



Traumatic Spondyloptosis: Neurological, Surgical, and Outcome Perspectives in a Tertiary Care Center

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Indian J Neurosurg 2021;00:1–9

Abstract

Objective To evaluate traumatic spondyloptosis cases for neurological, surgical, and outcome perspectives.

Materials and Methods This retrospective study includes 17 patients of spondyloptosis admitted in our department between August 2016 and January 2020. Each patient was evaluated in terms of demographic profile, clinical presentation, duration of injury, mode of injury, associated injuries, level and type of spondyloptosis, spinal cord status, nociceptive and neuropathic pain severity, severity of injury based on International Standards for Neurological Classification of Spinal Cord Injury (ISNCSI) assessment, surgical approaches, complications, and outcome. Unpaired t- test and Chi-square test were used for statistical analysis. Values with $p < 0.05$ were considered statistically significant.

Results Fall from height (58.8%) was the most common mode of injury. Most common level of spondyloptosis was T12–L1 (41.1%). Sagittal–plane spondyloptosis (76.5%) were more common than coronal–plane spondyloptosis (23.5%). Most common associated injury was musculoskeletal (64.7%). Neurological status of the patient at presentation ($p = 0.0007$) was significantly associated with outcome after 3 months of surgery/conservative management. Residual listhesis was present in 53.3% of patients postoperatively. Postoperative nociceptive pain ($p = 0.0171$) and neuropathic pain (0.0329) were significantly associated with residual listhesis. Duration of injury ($p = 0.0228$) was also significantly associated with postoperative residual listhesis.

Conclusion Complete reduction of spondyloptosis should be the goal of surgery. Overall prognosis of spinal cord injury (SCI) due to traumatic spondyloptosis is poor.

Keywords

- ▶ traumatic spondyloptosis
- ▶ neurological status
- ▶ spondylolisthesis
- ▶ ASIA scale
- ▶ spine injury

Introduction

Spondyloptosis is the most severe form of spondylolisthesis, characterized by complete subluxation (> 100%) of a vertebral body with respect to another vertebra. This complete subluxation may occur in either coronal or sagittal planes (▶ **Figs. 1 and 2**).¹ It can be degenerative or traumatic. Traumatic

spondyloptosis results from high-energy trauma causing flexion-rotation stress or shearing force, which causes disruption of facets and ligaments of spine. In coronal spondyloptosis (▶ **Fig. 2**), subluxated vertebral bodies lie in coronal plane and is also called lateraloptosis.² In Denis classification, traumatic spondyloptosis lies in fracture dislocation category³ and is a very unstable injury. X-ray of the involved

DOI <https://doi.org/10.1055/s-0041-1726608>
ISSN 2277-954X

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region is sufficient to distinguish a case of spondyloptosis. However, noncontrast CT and MRI of the involved segments better delineate the displacement and extent of spinal cord injury (SCI). The most common location of traumatic spondyloptosis is thoracolumbar junction (T10–L2) due to transition between relatively fixed thoracic spine and mobile lumbar segments of spine.⁴ Since it is associated with either cord transection or there is severe cord damage, it is always associated with neural deficit. In 80% of cases, spondyloptosis is associated with complete neurological deficit.⁵ Due to complete neurodeficit associated with this type of injury, the prognosis is poor and the treatment is aimed at rehabilitation rather than the neurological improvement. These injuries are severely unstable, these should not be treated conservatively, because conservative treatment can lead to increased complications related to being bedridden for long; further, nonsurgical treatment may cause future spinal deformity, continuous back pain, and delayed rehabilitation.⁶ Surgical treatment with reduction and rigid stabilization is advisable for such complete dislocation in order to achieve alignment and early rehabilitation. The surgery can be done via anterior, posterior, or combined approach.⁶ The posterior approach is most commonly used and has shown good success and fewer complications.⁵ Surgical reduction of spondyloptosis is quite challenging. In this study, we aim to evaluate traumatic spondyloptosis cases for neurological, surgical and outcome perspectives with respect to ambulation, postoperative pain, degree of reduction following surgery and complications of surgery.

Materials and Methods

This retrospective cohort study includes cohort of 17 patients of spondyloptosis who underwent surgery or managed conservatively in our department between 1 August 2016 and 31 January 2020. Traumatic spondyloptosis on CT scan was the inclusion criteria in the study.

