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Treatment of Spinal Fractures in Children and Adolescents

Long-Term Results in 44 Patients

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Study Design. The authors examined a case series of patients younger than 16 years who had sustained a traumatic spine injury.

Objectives. To evaluate clinical and radiologic findings and the effectiveness of conservative *versus* surgical treatment at long-term follow-up.

Summary of Background Data. Although injuries to children have received increasing coverage in the literature over the last several years, few reports have focused on the long-term results of conservative *versus* surgical treatment.

Methods. Forty-four patients who had sustained a traumatic spine injury at the average age of 14 years (range 3–16 years) were clinically and radiographically reviewed. The fractures were separated into three groups: stable (n = 20) and unstable (n = 13) injuries without cord lesion and fractures with spinal cord lesion (n = 11). Mean follow-up was 18 years (range 9–23 years).

Results. Conservative treatment was successful in all stable fractures, whereas it failed in the unstable injuries. The surgical treatment stabilized without significant deformity in five of the seven unstable fractures. Of 11 with spinal cord injuries, the 4 children conservatively treated developed a severely progressive, paralytic scoliosis. Only three of the seven surgically treated patients were stabilized without any deformity at follow-up.

Conclusion. In children and adolescents, conservative treatment is an available option for stable fractures without neurologic lesion. Early surgical treatment (instrumentation and fusion) is mandatory for unstable fractures and injuries associated with spinal cord lesion. In children, a traumatic spinal cord lesion may develop a deformity that is mainly scoliotic, kyphotic, or lordotic in >90% of the cases. [Key words: spinal injuries, children, adolescents] **Spine 2002;27:1989–1994**

Spine injuries in children are still relatively rare, represent a small percentage of overall injuries to children (*i.e.*, 0.34%),[2,17] and are less common than in adults because of the greater mobility and elasticity of the pediatric spine and the smaller mass of the child's body. The incidence of pediatric spine injuries has been reported to be 2–5% of all spine injuries.[4,19,32]

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There are some aspects of childhood and adolescence fractures of the spine that differ from their adult counterparts: the head size relative to the body size, the flexibility of the spine and supporting structures, the growth plates, and the elasticity and compressibility of the bone.[2,4,22] Because of these spine characteristics, spine injuries may behave differently in children than in adults. Finally, spine injuries in children remain a challenge despite some technical changes in assessment and treatment.[13] Although injuries to children have received increasing coverage in the literature over the last several years,[8,20,30–32] few reports have focused on the time course of clinical and radiologic findings and long-term results. The aim of the present study was to investigate the long-term results and effectiveness of the surgical management in children younger than 16 years who had sustained a traumatic spine injury.

Development of the Vertebral Column

The presence of growth plates determines the specific patterns of injury in children.[11,22] Vertebral growth is accomplished by three groups of growing cartilage, which allow the three-dimensional growth of the vertebrae: the cartilage of the vertebral endplate, the neurocentral cartilage, and the ring apophysis. At birth, a large bony nucleus occupies almost the entire vertebra, from front to back, and a cartilaginous endplate separates the nucleus from the adjacent disc. During the fifth year of life, centers of ossification appear in the thickened margins of the upper and lower cartilaginous plates and gradually fuse so as to form an anular apophysis by the 12th year of life. This apophyseal ring remains separate from the vertebral body by a thin seam of cartilage, and fusion with the vertebral body commences during the 14th or 15th year and is complete by the 24th year. The apophyseal ring (secondary ossification center) contributes little to the longitudinal growth of the vertebral body and is responsible for the growth of the vertebral body breadth. This is why traumatic separation or fracture of the epiphyseal ring does not alter vertebral growth in height severely. The cartilage of the vertebral endplate is like the growth plate of a long bone, providing for growth in height through the same mechanism. A fracture crossing the disc in the immature spine and traversing almost exclusively the growth zone of the physis, exactly the same as the patterns seen in long-bone injuries,[2] can heal without any displacement and result in no deformity at follow-up. Similarly, a traumatic separation of the vertebral endplate can leave not only the germina-

