Intraoperative Use of Rib-to-Pelvis Traction to Correct Pelvic Obliquity in the Neuromuscular Spine

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Introduction

The goal of posterior spinal fusion in neuromuscular scoliosis is to obtain a balanced trunk as well as accommodative, pressure-free seating on a level pelvis. Development of pelvic obliquity or involvement of the pelvis in the scoliotic curve can cause difficulties with seating, costopelvic impingement, and worsening pulmonary function, ultimately leading to difficulty with caregiving, decubitus ulcers, or other comorbidities. Over time, flexible deformities become more rigid, making correction of the pelvic obliquity more difficult. Correcting pelvic obliquity can be challenging in this patient population due to poor bone quality.[1] Unit rod instrumentation has traditionally controlled pelvic obliquity well.[2] While third-generation instrumentation is technically difficult with extension to the pelvis, previous results were less than encouraging.[3] More recently, use of third-generation instrumentation has shown improved results.[4] Anteroposterior surgery has recently fallen out of favor due to patient comorbidities and comparable success and decreased complications of posterior surgery.[5] Ideally, indirect correction performed before instrumentation can decrease risk of failure at either the bone-implant interface or failure of the implant itself. Many types of traction techniques have previously been implemented in order to achieve this correction prior to instrumentation. Methods have included preoperative halo-gravity traction,[6,7] intraoperative halo-femoral traction,[8-10] halo-pelvic traction,[11-13] and temporary rods from vertebral body to vertebral body.[14,15]

Methods

We present a case of a 13 year-old female with GMFCS Level V spastic quadriplegic cerebral palsy. She had been followed in the spine clinic and was observed to have an 83° left lumbar scoliosis with severe apical rotation and significant pelvic obliquity (Figure 1). Preoperative bending films over a bolster showed reasonable flexibility in the lumbar curve but persistent pelvic obliquity. At our institution, we have implemented sacral alar iliac (SAI) screws as the preferred pelvic instrumentation technique for fusions to the pelvis. As previously described, they are in line with the spinal construct, allowing easy connection to the segmental instrumentation. They are usually long and larger in diameter, providing stronger fixation. They are recessed under the posterior superior iliac spine so as to not be prominent. They also have a decreased infection risk, and they utilize a solid column of bone for stout fixation.[16,17] Also, we use intraoperative navigation with the O-Arm® Surgical Imaging with StealthStation® Navigation (Medtronic Navigation, Inc., Louisville, CO).

During preoperative planning, we considered cantilever reduction using unit rod fixation versus screw and rod construction, which often uses derotational maneuvers to correct coronal and sagittal imbalance. The senior author's results after transition to screw and rod constructs left us searching for an improved method for correcting pelvic obliquity that was previously handled well by the unit rod. Our intraoperative setup was intended to optimize

Figure 1. Preoperative posterior-anterior (A) and lateral (B) radiographs.

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safe navigation of screw placement while allowing for the application of traction to correct the patient's pelvic obliquity. The patient was positioned prone on the Mizuhosi Spinal Surgery Top (Mizuho OSI, Union City, CA) table in the knee-chest position with both knees in 90° of flexion using the assistance of a leg sling. A standard subperiosteal posterior approach was performed with confirmatory imaging to assess the correct levels for fusion. O-Arm® navigation was used, and three "spins" were obtained off of two arrays, according to our standard protocol.

After acquiring navigational data, all pedicle screws and both SAI screws were safely placed. At this point, a temporary distraction rod was placed on the right (concave) side of the lumbar deformity, corresponding to the high side of the pelvic obliquity. It was constructed from the seventh rib to the pelvis using the vertical expandable prosthetic titanium rib (VEPTR®, DePuy Synthes Spine, West Chester, PA) system components: rib hook, 90° pelvic S-hook, S-hook rod (with the S-hook removed and the rod cut) and two parallel connectors (Figure 2). Minimal lateral dissection was needed to place the construct consistent with placement of a rib-to-pelvis VEPTR®. The seventh rib was exposed through a small incision in the fascia, and the rib hook was placed. The right posterior pelvic brim was exposed through a separate fascial incision, and the S-hook was seated on the pelvis. A subfascial tunnel was created to connect the rib hook to the pelvic S-hook using two parallel connectors and two rod segments (Figure 3). A series of stepwise corrections were performed using a distractor to reduce the pelvic obliquity under fluoroscopic imaging and intraoperative neuromonitoring. A half-ring was used to obtain additional distraction. The construct was locked in position in order to take advantage of the viscoelastic properties of the spine. After safe correction, attention was turned back to the spine for soft tissue releases and rod contouring. With the pelvic obliquity corrected, cantilever rod placement was performed first on the left, then on the right side. After setting the rods, traction was released from the temporary distraction rod. No collapse was noted as the rods maintained the correction. The integrity of the bone-screw interface was examined at each level and noted to be intact.

