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Atypical Hangman's Fractures

John K. Starr, MD,* and Frank J. Eismont, MD, FACS†

Nineteen cases of traumatic spondylolisthesis of the axis, including 13 standard hangman's fractures and 6 anterolistheses of the C2 vertebral body associated with Effendi's atypical hangman's fractures, were studied. Unlike the standard Effendi Type I or Type II fractures, atypical hangman's fractures, occurring through the posterior aspect of the vertebral body with unilateral or bilateral continuity of the posterior cortex or pedicle, routinely narrow the spinal canal because of the fracture pattern and degree of subluxation. These atypical C2 injuries were more frequent and more often accompanied by paralysis (33%) than was previously anticipated. Because of their greater potential for neurologic compromise, it is essential that these fractures be recognized as distinct from standard Types I and II C2 fractures. Larger series should clarify both the true incidence of paralysis and long-term results from these unique C2 injuries. [Key words: hangman's fracture, traumatic spondylolisthesis of the axis]

The term "hangman's fracture," describing traumatic spondylolisthesis of C2, has been used inconsistently by many authors[1,3–9,11–13] since the original description in 1965 by Schneider et al.[10] Although earlier reports noted similarities between these fractures and injuries suffered during judicial hangings, use of the term hangman's fracture gained popularity only after the report of Schneider et al, and referred generally to a fracture through the neural arch, with or without vertebral translation.[7,8,12,13] Published depictions[1,3,4,11] of hangman's fractures represented a spectrum of injuries until 1981, when Effendi et al,[5] followed by Francis et al,[6] offered the initial classification schema based on radiographic and biomechanical criteria, respectively.

In the most recent classification, Levine and Edwards[9] both modified the Effendi system and described a continuum of mechanisms for their four fracture types. In the present series, Effendi's atypical C2 fractures are identified uniquely as canal-compressive and associated with significant neurologic dysfunction, rather than expansile without attendant deficits, as previously described. We therefore expand the existing classification systems, highlighting the neurologic instability of this particular fracture type and emphasizing its importance in patient evaluation and treatment.

■ Materials and Methods

Sixty-three patients with fractures of the atlas or axis vertebrae were admitted to the Jackson Memorial Hospital spine service between 1986 and 1991. Among this group were 13 male and 6 female patients with traumatic spondylolisthesis of the axis. These 19 hangman's injuries were produced by vehicular accident in 15 cases and falls from a height in 4 cases. The mean age of these patients was 32.9 years (range 17–63 years). As with the majority of patients admitted to our institution with cervical spine injury, these 19 patients were managed initially with Gardner–Wells tong traction to protect neurologic function during the diagnostic work-up. A complete multisystem and neurologic evaluation was performed.

All patients had anteroposterior and lateral plain radiographs of the cervical spine while in 2.3–3.2 kg cervical traction. If increased displacement or distraction was seen on initial films, as it is in the Levine–Edwards[9] Type IIa fractures, the traction was relaxed. All patients additionally underwent either lateral tomography or computed tomography, or both, either to define the fracture or to visualize the entire cervical spine.

The initial classification of the fractures was based on the lateral plain films or tomograms and followed the Levine–Edwards system.[9] The fracture deformity was described, with notation of the relative translation of the involved vertebrae

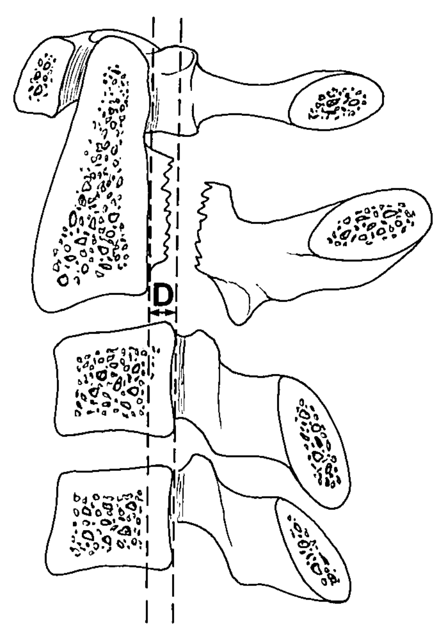

Figure 1. Measurement of anterior translation.

From the *Department of Orthopaedic Surgery, George Washington University, Washington, DC, and the †Department of Orthopaedic Surgery, University of Miami, Miami, Florida. Study conducted at Jackson Memorial Hospital, University of Miami, Miami, Florida.
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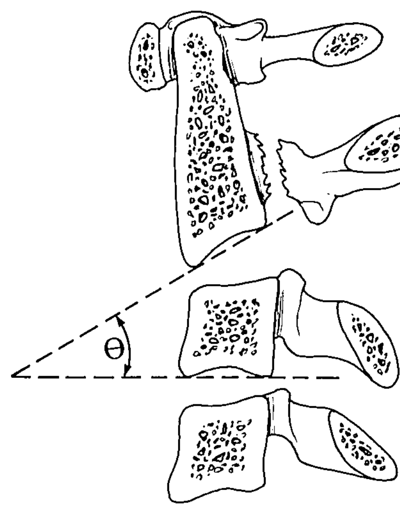

Figure 2. Measurement of angular deformity.

and the angulation between them. Translation was measured as the distance between lines drawn parallel to the posterior vertebral cortices of C2 and C3 at the intervertebral disc level (Figure 1). The angular measure was made in accordance with the criteria of White and Panjabi,[11] with lines drawn parallel to the inferior endplates of C2 and C3 (Figure 2).

