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Nonaccidental Trauma Managed with Open Spinal Fixation and Instrumentation and a Review of the Literature

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Abstract

Nonaccidental trauma (NAT), causing spinal injury is rare and occurs in up to 3% of cases. Management of these injuries is typically conservative, and thus surgical management is not widely reported in the literature. In this case report, we presented three patients to review the effectiveness of spinal instrumentation and posterior fusion in pediatric patients due to NAT. All patients recovered well and were neurologically intact at last follow-up with no postprocedural complications noted. Spinal arthrodesis is a safe, effective way to manage spinal injuries due to NAT in cases of fracture-dislocation, distraction injuries, as well as cases involving neurologic compromise.

Keywords
- ► nonaccidental trauma
- ► fusion
- ► spinal injury
- ► trauma

Background

Nonaccidental trauma (NAT) is estimated to occur in 2.4 to 23.8% of cases involving pediatric blunt trauma. It is often present with concomitant injuries to the head, thorax, abdomen, and musculoskeletal system.[1] Vertebral spinal injuries secondary to NAT are rare, accounting for 0 to 3% of injuries observed.[1-4] The incidence of spinal injuries and NAT have an inverse relationship to age, but a positive relationship between gender (female), race (Black), and socioeconomic status (lower median household income).[3,5,6]

Lower thoracic and upper lumbar vertebral body compression fractures are the most common form of spine injury seen in child abuse. However, the cervical spine above C3, the cervicothoracic, and thoracolumbar junction appear to be more susceptible to fracture-dislocation injury.[3] These injuries are thought to occur due to violent and forceful hyperflexion and hyperextension of the spinal column. They may result in an asymptomatic to clinically severe picture.[3] However, many spine injuries are stable and without neurologic compromise, and spinal cord injuries are rare unless listhesis is present.[7,8] Surgical management of these types of injuries is not frequently reported in the literature.[8-10] We presented three cases to review the efficacy of spinal instrumentation and fixation in pediatric patients presenting as a result of NAT.

Illustrative Cases

Case 1

A 3-year-old male patient presented after jumping on a trampoline as well as a fall over six steps 2 weeks prior and complained of severe pain. The patient initially saw his pediatrician, who obtained imaging after noting a lump on his back. Imaging revealed L1 compression fracture, widening of the L1 and L2 facet joint, rotatory subluxation of L1 on L2, and kyphotic deformation of the spine with hydromyelia in the thoracolumbar region (►**Figs. 1, 2**). Physical examination was significant for bilateral lower extremity clonus. The patient underwent L1-L2 posterior instrumented fusion with open fracture reduction, utilizing pedicle screws. The patient

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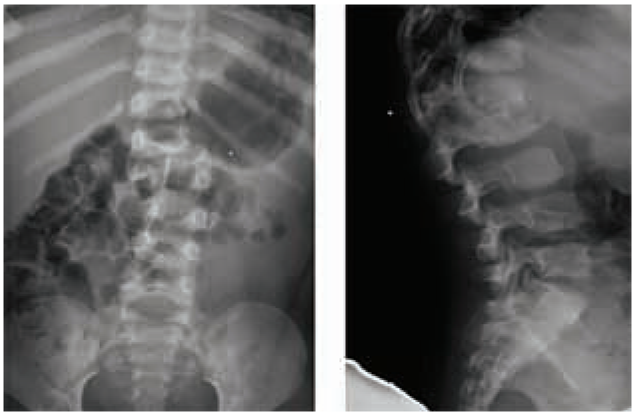

Fig. 1 AP view (left) and lateral view (right) X-ray, revealing widening of the L1 and L2 facet joint and rotary subluxation of L1 on L2.