This is a retrospective cohort study in two phases: a cross-sectional phase where the patients included in the sample were evaluated for the following described variables and a follow-up phase at hospital discharge and at subsequent OPD visits by the patient. Each patient was evaluated in terms of demographic profile, clinical presentation, duration of injury, mode of injury, associated injuries, level of spondyloptosis, type of spondyloptosis, spinal cord status based on CT and MRI, pain severity based on numeric rating scale (NRS)⁷ for nociceptive pain (due to musculoskeletal or visceral injury), and neuropathic pain scale (NPS)⁸ at presentation.

The NRS consists of a numeric version of the visual analog scale (VAS). We categorized pain screening NRS scores as mild (1–3), moderate (4–6), or severe (7–10) and NPS scores as mild (0–30), moderate (30–60), or severe (60–100), depending upon severity.

Patients were also evaluated for severity of injury, based on neurological status and International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) assessment.⁹ Management, surgical approaches,

complications, and outcomes (ambulatory/nonambulatory) were analyzed. Residual listhesis and its relationship with postoperative pain and duration of injury along with outcome after 3 months of surgery were also evaluated.

All patients underwent a CT scan as well as MRI scan of the affected segment of spine to assess the bony injury pattern and document the cord and neural injury. Prior consent for surgery from the patient was taken in each case. We used posterior approach in 13 patients of thoracic, thoracolumbar, lumbar, and lumbosacral level spondyloptosis. We performed a 4-level fixation (2 above and 2 below the affected vertebra) using titanium pedicle screws and a titanium rod in these patients. In two cases of cervical spondyloptosis, we did a 360° fixation. All patients were discharged on home-based rehabilitation training consisting of active and passive muscle stretching and exercises, bladder and bowel care, back care, and psychological support of family members.

The data was summarized using medians/mean, counts, and percentages. Differences of significance in continuous variables and categorical variables were evaluated using the unpaired t- test and Chi-square test, respectively. Values with $p < 0.05$ was taken statistically significant. Statistical tests were done using GraphPad Prism version 8.3.0 software.

Results

A total of 412 patients of traumatic spine injury were operated in our department over the period of 4 years, 2016 to 2020. We had a total of 17 patients of spondyloptosis, out of which 15 (3.64%) were operated during this period. In this study, the mean age was 34.5 years, ranging from 15 to 48 years. Most of the patients were males (70.6%) with male to female ratio of 2.4:1. Fall from height (58.8%) followed by fall of object over back (23.5%) were the most common modes of injury causing spondyloptosis. The most common associated injury was musculoskeletal (64.7%) followed by abdominal visceral injury (29.4%), head injury (23.5%) and thoracic injury (23.5%) (►Table 1). Thoracic injuries were managed by intercostal drainage (ICD) and musculoskeletal injuries in accordance to type of injury. Both head injury and abdominal visceral injuries were managed conservatively. The most common level of traumatic spondyloptosis was T12–L1 (41.1%) followed by T11–T12 (11.8%) and L1–L2 (11.8%). Sagittal–plane spondyloptosis (76.5%) was more common than coronal–plane spondyloptosis (23.5%) (►Table 1). On NRS of nociceptive pain, most of the patients were having severe (58.8%) and moderate (23.5%) pain at presentation (►Table 1). On pain severity of neuropathic pain (NPS), most patients were having moderate (76.5%) severity at admission (►Table 1).

Patient's injury profile, management and outcome of 17 patients of traumatic spondyloptosis in this study is summarized in ►Table 2. Neurologically, most of the patients were having American Spinal Injury Association (ASIA)–A status (14, 82.3%). There was 1 patient each in ASIA–C and ASIA–B and 1 patient was neurologically intact (►Table 2). Spinal cord transection (12, 70.6%) and dural injury (13, 76.5%)

Table 1 Demographic profile, mode of injury, associated injury and level and type of traumatic spondyloptosis ($n = 17$)

Patient characteristics	Number of patients/ value	Percentage
Age		
Mean	34.5 years	
Range	15–48 years	
Sex		
Male	12	70.6
Females	5	29.4
Mode of injury		
Fall from height	10	58.8
Fall of object over back	4	23.5
Road traffic accident	3	17.7
Associated injuries		
Head injury	4	23.5
Maxillofacial injury	3	17.6
Musculoskeletal injury	11	64.7
Thoracic injury (hemothorax/ pneumothorax)	4	23.5
Abdominal visceral injury	5	29.4
Level of spondyloptosis		
C6–C7	1	5.9
C7–T1	1	5.9
T5–T6	1	5.9
T12–L1	7	41.1
T8–T9	1	5.9
T11–T12	2	11.8
L1–L2	2	11.8
L4–L5	1	5.9
L5–S1	1	5.9
Type of spondyloptosis		
Sagittal–plane spondyloptosis	13	76.5
Coronal–plane spondyloptosis	4	23.5
Pain severity scale (NRS) of nociceptive pain at admission		
None (0)	2	11.8
Mild (1–3)	1	5.9
Moderate (4–6)	4	23.5
Severe (7–10)	10	58.8
Pain severity of neuropathic pain at admission		
Mild (0–30)	2	11.8
Moderate (30–60)	13	76.5
Severe (60–100)	2	11.8

