Three-stage correction of severe idiopathic scoliosis with limited skeletal traction during a humanitarian surgical mission: illustrative case

J. Manuel Sarmiento, MD,1,2 Jordan Fakhoury, DO,1,3 Angadh Singh,1 Cameron Hawk,1 Khalid Sethi, MD,4 and Ravi Bains, MD1,3

1Standing Straight, Inc., Orinda, California; 2Department of Pediatric Orthopedic Surgery, Morgan Stanley Children’s Hospital of New York-Presbyterian/Columbia University Irving Medical Center, New York, New York; 3Northern California Regional Spine Center, Kaiser Permanente Oakland Medical Center, Oakland, California; and 4Neurosciences and Spine Group, Vestal, New York

BACKGROUND Underprivileged and underserved patients from developing countries often present late with advanced, untreated spinal deformities. We report a three-stage all-posterior approach using limited skeletal traction with Gardner-Wells tongs (GWTs) for the management of severe idiopathic scoliosis during a humanitarian surgical mission trip.

OBSERVATIONS A 17-year-old high-school female was previously diagnosed with juvenile idiopathic scoliosis (diagnosed at age 8) and progressed to a severe 135° kyphoscoliosis. Procedural stage 1 involved spinal instrumentation and posterior releases via posterior column osteotomies from T3 to L4. She then underwent 7 days of skeletal traction with GWTs in the intensive care unit as stage 2. In stage 3, rod engagement, posterior spinal fusion, and partial T10 vertebral column resection were performed. There were no changes in intraoperative neuromonitoring during either surgery and she woke up neurologically intact after both stages of the surgical procedure.

LESSONS Skeletal traction with GWTs is a viable alternative to traditional halo-gravity traction in settings with limited resources. Three-stage spinal deformity correction using limited skeletal traction is a feasible and effective approach for managing severe scoliosis during humanitarian surgical mission trips.

https://thejns.org/doi/abs/10.3171/CASE23311

KEYWORDS pediatric spinal deformity; kyphoscoliosis; skeletal traction; Gardner-Well tongs; halo-gravity traction; humanitarian surgical mission

Pediatric spinal deformities, including idiopathic scoliosis, can significantly impact a child’s physical and emotional well-being. If scoliosis is left untreated, long-term complications include cor pulmonale, back pain, increased disability, and adverse socioeconomic effects on work and marital status.1,2 Underprivileged and underserved patients from developing countries often present late with advanced, untreated spinal deformities. For example, in a modern orthopedic surgery department at a major Indian academic medical center, approximately 30% to 40% of patients with scoliosis present late with severe rigid scoliosis, defined as a major curve >90° and <30% correction on bending radiographs.3 These rigid spinal deformities were historically managed with combined anterior and posterior approaches preceded by some form of skeletal traction to provide a more gradual, safer correction. Halo-gravity traction (HGT) is the favored form of skeletal traction in the Western hemisphere,4 whereas our colleagues in the Eastern hemisphere have made great advances with halo-pelvic traction.5 Over the past decade, advances in modern instrumentation, intraoperative neuromonitoring (IONM), and deformity correction techniques, including various forms of spinal osteotomy, have shifted the treatment paradigm for severe scoliosis to an all-posterior approach.6 We report a three-stage all-posterior approach using limited skeletal traction with Gardner-Well tongs (GWTs) for the management of severe idiopathic scoliosis during a humanitarian surgical mission trip.

Illustrative Case

A 17-year-old high-school female, who was previously diagnosed with juvenile idiopathic scoliosis (initially diagnosed at age 8) that

ABBREVIATIONS 3D = three-dimensional; AP = anteroposterior; CT = computed tomography; DAR = deformity angular ratio; GWT = Gardner-Wells tongs; HGT = halo-gravity traction; IONM = intraoperative neuromonitoring; VCR = vertebral column resection.

INCLUDE WHEN CITING Published September 25, 2023; DOI: 10.3171/CASE23311.


