

Halo-Femoral Traction and Staged Surgical Correction for Severe Rigid Adult Scoliosis: A Case Report

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Case Report

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Abstract

Background: Surgical correction of severe rigid adult spinal deformities (ASD) with Cobb angles exceeding 100° is highly challenging due to risks of neurological injury and poor spinal flexibility. Preoperative halo-femoral traction enhances spinal compliance, facilitating safer staged corrective surgery. Few cases of this procedure for curvatures approaching 150° have been reported.

Case Presentation: A 24-year-old female presented with severe right thigh and knee pain secondary to a 148° rigid thoracolumbar kyphoscoliosis. Initial imaging revealed minimal flexibility (bend correction to 94°) without neural compromise. The patient underwent continuous halo-femoral traction for several weeks to improve spinal flexibility. The patient was managed via a sequential two-step protocol: initially, under anesthesia, halo and femoral pins were placed to apply continuous traction for maximizing spinal flexibility. Subsequently, the patient underwent definitive single-stage posterior spinal instrumentation and deformity correction. Intraoperative neuromonitoring was utilized throughout to ensure neurological safety. Continuous multi-modal intraoperative neuromonitoring (IONM), including somatosensory-evoked potentials (SSEPs) and motor-evoked potentials (MEPs), was utilized throughout all two surgical stages. No significant or sustained changes in SSEP or MEP signals were observed during the corrective maneuvers, supporting the early detection of potential neurological compromise and guiding safe deformity correction.

Conclusion: Postoperatively, the patient achieved significant correction with a final Cobb angle of approximately 50°, accompanied by marked pain relief, improved truncal balance, and enhanced functional status as measured by clinical video-based clinical observation of gait. Radiographs at 6 weeks and subsequent follow-ups demonstrated stable fusion and sustained alignment. No neurological deficits or major complications were observed. This case illustrates the feasibility of utilizing prolonged halo-femoral traction combined with a carefully planned surgical algorithm in the management of extreme rigid adult scoliosis. The technical and strategic framework provided herein may inform clinical practice guidelines and warrants further investigation in larger cohorts.

1. Background

Surgical correction of severe, rigid adult spinal deformity (ASD) with curvatures exceeding 100° poses a formidable challenge, as single-stage procedures carry a high risk of iatrogenic neurological injury [1]. Preoperative halo-femoral traction is a cornerstone of staged management, designed to enhance spinal column compliance and mitigate the forces required for definitive correction, thereby improving safety [2, 3].

Despite its established utility, the literature lacks granular protocols detailing the integrated application of prolonged traction and multi-stage surgery for patients at the apex of the deformity spectrum specifically, those with Cobb angles approaching 150°. The novelty of this case report is its exposition of a systematic, two-stage surgical algorithm successfully applied to such an extreme case. By providing a detailed technical and strategic blueprint, this study addresses a critical gap in evidence-based practice.

It offers a reproducible framework that can inform and refine therapeutic strategies for this uniquely complex patient cohort, pushing the boundaries of safe and effective spinal reconstruction.

2. Case Presentation

2.1. Patient Information

A 24-year-old female was admitted to the orthopedic surgery department in September 2025 with a chief complaint of persistent pain in the right thigh and knee. She remained hospitalized for 57 days, undergoing a comprehensive two-step treatment protocol that included continuous halo-femoral traction to maximize spinal flexibility before definitive posterior surgical intervention. A detailed chronological overview of the patient's clinical course, interventions, and follow-up is summarized in Table 1.

Table 1
Clinical Timeline of Interventions and Follow-up

Timeline	Clinical Event
Day 0	Hospital admission and baseline clinical/radiographic evaluation.
Day 1	Application of halo ring and distal femoral pins under anesthesia; initiation of continuous traction (6 kg halo / 6 kg per femur).
Day 8	Transition to an intermittent (alternating) 4 kg traction protocol to ensure patient tolerance.
Day 11	Definitive single-stage posterior spinal fusion (T9-L3) with intraoperative neuromonitoring.
Day 18	Postoperative physical rehabilitation protocol initiated.
Day 57	Hospital discharge; patient achieved independent ambulation.
6 Months	Postoperative follow-up: stable clinical alignment, sustained pain relief, and maintenance of radiographic correction.

