

Motion-Preserving Bilateral Isthmus Screw Fixation for Unstable Hangman's Fracture: A Case Report

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Learning Point of the Article:

Bilateral isthmus screw fixation can preserve C2/3 mobility in selected unstable Type IIa Hangman's fractures, although post-traumatic disc degeneration may develop despite successful fracture union.

Abstract

Introduction: Hangman's fractures account for 4–7% of cervical spine fractures. Unstable fractures require surgical treatment, yet traditional fusion techniques sacrifice upper cervical motion. Direct isthmus screw fixation, first described in 1970, offers anatomic reduction with motion preservation but remains underutilized. We report bilateral dorsal isthmus screw fixation for an unstable Type IIa Hangman's fracture with functional follow-up at 13 months.

Case Report: A 26-year-old male sustained a Type IIa Hangman's fracture according to the Levine–Edwards classification with 12.4° kyphotic angulation and approximately 3 mm ventral translation following a 3-m fall. He had no neurological deficit. Combined closed and Penfield dissector–assisted open reduction followed by bilateral dorsal isthmus screw fixation was performed under biplanar fluoroscopic guidance.

Outcome: Stable fracture reduction and radiographic bony union were achieved without neurological or vascular complications. At 1 year, the patient was asymptomatic, had returned to full-time work, and participated in sports without restrictions. Radiographs showed progressive C2/3 degenerative changes with osteophyte formation. Functional flexion-extension radiographs at 13 months confirmed preserved segmental mobility at C2/3 without pathological instability.

Conclusion: Bilateral dorsal isthmus screw fixation achieved radiographic union, excellent clinical recovery, and preserved C2/3 motion at 13 months in this young patient with an unstable Type IIa Hangman's fracture. Progressive C2/3 degeneration despite preserved mobility suggests that longer-term follow-up is required in similar cases.

Keywords: Hangman's fracture, traumatic spondylolisthesis, isthmus screw fixation, motion preservation, cervical spine, C2 fracture.

Introduction

Traumatic spondylolisthesis of the axis (Hangman's fracture) accounts for 4–7% of cervical spine fractures [1, 2]. The Levine–Edwards classification [3, 4] divides these fractures into four types based on displacement, angulation, and facet integrity (Fig. 1). Type IIa fractures, characterized by significant angulation ($>11^\circ$) with minimal translation (<3 mm) from a

flexion-distraction mechanism, are considered unstable and typically require surgical stabilization [3, 5].

Standard surgical options include anterior C2–C3 fusion (anterior cervical discectomy and fusion [ACDF]) and posterior C1–C3 fusion, both of which permanently sacrifice motion segments. The C1–C2 joint provides approximately 50% of cervical rotation, and C2–C3 contributes 5–10° of rotation and

Author's Photo Gallery



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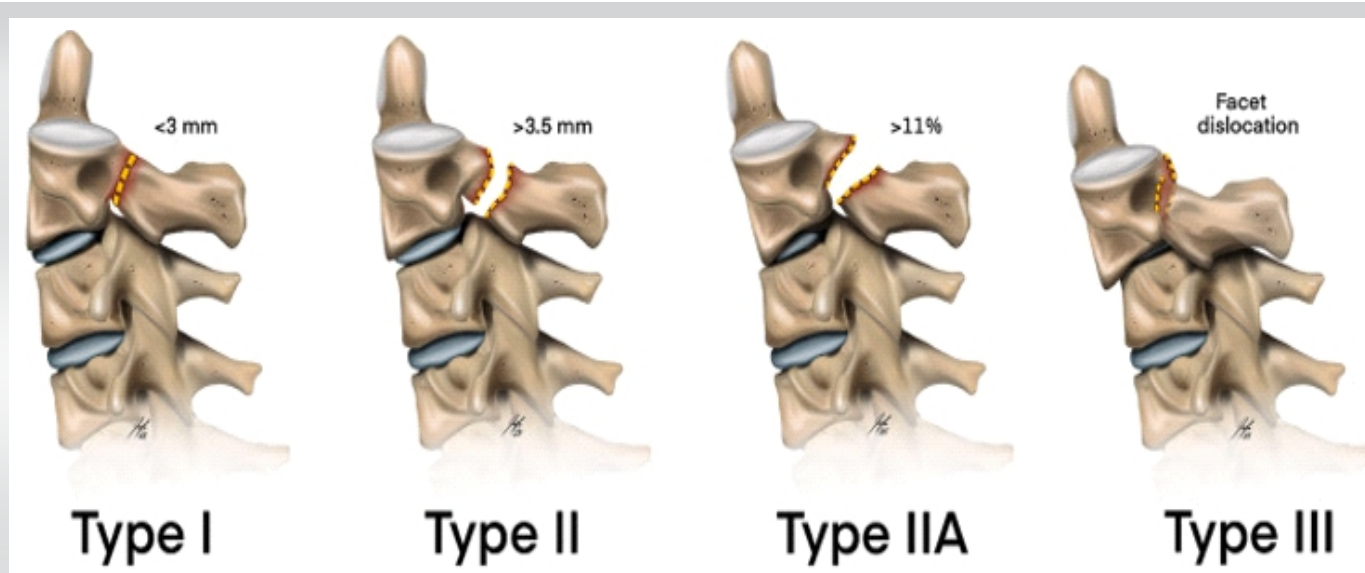


