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Hangman's Fracture: The Critical Role of Imaging in Diagnosis and Management

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Abstract | **Case Report**

We present two cases of Hangman's fracture that highlight the essential, complementary roles of CT and MRI. In the first case, CT alone confirmed an unstable Type II fracture with significant displacement. The second case appeared stable on CT (Type I) but was reclassified as unstable (Type II) after MRI revealed a C2-C3 disc injury. This demonstrates that while CT is crucial for initial diagnosis and classification, MRI is indispensable for detecting disco-ligamentous damage, ensuring accurate classification and guiding appropriate treatment decisions for optimal patient management.

Keywords: Hangman's Fracture, Traumatic Spondylolisthesis, Axis, Cervical Spine, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Levine-Edwards Classification.

INTRODUCTION

The Hangman's fracture, a bipedicular lesion of the axis, accounts for 15-20% of upper cervical spine fractures. Characterized by bilateral fractures through the C2 pars interarticularis, it typically results from hyperextension trauma with axial loading. While generally stable without major neurological complications due to spinal canal widening, its potential instability - particularly when involving the C2-C3 discoligamentary complex - requires precise assessment. Cervical CT scan emerges as the gold standard for diagnosis, Levine-Edwards classification, and therapeutic guidance. We present two clinical cases to illustrate CT imaging's crucial role in the decision-making process for radiology trainees.

OBSERVATIONS

Case 1

A 36-year-old male presented to the emergency department following a high-velocity motor vehicle accident. The patient reported significant cervical pain but maintained full neurological function without motor or sensory deficits. Initial cervical computed tomography (CT) with multiplanar reconstructions demonstrated a bilateral fracture of the C2 pars interarticularis with marked instability, evidenced by 9 mm of anterolisthesis of C2 over C3. The imaging revealed significant disruption of the C2-C3 disc complex and associated anterior spinal epidural hematoma. These radiological features, particularly the substantial displacement and disco-ligamentous injury, confirmed a Levine-Edwards Type II fracture pattern.

Findings

Bilateral C2 isthmic fracture (**white arrows**) with 9mm anterolisthesis of C2 on C3, consistent with a Levine-Edwards Type II fracture pattern. There is an associated anterior spinal epidural hematoma (**red arrows**).

CASE 2

A 25-year-old male was admitted following an occupational accident, presenting with clinical findings of torticollis and significant restriction of cervical mobility. Neurological examination remained intact throughout assessment. Initial cervical CT imaging identified a bilateral C2 pars interarticularis fracture with minimal displacement, characterized by 3 mm of anterolisthesis of C2 over C3. These initial findings suggested a stable Levine-Edwards Type I fracture. However, subsequent magnetic resonance imaging (MRI) with sagittal T1, T2, and STIR sequences provided crucial soft tissue characterization, revealing minimal C2/C3 retrolisthesis and left posterolateral disc injury. Although no spinal cord compression or hematoma was observed, the identified disc complex

disruption necessitated reclassification to Levine-Edwards Type II fracture.

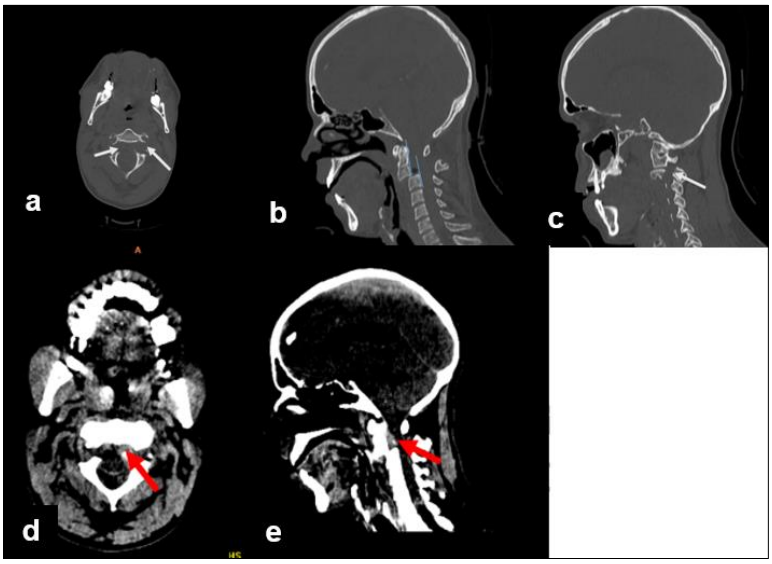

Figure 1: CT scan, bone window on axial (a), sagittal (b and c) planes; parenchymal window on axial (d), sagittal (e) planes