tive layer, but also the intervertebral disc, intact. In contrast, bursting fractures of the vertebral body can include the anular epiphysis and involve damage to the germinative layer and intervertebral disc. This implies a danger of abnormal growth because of premature epiphyseal fusion in the manner described by Salter and Harris, as happens with long bones. The unique and vertical neurocentral cartilage, which is located between the vertebral body and posterior arch, induces growth of vertebral body and pedicles in horizontal plane. Finally, it should be remembered that growth and maturation of each vertebra are regulated not only by the general hormonal factors but also by the proper special balance that is contributed to by the function of muscles and ligaments surrounding the vertebrae.

■ Materials and Methods

During the years 1978–1992, 80 patients younger than 16 years were treated for spinal injuries at the authors' institution. The patients' hospital charts were reviewed for sex, age, injury mechanism, fracture level, neurologic injury, treatment, and follow-up assessment. After exclusion of the subjects who had had a pathologic fracture, 44 patients were available for follow-up. Thirty-eight patients returned for radiographs, whereas the remainder (n = 6) had radiographs made elsewhere and mailed to the current authors. All children underwent anteroposterior and lateral plain radiographs, and all fractures were categorized using the Denis classification system.[10] The burst fractures were classified as being stable or unstable based on whether they involved a two- or three-column injury.[6] No CT or MRI scans were available for many patients of this series, and it was therefore difficult to retrospectively assess whether the lesion was stable or unstable. The current authors assessed for the presence of progressive neurologic deficit, associated posterior element disruption, progressive kyphosis of ≥20°, and loss of vertebral body height >50% with facet joint subluxation to determine the presence of "unstable" burst fractures.[24] The presence of an anomalous opening in the spinous apophysis associated with kyphosis, articular subluxation or the anterior, dorsal, or ventral displacement of the vertebral body led the authors to establish the diagnosis of flexion–distraction injury.

Each patient responded to a questionnaire containing multiple-choice questions regarding residual pain, neurologic and work status, and function in activities of daily living. All patients were divided into two groups based on the presence of cord lesion and were clinically evaluated at an average follow-up of 18 years (range 9–23 years). The age at the time of injury for the 44 children ranged from 3 to 16 years (mean 14 years). The age at the time of follow-up ranged from 23 to 39 years (mean 33 years).

■ Results

This study included 26 males and 18 females. The spinal injury level was cervical in 12 cases, thoracic in 10, thoracolumbar in 7, and lumbar in 12. The level of injury could not be identified in the three children with spinal cord injuries without any evidence of radiographic abnormality (SCIWORA).[28]

Table 1. Classification and Distribution of Injuries Below the Cervical Spine

Description	Thoracic	Thoracolumbar	Lumbar
Stable/no SCI			
Compression	6	0	3
Burst	1	2	5
Unstable/no SCI			
Seat belt	0	2	0
Burst	2	0	3
With SCI			
Burst	1	0	1
Seat belt	0	3	0
Total	10	7	12

SCI = spinal cord injury.

Thirty-three patients were neurologically intact and 11 (6 paraplegia, 3 tetraparesis, 2 paraparesis) sustained spinal cord injury. Among the 33 neurologically intact patients there were 20 stable and 13 unstable injuries.

Of the 12 cervical injuries, 3 were stable (2 fractures of the arch of the atlas, an incomplete fracture of the odontoid process basis). Of the remaining 9 unstable fractures, 6 were neurologically intact and were a burst fracture of C7, 2 unilateral dislocations of C3–C4 and C4–C5, a severe strain of C3–C4, a teardrop fracture of C4, and a unilateral dislocation of C1–C2. The remaining 3 cases (2 burst fractures of C7 and a teardrop fracture of C4) exhibited neurologic impairment. The classification and distribution of the 29 injuries localized below the cervical spine are described in Table 1.