Figure 1: Schematic drawing of the Levine-Edwards classification for Hangman's fractures. Reproduced from McDermott et al. [4], under CC BY-NC-ND 4.0 license. Type I: Minimal displacement (<3 mm) and angulation (<11°). Type II: Significant displacement (>3 mm) with angulation. Type IIa: Significant angulation (>11°) with minimal translation (<3 mm). Type III: Severe displacement with bilateral facet dislocation.

8–10° of flexion-extension per side [6,7]. Fusion may also accelerate adjacent segment degeneration [8].

Direct isthmus screw fixation, first described by Judet et al. [9] in 1970, offers anatomic fracture reduction while preserving all upper cervical motion segments. Clinical studies have demonstrated favorable fracture union rates following direct pars/isthmus screw fixation, whereas preservation of the C2/3 motion segment represents a potential advantage over fusion-based techniques [10, 11]. Li et al. [12] systematically reviewed the management of Hangman's fractures, providing broader context for treatment selection. Despite these advantages, the technique remains underutilized due to concerns regarding technical complexity and vertebral artery injury risk [13,14]. Costa et al. [15] described intraoperative three-dimensional navigation for upper cervical fracture fixation, emphasizing the importance of precise anatomical assessment and

instrumentation.

This case report describes the successful application of bilateral dorsal isthmus screw fixation in a young patient with an unstable Type IIa Hangman's fracture, with emphasis on surgical technique, clinical outcomes, and functional motion assessment at 13-month follow-up.

Case Report

A 26-year-old male presented to the emergency department following a 3-m fall from a construction platform. The Glasgow Coma Scale was 15/15 with stable hemodynamics. Neurological examination was intact (Medical Research Council grade 5/5 bilaterally) with focal cervical paraspinal tenderness.

Contrast-enhanced computed tomography (CT) with angiography revealed a Type IIa Hangman's fracture (Levine-Edwards classification) [3] with bilateral C2 isthmus fractures, 12.4° kyphotic angulation, and approximately 3 mm ventral translation (Fig. 2a, b, c). CT angiography confirmed normal bilateral vertebral artery anatomy. Axial imaging demonstrated bilateral pars fractures with adequate isthmus dimensions for screw placement (Fig. 2b).

Given the patient's young age, high functional demands, and unstable fracture pattern, a motion-preserving approach was favored over conventional fusion [3,5]. Pre-operative planning confirmed anatomical suitability: Adequate isthmus dimensions for 3.5 mm screws,



Figure 2: Pre-operative imaging demonstrating Type IIa Hangman's fracture. (a) Sagittal CT showing bilateral C2 isthmus fractures with 12.4° kyphotic angulation and 3 mm ventral translation. (b) Axial CT demonstrating bilateral pars interarticularis fractures with normal vertebral artery positioning. (c) Lateral radiograph confirming malalignment.



Figure 3: Intraoperative fluoroscopic documentation of combined closed and open reduction with bilateral isthmus screw placement. (a) Baseline alignment under initial traction. (b and c) Drilling through the C2 isthmus under combined traction and Penfield-assisted open reduction. (d and e) Bilateral guidewire placement. (f) Initial screw insertion over the guidewire. (g) Progressive screw tightening with interfragmentary compression. (h) Final bilateral screw position with maintained reduction after traction release.

normal vertebral artery course, sufficient spinal canal diameter, and good bone quality on CT.