Results

After placement of both rods and completion of the correction, the temporary rib-to-pelvis distraction was released. All bone-screw interfaces were inspected and deemed to be intact. Fluoroscopic imaging confirmed maintenance of screw positions and a level pelvis. All neuromonitoring signals, including somatosensory evoked potentials (SSEP) and motor evoked potentials (MEP), were unchanged from baseline. Postoperative radiographs (Figure 4) revealed significant improvement of the scoliosis, complete correction of pelvic obliquity, no evidence of pneumothorax or rib fractures, and no changes at the site of the pelvic S-hook.

Discussion

Difficult spinal deformities challenge us to utilize a host of reduction and instrumentation techniques. In particular, patients with neuromuscular scoliosis are often less medically optimized, making staged procedures more difficult.[5] The ultimate goal in this patient population is to safely perform an instrumented fusion with a balanced trunk and pelvis with minimal morbidity along with long-term goals of improved quality of life for the patient, family members, and other caretakers. Residual deformity and imbalance compromise these goals.

While previous use of the unit rod allowed for increased correction of pelvic obliquity due to the nature of its construct, there are several drawbacks. It is a technically demanding procedure, it has a fixed angle to the pelvis, and it necessitates the use of segmental sublaminar wires that require entering the canal at multiple levels. Mechanical failure can also occur either intraoperatively, due to cut out from poor bone quality, or postoperatively, due to loosening. Transition to segmental rod use has evolved from hooks and wires to hybrid constructs that use hooks, wires, and pedicle screws, and finally to predominantly all-screw constructs. The benefits of pedicle screws have been well described, including 3-column fixation and improved axial correction.[18-20] In cases when pelvic fixation is required, options include iliac screws, sacral (S1) screw fixation, or both. Recently, popularization of SAI screw fixation has led to novel pelvic fixation.

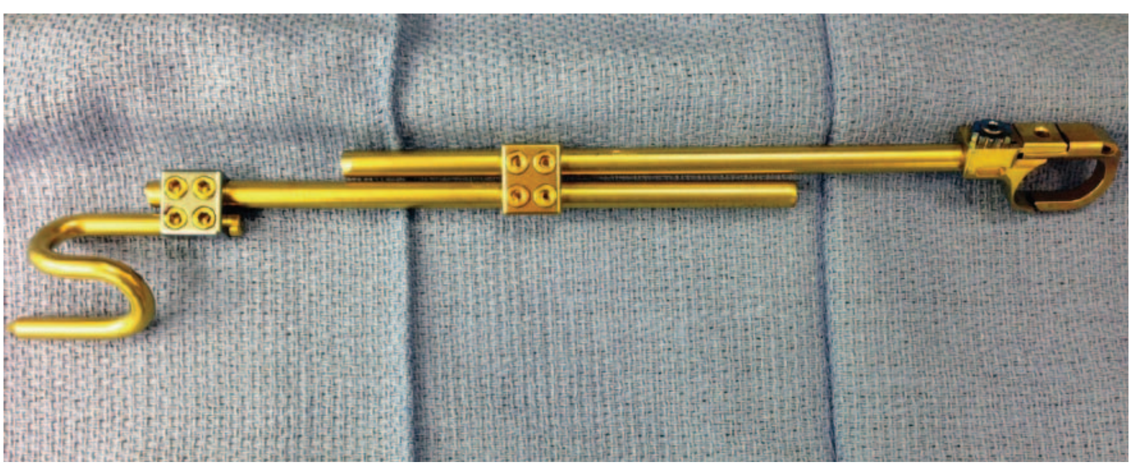

Figure 2. Construct used for the temporary intraoperative rib-to-pelvis traction.

Figure 3. Intraoperative posterior-anterior (PA) radiograph with rib-to-pelvis distraction in place with level pelvis

Figure 4. Postoperative posterior-anterior (A) and lateral (B).

In our case, we were able to rely on the VEPTR® to correct our pelvic obliquity safely in a single setting without having to rely on the screws when the potential for bone-screw interface failure is significant in patients with poor bone quality. Also, having our temporary distraction away from the midline afforded us multiple benefits: 1) the moment arm of correction was more powerful than having to correct the pelvic obliquity near the midline, 2) we were able to instrument the entire spine while the distraction rod continued to work as it was not obstructing our operative field, 3) the temporary distraction was entirely within the operative field and controlled by the surgeon, 4) none of our final implants utilized an area occupied by the temporary rib-to-pelvis rod so as not to compromise any fixation points, and 5) the temporary distraction could also take advantage of the viscoelastic properties of the spine and be left in, if needed, for a staged procedure.

Conclusion

Intraoperative rib-to-pelvis temporary distraction can be safely performed to correct pelvic obliquity in the neuromuscular spine in a single setting and should be considered in the challenging neuromuscular patient.

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