© 2023 The authors, CC BY-NC-ND 4.0 (http://creativecommons.org/licenses/by-nc-nd/4.0/)
progressed to a severe kyphoscoliosis, presented to the biannual spinal deformity clinic at SGL Super Specialty Charitable Hospital in Jalandhar, India. She had never been braced or underwent formal physical therapy. She denied complaints of pain, gait instability, or bowel/bladder incontinence. However, she did endorse some shortness of breath after strenuous exercise at school. Besides her spinal deformity, she had no other relevant past medical history, surgical history, or medication use. Forced expiratory volume and forced vital capacity values within the last year were 40% and 44% of normative values, respectively. On physical examination, she stood at 4’8” and weighed 66 lbs for a body mass index of 14.8 kg/m². She had a severe right-sided thoracolumbar kyphoscoliosis razorback spinal deformity with associated right truncal shift (Fig. 1). There was no neurocutaneous evidence of dysraphism. She had full strength in all muscle groups with normal deep tendon reflexes throughout.

Standing anteroposterior (AP) and lateral scoliosis radiographs revealed a left-sided 36° proximal thoracic curve, right-sided 135° main thoracic curve, and left-sided 58° thoracolumbar curve with associated right-sided truncal shift of >2 cm (Fig. 2). She had 12 rib-bearing thoracic vertebrae and 5 lumbar vertebrae. Her right-sided T12 rib could be seen almost touching her right iliac crest when standing. No supine or bending radiographs were available. The severe rotational nature of her deformity was best appreciated on the three-dimensional (3D) computed tomography (CT) reconstruction, which did not show any congenital fusion or anomalous vertebrae. Her deformity angular ratio (DAR) measurements were as follows: thoracic DAR, 25.7°; coronal DAR, 21.3°; and 3D CT DAR, 27.3°. Magnetic resonance imaging (MRI) was negative for Chiari malformation, syrinx, or low-lying conus medullaris but did reveal a type 3 spinal cord pressed against the concave pedicle at the coronal apex.

We recommended this patient for a three-stage all posterior approach for spinal fusion and deformity correction. Stage 1 involved spinal instrumentation and posterior releases by posterior column osteotomies from T3 to L4. After the spine was rendered more flexible, she underwent 7 days of skeletal traction with GWTs in the intensive care unit as stage 2. In stage 3, rod engagement, posterior spinal fusion, and partial T10 vertebral column resection (VCR) were performed. The patient was positioned prone on a standard operating room table with bolsters under her chest and pelvis. Intraoperative HGT was applied with GWTs and 7 kg of weight. Pedicle screw placement was achieved via the free-hand technique, and final placement was confirmed with fluoroscopy. Upgoing thoracic pedicle hooks served as fixation points on the left side of T3–5. Posterior column osteotomies were performed at each level from T3 to L3. This technique has been described in detail elsewhere. The periapical levels of T9 and T10 were not instrumented because the spinal cord was compressed against the concave pedicle at each of these levels, posing significant risk of IONM signal loss and subsequent neurological deficit. Furthermore, the ribs were prominent over the curve convexity at these levels, making it difficult to achieve the optimal pedicle screw trajectory without performing a thoracoplasty.

The patient was kept in 8 kg of skeletal traction with GWTs postoperatively with close monitoring in the intensive care unit for 7 days (Fig. 3). A standing AP radiograph was obtained on postoperative day 4 and showed a 28% reduction in magnitude of the main thoracic curve to 97°. She tolerated this week-long period of skeletal traction well without any neurological deficits.

On postoperative day 7, she returned to the operating room for the second stage of her procedure. At this time, a partial T10 VCR was performed with a temporary rod along the periapical convexity of the curve to secure the spine in place. A sublaminar wire was placed at the T8 level to assist with coronal translation. Two 5.5-mm titanium rods were used for deformity correction using a combination of differential rod bending, derotation of the left-sided correcting rod, cantilever of the right-sided concave rod, coronal translation through a series of reduction towers, and compression/distraction techniques. There were no changes in IONM during either surgery, and she woke up neurologically intact after both stages of the procedure. Postoperative standing radiographs showed good realignment in the sagittal plane and a residual curve in the coronal plane (Fig. 4). Postoperative clinical photographs showed improved posture, restoration of thoracic kyphosis to within normal range, improvement in truncal shift, and a residual right-sided thoracic prominence (Fig. 5).

**Patient Informed Consent**

The necessary patient informed consent was obtained in this study.