Surgical technique

Under general anesthesia with fiberoptic intubation and manual inline stabilization, Mayfield pins were applied, and the patient was positioned prone. Closed reduction was performed under lateral fluoroscopy with incremental axial traction (2.3–5.4 kg), achieving partial reduction of kyphotic angulation from 12.4° to approximately 5–7° (Fig. 3a) [16].

Through a midline posterior cervical incision (~6 cm), subperiosteal dissection exposed the C2 posterior elements bilaterally while preserving C2–C3 facet capsules. Under biplanar fluoroscopic guidance, bilateral entry points were identified at the inferior C2 lateral mass, approximately 3–4 mm lateral to the medial border [17]. Intermittent

oscillating drilling (2.5 mm drill bit) was performed through the C2 isthmus bilaterally.

During drilling, reduction was augmented using a Penfield dura dissector to apply controlled anterior-inferior pressure to the C2 spinous process with countertraction on C3 posteriorly,

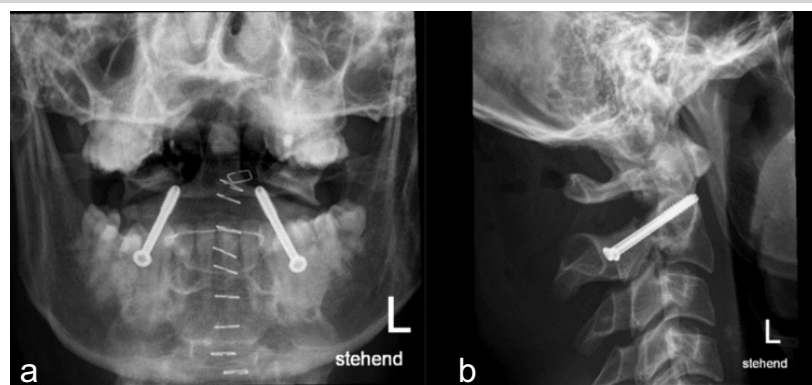


Figure 4: Immediate post-operative radiographs. (a) Anteroposterior view showing symmetric bilateral screw placement. (b) Lateral view showing restored C2–C3 alignment with kyphotic angulation corrected to <5°.

progressively closing the residual fracture gap (Fig. 3b and c). This combined traction and Penfield-assisted technique achieved near-anatomic alignment with fracture gaps reduced to <1 mm and angulation corrected to approximately $3-5^\circ$ (Fig. 3b and c).

Guidewires (2.0 mm) were placed bilaterally (Fig. 3d and e), followed by cannulated 3.5 mm cortical screws (Fig. 3f): right side 34 mm (11 mm thread), left side 36 mm (12 mm thread). Progressive tightening achieved interfragmentary compression with bicortical purchase. Following traction release, alignment remained stable, confirming adequate fixation (Fig. 3g and h). Operative time was 70 min; estimated blood loss was <50 mL with no intraoperative complications.

A rigid Aspen cervical collar was applied postoperatively for 6 weeks.

Post-operative course and follow-up

The patient was extubated without complications and discharged on post-operative day 6. Post-operative radiographs confirmed bilateral screw placement with kyphotic angulation corrected to $<5^\circ$ and fracture gap reduced to <1 mm (Fig. 4a and b).

Recovery was uneventful. The cervical orthosis was discontinued at 6 weeks, 50% work capacity was achieved at 3 months, and full work capacity (100%) with near-normal cervical rotation ($70-75^\circ$ bilaterally, $>85\%$ of normative values) was restored by 6 months. Clearance for contact sports, including ice hockey, was granted at 6 months (Fig. 5a and b).

Sequential radiographs demonstrated progressive healing, with early callus formation at 6 weeks (Fig. 5c and d), bridging consolidation at 3 months (Fig. 5e and f), and solid bony union at 6 months (Fig. 5g and h). Mild physiologic settling ($2-3^\circ$ increased kyphosis) was observed at 3 months but stabilized within acceptable parameters. No hardware failure, screw loosening, or implant migration occurred.

At 1-year follow-up, the patient remained asymptomatic with full work capacity and unrestricted athletic activity. Physical examination demonstrated painless cervical range of motion (chin-sternum distance 1–13 cm, bilateral head rotation 90°). Radiographs confirmed stable hardware and maintained consolidation but showed progressive C2/3 degenerative changes including anterior osteophyte formation and disc space narrowing (Fig. 5i and j).