The patient's lower extremity pain was considered to have a multifactorial etiology, likely clinically associated with the severe spinal deformity, pelvic obliquity, and resulting compensatory mechanism. Clinically, the patient exhibited severe truncal imbalance and a prominent, severe right-sided rib hump. The patient had no history of prior surgical interventions for this condition.

Initial radiographic evaluation included standing anteroposterior and lateral full-spine X-rays, which demonstrated a severe, rigid thoracolumbar kyphoscoliosis. The primary curve measured 148° from the T4 superior endplate to the L5 inferior endplate. Flexibility of the deformity was assessed with supine side-bending radiographs, which confirmed its rigid nature, showing limited correction to only 94°. Pre-operative Magnetic Resonance Imaging (MRI) of the entire spine was performed to assess intraspinal anatomy, rule out congenital anomalies, and detect any neural element compression that could complicate surgical instrumentation (Fig. 1). In addition, preoperative anteroposterior radiograph of the

cervical spine was obtained to evaluate baseline alignment and vertebral anatomy prior to halo-femoral traction (Fig. 2).

2.2. Physical Examination

On physical examination, the patient was alert and oriented. A severe, right-sided thoracolumbar prominence (rib hump) was grossly visible, consistent with the rotational component of her deformity. She exhibited significant coronal and sagittal imbalance, with a noticeable pelvic obliquity and compensatory right knee and thigh pain. The Adam's forward bend test markedly accentuated the rib deformity. A comprehensive neurological assessment of the lower extremities revealed intact motor function (5/5 strength in all myotomes), normal sensation to light touch, and symmetric 2+ deep tendon reflexes. There were no upper motor neuron signs, such as clonus or a positive Babinski reflex. The skin overlying the spine was unremarkable, with no cutaneous stigmata suggestive of underlying congenital or syndromic etiologies.

Given the extreme magnitude of the 148° kyphoscoliosis, a preoperative pulmonary assessment was conducted. Pulmonary function tests (PFTs) revealed a moderate restrictive ventilatory defect, which is consistent with severe thoracic deformity. Despite this restrictive pattern, the patient maintained a normal oxygen saturation of 97% on room air at rest and exhibited no overt signs of respiratory distress during the clinical evaluation.

2.3. Diagnostic Assessment

The primary diagnosis was considered most consistent with idiopathic scoliosis after exclusion of identifiable congenital, neuromuscular, and syndromic causes. The diagnostic reasoning was based on the patient's age of presentation, the absence of congenital vertebral malformations on imaging, and a normal neurological examination, which collectively made idiopathic scoliosis the most likely etiology. Other diagnoses, such as neuromuscular or syndromic scoliosis, were considered but deemed less likely due to the lack of supporting clinical or radiographic findings.

The primary clinical challenge was the magnitude (148°) and rigidity (correction to only 94° on bending films) of the deformity. Such severe, stiff curves present a high risk of neurological injury (e.g., spinal cord ischemia or traction injury) during a single-stage surgical correction. The risk of implant failure, pseudarthrosis (non-union of the fusion), and suboptimal correction is also significantly elevated. Therefore, a sequential two-step approach (preoperative traction followed by single-stage definitive surgery) was deemed necessary to gradually and safely improve spinal flexibility before the final correction.

2.4. Therapeutic Interventions

The patient was managed via a sequential two-step protocol aimed at maximizing spinal flexibility and ensuring neurological safety prior to definitive correction:

Phase 1 (Pre-operative Halo-Femoral Traction)

Following the application of a halo ring and distal femoral pins, a robust traction protocol was initiated with a weight of 6 kg applied to the halo and 6 kg to each femur. After an initial 7-day period of continuous traction, the protocol was transitioned to a 4 kg intermittent (alternating) traction system. This strategic adjustment was implemented to optimize soft tissue release while ensuring patient tolerance and mitigating potential traction-related complications (Fig. 4).