Abbreviation: NPS, neuropathic pain scale.

was commonly observed (►Table 2). Eight patients presented within 24 hours, two patients between 24 to 72 hours, and five patients between 72 hours to 1 month. Two patients

presented after 1 month of injury and 1 of them was operated for kyphotic deformity (►Table 3).

Out of 17, fifteen patients (88.2%) were operated for spondyloptosis, and conservative management of two patients was done. Of these two, one patient did not give consent for surgery and the other who presented after 3 months of injury had fixed deformity and was neurologically ASIA–C and so was managed conservatively. Posterior approach was used in most of the cases (93.3%) and combined posterior and anterior approach was used in one each of C7–T1 and C6–7 spondyloptosis (►Table 2).

Postoperatively, deep vein thrombosis (DVT) developed in 2 patients, bed sore in 3 patients, pulmonary complications in 2 patients, and wound infection in one patient. Two patients developed postoperative cerebrospinal fluid (CSF) leak that resolved spontaneously on conservative management. There were 2 mortalities in this study group due to pulmonary complications and DVT (►Table 2).

In 15 (88.2%) patients, there was no improvement in the neurological status with respect to ambulation. Two patients (11.8%) showed improvement and were able to ambulate with support (►Table 3).

Neurological status of the patient at presentation ($p = 0.0007$) was significantly associated with outcome after 3 months of surgery/conservative management (►Table 3). No significant difference was observed in age, sex, and injury to surgery time for outcome prediction (►Table 3).

Residual listhesis was present in 53.3% of patients postoperatively. Postoperative nociceptive pain ($p = 0.0171$) and neuropathic pain (0.0329) were significantly associated with residual listhesis (►Table 4). Duration of injury ($p = 0.0228$) was also significantly associated with postoperative residual listhesis in the study cohort who underwent surgery (►Table 4; Fig. 3).

The mean duration of hospital stay was 20 days (range 8–36 days). All of the patients were discharged from the hospital for home-based rehabilitation. The mean duration of the follow-up period was 2.1 years (range 3–38 months). In total, 2 patients (11.8%) died during the follow-up period, mainly from complications resulting from bed sores, DVT, and pulmonary affection.

Discussion

High-energy trauma frequently results in spine fractures of various grades. Spondyloptosis is the most severe form. Spondyloptosis usually results from high-velocity injury.¹⁰ In this study, incidence of spondyloptosis cases among operated cases of traumatic spine injury was 3.64% over the period of 4 years.

Various case series have reported greater incidence of traumatic spondyloptosis among the young productive population (2nd to 4th decades) and male predominance.^{4,11} In this study, age of patients ranged from 15 to 48 years, and most of them were young. Males (70.6%) were more in number. Fall from height (58.8%) followed by fall of object over back (23.5%) were the most common modes of injury causing spondyloptosis in our study. In various series, fall from height