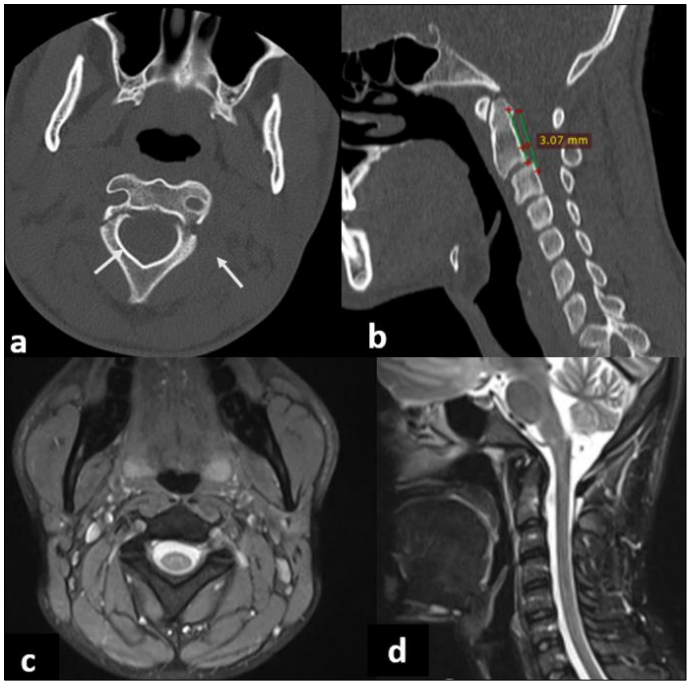

Figure 2: CT scan, bone window on axial (a) and sagittal (b, c) planes; and MRI, T2-weighted on axial (d) and sagittal (e) planes

Findings

CT imaging identified a bilateral C2 pars interarticularis fracture (**white arrows**) with minimal displacement, characterized by 3 mm of anterolisthesis of C2 over C3. These initial findings were consistent with a stable Levine-Edwards Type I fracture. Subsequent MRI revealed minimal C2/C3 retrolisthesis and a left posterolateral disc injury. The patient remains neurologically intact, as no spinal cord compression or hematoma was observed.

DISCUSSION

Imaging Correlation

The comparative analysis of these two cases effectively demonstrates the clinical spectrum of Hangman's fractures. While both patients sustained the defining characteristic of bilateral C2 pars interarticularis fractures, they represented contrasting points on the stability spectrum. Case 1 exhibited overt instability on initial CT, characterized by significant displacement. In contrast, Case 2 presented a more subtle clinical picture,

where the underlying disco-ligamentous instability was only fully elucidated through subsequent MRI. This dichotomy powerfully illustrates the indispensable, complementary roles of CT and MRI. CT provides the essential structural blueprint for fracture identification and initial classification, while MRI delivers critical prognostic insight by visualizing soft tissue integrity. Together, these modalities enable a comprehensive radiological assessment that is fundamental to guiding precise therapeutic decision-making in cervical spine trauma, ensuring stable injuries are managed conservatively and unstable ones receive appropriate surgical stabilization.

Lesional Mechanism and Historical Context

The bipedicular fracture of the axis represents the second most common fracture location of C2 after the odontoid fracture. The main causal mechanism, well illustrated by our two cases (motor vehicle accident and occupational accident), is a hyperextension of the craniocervical junction with redistribution of mechanical forces on the vertebral body and articular processes, leading to a rupture of the weakest part of the neural arch [1-8]. Initially described by Bouvier in 1843, this lesion owes its common name "Hangman's fracture" to the work of Schneider in 1965 on judicial autopsies.

Evolution of Classifications: From Francis-Fielding to Levine-Edwards

Several classifications have been proposed to guide therapeutic decisions. The Francis and Fielding classification (1978) [3, 4], distinguishes 5 grades based on the degree of angulation and anterior displacement of C2 relative to C3, with an increased risk of non-union when angulation exceeds 11 degrees or displacement exceeds 3.5 mm. However, this classification has the major limitation of not considering the injury mechanism.