Functional flexion-extension radiographs at 13 months (Fig. 6) demonstrated preserved segmental mobility at C2/3 without pathological instability. A 2 mm anterolisthesis at C2/3 was

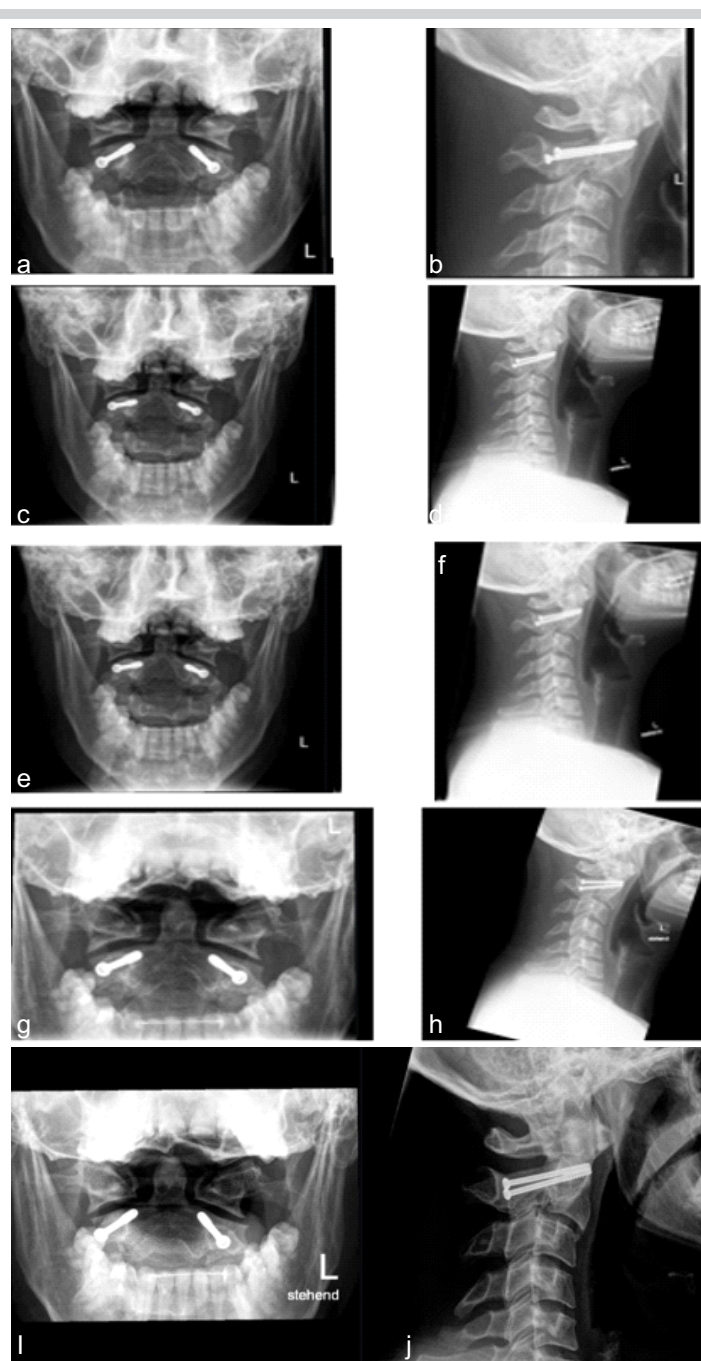


Figure 5: Sequential radiographic follow-up at 2 weeks (a and b), 6 weeks (c and d), 3 months (e and f), 6 months (g and h), and 1 year (i and j). Progressive fracture healing from early callus formation to solid bony union. Progressive C2/3 degenerative changes are evident at 1 year (i and j).

noted but remained stable during dynamic imaging, confirming that the motion-preserving objective was achieved despite degenerative changes.

Discussion

We present a rare case of bilateral isthmus screw fixation for an unstable Type IIa Hangman's fracture, with objective documentation of preserved C2/3 motion at 13-month follow-