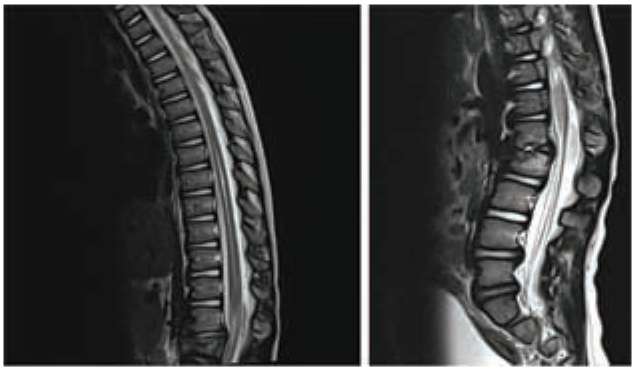

Fig. 2 T2-weighted MRI shows kyphotic deformity of the spine with disc protrusion due to L1 compression fracture (right) and incidentally found hydromyelia (left) at T7 to T12.

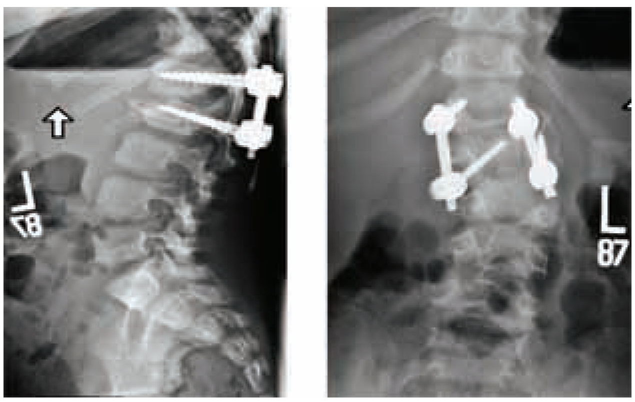

Fig. 3 Lateral (left) and AP (right) view X-ray, revealing stable hardware without failure and good placement of L1 and L3 pedicle screws with correction of kyphotic deformity.

tolerated the procedure well, and his hospital course was uncomplicated. Prior to discharge, the child protective team evaluated the patient and concluded that the patient's lumbar injuries were likely nonaccidental. At his last follow-up 5 months postoperatively, the patient was doing well and was neurologically intact. His last X-ray did not have evidence of hardware malfunction or abnormalities (►**Fig. 3**).

Case 2

A 1-year-old female presented to the hospital with new-onset, painful torticollis. Evaluation revealed bruising on her left cheek, forehead, right cheek, left hand, and left forearm. Additionally, the patient's head had 20 degrees of rotation to the right, and her neck was in a cervical collar. She did not have any focal neurological deficits. Imaging revealed a type II dens fracture with grade 4 anterolisthesis (►**Fig. 4**). The child protective team evaluated the patient at admission and determined that the patient's injuries were highly suggestive of physical abuse.

The patient was taken to the operating room, and her fracture was reduced with a halo. A posterior C1-C2 arthrodesis and fusion were performed using intralaminar wires and an autologous rib graft. Postoperative imaging revealed a slight increase in the dens' anterior displacement compared with immediate postoperative imaging (►**Fig. 5**). However, this was reduced (grade I/II) in comparison to preoperative films (grade IV). The patient was discharged 5 days after her surgery to inpatient rehabilitation and was neurologically intact at discharge. She was discharged with her halo in place.

The patient represented to the emergency department 2 months after her discharge due to concern for one of her halo pins coming out. The halo pins were cleaned, readjusted, and she was discharged. At 4-month clinic follow-up, her halo was removed and replaced with a cervical collar, which was discontinued after 7 months. At her last follow-up at 8 months after her operation, she was neurologically intact, and her imaging did not reveal hardware failure or abnormalities.

Discussion

While nonsurgical management is commonplace to achieve stabilization, surgical intervention has proven successful in pediatric cases of spinal injury due to NAT.[1,8-10] Open spinal reduction and fixation may be preferable in patients experiencing marked neurologic dysfunction and radiographic abnormalities, depicting fracture-dislocation, ligamentous disruption causing anterolisthesis, spinal cord signal changes, or facet disruption.