Table 2 Patient profile and characteristics of traumatic spondyloptosis

S. no	Level of traumatic spondyloptosis	MOI	Associated injury	Neurological status at admission	Spinal cord status	Duration of injury	Management	Complications	Outcome
1	C6–C7	RTA	Maxillofacial injury	ASIA A	Transected	3.5 days	360° fixation	Bed sore + pulmonary complications	Death
2	C7–T1	FFH	Head injury + clavicle fracture	ASIA A	Transected Dural tear +	4 days	360° fixation	–	No improvement
3	T5–T6	FOB	Hemothorax	No neurological deficit	Intact	17 hours	4-level fixation	–	Recovered ambulation
4	T8–T9	FFH	Pneumo-hemothorax + femur fracture	ASIA C	–	3.2 months	Conservative	–	Recovered ambulation
5	T11–T12	FFH	Grade II splenic injury + radius fracture	ASIA A	Transected Dural tear +	7 days	4-level fixation	CSF leak + wound infection	No improvement
6	T11–T12	FOB	Hemothorax	ASIA A	Transected Dural tear +	17 hours	4-level fixation	–	No improvement
7	T12–L1	FFH	Grade III liver injury with hemoperitoneum	ASIA A	Transected Dural tear +	6 hours	4-level fixation	CSF leak	No improvement
8	T12–L1	FOB	Rib fracture	ASIA A	Transected Dural tear +	10 days	4-level fixation	–	No improvement
9	T12–L1	RTA	Tibia shaft fracture with maxillofacial injury	ASIA A	Transected Dural tear +	1.5 months	4-level fixation	DVT + bed sore + pulmonary complications	Death
10	T12–L1	FFH	Head injury + Grade I splenic injury with humerus fracture	ASIA A	–	22 hours	Not Consented for surgery	DVT	No improvement
11	T12–L1	FFH	Hemothorax	ASIA A	Transected Dural tear +	36 hours	4-level fixation	Bed sore	No improvement
12	T12–L1	FFH	Grade I liver injury + femur fracture	ASIA A	Transected Dural tear +	4 days	4-level fixation	–	No improvement
13	T12–L1	RTA	Grade III splenic injury	ASIA A	Transected Dural tear +	47 hours	4-level fixation	–	No improvement
14	L1–L2	FFH	Maxillofacial injury + head injury + femur fracture	ASIA A	Transected Dural tear +	6 hours	4-level fixation	–	No improvement
15	L1–L2	FFH	Pelvis fracture	ASIA A	Transected Dural tear +	22 hours	4-level fixation	DVT	No improvement
16	L4–L5	FOB	Femur fracture	ASIA B	Contused + dural tear	17 hours	4-level fixation	–	Recovered bladder/ bowel function
17	L5–S1	FFH	Pelvis fracture + head injury	ASIA A	Transected Dural tear +	13 hours	4-level fixation	–	No improvement

Abbreviations: ASIA, American Spinal Injury Association; DVT, deep vein thrombosis.

and motor vehicle accidents have been reported to be the most common modes of injury causing spondyloptosis.^{2,4,11,12}

The most common associated injury were musculoskeletal, abdominal visceral injury, head injury, and thoracic injury. The management of traumatic spondyloptosis is guided by associated injuries. First and foremost, life-threatening associated injuries should be addressed and a holistic approach for polytrauma must be enacted. Associated injuries are common, as traumatic spondyloptosis are indicative of

high-energy trauma, which may also affect other parts of the body.

In our study, we found that most common level of traumatic spondyloptosis was T12–L1 level (41.1%) followed by T11–T12 & L1–L2 levels (11.8% each). Thus, located at the thoracolumbar junction. Studies have reported thoracolumbar junction (T10–L2) as the most common location of traumatic spondyloptosis,^{4,11} which is similar to our findings. Cause of higher incidence of spondyloptosis at this location

Table 3 Outcome analysis after 3 months of surgery/conservative management

Patient characteristics	No improvement (<i>n</i> = 15)	Recovered ambulation (<i>n</i> = 2)	<i>p</i> -Value
Age (years)			0.1103
< 30	6	2	
> 30	9	0	
Sex			0.3311
Male	10	2	
Female	5	0	
Neurological status at presentation			0.0007 ^a
ASIA-A (14)	14	0	
ASIA-C (1)	0	1	
ASIA-B (1)	1	0	
Neurologically intact (1)	0	1	
Injury to surgery time (<i>n</i> = 15)			0.3539
< 24 hours (7)	6	1	
24–72 hours (2)	1	1	
72–1 month (5)	5	0	
> 1 month (1)	1	0	

Abbreviation: ASIA, American Spinal Injury Association.

^aStatistically significant (*p* < 0.05).

Table 4 Relation of postoperative residual listhesis with postoperative pain and time of surgery

Patient characteristics	Residual listhesis present (<i>n</i> = 8)	Residual listhesis absent (<i>n</i> = 7)	<i>p</i> -Value
Postoperative nociceptive pain (NRS)			0.0171 ^a
None (0)	0	4	
Mild (1–3)	2	3	
Moderate (4–6)	5	0	
Severity (7–10)	1	0	
Follow-up neuropathic pain			0.0329 ^a
Mild (0–30)	1	5	
Moderate (30–60)	3	2	
Severe (60–100)	4	0	
Injury to surgery time			0.0228 ^a
< 24 hours	1	6	
24–72 hours	1	1	
72–1 month	5	0	
> 1 month	1	0	

Abbreviation: NRS, numeric rating scale.