Treatment

All 20 stable fractures were treated conservatively applying a Minerva cast in 3 cases and a plaster cast in 17. The average duration of casting was 2 months (range 8–17 weeks).

Six cases with unstable fractures were managed conservatively. Two patients with a cervical injury were placed in a halo vest for an average of 8 weeks. Four patients with injuries below the cervical spine were maintained on bed rest until acute symptoms subsided and were then placed in a well-molded body cast.

Seven cases with unstable fractures were treated surgically. Four patients with cervical injuries underwent posterior fusion following the Gallie procedure (one case) or using Roy-Camille plates (three cases). Three injuries below the cervical spine were instrumented with Harrington-Luque rods.

The kind of treatment received by the 11 patients with spinal cord lesion is summarized in Table 2.

Long-term Results

Radiologic Findings. At follow-up, all of the 20 patients with conservatively managed stable fractures showed good stability without significant deformity (Figure 1).

The nine wedge-shaped compression and three cervical fractures had healed without significant deformity.

The eight "stable" burst fractures showed a nonper-

Table 2. Treatment of Patients With Spinal Cord Lesions

Treatment	Halo/Vest	Minerva Cast	Body Cast	
Conservative	1 RC plates	1 H rod	2 CDI	Laminectomy
Surgical	1	3	2	1 (SCIWORA)

RC plates = Roy Camille plates; H rod = Harrington rod; CDI = Cotrel-Dubousset instrumentation.

fect reconstruction of the vertebral body, either in frontal or in sagittal plane. At follow-up, the deformity never exceeded 10°, appeared only at the level of the lesion, and involved one segment below and one above the fractured vertebra.

At follow-up, six conservatively managed unstable injuries resulted in significant angular deformities in both planes. A burst fracture of C7 and a teardrop fracture of C4 treated with a Minerva cast for an average of 3 months showed a residual kyphosis of 18° and 24°, respectively. The remaining four patients with unstable burst fractures of L1 (two cases), L3, and T5 treated with plaster cast for an average of 4 months, showed a mean value of 18° and 20° for kyphosis and scoliosis, respectively. In these cases, the deformity was not only segmental, as observed for the stable fractures, but it also extended some levels above and below the fractured vertebra. Seven unstable injuries were treated surgically. Five cases appeared to be stabilized without significant deformity at follow-up. They presented with two cervical unilateral dislocations, a severe C4–C5 strain treated with Roy-Camille plates, a C1–C2 rotatory luxation treated by Gallie procedure, and a T4 burst fracture instrumented with the Harrington-Luque instrumentation. The patient with a severe C4–C5 strain presented a significant increase in mobility of the junctional unfused segment, despite the good stabilization achieved at the level of lesion.[25] On the contrary, the remaining two patients with flexion–distraction injuries at T12–L1 and T11–T12 instrumented with the Harrington-Luque technique, presented a poor result (scoliosis and kyphosis averaging 35° and 20°, respectively).

Four of the 11 neurologically compromised children were treated conservatively. Two cases (tetraparesis) with a C4 teardrop injury and an unstable C7 burst fracture, immobilized in a halo vest and a Minerva cast, presented with segmental kyphosis and paralytic thoracolumbar scoliosis, respectively, at follow-up. Two children with paraplegia resulting from SCIWORA and treated by brace developed progressive paralytic scoliosis over time and required posterior surgery 10 years after injury. The remaining seven cases were treated surgically. Three children (one tetraparesis, two paraplegia) with an "unstable" burst fracture of C7 and of T8 and flexion–distraction injury at T12–L1, treated with Roy-Camille plates and Harrington rods, appeared to be stabilized without deformity at follow-up. Another two cases with an "unstable" L3 burst fracture and a flexion–distraction injury at T11–T12 treated with short Cotrel-Dubousset instrumentation (one level below and one level above the lesion) presented severe kyphosis and scoliosis averaging 24° and 26°, respectively, at follow-up. Another patient with a flexion–distraction injury at T11–T12 had developed paralytic scoliosis of 40° at follow-up because of the immediate postoperative failure of the instrumentation (Harrington rod). Finally, the remaining patient with SCIWORA underwent laminectomy on an emergency basis. At a 20-year follow-up, he had very severe kyphosis exceeding 70°.

