Successful Correction of Severe Early-Onset Kyphoscoliosis Using Navigation-Assisted Halo-Pelvic Traction and Posterior Spinal Surgery: A Case Report from Oman

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Abstract

Early-onset scoliosis (EOS) presents substantial management challenges, particularly in severe and rigid deformities that progress despite non-operative treatment. Halo-pelvic traction (HPT) can produce gradual correction, but its use in children younger than 5 years is technically demanding due to narrow pelvic bone corridors. We report the case of a 2 year old boy with progressive idiopathic EOS who failed elongation-derotation-flexion casting and subsequently required revision posterior vertebral tethering due to tether breakage. The deformity advanced to severe thoracolumbar kyphoscoliosis exceeding 90°. Navigation-assisted HPT was initiated using supraacetabular and anterior superior iliac spine pins placed under navigation guidance. Gradual distraction at 3 mm/day was performed over 52 days, followed by Mehta casting and later posterior spine surgery utilizing active apex control. Significant correction was achieved without neurological complications. This case highlights the utility of navigation-assisted HPT as a safe and effective preparatory strategy for severe early-onset spinal deformity in children younger than five years of age. The use of navigation-assisted HPT in children younger than five years is rarely reported and is particularly relevant because of the limited pelvic bone corridors in this age group.

Introduction

Early-onset scoliosis (EOS) represents a distinct clinical challenge due to its potential for rapid progression and its detrimental effects on thoracic growth and pulmonary development.[1] As deformities progress, particularly in very young children, the combination of spinal curvature, thoracic cage distortion, and reduced lung volumes increases the risk of long-term cardiopulmonary morbidity.[1,2]

Growth-preserving strategies, such as serial elongation-derotation-flexion (EDF) casting, bracing, and vertebral body tethering have become established early interventions; however, their effectiveness is limited in rigid curves exceeding 45° or when structural wedging and stiffness are severe.[2] In such cases, gradual correction techniques, including halo-pelvic traction (HPT), provide an important adjunct by enhancing curve flexibility and reducing the risks associated with single-stage correction.[3,4]

Originally introduced in the 1970s, halo-pelvic traction has evolved significantly, with modern systems demonstrating improved tolerance, stability, and safety.[3,5,6] The incorporation of navigation technology has further enhanced accuracy in pelvic pin placement, addressing concerns regarding narrow pelvic bone corridors in children younger than five years of age.[7,8] This advancement has renewed the role of HPT as a preparatory modality, allowing safer staged correction of severe, rigid deformities before growth-friendly posterior spinal procedures.[4,9,10] A recent report described CT-based navigation for HPT pelvic pin placement in a 15-year-old adolescent; published experience with navigation-assisted HPT in children younger than 5 years remains extremely limited.[7]

This case report illustrates the successful use of navigation-assisted HPT in a 2-year-old child with severe idiopathic EOS, highlighting how modern guidance systems and staged management can optimize outcomes while minimizing neurological and pulmonary risk. Although navigation-guided HPT has been described, published experience with navigation-assisted pelvic pin placement in children younger than five years remains very limited; this case highlights its feasibility in this particularly challenging age group.[7]

Case Report

A healthy male infant presented at six months of age with a noticeable left thoracic prominence. No neurological deficits or syndromic features were identified. Initial radiographs revealed a 60° double thoracic curve, **Figure 1**, and MRI at 15 months excluded intraspinal anomalies. Despite serial elongation-derotation-flexion (EDF) casting followed by Minerva bracing, **Figure 2**, the deformity progressed to 80° by 22 months. Posterior vertebral body tethering (T3–T4, T9, and T12–L1) was subsequently performed overseas; however, tether breakage occurred, necessitating revision surgery. Two months later, rapid progression to >90° thoracolumbar kyphoscoliosis was documented.