^aStatistically significant (*p* < 0.05).

may be due to the fact that there is a relatively fixed thoracic spine and mobile lumbar segments of spine⁴ in this region.

Cervical, lower lumbar, and lumbosacral traumatic spondyloptosis were few in this study as compared to that at thoracolumbar junction. Studies have shown subaxial cervical spine C7–T1 as the most common location of cervical spondyloptosis.¹² Among lower lumbar and lumbosacral spondyloptosis, studies have reported lumbosacral junction as the

most common site.¹³ Although cervical traumatic spondyloptosis is less common in our study, but it is the most neurologically devastating injury with resultant quadriplegia.

In this study, sagittal-plane spondyloptosis (76.5%) was more common than coronal-plane spondyloptosis (23.5%). In various case series, similar findings were present.^{4,11}

Neuropathic pain following SCI results in poor rehabilitation outcomes.^{14,15} Around half to two-thirds of all people

with SCI have neuropathic pain.¹⁶ Studies have found that people with tetraplegia were prone to report below-level neuropathic pain than people with paraplegia.¹⁷ In this study, we used NPS for pain severity assessment at presentation and follow-up. Most of the patients were having moderate (76.5%) neuropathic pain at presentation and mild neuropathic pain (35.3%) at follow-up. There is paucity of literature with regard to neuropathic pain severity assessment in spondyloptosis patients. In our study, most patients were having severe nociceptive pain (58.8%) at admission and moderate (29.4%) at postoperative period. It is very important to distinguish the pain complained by the patient into nociceptive and neuropathic because both entities require different management strategies. The use of simple analgesics, non-steroidal anti-inflammatory drugs (NSAIDs), and opioids are

frequently reported for treatment of patients with musculoskeletal pain after SCI.¹⁸ Neuropathic pain relief in patients with SCI requires a broad approach. Medications (anticonvulsants, antidepressants, opioids, and antispasticity medications), surgical interventions, the use of modalities, and psychotherapy are included in this approach.¹⁹

Spondyloptosis is associated with complete neurological deficit in most of the cases.⁵ In our study, most of the patients were having ASIA-A status (82.3%). However, various case reports are there with different level spondyloptosis presenting with intact or remaining neurological functions.^{7,20-26} There was 1 patient each in ASIA-C and ASIA-B and 1 patient was neurologically intact in our study cohort.

Spinal cord transection and dural injury was present in most of the cases intraoperatively in our study. Severe