Phase 2 (Definitive Posterior Surgery)

Following the traction phase, definitive surgery was performed on in September 2025. Under general anesthesia and with the patient in the prone position, a standard midline incision was made extending from T8 to L3. Following meticulous subperiosteal dissection of the paraspinal muscles to expose the laminae and spinous processes, the severe apex of the kyphoscoliosis was visualized. Pedicle screws were instrumented bilaterally from T9 to L3. Deformity correction was achieved through the placement of bilateral rods and the application of careful compression maneuvers to obtain partial, safe alignment correction. Continuous multi-modal intraoperative neuromonitoring (IONM), including somatosensory-evoked potentials (SSEPs) and motor-evoked potentials (MEPs), was utilized throughout the procedure, with no significant signal degradation observed. Posterior spinal fusion was then completed using bone grafts over the decorticated posterior elements. A subfascial surgical drain was inserted, and the wound was closed in anatomical layers. The patient tolerated the procedure well, and no intraoperative complications were encountered.

The patient's post-operative course was marked by progressive recovery. A CT scan performed prior to discharge confirmed significant reduction in the deformity angle and stable hardware placement. Notably, the patient achieved independent ambulation without assistive devices 57 days after the final surgery, demonstrating excellent functional recovery. Postoperative radiograph obtained three days after the final correction and posterolateral fusion demonstrated satisfactory coronal alignment and intact pedicle-screw construct (Fig. 5). The patient's post-operative course demonstrated significant clinical and radiographic improvements consistent with successful management of severe rigid adult scoliosis. Radiographically, the final Cobb angle was substantially reduced from the preoperative 148° to approximately 50°, representing roughly a 65% correction rate. This aligns with published data in severe scoliosis surgery, where correction rates of 50–65% are considered favorable and achievable without excessive neurological risk.

Clinically, the patient experienced marked reduction in right thigh and knee pain corresponding to decreased compensatory pelvic obliquity and truncal imbalance. Clinical photographs clearly illustrate these substantial improvements, as seen in the preoperative (A) and postoperative (B) images (Fig. 6). Functional status improved significantly, mirroring the radiographic correction.

6-Month Follow-Up and Functional Outcomes

At the 6-month postoperative visit, the patient reported substantial relief from lower extremity discomfort. Due to the retrospective nature of this report, standardized patient-reported outcome measures (PROMs) such as ODI or SRS-22 were not routinely recorded. However, objective functional recovery was documented via physical examination and clinical video-based clinical observation of gait (see Supplementary Video 1). The analysis demonstrated restoration of independent ambulation without the need for assistive devices, correction of the preoperative pelvic obliquity, and marked improvement in both coronal and sagittal global balance. Soft-tissue and postural photographs further confirmed the resolution of the severe right-sided rib hump and truncal decompensation, with sustained improvements visibly evident at both 6 weeks and 6 months postoperatively (Fig. 6A-C). Radiographically, standing full-spine X-rays at 6 months demonstrated the maintenance of the initial deformity correction with a stable Cobb angle of approximately 50°, showing no evidence of hardware failure, pseudarthrosis, or junctional kyphosis.

Coronal and sagittal balance parameters including sagittal vertical axis (SVA), radiographic shoulder height, and coronal balance distance improved to within normal or near-normal ranges, signifying effective global spinal realignment.

Compliance with post-operative protocols was critical to optimize outcomes. The patient adhered well to a customized bracing regimen and participated consistently in a tailored physical therapy program focused on strengthening paraspinal musculature and improving posture. These interventions likely contributed to maintenance of spinal correction, pain control, and functional gains during the rehabilitation phase. Potential complications commonly reported after surgery for severe rigid scoliosis include postoperative coronal imbalance, implant-related issues, pulmonary complications, and neurological deficits. None of these adverse events were observed in this patient throughout follow-up, highlighting a favorable clinical course following the two-step protocol with preoperative halo-femoral traction.