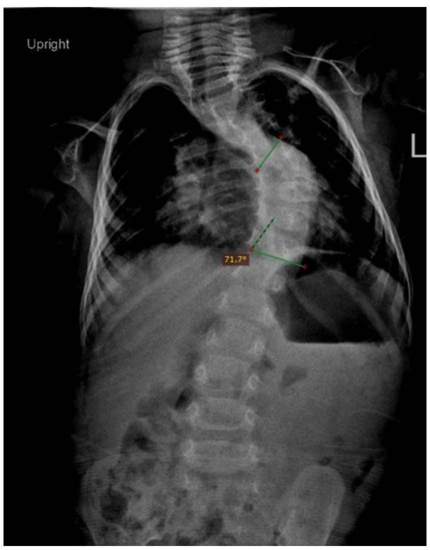

Figure 1: Initial standing radiograph at presentation showing a double thoracic curve measuring > 60°.

Figure 2: Radiograph obtained after serial elongation-derotation-flexion (EDF) casting and bracing, showing persistence of the thoracic curvature.

Preoperative assessment demonstrated a severe, rigid thoracolumbar kyphoscoliotic deformity with evident truncal imbalance, **Figure 3**. Neurological examination was normal, with full motor strength, intact sensation, and symmetrical deep tendon reflexes. Cranial nerve function was intact. No neurocutaneous stigmata or skin abnormalities were present over the spine. Limb lengths were equal, and no joint contractures were noted. These findings confirmed a structurally rigid but neurologically intact deformity.

Figure 3: Pre-HPT clinical photographs showing the rigid spinal deformity and truncal imbalance.

Radiographs confirmed a rigid thoracolumbar deformity measuring >90° with marked kyphosis, **Figure 4**. MRI excluded congenital vertebral anomalies, syringomyelia, and tethered cord. Preoperative cranial CT demonstrated adequate cortical thickness for safe halo pin placement. Serial coronal Cobb measurements were performed by the treating spine consultant using the digital Cobb-angle tool on the institutional PACS workstation. On standing AP whole-spine radiographs, the major curve was measured using the superior endplate of the maximally tilted upper end vertebra and the inferior endplate of the maximally tilted lower end vertebra; the same end vertebrae were used for serial comparison whenever clearly identifiable. Preoperative side-bending radiographs demonstrated limited correction, confirming marked structural rigidity. The major curve measured >90° before HPT, reached a best measured Cobb angle of 54° during the traction/casting phase, rebounded to 77° after HPT removal (23° loss of correction), and was subsequently controlled to 65° before definitive surgery. Following active apex control, the early postoperative Cobb angle was 33°, corresponding to a 32° (49.2%) correction from the immediate preoperative 65° measurement.

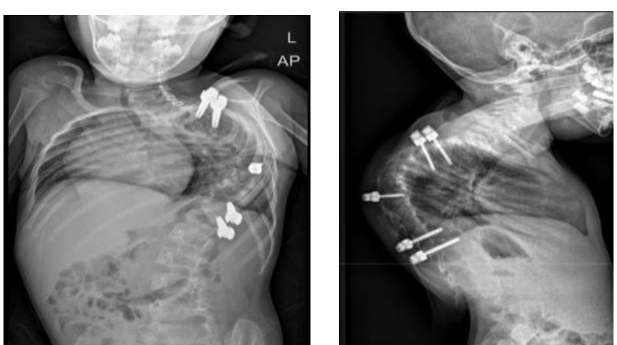

Figure 4: Standing AP and lateral radiographs obtained after posterior vertebral tethering and before HPT, demonstrating progression of the rigid thoracolumbar kyphoscoliosis and tether failure.

Given the patient's age and the severity of the deformity, navigation-assisted halo-pelvic traction (HPT) was selected to allow controlled gradual correction. HPT was applied in December 2024. Under navigation guidance, six halo pins and four pelvic pins-two supraacetabular and two anterior superior iliac spine pins—were inserted with optimal trajectory and depth, **Figure 5**. An Ilizarov-based construct linked the halo and pelvic rings, **Figure 6**. Distraction commenced on postoperative day 4 at a rate of 3 mm per day and continued for 29 days, resulting in gradual spinal elongation and partial correction. The 3 mm/day distraction rate was chosen to achieve gradual correction while allowing soft-tissue and neural adaptation with serial neurological assessment; this is within the 2–3 mm/day range reported in contemporary modified halo-pelvic distraction protocols.[11] Minor pin-site erythema resolved with local care. During traction, additional treatment-related issues included transient pain during distraction, occasional serous pin-site discharge with localized skin irritation, and constipation-associated dysuria. These were managed with analgesia, local pin-site care, pediatric review, bowel treatment, and continued physiotherapy, without deep pin-site infection or neurological deficit. The HPT construct was maintained for a total of 52 days to allow soft-tissue adaptation before removal.