The 19 patients in this series suffered 4 Type-I injuries, 14 Type-II injuries, 2 Type-IIa, and 1 Type-III fracture–dislocation. The fracture types suffered appeared randomly distributed with respect to patient age and mechanism of injury.

Careful assessment by computed tomography, plain tomography, or more recently, magnetic resonance images revealed six patients (32%) with a fracture configuration involving the posterior cortex of C2. This fracture configuration was not expansile and, when accompanied by translation, placed the spinal cord at risk for compression against the cortical fragment (Figure 3).

■ Results

The incidence of fracture types and neurologic findings for each of these atypical cases were reviewed (Table 1). All six atypical fractures were sustained by drivers in

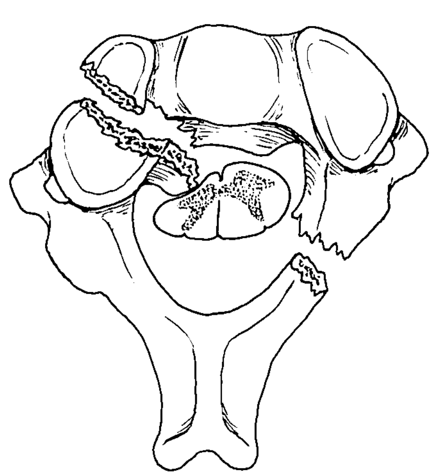

Figure 3. Diagram of atypical fracture with cord impingement.

Figure 4. Example of Type-I injury.

motor vehicle accidents. The four men and two women were an average of 30.8 years old (range 17–42 years). According to the Levine–Edwards classification scheme,[9] two of the six atypical fractures in this series were Type-I injuries and four were Type-II. The Type-I fractures demonstrated no angulation between C2 and C3 averaging 2.5 mm anterior translation (Figure 4). Because these patients showed no distraction or displacement with cervical traction, they were immobilized in halo vests for 3 months when fracture union and stability were verified on dynamic lateral radiographs (Figure 5). Use of the halo-vest was the definitive treatment except for the patient with complete quadriplegia, who first underwent occipitocervical fusion to C3 for associated ligamentous injuries.

Atypical Fractures

Four patients with atypical fractures were neurologically intact at the time of presentation (Table 1). Two patients with Type-I injuries demonstrated no angulation and less than 4 mm translation, whereas two patients with Type-II injuries (Figure 6) suffered associated fracture deformity averaging 7 mm translation (4 and 10 mm, respectively) and 14.5° angulation (8° and 21°, respectively).

Table 1. Atypical Fracture Types

Patient	Fracture Type	Neurologic Status
1	Type II	Complete C3 quadriplegia
2	Type II	Incomplete C3 hemiplegia
3	Type II	Intact
4	Type I	CHI
5	Type I	Intact
6	Type I	CHI

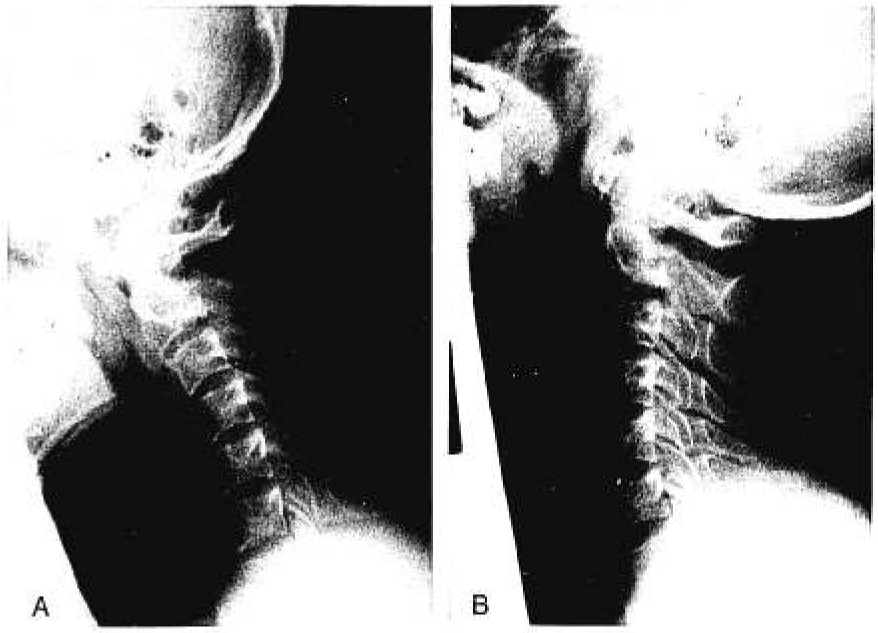

Figure 5. Fracture union in Type-I injury treated with halo immobilization. **A**, Flexion. **B**, Extension.