In summary, the patient's post-operative course illustrates a favorable outcome in managing extreme rigid adult scoliosis through careful multidisciplinary planning, preoperative traction, and single-stage definitive surgery, vigilant clinical monitoring, and structured rehabilitation focused on pain reduction, functional improvement, and deformity stabilization.

3. Discussion and Conclusions

Severe rigid adult spinal deformities with curvatures approaching 150° present exceptional surgical challenges due to the risk of neurological injury, implant failure, and limited spinal flexibility [4]. This case report describes a systematic, staged surgical approach incorporating prolonged preoperative halo-femoral traction to safely and effectively address an extreme 148° thoracolumbar kyphoscoliosis in a young adult. The outcomes demonstrate that, even at this severity, substantial deformity correction can be achieved while maintaining neurological integrity [5].

A key strength of this approach lies in its gradual, biomechanically sound strategy that reduces the forces needed for realignment. The extended halo-femoral traction phase incrementally stretches contracted soft tissues and partially remodels bony constraints, thus improving passive spinal flexibility prior to any invasive surgery [6, 7]. This preparatory step differentiates our approach from many single-stage surgeries or limited traction protocols, offering a safer surgical environment. The surgical algorithm anterior release to improve anterior column mobility, posterior release with instrumentation to establish a robust fixation foundation, and final controlled deformity correction synergistically optimizes spine mobility and correction potential. Additionally, continuous intraoperative neuromonitoring throughout all stages enhanced neurological safety by enabling real-time detection of spinal cord stress [4]. This comprehensive staged intervention allowed for maximal deformity correction without intraoperative complications. The ability of the patient to ambulate independently in less than two months, despite the extreme magnitude of the initial curve (148°), validates the efficacy of this combined traction and staged-surgery protocol compared to high-risk vertebral column resection (VCR) procedures.

Nonetheless, this approach has limitations. The prolonged preoperative traction and multi-stage surgery necessitate an extended hospitalization period, increasing healthcare resource utilization and requiring patient cooperation and tolerance over weeks. Furthermore, this report centers on a single patient, limiting broader generalizability. Our protocol may need adaptation in patients with different curve morphologies or comorbidities. Also, although follow-up beyond the immediate postoperative period is ongoing, long-term outcomes including fusion rates and functional recovery remain to be fully established. This emphasizes the need for further studies with larger cohorts and controlled designs to confirm the reproducibility and safety of this strategy [7].

In terms of clinical practice implications, this case report provides an evidence-based framework supporting the use of prolonged halo-femoral traction integrated with a staged surgical approach for extreme rigid adult scoliosis. Existing clinical practice guidelines (CPGs) for adult spinal deformity highlight the benefits of staged interventions and traction for severe curves but often lack detailed protocols for cases with curves near 150° [7]. By detailing each surgical stage, specifying traction duration, and emphasizing neuromonitoring, this report addresses these gaps. Surgeons managing similarly severe adult deformities may adopt or adapt this algorithm to optimize patient safety and outcomes. Furthermore, the case underscores the importance of individualized planning in spinal deformity surgery, particularly in rare, extreme presentations.

A notable aspect of this case is the decision to perform a short-segment apical fusion (T9-L3) despite the structural curve extending from T4 to L5. This targeted posterior instrumentation strategy was deliberately chosen to correct the most rigid and prominent apex of the deformity. By limiting the fusion levels, we aimed to minimize operative time, reduce intraoperative blood loss, and lower the risk of neurological complications associated with extensive multi-level fusions, while successfully preserving the mobility of the adjacent uninstrumented segments.

This case also proposes a testable hypothesis: prolonged preoperative halo-femoral traction combined with multi-stage surgical correction improves spinal flexibility, reduces neurological complication rates, and enhances deformity correction in patients with severe rigid scoliosis (Cobb angle > 140°) compared to single-stage procedures or shorter traction durations. This hypothesis could be evaluated in future prospective cohort studies or randomized controlled trials, assessing outcomes including Cobb angle correction, neurological safety, surgical complication rates, and patient-centered functional outcomes.