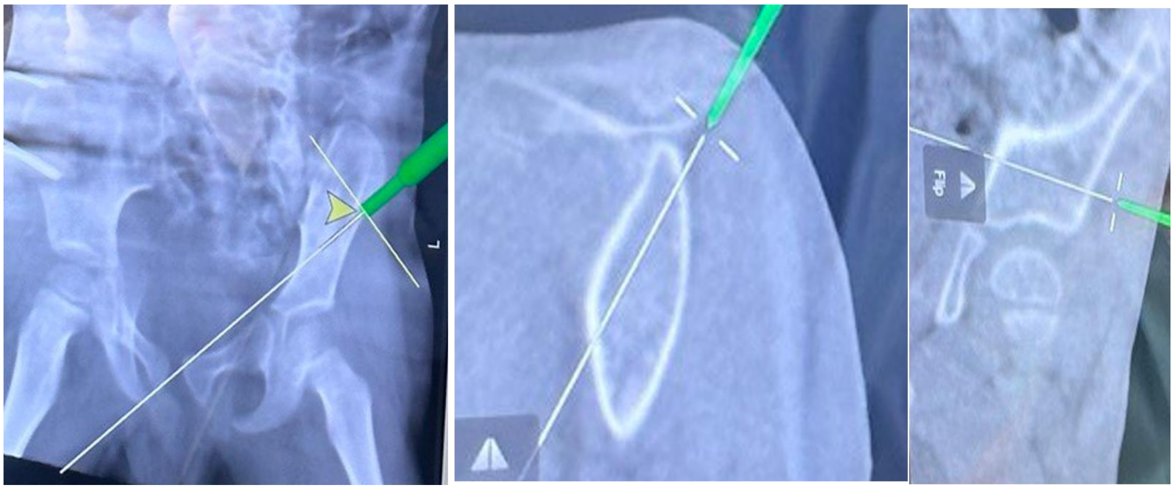

Figure 5: Intraoperative CT-based navigation views used to define safe supraacetabular/anterior iliac pelvic pin trajectories and depth.