Clinical Findings. The initial neurologic lesion of the four conservatively treated patients remained unchanged at follow-up. Three of the seven surgically treated cases with preoperative paraplegia were unchanged, whereas

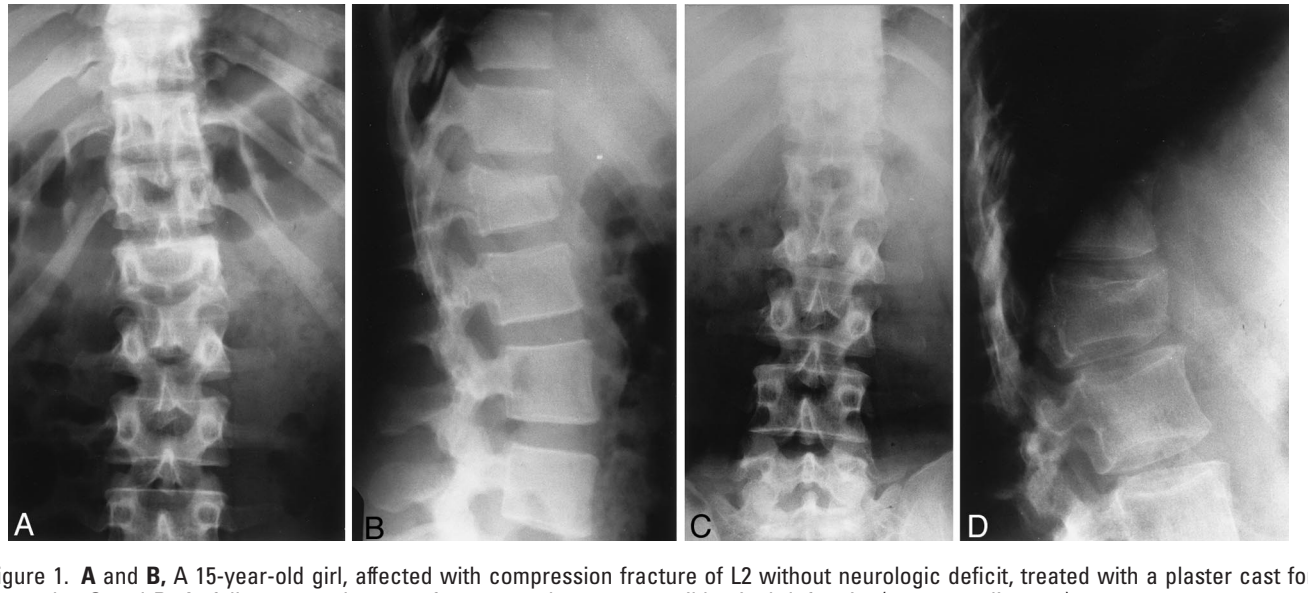

Figure 1. **A** and **B,** A 15-year-old girl, affected with compression fracture of L2 without neurologic deficit, treated with a plaster cast for 2 months. **C** and **D,** At follow-up at the age of 37 years, there was a mild spinal deformity (not exceeding 10°).

those four with preoperative incomplete spinal cord injuries showed a mild improvement.

A review of the patients' pain and work scale questionnaires showed generally favorable results. No patient complained of disabling pain. Twenty had moderate pain but no significant change in daily activities, and five had moderate pain and needed medication.

Twenty patients were working full time but with lifting restrictions, 15 were working full time in a less physically demanding job, and 9 were retired.

