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Original Article

Surgery for traumatic fractures of the upper thoracic spine (T1–T6)

Domenico A. Gattozzi, Lisa A. Friis[1], Paul M. Arnold

Department of Neurosurgery, University of Kansas Medical Center, Kansas City, [1]Department of Mechanical Engineering, University of Kansas, Lawrence, KS, USA

E-mail: *Domenico A. Gattozzi - dgattozzi@kumc.edu; Lisa A. Friis - lisa.friis@gmail.com; Paul M. Arnold - parnold@kumc.edu
*Corresponding author

Received: 06 August 18 Accepted: 28 September 18 Published: 19 November 18

Abstract

Background: The management of traumatic upper thoracic spine fractures (T1–T6) is complex due to the unique biomechanical/physiological characteristics of these levels and the nature of the injuries. They are commonly associated with multiple other traumatic injuries and severe spinal cord injuries. We describe the safety and efficacy of surgery for achieving stability and maintaining reduction of upper thoracic T1–T6 spine fractures.

Methods: We retrospectively analyzed a series of traumatic unstable upper thoracic (T1–T6) spine fractures treated at one institution between 1993 and 2016. All patients were assessed neurologically and underwent complete preoperative radiographic analysis of their T1–T6 spine fractures including assessment of instability. Neurological and radiographic outcomes including fusion rates, kyphotic deformity, and successful reduction of the fracture were evaluated along with hospital length of stay (LOS), intensive care unit LOS, and overall complication rates.

Results: There were 43 patients (29 males, 14 females) with an average age of 37.7 years. Between 1993 and 1999, 8 patients were treated with hook/rod constructs, whereas between 1995 and 2016, 35 patients received pedicle screw fixation utilizing intraoperative fluoroscopy or computed tomography (CT) navigation. Forty-three patients had a total of 178 levels fused. In this series, there were no intraoperative vascular or neurological complications. Instrumentation was removed in five patients due to pain, wound infection, or hardware failure. The mean hospital LOS was 21.1 days (range 4–59 days), and there was a 95% fusion rate based on follow-up imaging (X-rays or CT scan).

Conclusions: Surgical treatment of upper thoracic spine fractures (T1–T6), although complex, is safe and effective. Reduction and fixation of these fractures decreases the risk of further neurological complications, allows for earlier mobilization, and correlates with shorter hospital LOS and improved outcomes.

Key Words: Fracture, spine, surgery, thoracic, trauma

Access this article online
Website:
www.surgicalneurologyint.com
DOI:
10.4103/sni.sni_273_18
Quick Response Code:

How to cite this article: Gattozzi DA, Friis LA, Arnold PM. Surgery for traumatic fractures of the upper thoracic spine (T1–T6). Surg Neurol Int 2018;9:231.
http://surgicalneurologyint.com/Surgery-for-traumatic-fractures-of-the-upper-thoracic-spine-(T1–T6)/

INTRODUCTION

The management of fractures of the upper thoracic spine (T1–T6) is technically and biomechanically challenging due to the transition from the mobile cervical spine to the fixed thoracic spine.[2] Traumatic fractures between T1 and T6 are often associated with complete spinal cord injuries, as well as other major traumatic injuries such as chest and cardiac injuries.[3,9] We report our surgical management of unstable traumatic upper thoracic T1–T6 spine fractures.

MATERIALS AND METHODS

Patient demographics

Forty-three patients with T1–T6 fractures were included in this study (1993–2016). The AO/Magerl and thoracolumbar injury classification system (TLICS) classification system were used to describe fracture patterns.[5,7,11] American Spinal Injury Association (ASIA) impairment scale scores were assessed. All patients had anterior/lateral plain films or computed tomography (CT). Most patients also underwent magnetic resonance imaging (MRI). Timing between injury and surgery, timing of postoperative mobilization, and hospital length of stay (LOS) were calculated. Patients were followed clinically with neurological examination during outpatient follow-up visits. Postoperative X-rays were obtained at 3, 6, and 12 months after surgery. The extent of fusion was assessed by the senior surgeon and correlated with a staff radiologist report. If there was no evidence of bony fusion on X-rays, or there was concern regarding the construct, a CT was performed and utilized to assess fusion and alignment (e.g., kyphotic deformity/Cobb angle).