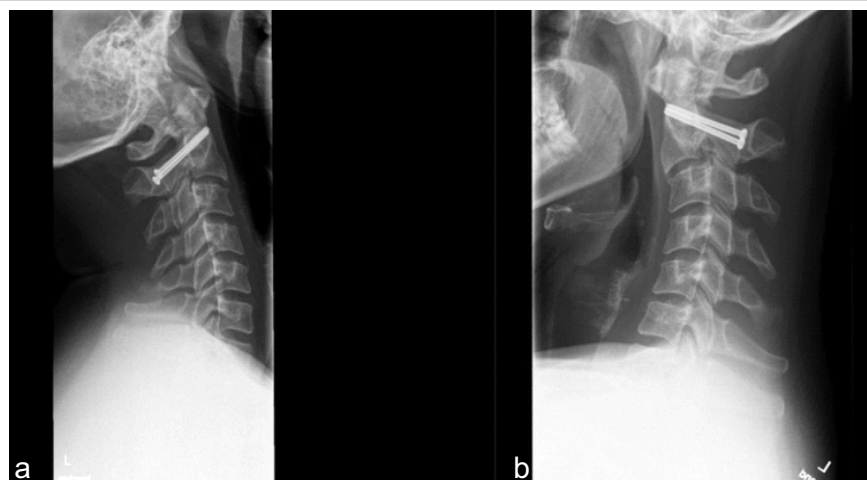


Figure 6: Functional flexion-extension radiographs at 13 months postoperatively. (a) Flexion view. (b) Extension view. Preserved C2/3 segmental motion without pathological instability. Stable 2 mm anterolisthesis at C2/3.

up. Our patient achieved solid osseous union at 6 months and excellent functional outcomes, consistent with the high fracture union rates reported in previous clinical series of direct pars/isthmus screw fixation [10,11]. No complications occurred, including no vertebral artery injury, hardware failure, or neurological deterioration.

Compared with the published literature, the present case is most consistent with posterior direct pars/isthmus fixation as originally described by Judet et al. [9] and subsequently reported by Verheggen and Jansen [18] and Bristol et al. [19]. Bristol et al. [19] described direct C2 pars screw fixation without intervertebral fusion, supporting the feasibility of motion-preserving stabilization in selected patients. ElMiligui et al. [10] reported transpedicular fixation, while Li et al. [12] systematically reviewed the management of Hangman's fractures and Schleicher et al. [5] reviewed traumatic spondylolisthesis of the axis.

What distinguishes the present case is the addition of objective dynamic flexion–extension assessment at 13 months, documenting preserved C2/3 motion despite progressive C2/3 degenerative changes.

Recent reviews and clinical studies discuss direct isthmus fixation as a safe option for appropriately selected patients [11,20,21,22]. However, the evidence base consists primarily of small clinical series and observational studies, and objective range-of-motion data are rarely reported.

Successful application requires careful patient selection. Pre-operative CT should assess individual C2 isthmus dimensions and the feasibility of the planned screw trajectory [23], whereas spinal canal dimensions and vertebral artery anatomy require careful evaluation [13,24,25]. Ideal candidates are selected according to fracture stability, anatomical suitability, bone

quality, and functional requirements [3,5].

Our hybrid reduction technique – combining Mayfield traction with intraoperative Penfield dissector–assisted open reduction – was essential for achieving near-anatomic alignment in this Type IIa fracture with significant angulation, where traction alone proved insufficient. In contrast to prolonged skeletal traction, reduction was performed intraoperatively under fluoroscopic guidance, with controlled traction supplemented by direct Penfield-assisted manipulation to correct residual kyphotic angulation. Compared to ACDF, direct isthmus fixation avoids intentional C2–C3 fusion but demands technical expertise and meticulous pre-operative planning [8,21].

Importantly, although functional flexion-extension imaging at 13 months confirmed preserved segmental mobility at C2/3, progressive degenerative changes with osteophyte formation were observed radiographically. This post-traumatic disc degeneration – despite successful non-fusion fixation – highlights a potential limitation of this technique in Type IIa fractures where the initial flexion-distraction mechanism may cause irreversible disc and ligamentous injury. Whether the degree of initial displacement correlates with long-term degeneration warrants further study.

Key limitations include the single-case design. Multicenter registries with standardized outcome measures and long-term dynamic imaging are needed to validate motion preservation claims and establish whether this technique offers durable advantages over fusion.

Conclusion

Bilateral dorsal isthmus screw fixation achieved solid bony union, excellent functional outcomes, and confirmed motion preservation at 13 months in a 26-year-old patient with an unstable Type IIa Hangman's fracture. Progressive C2/3 degenerative changes despite preserved segmental mobility warrant further investigation, particularly regarding long-term implications in fractures with significant initial angulation.

Clinical Message

In young, active patients with unstable Type IIa Hangman's fractures and favorable anatomy, bilateral dorsal isthmus screw fixation should be considered a motion-preserving alternative to fusion, though patients should be counseled about possible progressive post-traumatic degenerative changes.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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