Sacral-Alar-Iliac Fixation in Children with Neuromuscular Scoliosis: Minimum 5-Year Follow-Up

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OBJECTIVE: **To investigate the 5-year outcomes of children with neuromuscular scoliosis treated with sacral-alar-iliac screws.**

METHODS: **We reviewed clinical and radiographic records of patients aged ≤18 years treated by 1 pediatric orthopedic surgeon for neuromuscular scoliosis with spinal fusion using sacral-alar-iliac pelvic anchors. Thirty-eight patients with a minimum 5-year radiographic follow-up (mean, 6.0 ± 1.2 years) were studied. The mean patient age was 13 ± 2.0 years, and 47% were female. The mean number of levels fused was 18 ± 0.7. Two-thirds (66%) of the patients were diagnosed with cerebral palsy.**

RESULTS: **Between the preoperative period and final follow-up, the patients exhibited a mean correction of the major coronal curve of 79% (preoperative, 85° to final, 18°) and a mean 57% correction of the pelvic obliquity (preoperative, 16° to final, 7°). Patients maintained the correction of mean pelvic obliquity from the early postoperative period (6°) to final follow-up (7°). Preoperatively, 76% of the patients had a pelvic obliquity of >10°, compared with 26% of patients postoperatively. There were no cases of neurologic or vascular complications or pseudarthrosis. Radiographs revealed bilateral sacral-alar-iliac screw lucency in 8 patients; 4 of these patients had deep wound infections, and the other 4 were asymptomatic. Unilateral screw fracture was found in 1 patient with an 8-mm-diameter screw (1.3%; 1 of 76 screws); the patient was observed and remained asymptomatic. There were no cases of set screw displacement, screw back-out, or rod dislodgement.**

CONCLUSIONS: **Sacral-alar-iliac screws are safe and effective pelvic anchors for use in children with neuromuscular scoliosis.**

INTRODUCTION

Correction of pelvic obliquity in children with neuromuscular deformity is an indication for the use of spinopelvic fixation. Deformity, poor bone quality, and high biomechanical stresses across the lumbosacral junction make spinopelvic fixation challenging in this population.[1] First proposed in 2007,[2] the sacral-alar-iliac technique is a type of spinopelvic fixation that uses the pedicle between the first and second sacral foramina, in line with the S1 pedicle, as the starting point of pelvic fixation.[3]

In a previous study, sacral-alar-iliac screws were found to provide superior correction of pelvic obliquity with lower rates of complications compared with iliac screws.[4] Theoretically, the placement of sacral-alar-iliac screws in line with the other spinal anchors allows for better control of the pelvis with the use of appropriately contoured spinal rods. Furthermore, the sacral-alar-iliac anchors are set 15 mm deeper than iliac screws on average, potentially decreasing the risk of implant prominence[5] and wound-related complications by precluding the need for the paraspinal muscle dissection required with iliac screws.

To our knowledge, to date only 1 study has reported the medium-term outcomes of patients treated with sacral-alar-iliac screws,[6] although a number of studies have investigated the short-term stability and efficacy of these screws and cited the need for longer follow-up.[7-12] In a retrospective comparison of iliac and sacral-alar-iliac screws, Shabtai et al.[6] found that sacral-alar-iliac screws had a significantly lower implant failure rate (7% vs. 24%) and required fewer revision surgeries during a 3-year follow-up period.

Our aim in the present study was to analyze the radiographic outcomes and complications in patients with neuromuscular scoliosis treated with spinal fusion using sacral-alar-iliac pelvic fixation with a minimum of 5-year clinical and radiographic follow-up. We hypothesized that sacral-alar-iliac screws would maintain deformity correction and cause minimal complications.

MATERIALS AND METHODS

This study was approved by our hospital's Institutional Review Board. We retrospectively reviewed radiographic and clinical

Key words
- Neuromuscular
- Pelvic fixation
- Sacral-alar-iliac screw
- Spinal deformity

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Citation: World Neurosurg. (2017) 108:474-478.
http://dx.doi.org/10.1016/j.wneu.2017.08.169