■ Discussion

The present series has confirmed[4,22,27] that the conservative treatment of wedge compression fractures without neurologic lesion ensures stabilization with moderate residual deformity. A simple compression fracture of the vertebral body is stable and nonprogressive because it is not accompanied by a fracture of the articular processes and the posterior cortex of the vertebral body. The presence of a segmental deformity alone, which did not extend more segments above or below the lesion, confirmed that the damage to the vertebral endplate was likely not to be severe enough to cause cessation of endplate growth. In three of the present nine cases, a residual mild scoliosis of the order of 5°, which was not associated with a later onset of pain, was observed at follow-up. Few such injuries in this series demonstrated the ability of the immature spine to remodel the vertebral body,[17] and in the majority of the cases partial restoration of height was inconclusive.

The present review has highlighted the need for an accurate diagnosis in children as in adults to identify "stable" *versus* "unstable" burst fractures.

After Denis classification many authors[1,6,14] have hypothesized the presence of "stable" and "unstable" burst fractures in adults. In the so-called "stable" burst fractures, the centrum of the vertebral body is severely compressed and the posterior wall is fractured. However, the remaining posterior structures, such as the articular processes and the intact ligaments, function as a posterior tension band and resist the compression forces. On the contrary, the "unstable" burst fractures are accompanied by injuries of the posterior column,[1,14] such as those resulting from flexion–distraction fractures (seat belt-type injuries). Indeed, there has been some confusion concerning the diagnosis of these two types of injuries both in children and in adults, and their treatment has not been clearly recognized.[5,18]

Eight children of the present series with "stable," conservatively treated burst fractures tended to develop mild progressive angular deformity at the site of fracture, which never exceeded 10° at follow-up. However, five of the six cases with "unstable" conservatively treated burst fractures appeared to be stabilized at follow-up but presented with segmental scoliosis and kyphosis, averaging 20° and 18°, respectively. In these latter cases, deformity was not segmental as happened with "stable" burst fractures, but it extended two or even three segments above or below the fracture level. Such findings would lead to the conclusion that a trauma in children can rarely bring about severe impairment of vertebral growth. A fundamental role in the onset of a posttraumatic deformity is probably played by the instability because of the bony or ligamentous posterior elements. Nonoperative treatment of burst fractures is therefore a viable option in children with "stable" burst fractures, minimal initial kyphosis, and no neurologic deficit.[21] Operative treatment achieves and maintains correction of the deformity and is recommended for "unstable" burst fractures.

Because of its protected position and greater elasticity resulting from the increased thickness of the intervertebral discs and the greater proportion of cartilage, the vertebral column of a child has to be subjected to more considerable violence than in adults before an unstable injury occurs. Hence, there are some aspects of childhood and adolescence seat belt fractures that differ from their adult counterparts.[15–17,29,33] There is always an injury to the anterior column, and the middle column injury is usually through the bone[7] or the ring apophysis but not through the posterior disc. Hence, flexion–distraction injuries in the spine of children and adolescents are more unstable than in adults, and the association with the three-column injury is more often observed than in adults.[33,34] The present series has highlighted the difficulties encountered in the treatment of this kind of lesion, even when early surgery is performed. Of the five surgically treated cases with flexion–distraction lesions (two without neurologic impairment and three with immediate spinal cord lesion), only one appeared without any residual deformity at follow-up, whereas the other four showed significant kyphoscoliosis at follow-up. The residual deformity involved more segments above and below the level of lesion (Figure 2). In all cases, progression of deformity despite early instrumentation was the result not only of the severe instability with secondary growth alteration but also of the choice of inadequate instrumentation. Distraction-type instrumentation, such as the Harrington rod, is unable to stabilize lesions resulting from a predominantly distraction force, even if associated with sublaminar wiring. The use of modern instrumentation, such as the segmental instrumentation (Cotrel-Dubousset), also failed to stabilize the lesions because fusion was extended only one segment above or below the fracture, as happened in three cases (two flexion–distraction injuries and an unstable lumbar burst fracture) of the present series. Such findings have confirmed that short fusion is unable to prevent progression of deformity in the presence of traumatic unstable injuries in children and adolescents, as well as in adults.[26] The children who were compromised neurologically presented a special challenge.[2,4,22] Several authors have claimed that the prognosis for recovery of the paralytic lesions following spinal cord traumas may be better in younger patients than in adults.[3,17] Recent studies and the current findings are not consistent with this idea and confirm that those patients who sustained complete cord