Two other patients with atypical fractures were admitted to the hospital with neurologic deficit. The first, immediately and irreversibly quadriplegic with a C3 sensory level, exhibited a fracture deformity measuring 15 mm anterior translation and 20° of angulation. The second patient, with a partial C3 hemiplegia and initial 2/5 motor deficit in all four extremities, had 10 mm of anterior translation and 21° of angulation. With immobilization in a halo vest and rehabilitation therapy, this patient's condition improved dramatically within 3 months. Follow-up at 6 months revealed the patient to be ambulatory and having returned to his previous job as an exterminator.

■ Discussion

Hangman's fractures, a term originally coined by Schneider et al in 1965,[10] referred to a fracture line through the neural arch of the axis with or without anterior C2 body displacement.[1,3,4,7,8,12,13] In 1981, Effendi et al[5] characterized three types of hangman's fractures based on fracture location; nearly simultaneously, Francis et al[6] proposed a classification based on White and Panjabi's[11] translational and angular criteria for stability. Finally, in 1985, Levine and Edwards published the most recent categorization for traumatic spondylolisthesis of the axis, emphasizing the mechanism of injury and its management.[9]

These series have assumed, and most have proposed, that these C2 injuries are usually neurologically benign. Francis et al[6] attributed the low incidence of neurologic deficits to the "lack of distraction force during hyperextension and the enlargement of the spinal canal and neural foramina." Even Effendi et al,[5] aware that one of his Type-II patients was permanently quadriplegic after an axis injury, observed that fractures of the axis were usually benign, resulting in canal expansion, and therefore were rarely associated with severe, permanent deficits. Similarly, Levine and Edwards[9] determined that their Type-II subgroup suffering neurologic injuries had sustained these injuries with a larger rather than smaller neural canal.

This study highlights the increased incidence of neurologic injury occurring in patients with previously defined[2] but incompletely characterized atypical Type-II fractures. These fractures, unlike other traumatic

Figure 6. Example of Type-II injury.

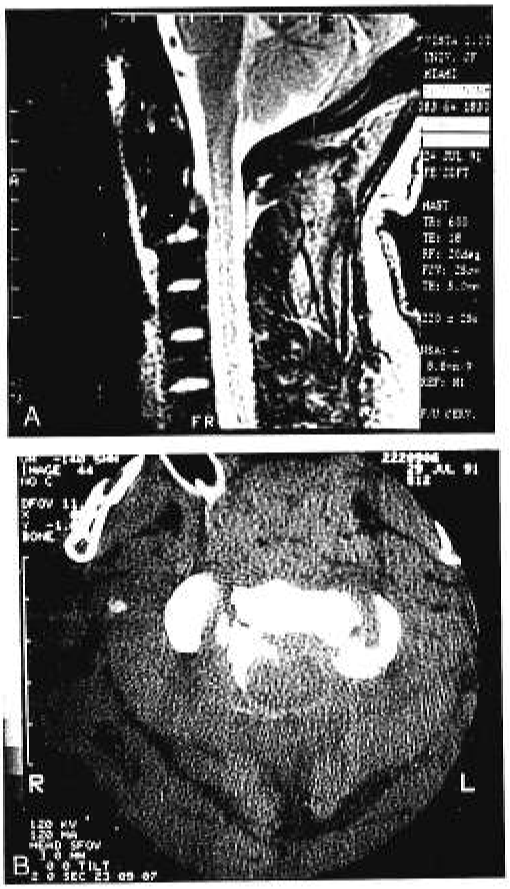

Figure 7. Magnetic resonance (A) and computed tomographic (B) images of atypical fracture demonstrating spinal cord impingement.

spondylolistheses, produce canal compromise rather than canal expansion. As the anterior elements of the axis separate from the posterior elements during C2–C3 disc rupture, the anterior elements translate anteriorly, resulting in spinal cord compression against the posterior vertebral body cortex, which remains fixed to the posterior elements (Figures 3, 6, and 7).

Reclassification of Hangman's injuries is unnecessary. Levine and Edwards'[9] modification of Effendi's system[6] affords a clear picture of the mechanism of injury. Still, these atypical fractures, seen with both Type-I and Type-II injuries and exhibiting modest deformity, must be recognized as distinct fracture types. These atypical injuries presented with a higher frequency and were associated with a higher incidence of neurologic compromise than was previously anticipated.

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Address reprint requests to

Frank J. Eismont, MD
Department of Orthopedics and Rehabilitation
University of Miami School of Medicine
P.O. Box 016969 (D27)
Miami, FL 33101