RESULTS

Patient demographics

Forty-three patients were included in this study (1993-2016). Average age was 37.7 years old (range 14-83 years). For full patient demographics, fracture characteristics, and preoperative neurological assessments, see Table 1. Surgery was performed utilizing intraoperative fluoroscopy or CT-guided navigation. Neuromonitoring was used in selective cases based on each patient's preoperative neurological function. The two instrumentation procedures were then routinely performed.[1,6] There were 178 total levels fixed, and a total of 324 pedicle screws inserted. Fusions were performed two or three levels above and two levels below the fracture. Iliac crest bone graft and/or local autograft was used across the fracture site in all cases, with 18 patients also receiving allograft.

Timing of surgery dependent on neurological deficit

Patients with incomplete injuries (10, 23.3%) had emergent surgery within 72 hours, whereas those with no deficits or with complete spinal cord injuries had surgery once medically stable from comorbid injuries. All patients had surgery within 1 month after injury. The average time to surgery was 7.78 days. Twenty-three patients (53.5%) also underwent cord decompression (laminectomy and/or ventral decompression) in addition to instrumented fusion. Patients were mobilized on postoperative day 1. Neurologic deficits were graded with the ASIA scale at 3, 6, and 12 months postoperatively. Of 33 patients, 11 (33.3%) improved 1 year postoperatively [Table 2].

Table 1: Fracture morphologies and baseline preoperative characteristics

Characteristic	Number of patients (%)
Male	29 (67.4%)
Female	14 (32.6%)
Mechanism of Injury	
MVA	32 (74%)
Fall	9 (21%)
Sports-related	1 (2%)
Falling object	1 (2%)
Fracture type	
Burst fracture	18 (42%)
Fracture dislocation	13 (30%)
Compression fracture	12 (28%)
Other fracture characteristics	
Subluxation	5 (12%)
Unstable fracture	5 (12%)
Transverse process fracture	5 (12%)
Pedicle fracture	5 (12%)
Laminar fracture	3 (7%)
Spondyloptotic fracture	1 (2%)
Vertebral body fracture	1 (2%)
Concomitant injuries	
Rib fractures/hemothorax	22 (51%)
Pneumothorax	21 (49%)
Head injury	12 (28%)
Extremity fractures	12 (28%)
Other spinal fractures	18 (42%)
Neurological deficit on admission	
Complete SCI	
MVA=20	26 (60.4%)
Fall=4	
Sports-related=1	
Falling object=1	
Incomplete SCI	
MVA=8	10 (23.3%)
Fall=2	
Neurologically intact	
MVA=4	7 (16.3%)
Fall=3	

MVA=Motor vehicle accident, SCI=Spinal cord injury

Table 2: Neurological and radiographic results

Neurological outcomes		
ASIA score	Preoperative number of patients (%)	Postoperative number of patients (%)*
A	26 (60%)	14 (42%)
B	3 (7%)	7 (21%)
C	3 (7%)	1 (3%)
D	4 (9%)	1 (3%)
E	7 (16%)	10 (30%)
Levels fused		
Spinal level	Number fused (% successful)	
C7	13 (86%)	
T1	15 (88%)	
T2	9 (100%)	
T3	15 (88%)	
T4	26 (92%)	
T5	37 (100%)	
T6	43 (95%)	
T7	11 (100%)	
T8	7 (100%)	
T10	2 (100%)	

*10 patients (23%) were lost to follow-up prior to 1-year postoperative evaluation

Complications and indications for reoperation

There were no intraoperative vascular or neurological complications. Other complications were noted and divided into early and late, depending on whether they occurred before or after 1 year from the time of surgery [Table 3]. Eight patients underwent reoperation an average of 11.3 months (range 3 days to 40 months) postoperatively. Five patients required instrumentation removal an average of 10.5 months postsurgery (range 4.5–16 months); this was due for back pain in three patients and poor screw positioning in two patients. Two patients required repeat laminectomies due to spinal stenosis (mean 32.5 months postsurgery, range 25–40 months). One patient had additional surgery 6 weeks postoperatively due to a persistent high white cell count and required another procedure 1 week later due to a cerebrospinal fluid leak. The mean hospital LOS was 21.1 days. Patients undergoing early surgery (e.g., within 72 hours of injury) had a shorter mean hospital LOS (9.5 days) compared to the LOS for patients having late surgery (17 days) [Table 4].

Assessment of radiological fusion rates/outcomes

The fusion rate across all levels was 95%. There were no broken screws or instances of instrumentation failure. Given the increased cost and higher level of radiation to the patients, we do not routinely perform CT scans after spinal fusion at our institution and prefer X-rays. Postoperative CT analysis was reserved for patients with no evidence of fusion on plain films or where there was concern regarding the instrumented construct. Using the Cobb method, the mean preoperative kyphosis was 22.25°. At 3 and 12 months, the mean kyphosis calculations were 13.5° and 17.6°, respectively. Seven of the 43 patients died an average of 4.2 years postoperatively. The deaths were due to causes unrelated to the upper thoracic spine surgery. These patients averaged 47 years of age (range 23–78 years). For a sample patient case see Figure 1.