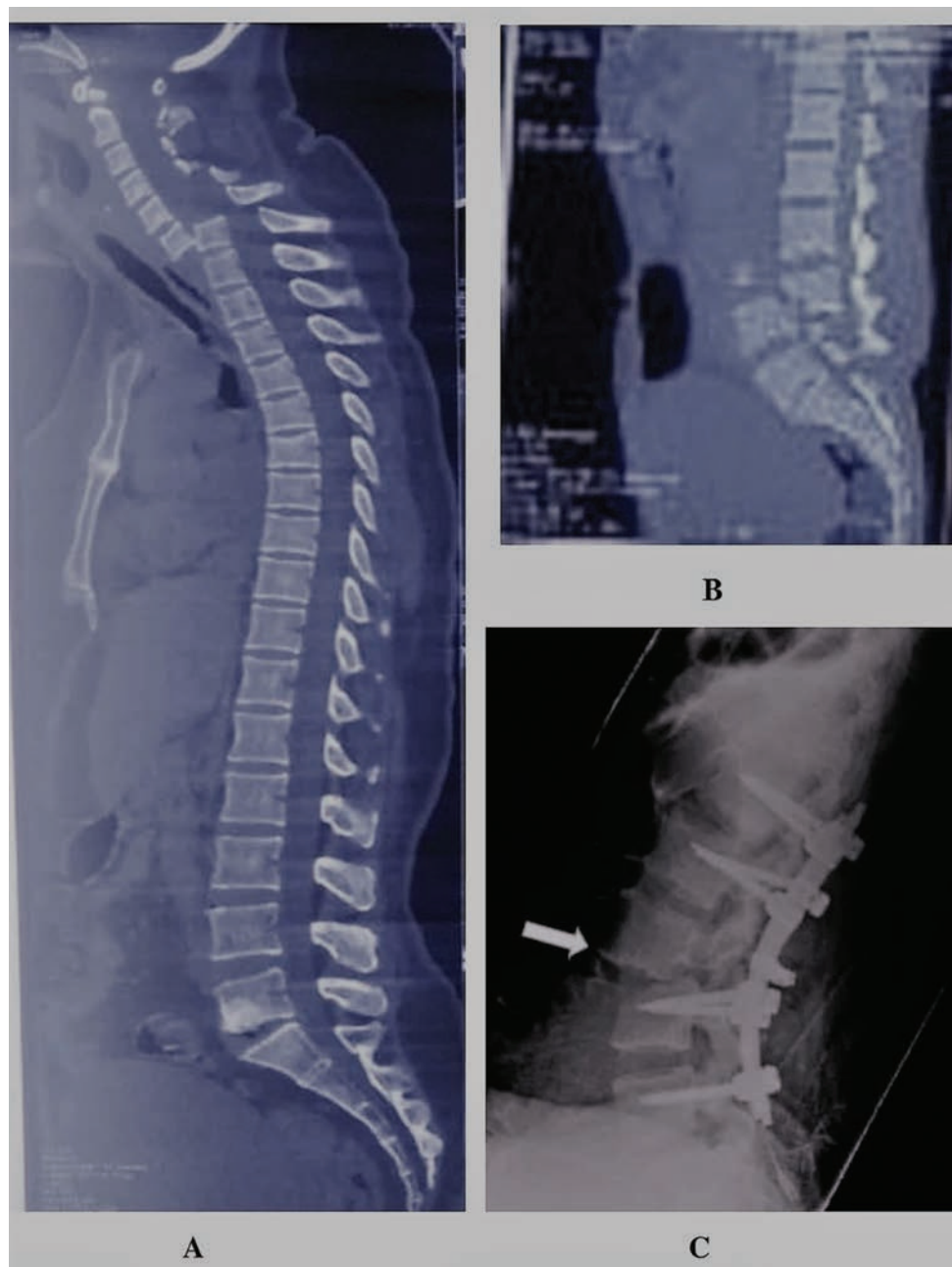


Fig. 1 Sagittal spondyloptosis (A–C6/C7 spondyloptosis, B–L3/L4 spondyloptosis, C–arrow showing residual listhesis after reduction and fixation).