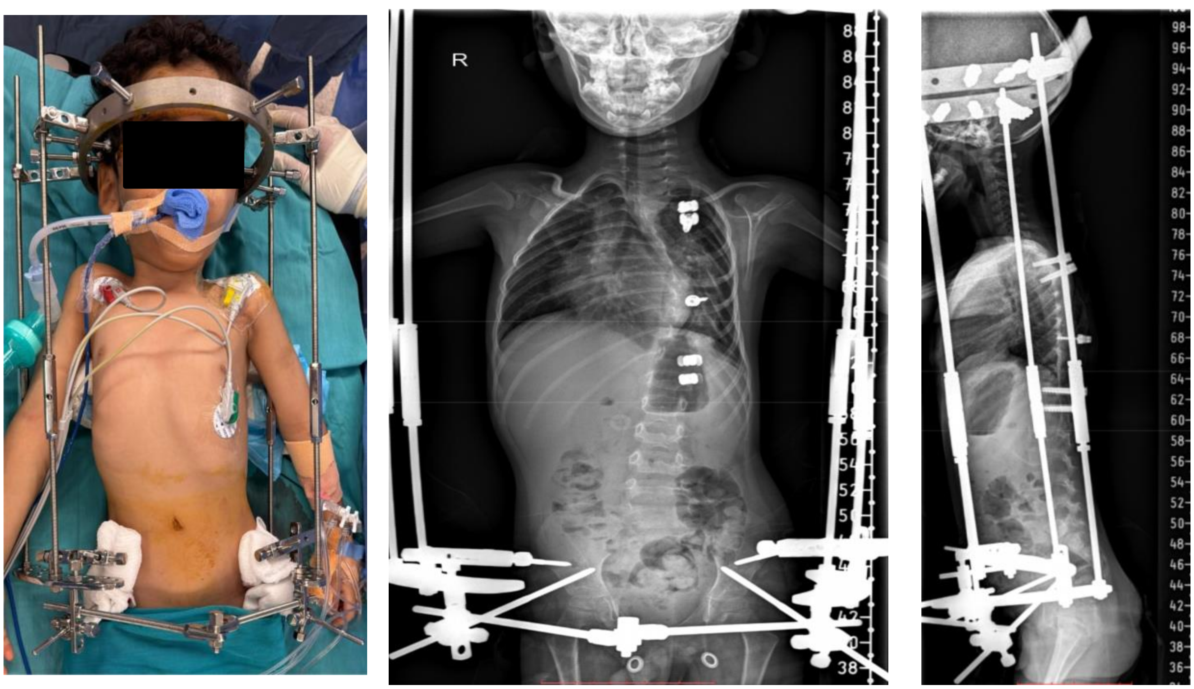

Figure 6: Intra operative Halo-pelvic traction application and interval AP/lateral radiographs during the traction phase, demonstrating gradual spinal elongation and coronal/sagittal correction.

Following traction removal, a Mehta corrective cast was applied to preserve alignment. Partial coronal rebound occurred after HPT removal **Figure 7**: the best measured Cobb angle of 54° increased to 77°, representing a 23° loss of correction. Continued corrective casting subsequently improved the curve to 65° before definitive surgery, while sagittal alignment remained stable. Given the child's age and the need to minimize the risks associated with early major spinal surgery, close monitoring was adopted. Four months later, because of the persistent severe structural deformity and its demonstrated tendency to recur despite casting, posterior spine surgery utilizing active apex control was performed using navigation-guided pedicle screws and a growth-friendly construct from T2 to L2. Intraoperative neuromonitoring was used, and no new postoperative neurological deficit was identified. Postoperative management included early mobilization and chest physiotherapy, with an ultimately favorable recovery. The immediate postoperative Cobb angle was 33°, representing a 32° (49.2%) correction from the immediate preoperative 65° measurement. The definitive operation was nevertheless physiologically demanding, with an estimated blood loss of approximately 600 mL and requirement for intraoperative packed red blood cells and fresh frozen plasma. On postoperative day 1, the child developed tachycardia with wound-dressing soakage and a hemoglobin nadir of 6.8 g/dL, requiring an additional packed-cell transfusion and ICU monitoring. He subsequently stabilized, was transferred out of ICU, and continued mobilization, chest physiotherapy, and incentive spirometry. **Figure 8** At follow-up on May 2025, standing AP and lateral radiographs demonstrated maintained overall coronal and sagittal correction with intact instrumentation and no obvious mechanical failure.

Figure 7: Sequential standing whole-spine radiographs before and after active apex control. The preoperative AP/lateral images were obtained after HPT removal and casting and demonstrate persistent coronal deformity, measuring 65° immediately before definitive surgery.

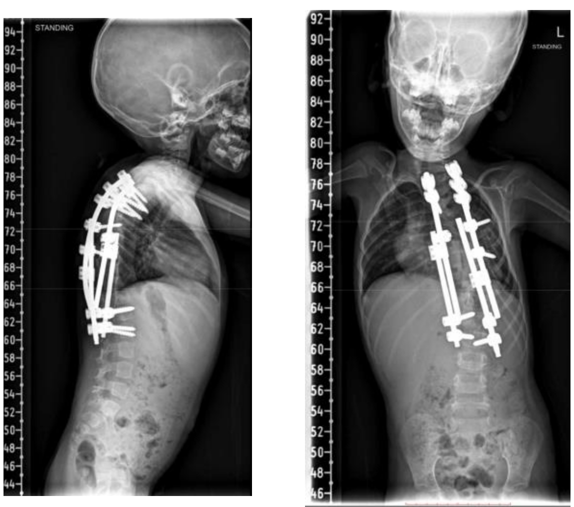

Figure 8: Clinical postoperative AP and lateral radiographs from May 2025 demonstrate a major coronal curve correction to 33° with improved overall alignment. The instrumentation from T2 to L2 remains intact, showing satisfactory placement and no evidence of mechanical failure.