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

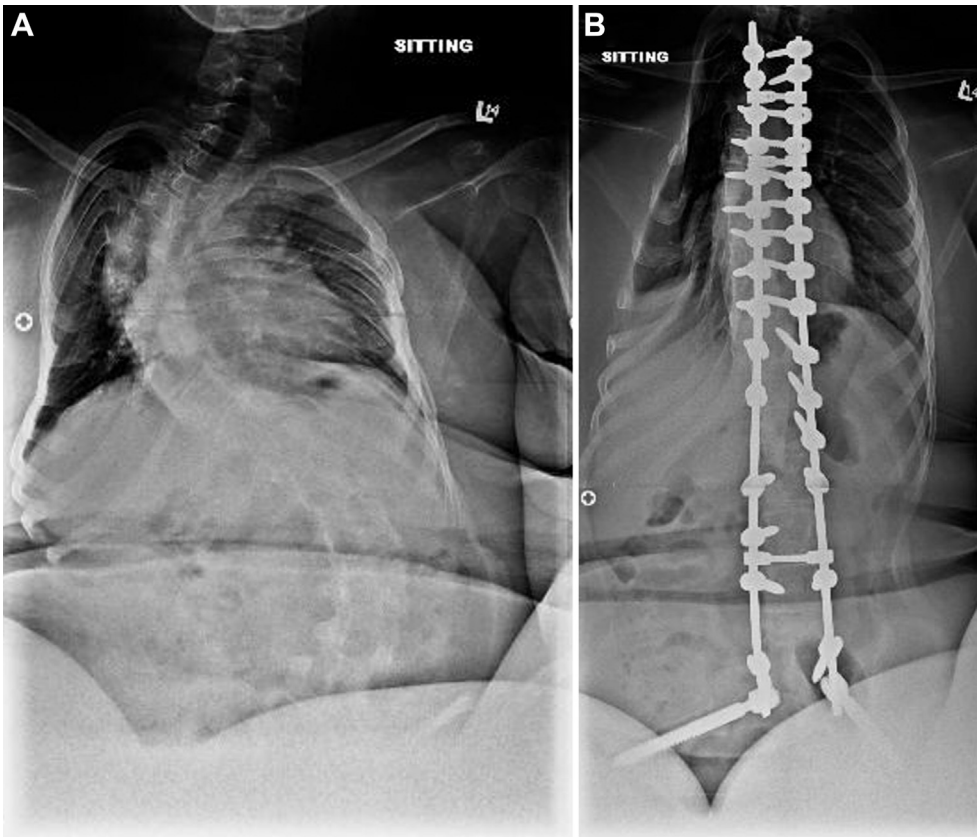

Figure 1. Preoperative (**A**) and 5-year follow-up (**B**) radiographs of a boy with neuromuscular scoliosis secondary to spinal muscular atrophy treated surgically with spinal fusion and sacral-alar-iliac pelvic fixation.

records of consecutive patients aged ≤18 years with a diagnosis of neuromuscular scoliosis who underwent posterior spinal fusion surgery using sacral-alar-iliac fixation (Figure 1) performed by a single pediatric orthopedic surgeon at our tertiary care center from 2006 through 2010. Patients with growing rods were excluded. A total of 38 patients were found to have a minimum 5-year follow-up and were included. In these patients, the mean (±standard deviation) duration of follow-up was 6.0 ± 1.2 years (range, 5–9 years).

The mean patient age at surgery was 13 years (Table 1). Most patients (25 of 38) had a diagnosis of cerebral palsy. The remaining 13 patients had various other neuromuscular diagnoses (Table 1). Sacral-alar-iliac screws were inserted in all patients under fluoroscopic guidance using a well-described technique.[4] Anterior column support was not used in any patient.

Three-foot-long posteroanterior radiographs were reviewed to assess coronal curvature and pelvic obliquity preoperatively, at 6-week follow-up, and at final follow-up. Additional variables studied were surgical complications (i.e., deep infection, neurologic complications, superficial infection, vascular complications, and wound dehiscence), implant outcomes (i.e., lateral screw protrusion, screw fracture, and screw lucency >2 mm), and other clinical parameters (i.e., implant prominence, pain, and pseudarthrosis).

Statistical Analysis

Changes in coronal curve angle and pelvic obliquity were evaluated using paired *t* tests. Stata/SE version 12.0 was used for statistical analysis (StataCorp LP, College Station, Texas, USA). The threshold for significance was set as $\alpha = 0.05$.

RESULTS

Radiographic Results

Between the preoperative and final follow-up periods, there was a mean (±standard deviation) 79% ± 14% correction of the major coronal curve (85° to 18°; $P < 0.001$) and 57% ± 29% correction of pelvic obliquity (from horizontal) (16° to 7°; $P < 0.001$) (Table 2). Preoperatively, 25 patients (66%) had pelvic obliquity of >10°. At final follow-up, 9 patients (24%) had pelvic obliquity of >10°. Patients maintained correction of pelvic obliquity over the 5-year follow-up period, with mean initial postoperative pelvic obliquity of 6° ± 4°, compared with a 5-year follow-up pelvic obliquity of 7° ± 5° ($P = 0.32$).

Complications

There were no perioperative neurologic or vascular complications in any patient. Radiographs revealed sacral-alar-iliac screw