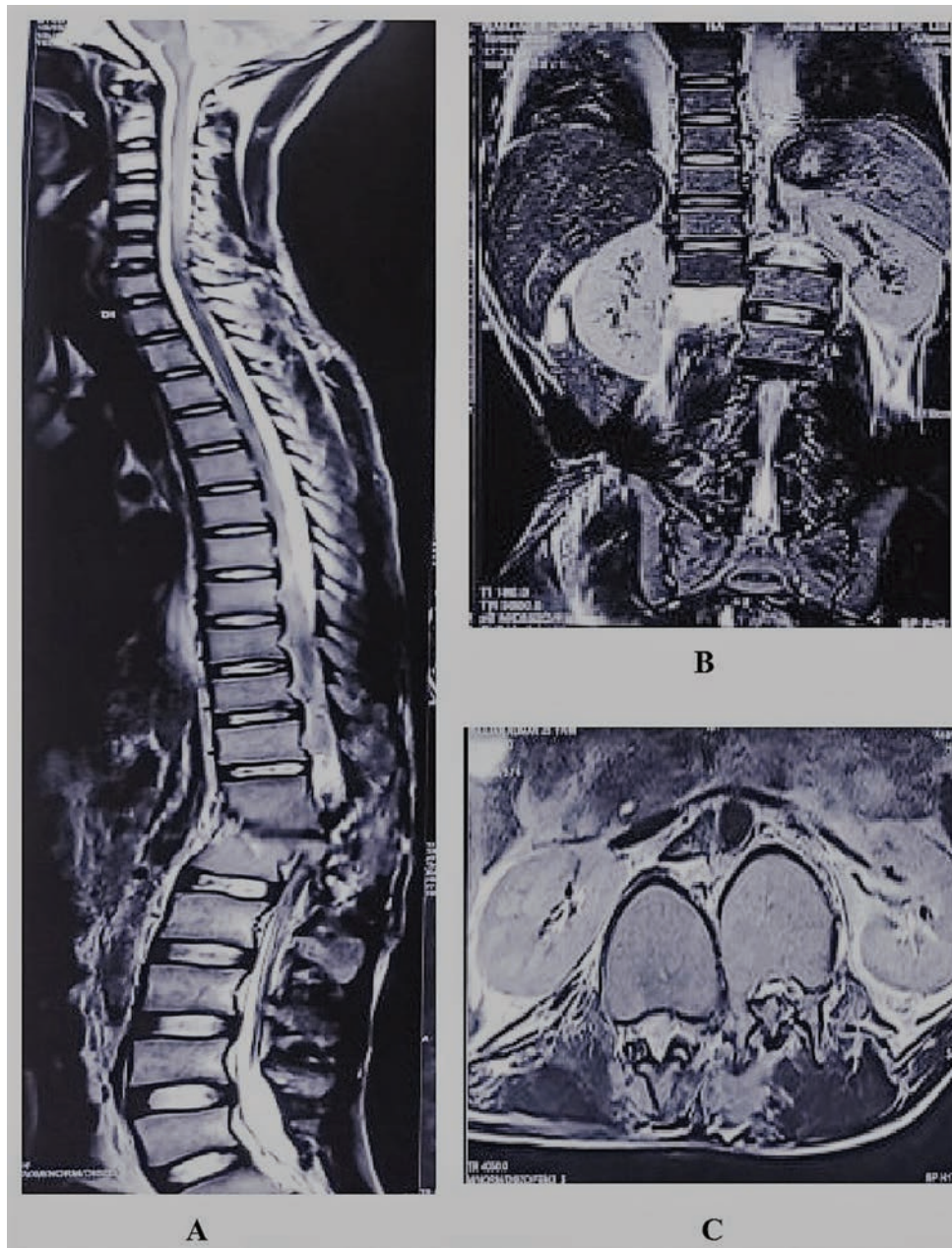


Fig. 2 Coronal spondyloptosis D12–L1 level (A–sagittal view, B–coronal view and C–axial view).

dislocation seen in spondyloptosis puts a shearing force on dura and spinal cord, leading to such injury. Mechanism of injury described for these injuries is due to high-impact trauma, causing axial compression and shearing simultaneously, leading to fractured facet joints and all ligament rupture which, in turn, leads to complete dislocation of spine. Hence, these injuries involve disruption of all the three spinal column, and they are inherently severely unstable injuries.⁶

Due to complete neurodeficit associated with this type of injury, the prognosis is poor and the treatment is aimed for rehabilitation rather than the neurological improvement. Surgical treatment with reduction and rigid stabilization is advisable for such complete dislocation in order to achieve alignment and early rehabilitation. The surgery can be done via anterior, posterior, or combined approach.^{7,20–26} We prefer

a 4-level posterior fixation (2 levels above and 2 levels below the lesion) with pedicle screws and a rod in traumatic spondyloptosis involving thoracic, thoracolumbar, lumbar, and lumbosacral region. In patients with cervical traumatic spondyloptosis, we do anterior cervical discectomy and fusion if spinal alignment can be achieved. If not, then posterior reduction and fixation is done (posterior lateral mass fusion with or without laminectomy), that is, 360° fixation. If the vertebral body of the involved vertebra is damaged, then corpectomy with expandable cage fixation may be required. In this study, we have used posterior approach in most of the cases and combined posterior and anterior approach (360°) in cases of cervical traumatic spondyloptosis. Studies have shown that there are no significant differences between the anterior-only, posterior-only, and 360° repair groups