**Discussion**

**Observations**

We present the case of a 17-year-old female with severe kyphoscoliosis in a developing country, who underwent delayed surgical
treatment via a three-stage all-posterior approach with a 7-day interlude of skeletal traction via GWTs. Since the time span of our organization’s surgical mission is only approximately 10 days long, patients with the largest and most ridged curves that require three-column osteotomies are prioritized first with staged surgeries to garner some benefit from skeletal traction over 7 days. In our experience, in staging large deformity-correction surgeries by posterior release, 1 week of skeletal traction then definitive spinal fusion with possible three-column osteotomy has provided a safe and effective strategy for managing complex pediatric spinal deformities in less developed countries where resources and time are limited. We incorporate skeletal traction in our surgical plan when facing severe scoliosis curves because it allows for a gradual reduction in these spinal deformities and reduces the amount of correctional force required during the final fusion surgery. An all-posterior approach for scoliosis correction was used in this case. An anterior approach was not favored because there was no available access surgeon and because we did not want to risk adversely affecting pulmonary function by entering the chest. The available apparatus for skeletal traction for our surgical missions was GWTs, which is not the standard modality for perioperative skeletal traction in scoliosis management. Therefore, we will draw corollaries from and focus this discussion on HGT—the most common form of skeletal traction for patients with severe spinal deformities.

Historically, HGT has been a widely accepted preoperative measure for patients with severe spinal deformities, especially those with particularly rigid curves. Prior to HGT, most of the deformity correction relied on osteotomies and aggressive releases; however, these procedures can be associated with an increased risk of neurological deficits, prolonged surgical time, and higher blood loss. Ideally the best-case scenario is when a three-column osteotomy can be avoided altogether if a spinal deformity can be reduced sufficiently by perioperative HGT. Studies have shown that even if a three-column osteotomy is required for optimal correction, skeletal traction by HGT reduces the neurological risks associated with this high-risk osteotomy. The process of HGT involves gradually increasing traction weight over an allotted period that can partially reduce severe spinal deformities, making the final fusion surgery easier and safer. HGT can effectively reduce both scoliosis and kyphosis Cobb angles in select patients. A meta-analysis of 20 studies (n = 591 patients) comparing pre-HGT and post-HGT coronal Cobb angles in pediatric patients with spinal deformities showed a pooled mean decrease of 27.66°. The same study analyzed
16 studies (n = 542 patients) comparing pre-HGT and post-HGT sagittal Cobb angles, showing a pooled mean decrease of 27.23°. In addition to correcting spinal curves before the final fusion procedure, HGT helps to create more flexibility in the spinal curves by elongating soft tissues. This reduces the amount of correctional force required during surgery, thus minimizing the risk of surgical complications. Other benefits of HGT include improved pulmonary function and nutritional status of the patient. The increased nutritional status is most beneficial for patients who are underweight preoperatively and risk developing issues with wound care and instrumentation prominence later in their postoperative course.

HGT is typically indicated for spinal deformity over 90° in any plane and for medical optimization of the patient. Patients with a major curve between 60° and 90° with a need for respiratory and/or nutritional optimization may also be reasonable candidates for HGT. HGT is not indicated in curves under 60°. HGT is usually...
administered to patients with particularly rigid curves, but this technique is even more effective in reducing the magnitude of curves that are flexible. Our experience has been that proximal thoracic and main thoracic curves achieve better correction with HGT than thoracolumbar or lumbar curves. Studies have shown improved correction of pure scoliosis versus pure kyphosis using HGT. Patients with pure kyphosis tend to have greater resistance to HGT because of a more rigid and angular curve pattern compared to scoliosis curves. These challenging kyphotic curves are seen primarily in patients with postinfectious and congenital kyphosis. Another factor that influences the success of HGT is the length of time in traction, typically spanning at least 2 weeks but can last as long as 3 to 5 months.\(^\text{6,11,18}\)

