seen even in asymptomatic patients (23). Our complications results confirm this pulmonary component of AS. In addition, we found a significant association between surgical approach and pulmonary complications in both cervical and thoracolumbar fractures in which the highest rate of pulmonary complications is seen in APSF. This is a significant finding that may assist surgeons in choosing a treatment approach for AS patients with spinal fractures who may have preexisting lung disease.Our study has several limitations inherent to large database studies.

Post surgical issue	PSF(%)	APSF(%)	ASF(%)	P value
Cervical Complications				
Pulmonary	30	45	35.5	0.01
Cervical spine-related	11.3	17.56	17.7	0.12
UTI	12.8	6.1	9.7	0.12
Implant-related	2.3	6.1	3.2	0.14
Thrombeombolic	3.8	7.6	4	0.23
Cardiac	13.2	10.7	8.1	0.32
infectious	5.3	3.8	7.3	0.49
Neurological	0.38	0.76	0.81	0.62
Renal	7.9	9.2	7.3	0.85
incidental durotomy	0.75	0	0	0.99
Died	7.1	9.9	13.7	0.11
Total complications	50.4	58	53.2	0.36
Blood Transfusion	22.6	18.3	7.6	<0.01

Table 2: In-house complication rates in different cervical spine fusion surgeries following vertebral fracture in AS vertebra. UTI=Urinary Tract Infection.

Post surgical issue	PSF(%)	APSF(%)	ASF(%)	P value
Thoracolumbar Complications				
Pulmonary	22.2	53.6	42.9	<0.01
Cervical spine-related	3.7	10.7	14.3	0.07
Infectious	4.8	7.1	14.3	0.25
Implant-related	2.3	7.1	0	0.3
Thrombeombolic	3.4	7.1	0	0.44
UTI	13.7	7.1	0	0.54
Neurological	1.8	0	0	0.99
Cardiac	16.2	14.3	14.3	0.99
Renal	13.5	10.7	14.3	0.99
incidental durotomy	2.1	0	0	0.27
Died	4.1	10.7	0	0.27
Total complications	49.5	71.4	57.1	0.06
Blood Transfusion	28.1	21.4	14.3	0.67

Table 2: Inhouse complication rates in different thoracolumbar spine fusion surgeries following vertebral fracture in AS vertebra.

UTI=Urinary Tract Infection.

Overall, complication risks ranged from 0 to 16.7% in the Closing Wedge Osteotomy group and from 0 to 23.6% in the Open Wedge Osteotomy group across the four studies [24-27]

- The risks of dural tear in the closing versus the opening wedge groups.
- Paralytic ileus occurred consistently less often in the CWO (0 to 5.9%) versus the OWO (10.5 to 16.7%)
- The risk of superficial infection following CWO ranged from2.0 to 8.3% comparedwith 0 to 1.5% followingOWO as reported by two studies.[24-25]
- Neurological injuries.

The complications in radiofrequency rhizotomy reported in the literature include: temporary increase in nerve pain, neuritis, neuroma, localized numbness, infection, allergic reaction to medications used during the procedure, and/or lack of pain relief (in less than 30% of patients).

Conclusion

Fractures are a serious complication of AS and patients are more prone to develop neurological deficits. Most often, the underlying mechanism of injury is a small magnitudeforce. Nonsurgical treatment has largely been replaced by surgical treatment in view of the significant risk for secondary loss of reduction and neurological aggravation along with pulmonary and decubitus complications. can be anterior, posterior (most commonly performed), or combined depending upon the location and pattern of injury. We found that surgical treatment has been growing in popularity for thoracolumbar fractures but staying consistent for cervical fractures in AS patients. Surgical approach has shifted for cervical fractures with APSF transitioning from the most popular to the least popular approach from 2003 to 2014. For thoracolumbar fractures, PSF has remained the preferred approach. Patients undergoing APSF had significantly higher pulmonary complication rates in both cervical and thoracolumbar fractures. This finding can help surgeons in treating fractures in AS patients with underlying pulmonary disease. However, surgical management does not change the inherent complication rates and mortality risks which are largely dependent on the initial injury severity and comorbid conditions. Choice of osteotomy depended on predetermined patient characteristics (e.g., significant aortic atherosclerosis, severe osteoporosis, and classification of the longitudinal ligaments) in two studies resulting in potential confounding by indication in these cases [25-27]. Technical proficiency in both surgical techniques demands subspecialized training in spine surgery and substantial operative experience. Patients with TLKDs secondary to AS should be screened prior to undergoing OWO due to the risk of life-threatening vascular injury resulting from the rupture of a calcified aorta. The authors feel that the incidence of this complication in association with OWO was minimized due to astrong selection bias. It follows that in

patients with clinically significant atherosclerosis, the CWO may be a more appropriate procedure.

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