The most commonly accepted classification today is that of Effendi, modified by Levine and Edwards [4, 5], which represents significant progress by simultaneously integrating radiological semiology, traumatic mechanism, and therapeutic aspects. This classification distinguishes:

- Type I: Stable fracture without significant displacement (<3 mm) or angulation, without injury to the C2-C3 disco-ligamentous complex.
- Type II: Unstable fracture with anterior displacement >3 mm and angulation, involving rupture of the C2-C3 disco-ligamentous unit.
- Type IIa: Fracture with marked angulation but minimal anterior displacement, with a distracting flexion injury.

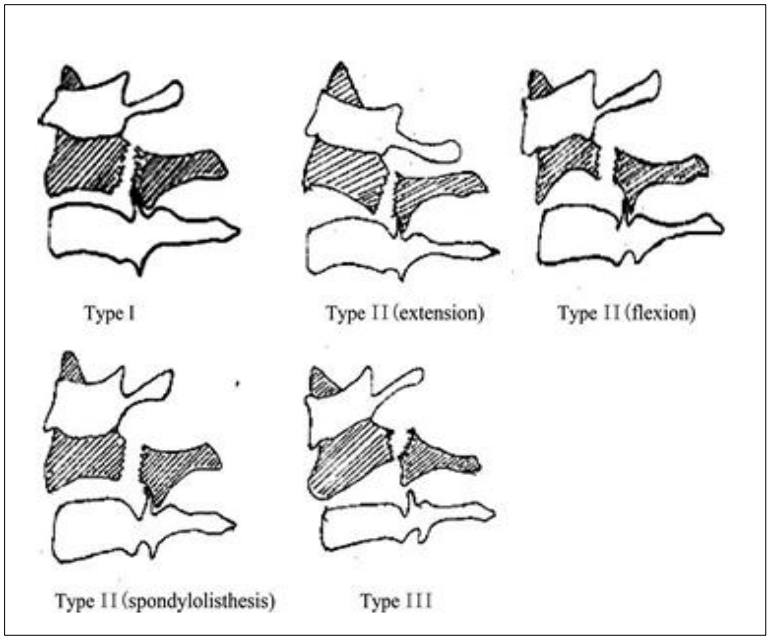

Figure 1: Effendi Classification

- Type III**:** Fracture with C2-C3 facet dislocation and severe neurological deficit.

Crucial Role of Imaging in Classification and Prognosis

CT with multiplanar reconstructions is the examination of choice for applying this classification [2-7]. In CT scanning, the anteroposterior displacement in Hangman's fractures is measured on median sagittal reconstructions in bone tomography. The standard method involves drawing a line along the posterior wall of the C3 vertebral body and measuring the distance between this line and the posterior wall of the C2 vertebral body [5-8]. This measurement quantifies the anterolisthesis and constitutes an essential criterion for the Levine-Edwards classification: displacement less

than 3 mm characterizes Type I, while displacement equal to or greater than 3 mm, as in our Case 1 (9 mm), indicates Type II [2-7]. This measurement must be performed accurately on dedicated reconstruction series using the calibrated measurement tools of the PACS system.As our cases demonstrate, CT allows precise quantification of key parameters: measurement of C2-C3 anterolisthesis (3 mm in Case 2 versus 9 mm in Case 1) and angulation. Our first case, with its significant displacement of 9 mm, was immediately classified as Type II based on CT data alone.

The limitation of CT lies in its inability to directly visualize ligamentous and disc structures. Our second case perfectly illustrates the decisive contribution of MRI. While initial CT suggested a stable Type I fracture, MRI demonstrated C2-C3 disc injury justifying reclassification to Type II [3-4]. This reclassification has major therapeutic implications, potentially modifying surgical indications.

Therapeutic and Prognostic Implications

The Levine-Edwards classification directly guides management: Type I are treated orthopedically with a rigid collar (8-14 weeks), while unstable Types II, IIa and III often require surgical stabilization. The union prognosis reflects this instability: 60% for Type II, 45% for Type IIa and 35% for Type III under orthopedic treatment [6, 7].

The widening of the spinal canal at C2 explains the rarity of neurological deficits in these fractures and their generally good prognosis after appropriate treatment [7, 3].

CONCLUSION

Mastery of the Levine-Edwards classification and understanding the respective contributions of CT (bone analysis, initial classification) and MRI (disco-ligamentous assessment, reclassification) are essential for the radiologist. The precise measurement of displacement on CT scans, following standardized methodology, provides critical quantitative data for initial classification. Integrated multimodal analysis enables precise lesional classification, an essential decision-making guide for optimizing the management of Hangman's fractures.

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