Table 3: Early and late complications

Complications	Number of patients (%)
Early (<1 year)	
Site infection	10 (23%)
Pleural effusion	7 (16%)
Respiratory infection	7 (16%)
Fever	6 (14%)
Atelectasis	6 (14%)
Confusion	4 (9%)
Pressure wound	3 (7%)
Deep vein thrombosis	2 (5%)
Late (>1 year)	
Pressure wound	5 (12%)
Spasticity, bilateral lower extremities	4 (9%)
Steroid-induced diabetes mellitus, type II	2 (5%)
Sepsis	2 (5%)
Myofascial pain	2 (5%)

DISCUSSION

Traumatic upper thoracic spine fractures are a complex surgical problem often complicated by multiple comorbidities due to the high forces required to cause these types of fractures.[9] In our series, 22 patients (51%) had a rib fracture/hemothorax and 21 (49%) patients had a pneumothorax at the time of presentation. Initial surgical intervention involved the use of hook and rod constructs, but has since progressed to the use of pedicle screws. On cadaveric studies, pedicle screws show a 15% to 50% incidence of poor placement such as violation of the pedicular cortex.[4] The accuracy of pedicle screw placement has improved with computer-assisted navigation.[2-4] In this study, screw sizes ranged from 4.5 to 6 mm in diameter. Of the 324 pedicle screws placed in this study, three screws in two patients placed under fluoroscopy were abutting the esophagus or descending aorta on intraoperative post-screw placement films and were subsequently repositioned. No pedicle screws in our series required repositioning when placed using CT-based navigation. The results of our series as well as the results from cadaveric[8] and other studies[2] show that the use of pedicle screws is both safe and effective in the upper thoracic region. Surgical stabilization of thoracic fractures has shown positive results, including more rapid mobilization and shorter periods of hospitalization and

Table 4: Mean hospital length of stay (HLOS)

Patient type	Mean HLOS	Range
All patients	21.1 days	4-71 days
All polytrauma	28.2 days	11-71 days
All nonpolytrauma	15.9 days	4-42 days
All acute (<72 H)	18.0 days	6-71 days
All nonacute (>72 H)	22.0 days	4-59 days
Acute nonpolytrauma	9.5 days	7-11 days
Nonacute nonpolytrauma	17.0 days	4-53 days

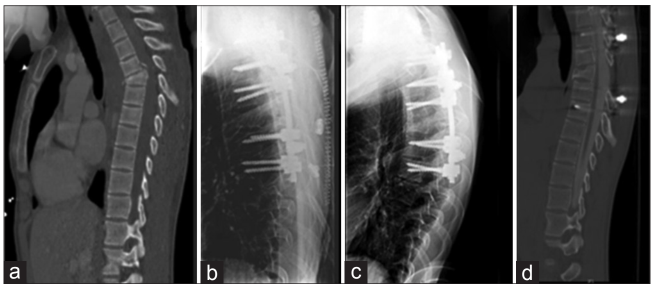

Figure 1: Representative case: 19-year-old male who sustained a motorcycle collision with a thoracic-5 anterior wedge flexion-compression fracture and paraplegia. He underwent T5 laminectomy, with T2–T7 posterior instrumentation under O-arm guidance. (a) Original fracture on mid-sagittal view of CT chest obtained as part of trauma workup. (b) Immediate postoperative lateral T-Spine X-ray showing pedicle screws at T2, 3, 4, 6, and 7. (c) Lateral T-Spine X-ray obtained 6 months postoperatively. (d) Mid-sagittal CT myelogram at 18 months showing continued patency of spinal canal and maintenance of correction of the preoperative kyphotic deformity

rehabilitation.[8,10] Although there were multiple early and late complications due to the nature of the polytraumatic injuries, there were no major vascular injuries or postoperative neurologic deficits due to decompression or instrumentation from surgery.

CONCLUSION

The surgical treatment of traumatic upper thoracic spine fractures T1–T6, although complex, is safe and effective. Reduction and fixation of these fractures results in a reduced risk of further neurological damage, and allows for earlier mobilization, shorter hospital LOS, and improved patient outcomes.

Prior Presentation

Portions of this work were presented as an oral abstract presentation at the Joint Section for Spine and Peripheral Nerves on March 16, 2018 in Orlando, FL, and as an electronic poster abstract at the AANS 2018 annual scientific meeting in New Orleans, LA.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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