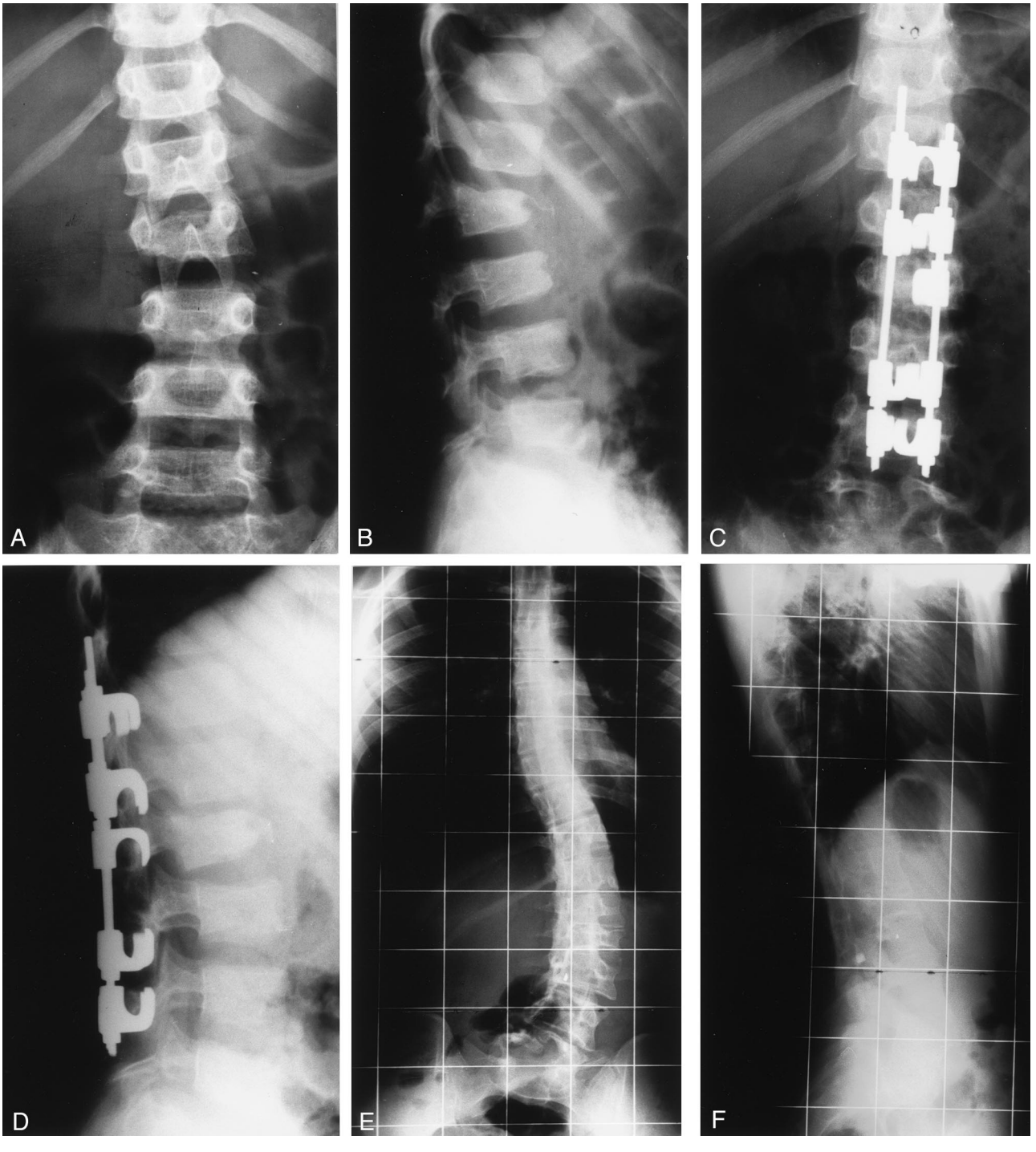

Figure 2. **A** and **B**, A 7-year-old boy, affected with seat belt-type fracture of L2 without neurologic deficit, treated with posterior reduction and Harrington instrumentation **(C** and **D)** removed 2 years later. Thoracolumbar scoliosis progressed despite the orthopedic brace: radiographic picture at follow-up at the age of 22 years **(E** and **F)**.