In conclusion, managing extreme rigid adult scoliosis requires nuanced, multi-disciplinary strategies that balance maximal correction with patient safety. This report demonstrates that a prolonged traction and staged surgical protocol can expand the surgical treatment frontier for these challenging cases, providing a replicable pathway for improved outcomes. Such detailed case evidence is essential to guide refinements in future CPGs and spur clinical research into optimizing treatment for severe adult spinal deformities.

A limitation of this case report is its retrospective nature, which precluded the prospective collection of standardized patient-reported outcome measures (PROMs) such as the SRS-22 or Oswestry Disability Index (ODI). However, the objective clinical improvements, including the restoration of independent ambulation and global spinal balance, were visibly documented through meticulous physical examinations and postoperative video-based clinical observation of gait.

Patient Perspective

Before the treatment, the severe curvature of my spine and the constant pain in my right leg severely limited my daily activities and affected my self-confidence. When the doctors suggested the halo-femoral traction, I was initially anxious. The first few days in traction were uncomfortable, but as I got used to it, I could actually feel the pressure on my back easing. After the final surgery, the recovery was challenging, but being able to stand straighter and walk without that severe leg pain just a few weeks later was truly life-changing. I am highly satisfied with the outcome and grateful for the staged approach that made this possible.

4. Conclusions

Managing patients with severe rigid adult scoliosis requires precise, staged approaches. This study's findings demonstrate that prolonged halo-femoral traction combined with surgery can achieve significant Cobb angle correction while preserving neurological safety and improving the patient's quality of life. This method provides a practical and reproducible framework for spine surgeons that could inform clinical guidelines. Despite the limitation of a single case report, the encouraging results warrant further validation in future studies.

Abbreviations

- **AP:** Anteroposterior

- **ASD:** Adult Spinal Deformity
- **CPG:** Clinical Practice Guidelines
- **CT:** Computed Tomography
- **EBL:** Estimated Blood Loss
- **IONM:** Intraoperative Neuromonitoring
- **MEP:** Motor-Evoked Potentials
- **MRI:** Magnetic Resonance Imaging
- **ODI:** Oswestry Disability Index
- **PFT:** Pulmonary Function Test
- **PROM:** Patient-Reported Outcome Measure
- **SSEP:** Somatosensory-Evoked Potentials
- **SVA:** Sagittal Vertical Axis
- **VCR:** Vertebral Column Resection

Declarations

Ethics approval and consent to participate

This study was performed in line with the principles of the Declaration of Helsinki. Ethical approval was waived by the local Ethics Committee of Mashhad University of Medical Sciences in view of the retrospective nature of the report and the fact that all procedures performed were part of routine clinical care. Written informed consent to participate was obtained from the patient.

Consent for publication

Written informed consent was obtained from the patient for the publication of this case report and any accompanying radiographic images, clinical photographs, and supplementary videos. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Availability of data and materials

All data generated or analyzed during this study are included in this published article and its supplementary information files.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

HA was the primary surgeon, conceptualized the case report, and critically revised the manuscript. AAT and EK collected the clinical data, conducted the literature review, and drafted the initial manuscript. EK analyzed the radiographic images and prepared the figures and supplementary video. All authors read and approved the final manuscript.

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Generative AI Declaration

The authors used Gemini 3.1 Pro (Google) during the preparation of this work solely for language editing and improving the readability of the text. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Figures



Figure 1

Anteroposterior (AP) chest and full-spine radiograph showing a severe rigid thoracolumbar kyphoscoliosis with a primary curve measuring approximately 148° (T4–L5). The spine demonstrates

marked rotational deformity and rib hump prominence on the right side, consistent with the patient's truncal imbalance and pelvic obliquity before traction and surgery.