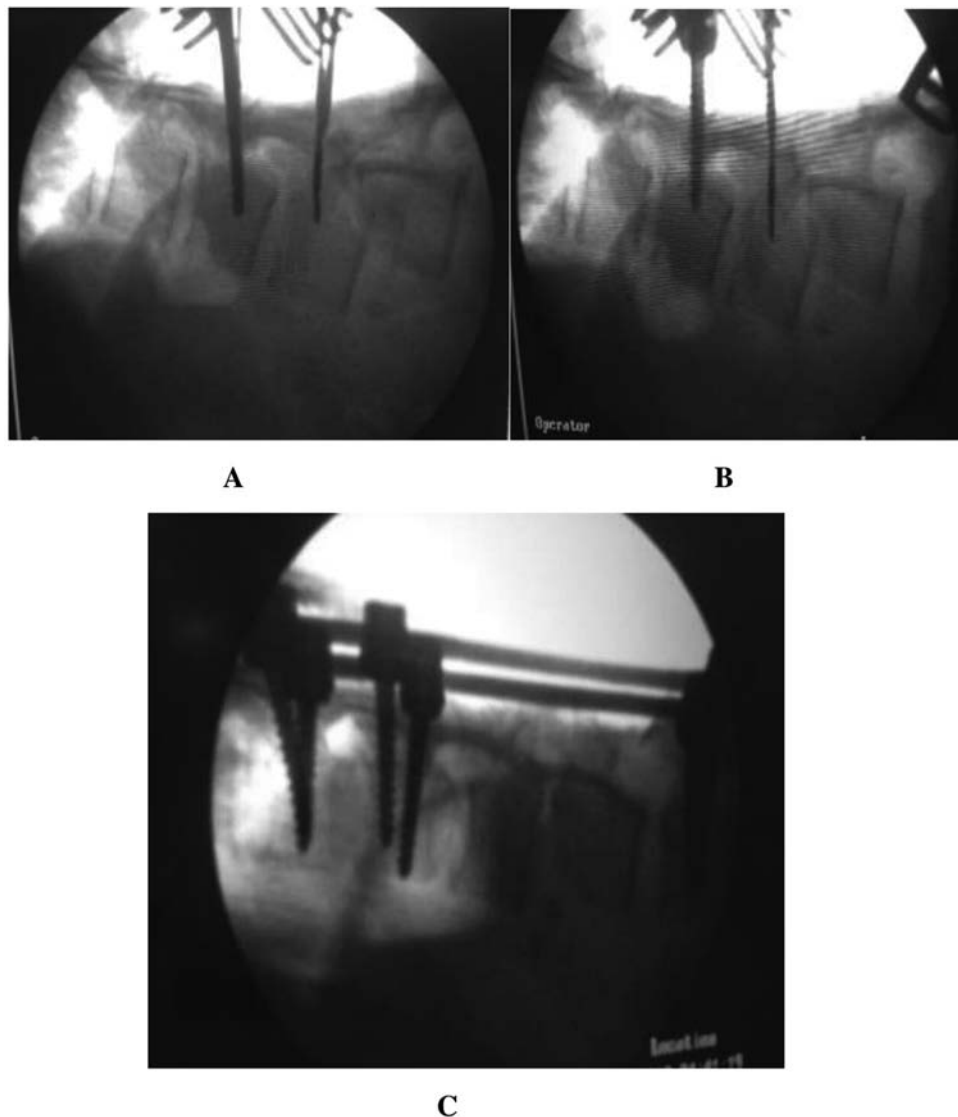


Fig. 3 Intraoperative C-arm instrumentation showing spondyloptosis reduction and fixation.

regarding immediate postoperative ASIA grade and ASIA grade at the end of the follow-up period.²⁷

DVT, wound infection, hematoma formation, bed sore, and CSF leak were main postoperative complications in this study group. CSF leak in our study resolved spontaneously on conservative management. In reported series, similar complications were evident.^{4,11} Spinal cord transection and dural injury was commonly observed intraoperatively in most of the cases irrespective of level of traumatic spondyloptosis. We prefer direct suture repair for dural tear followed by Valsalva maneuver to test the suturing. Augmented closure by means of fat, muscle tissue or fascial graft is indicated when the dural defect is too large to be directly repaired. Fibrin glue is used when we have possibility of CSF leak after dural closure. Various authors prefer similar methods in their studies.^{28,29}

In this study, neurological status of the patient was significantly associated with outcome after 3 months of surgery/conservative management. This can be attributed to severity of SCI. Greater the extent of SCI, more is the

neurological deficit and poorer recovery. However, no association was found between injury to surgery time and outcome. There is paucity of literature in this regard in cases of spondyloptosis.

While operating traumatic spondyloptosis at any spinal level, it is very difficult to achieve complete reduction of listhesis, especially when the injury is long-standing and fusion with adjacent structures had occurred. While providing traction for cervical region to achieve alignment, it is much easier than that for other segments. We prefer to reduce the listhesis as complete as possible. We accept the residual listhesis of less than or equal to grade 1, if despite maximum efforts and maneuvers complete alignment is lacking. Residual listhesis in our study was present in about half of our patients postoperatively. Postoperative nociceptive pain and neuropathic pain at follow-up were significantly associated with residual listhesis. This may be attributed to nerve compression due to residual listhesis. Studies have shown that residual stenosis, arachnoiditis, and psychological effects may cause neuropathic pain after spinal surgery.³⁰⁻³²

Duration of injury was also significantly associated with postoperative residual listhesis in the study cohort. More the duration, more is the fibrosis and fixation of deformity, leading to difficulty in achieving reduction.

Conclusion

Traumatic spondyloptosis is a rare entity. Using modern spinal stabilization techniques, anatomical alignment may be reliably obtained in these injuries. Early surgery is advocated for better result in terms of reduction and better relief of pain. Complete reduction of spondyloptosis should be the goal of surgery. Overall prognosis of spinal cord injury due to traumatic spondyloptosis is poor.

Conflicts of Interest

None declared.

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