lesions initially did not improve with conservative or surgical treatment.[12,13,21,27] In the present series, four conservatively treated children with an initial complete paraplegia were unchanged at follow-up. Moderately better results were obtained in the seven surgically treated cases, four of which with incomplete cord lesion improved, whereas three remained completely paraplegic at follow-up. None of them worsened at follow-up.

The uniform occurrence of paralytic scoliosis or kyphosis in the spinal cord injured was well documented in the present series.[9,11,21,23] The spinal cord lesion may develop a deformity that is mainly scoliotic, kyphotic, or lordotic in >90% of the cases in which a spinal cord trauma occurred before puberty. Eight of the 11 neurologically compromised patients developed severely progressive paralytic scoliosis and kyphosis. In these cases,

the deformity was not secondary to segmental alterations of the vertebral growth but to impaired muscle function. Tetraplegia or paraplegia developing in young children modifies weight bearing and disturbs the natural vertebral growth and development of muscle balance, which shapes the spine of the child when he stands spontaneously. Hence, even the perfect local treatment at the injury level cannot avoid secondary progression of the deformity because of the spinal growth.[11]

The current authors' experience has confirmed that laminectomy performed for decompression did not improve the neurologic damage and created instability.[4] After 23 years, one of the present cases with SCIWORA treated at the age of 2 years by laminectomy presented with a segmental kyphosis exceeding 70°.

In the present series, there were only six patients younger than 12 years. Two of them affected with stable compression fractures presented the same evolution pattern as adolescents did. However, the remaining four cases affected with spinal cord injury (three SCIWORA, one flexion–distraction injury) had paralytic deformities involving more segments. Such deformities were earlier and more severe than those observed in the adolescents presenting fractures with myeloradicular involvement.

■ Key Points

- A series of 44 patients who sustained a spinal fracture at the average age of 14 years (range 3–16 years) were reviewed at an average follow-up of 18 years (range 9–23 years).
- Results confirmed the validity of conservative treatment for stable fractures as well as the need for early surgical treatment for unstable injuries and injuries with spinal cord lesion.