Although there is no standardized protocol for the optimal duration of HGT, curve magnitude and flexibility are important factors to consider when determining the duration of HGT. Best-practice guidelines on the use of HGT for pediatric spinal deformity patients recommends that HGT should generally last from 4 to 6 weeks, but patient response to HGT should be used to help define the final length in traction.\(^\text{17}\) A 2015 study by Nemani et al.\(^\text{11}\) from FOCOS Hospital in Ghana reported their results in 29 patients who had undergone HGT for an average of 107 days (3.6 months) prior to definitive posterior spinal fusion or placement of growing rods. Their longest duration of HGT was a little more than 150 days (5 months). Importantly, their series showed that radiographic correction plateaued after approximately 2 months in HGT after a rapid initial correction. A 2013 study by Park et al.\(^\text{19}\) showed that the majority of correction in HGT occurs during the first 2 weeks. They recorded the percent of curve correction out of the total change in curve magnitude in 20 patients in HGT at different time points. The major coronal and sagittal curves corrected 66.3% and 62.7%, respectively, at 2 weeks, 21.7% and 24.3% at 3 weeks, and 7.5% and 15.9% at 4 weeks.

GW Ts have been a popular method of skeletal traction since 1973.\(^\text{20}\) They are relatively easy and safe to use, and they obviate any need for incisions. However, GWT use can be associated with significant complications and risks. A 1983 study reported a minor complication rate of 37.5% (6/16 patients), mostly consisting of pin loosening (18.8%), asymmetrical pin positioning (12.5%), and superficial infection (6.3%). The most serious complication involves pin perforation through the skull. Although there are no established incidence rates for the following complications, sporadic cases in the literature report transient ischemic attack,\(^\text{21}\) brain abscess,\(^\text{22}\) transient abducens nerve (cranial nerve VI) palsy,\(^\text{23}\) and laceration of the superficial temporal artery.\(^\text{24}\) A 2018 systematic review concluded that GWTs are a safe form of skeletal traction with a low rate of complications, most of which are minor, transient, and can be easily managed.\(^\text{25}\) A recent 2022 meta-analysis showed that neurological complications were observed in approximately 1.5% of patients undergoing HGT.\(^\text{5}\) These complications mainly consisted of transient paresthesia, nystagmus, and dizziness. Nearly all patients fully recovered after the traction weight was reduced. Motor changes in the extremities require the removal of all traction weight, whereas cranial nerve changes generally require removal of the most recently added weight.\(^\text{17}\) In the event of a neurological change, cervical spine radiographs should be obtained, and if the deficit persists, MRI should be performed as quickly as possible.

Side effects and complications can arise with prolonged skeletal traction. Sometimes circumstances may not allow for 2 weeks or more of skeletal traction before definitive spinal fusion. An interesting 2012 study by Koptan et al.\(^\text{18}\) compared outcomes among 47 adolescents with severe rigid idiopathic scoliosis. Twenty-one patients had three-stage correction via anterior release, 2 weeks of HGT, and posterior instrumentation. Twenty-six patients had an anterior release followed by posterior instrumentation. The main curve correction achieved in the three-stage cohort was 59% compared to 47% in the two-stage cohort (p < 0.01). A shorter operative time was found in the three-stage cohort, and there was no significant difference in blood loss or early or delayed complications between the groups. We believe that a three-stage approach to severe idiopathic scoliosis that incorporates a limited course of skeletal traction following posterior releases can improve surgical correction and minimize the risks of traction. This surgical approach is especially advantageous during surgical humanitarian missions in less developed nations in which resources are low and time is often limited.

**Lessons**

Skeletal traction with GWT is a viable alternative to traditional HGT in settings with limited resources. Three-stage spinal deformity correction using limited skeletal traction is a feasible and effective approach for managing severe scoliosis during humanitarian surgical mission trips.

**References**


Disclosures
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions
Conception and design: Sarmiento, Fakhoury, Bains. Acquisition of data: Sarmiento, Fakhoury, Hawk, Bains. Analysis and interpretation of data: Sarmiento, Fakhoury, Bains. Drafting the article: Sarmiento, Fakhoury, Singh, Hawk. Critically revising the article: Bains. Reviewed submitted version of manuscript: Sarmiento, Fakhoury, Sethi, Bains. Approved the final version of the manuscript on behalf of all authors: Sarmiento. Administrative/technical/material support: Fakhoury, Bains.

Correspondence
J. Manuel Sarmiento: Morgan Stanley Children’s Hospital at New York Presbyterian/Columbia University Irving Medical Center, New York, NY. sarmiento@post.harvard.edu.