Figure 2

Preoperative anteroposterior radiograph of the cervical spine demonstrating normal vertebral alignment and preserved intervertebral disc spaces. This imaging was obtained to assess cervical spine integrity before initiation of halo-femoral traction, ensuring safe application of the halo device.



Figure 3

Figure 4. Radiograph after 5 days of continuous halo-femoral traction, showing partial correction of the thoracolumbar curvature. The spinal column demonstrates increased flexibility and reduced rigidity compared to pre-traction images, demonstrating partial radiographic correction following gradual preoperative traction prior to definitive surgery.

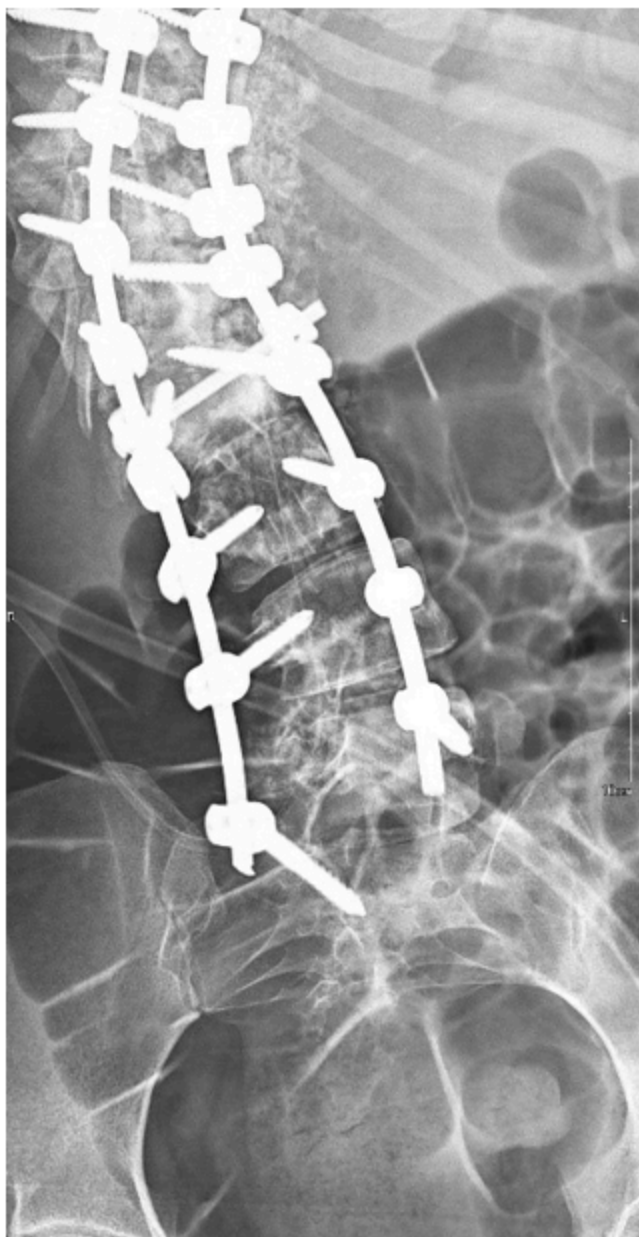


Figure 4

Figure 5. Final postoperative anteroposterior radiograph demonstrating the corrected alignment of the thoracolumbar spine following staged surgical correction and posterolateral fusion. The pedicle screw-rod construct extends from T9 to L3, with stable fixation with stable fixation and no evidence of implant failure or malalignment.



Figure 5

Figure 6. Clinical photographs of the patient before and after definitive surgical correction with preoperative halo-femoral traction. (A) Preoperative image highlighting a severe right-sided rib hump and truncal imbalance due to a 148° rigid thoracolumbar kyphoscoliosis. (B) Postoperative image at 6 weeks follow-up demonstrating substantial improvement in spinal alignment, correction of the truncal prominence, and improved posture. (C) Postoperative image at the 6-month follow-up, confirming the sustained correction of the rib hump, maintenance of global truncal balance, and stable overall alignment.