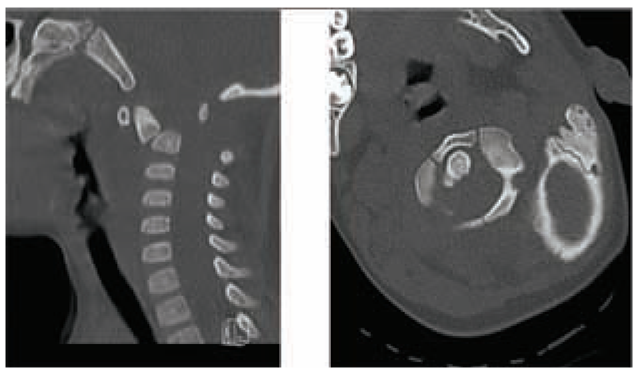

Fig. 4 Sagittal (left) and axial (right) view CT without contrast of the cervical spine, revealing grade IV anterolisthesis of the dens due to a type II dens fracture.

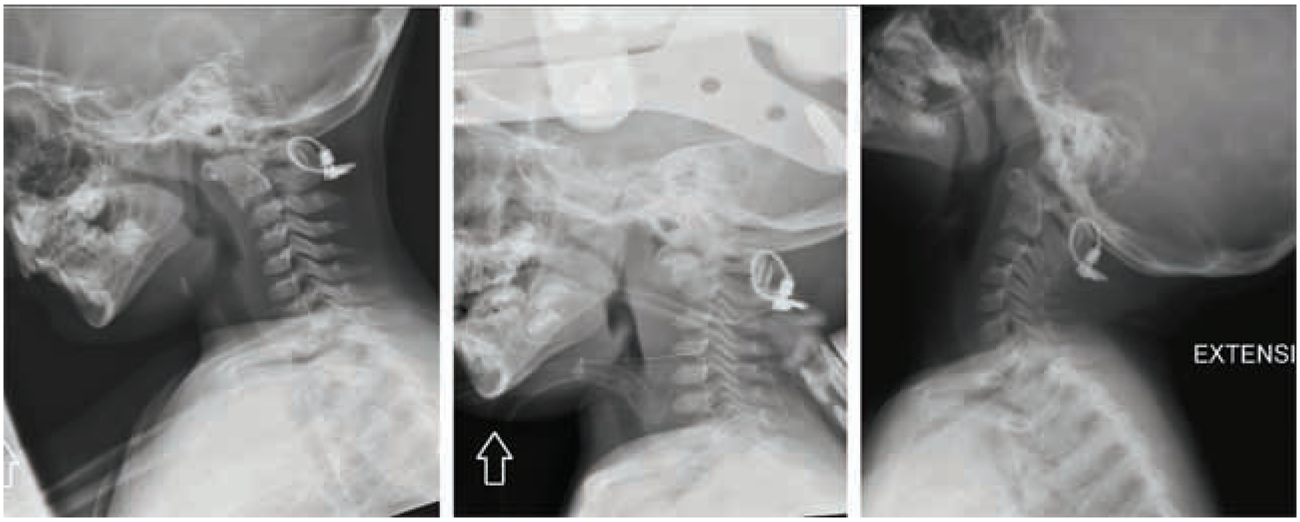

Fig. 5 Flexion (left), extension (right), and neutral (inset) position lateral view X-ray after placement of C1 to C2 cables and autologous rib graft. There is improvement of anterolisthesis of the dens from grade IV to grade I/II.

The two cases detailed above support the utilization of open reduction and fixation with instrumentation in certain pediatric NAT spinal injuries. A review of the available literature also demonstrates that neurologic improvement and successful bony reduction are possible in patients (►**Table 1**).[1,8-10] All instances found in the literature utilized a posterior approach, and three of the four cases had demonstrable neurologic improvement following surgical intervention. Similar to our cases, all of the operative cases in the literature had a successful spinal fusion and did not have any complications caused by surgical intervention.