References

1. Abe E, Sato K, Shimada Y, et al. Thoracolumbar burst fractures with horizontal fracture of the posterior column. Spine 1997;22:83–7.
2. Akbarnia BA. Pediatric spine fractures. Orthop Clin North Am 1999;30: 521–36.
3. Beatson TR. Fractures and dislocation of the cervical spine. J Bone Joint Surg Br 1963;45:21–35.
4. Bollini G. Thoracic and lumbar spine injuries in children. In: Floman Y, Farcy J-PC, Argenson C, eds. Thoracolumbar Spine Fractures. New York, NY: Raven Press, 1993; 307–25.
5. Cantor JB, Lebwohl NH, Garvey T, et al. Nonoperative management of stable thoracolumbar burst fractures with early ambulation and bracing. Spine 1993;18:971–6.
6. Chan DPK, Seng NK, Kaan KT. Nonoperative treatment in burst fractures of the lumbar spine (L2–L5) without neurologic deficits. Spine 1993;18:320–5.
7. Chance CG. Note on a type of flexion fracture of the spine. Br J Radiol 1948;21:452–3.
8. Christoffel KK. Violent death and injury in U.S. children and adolescents. Am J Dis Child 1990;144:697–706.
9. Dearloff WW, Betz RR, Vogel LC, et al. Scoliosis in pediatric spinal cord injured patients. J Pediatr Orthop 1990;10:214–8.
10. Denis F. The three column spine and its significance in the classification of acute thoracolumbar spinal injuries. Spine 1983;8:817–31.
11. Dubousset J. Spinal deformities secondary to traumatic lesions involving the spine and spinal cord in children. In: Floman Y, Farcy J-PC, Argenson C, eds. Thoracolumbar Spine Fractures. New York, NY: Raven Press, 1993; 327–37.
12. Eleraky MA, Theodore N, Adams M, et al. Pediatric cervical spine injuries: report of 102 cases and review of the literature. J Neurosurg 2000;92:12–7.
13. Farley FA, Hensinger, RN, Herzenberg JE. Cervical spinal cord injury in children. J Spinal Disord 1992;5:410–6.
14. Gertzbein SD, Court-Brown CM. Flexion-distraction injuries of the lumbar spine: mechanisms of injury and classification. Clin Orthop 1988;227:52–60.
15. Glass RBJ, Sivit CJ, Sturm PF, et al. Lumbar spine injury in a pediatric population: difficulties with computed tomographic diagnosis. J Trauma 1994;37:815–9.
16. Glassman SD, Johnson JR, Holt RT. Seatbelt injuries in children. Trauma 1992;33:882–6.
17. Hubbard DD. Injuries of the spine in children and adolescents. Clin Orthop 1974;100:56–65.
18. James KS, Wenger KH, Schlegel JD, et al. Biomechanical evaluation of the stability of thoracolumbar burst fractures. Spine 1994;19:1731–40.
19. Kewalramani LS, Tori JA. Spinal cord trauma in children: neurologic patterns, radiologic features, and pathomechanics of injury. Spine 1980;5: 10–8.
20. Lalonde F, Letts M, Yang J-P, et al. An analysis of burst fractures of the spine in adolescents. Am J Orthop 2001;30:115–20.
21. Lancourt JE, Dickson JH, Carter RE. Paralytic spinal deformity following traumatic spinal cord injury in children and adolescents. J Bone Joint Surg Am 1981;63:47–53.
22. Magerl F, Brunner Ch, Zoch K, et al. Fractures and dislocations of the vertebral column. In: Weber BG, Brunner C, Freuler F, eds. Treatment of Fractures in Children and Adolescents. Berlin: Springer-Verlag, 1980; 226–41.
23. Mayfield JK, Erkkila JC, Winter RB. Spine deformity subsequent to acquired childhood spinal cord injury. J Bone Joint Surg Am 1981;63:1401–11.
24. McAfee PC, Yuan HA, Lasda NA. The unstable burst fracture. Spine 1982; 7:365–73.
25. McGrory BJ, Klassen RA. Arthrodesis of the cervical spine for fractures and dislocations in children and adolescents: a long-term follow-up study. J Bone Joint Surg Am 1994;76:1606–16.
26. McLain RF, Sparling E, Benson DR. Early failure of short-segment pedicle instrumentation for thoracolumbar fracture. J Bone Joint Surg Am 1993;75: 162–7.
27. McPhee IB. Spinal fractures and dislocations in children and adolescents. Spine 1981;6:533–7.
28. Pang D, Wilberger JE. Spinal cord injury without radiographic abnormalities in children. J Neurosurg 1982;57:114–29.
29. Raney E, Bennet JT. Pediatric Chance fracture. Spine 1992;17:1522–4.
30. Reynolds R. Pediatric spinal injury. Curr Opin Pediatr 2000;12:67–71.
31. Rodriguez JG. Childhood injuries in the United States. Am J Dis Child 1990; 144:625–46.
32. Ruge JR, Sinson GP, McLone DG, et al. Pediatric spinal injury: the very young. J Neurosurg 1988;68:25–30.
33. Rumball K, Jarvis J. Seat-belt injuries of the spine in young children. J Bone Joint Surg Br 1992;74:571–4.
34. Sturm PF, Glass RB, Sivit CJ, et al. Lumbar compression fractures secondary to lap-belt use in children. J Pediatr Orthop 1995;15:521–3.

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