Management was multidisciplinary, involving pediatric spine surgery, anesthesia/ICU, pediatrics, physiotherapy/rehabilitation, respiratory therapy, nutrition/dietetics, and nursing. Because of the patient’s young age, treatment depended on parental participation. The parents were counselled regarding the staged treatment plan, expected prolonged treatment course, and potential complications. During traction, cooperation with mobilization was initially limited at times by pain and anxiety, with occasional crying or refusal to walk; participation improved with repeated physiotherapy and parental support. Written informed consent for publication of the clinical information and images was obtained from the patient's mother.

Discussion

This case illustrates the evolving role of navigation-assisted halo-pelvic traction (HPT) in staged correction of severe early-onset kyphoscoliosis, particularly in very young children where the morphology of the iliac bone presents anatomical limitations for pelvic pin placement. The patient's deformity progressed rapidly despite EDF casting and posterior vertebral tethering-consistent with reports showing that growth-modulating strategies perform poorly in curves exceeding 45° due to vertebral wedging and structural rigidity.[1,2] A recent navigation-guided HPT case involved a 15-year-old adolescent; to our knowledge, published experience with navigation-assisted pelvic pin placement for HPT in children younger than five years remains very limited.[7]

Gradual distraction at 3 mm/day promoted controlled soft-tissue elongation and increased curve flexibility, creating a safer mechanical environment for subsequent posterior spine surgery. The literature supports staged traction as an effective method to reduce risks related to acute deformity correction, including spinal cord ischemia, neuropraxia, and pulmonary compromise.[4,9,10,12]

Although HPT generates substantial correction, meta-analyses report 27–40% mean Cobb angle reduction in rigid curves,[4] loss of alignment may occur once traction is discontinued due to elastic recoil and gravitational forces. In this case, the best measured Cobb angle during the traction/casting phase was 54°. Following HPT removal, the curve rebounded to 77°, a 23° loss of correction, and subsequent corrective casting improved it to 65° before definitive surgery. Active apex control then reduced the curve from 65° to 33°, corresponding to a 32° (49.2%) immediate surgical correction. Management must therefore balance two key priorities: delaying major surgery to minimize complications in very young children, and intervening promptly when progressive deformity threatens long-term outcomes. Close clinical and radiographic surveillance is essential, and surgery becomes necessary when recurrence is evident, ideally through growth-friendly techniques rather than definitive fusion.

Navigation significantly improved the accuracy and safety of both halo-pelvic pin placement and posterior pedicle screw insertion. Accurate placement of supraacetabular and anterior superior iliac spine pins is crucial for traction stability; navigation decreases the likelihood of cortical breach, neurovascular injury, and asymmetric loading.[5,7,8] In posterior spinal surgery, navigation mitigates the challenges posed by rotated or dysplastic pedicles, enabling precise screw positioning and improved construct stability. Studies consistently demonstrate reduced breach rates, lower revision requirements, and enhanced biomechanical integrity with navigation-assisted instrumentation.

Early ambulation during traction, initiated by the third postoperative day, was another key factor contributing to the favorable outcome. Mobilization under traction improves pulmonary function, enhances thoracic compliance, and mitigates complications such as pressure injury and venous thrombosis.[6,12] These physiological benefits were reflected in the patient's stable respiratory course despite a prolonged treatment phase.

Overall, this case reinforces the value of a multidisciplinary, navigation-assisted, staged approach for severe early-onset deformities. HPT offers controlled realignment and neurological safety, while navigation-guided active apex control consolidates these gains using growth-friendly principles. Importantly, HPT and subsequent growth-friendly reconstruction are resource-intensive and not morbidity-free; successful treatment requires careful pin-site care, serial neurological assessment, rehabilitation, pulmonary support, nutritional optimization, and close coordination across multiple departments. The latest available radiographs, obtained approximately 11 months after active apex control, showed maintained overall alignment and an intact construct without obvious mechanical failure.

Conclusion

Navigation-assisted halo-pelvic traction represents a safe and effective preparatory strategy for correcting severe early-onset kyphoscoliosis in very young children. When combined with meticulous monitoring, Mehta casting, and growth-friendly posterior spine surgery utilizing active apex control, substantial deformity correction can be achieved without neurological compromise. This staged, navigation-enhanced approach reduces technical risks, supports pulmonary function, and improves the safety and durability of correction in complex pediatric spinal deformity.

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