Technical challenges exist for pedicle screw fixation, including ensuring that suitably sized hardware for small, developing bony structures while ensuring placement accuracy. However, the accuracy of pedicle screw fixation in the pediatric population has been shown to be as high as 94.9%, exceeding the accuracy rate reported among similarly placed screws in adults (91.5%).[11] Further, adjuncts such as intraoperative image guidance is useful to achieve correct placement on the first attempt, preventing additional complications or corrective surgeries for malpositioned screws.[12] There is scant evidence of whether short- versus long-segment instrumentation and fixation is preferable in the pediatric population, and a comparative study by Li et al suggest advantages to either approach.[13]For example, short-segment fixation leads to reduced blood loss and shorter intraoperative times, while long-segment instrumentation and fixation provided relief of low back pain and improved spinal-pelvic parameters.[13] A risk-benefit analysis in select pediatric patients should be performed to weigh the increased risk for operative complications to improve objective spinal-pelvic parameters in long-segment instrumentation versus less surgical trauma and the potential for fewer complications in short-segment fixation.

There is a lack of longitudinal follow-up of pediatric patients undergoing spinal fixation and the potential for mechanical alteration that may occur in adulthood with respect to spinal fusion. Abe et al found that 40% of patients undergoing cervical fusion had a reduction in the anteroposterior diameter; however, this exclusively occurred in patients undergoing anterior fixation and autologous bone placement.[14] Another study by Parsini et al found that 66% of patients had a normal postoperative alignment of the cervical spine which remained unchanged at follow-up.[15] Interestingly, the 33% of cases that had subaxial malalignment had spontaneous sagittal improvement during long-term follow-up.[15] Complications of traumatic spinal injury are rare but may include pseudomeningocele from dural tears, syrinx formation, and myelomalacia.[16,17] These findings are likely related to the inciting traumatic event and not from direct surgical intervention.[9,10] The complication rate following spinal arthrodesis is approximately 9%, with surgical site infections and wound dehiscence being the most common.[17]

Conclusion

Bony injury and alignment disruption, in addition to ligamentous injury, of the spinal column may require surgical fixation. The improved neurological and functional outcomes following spinal instrumentation due to nonaccidental trauma, lack of hardware malfunction, and other complications provide evidence that open reduction and internal fixation should be further studied as treatment options for the pediatric population.

Table 1 A review of the literature of patients undergoing spinal instrumentation following traumatic spine injury due to NAT

Author	Patient age/ gender	Presenting neurological status	Associated injuries	Location, type of spine injury	Type of intervention	Neurological Outcome	Complications	Fusion Successful	Follow-up
Knox et al[1]	4-month-old/M	No function	Cervical spine EDH, cerebral edema, TBI, multiple extremity fractures	Combined atlanto-occipital and atlantoaxial ligamentous injury with dens fracture	Occiput to C5 fusion and open reduction	Nonambulatory spastic quadriparesis, blindness, profound mental retardation	None	Yes	4 years
Bode et al[8]	8-month, 30-day-old/M	Intact	NR	T12 on L1 anterolisthesis, posterior ligamentous disruption; T11-12 cord contusion	Open reduction, T12-L1 posterior fixation with pedicle screws and K-wires	Intact	None	Yes	14 months
Holland et al[9]	3-week-old/F	ASIA A	Right clavicular fracture, rib fractures	C5-6 distraction injury, disruption of anterior and posterior elements, bilateral facet joint disruption, C6 intervertebral disk avulsion	Open reduction, C4-7 posterior segment fusion using rib autograft and augmentation with bone morphogenic protein	ASIA C	Posttraumatic bilateral pseudomeningoceles, myelomalacia at C5–6	Yes	2 years
Rooks et al[10]	3-month-old/F	Intact	Multiple extremity fractures, rib fractures, and sternal depression fracture	C5 compression fracture, anterior subluxation of C4 on C5	Total-body cast followed by C4-6 laminectomy and C3-7 posterior fusion	Bladder dysfunction, decreased left arm movement	Posttraumatic myelomalacia and syrinx	Yes	NR

Abbreviations: EDH, extradural hematoma; NAT, nonaccidental trauma; TBI, traumatic brain injury.

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Conflict of Interest
None declared.

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