



## Predicting Failure of Iliac Fixation in Neuromuscular Spine Deformity

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### Abstract

**Study Design:** Retrospective comparative cohort study.

**Objectives:** Identify whether there are patient or surgical risk factors to predict the probability of failure of iliac screw fixation after correction of neuromuscular scoliosis.

**Summary of Background Data:** There are high reported failure rates of pelvic fixation in long posterior spinal fusion (PSF) constructs to the sacrum for neuromuscular scoliosis.

**Methods:** Patients aged 5 to 25 years, at a single institution, had PSF to the sacrum from 2001 to 2009 with pelvic fixation using iliac screws. Clinical data were retrospectively reviewed to identify patient and surgical variables related to surgery. Failure of iliac fixation was identified strictly as a broken screw, disengagement of the screw from the connector or the connector from the rod, or set plug failure. Lucency around the screws greater than 2 mm was recorded but not considered a failure. Variables were analyzed in a statistical model to identify predictors of failure.

**Results:** A total of 108 patients met inclusion criteria; 100 (38 female and 62 male) had appropriate radiographs and minimum 2-year follow-up (average, 5.5 years). Coronal deformity correction averaged 59%. Most patients (89%) had fill of 6 of 8 possible distal fixation points composed of L4, L5, S1, and ilium bilaterally. Iliac screw failure occurred in 27 patients (27%). The initial single predictor statistical model identified 2 possible predictors of failure (patient: spastic tone; and surgical: absence of distal crosslink). In the multi-variable model, spastic tone remained a predictor of failure ( $p = .0103$ ), whereas absence of distal crosslink bordered on significance ( $p = .0516$ ).

**Conclusions:** Iliac screw fixation failure is common in patients with long PSF constructs for neuromuscular scoliosis. Spastic tone is a risk factor for failure of pelvic fixation. A distal crosslink may protect against pelvic fixation failure. Alternative techniques for pelvic fixation should be studied in an attempt to improve the failure rates of iliac screw pelvic fixation.

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**Keywords:** Iliac screw; Pelvic fixation; Neuromuscular scoliosis; Posterior spinal fusion

### Introduction

Spinal fusion with deformity correction is an option for patients with neuromuscular disease who have progressive spinal deformity causing pain and/or seating imbalance. Pelvic fixation is often used for these patients to correct pelvic obliquity and improve seating balance. Several techniques of pelvic fixation have been described, including

the Galveston technique, iliosacral screw fixation, iliac screw fixation, and sacral alar iliac (SAI) screw fixation [1-10]. Over the past decade, the authors' institution has used modular fixation with iliac screws for neuromuscular patients with posterior spinal fusion from the upper thoracic spine to the sacrum.

Prior reports have described relatively high rates of failure of modular iliac fixation (5% to 30%) and up to a 50% rate of lucency around iliac screws on radiographs [1-3,11]. The purposes of this study were to retrospectively evaluate the failure mode and failure rate of iliac screw fixation in patients with posterior spinal fusion for neuromuscular scoliosis and to determine whether there were patient or surgical risk factors for failure of pelvic fixation.

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## Materials and Methods

After institutional review board approval was obtained, a retrospective cohort review at a single center examined all children and adolescents who underwent surgery for correction of neuromuscular spinal deformity. An institutional surgery database was screened from 2001 to 2009, and patients aged 5 to 25 years with neuromuscular disease who underwent instrumented posterior spinal fusion from the upper thoracic spine to the sacrum with supplemental iliac screw fixation were included for study. Patients without adequate clinical and radiographic 2-year follow-up were excluded.

Patient charts, operative records, and radiographs were reviewed for patient demographics and factors that may be related to failure of iliac fixation. Specifically, the researchers examined age at time of surgery, body mass index (BMI), gross motor function classification system (GMFCS), gender, diagnosis, muscle tone (spastic or flaccid), number of fusion levels, preoperative and postoperative coronal plane deformity, preoperative and postoperative pelvic obliquity, implant metal alloy, rod diameter, iliac screw diameter, presence of implant failure, presence of iliac screw lucency greater than 2 mm, number of distal fixation points, and the use of a distal crosslink (distal to L4). Failure was identified on radiographs as a broken screw, disengagement of the screw from the connector or the connector from the rod, or set plug failure. Radiographic lucency greater than 2 mm around iliac screws was noted, but this was not considered implant failure.

Patients had a potential of 8 distal fixation points (2 per level) at L4, L5, S1, and ilium. Crosslinks at any of these intervals were documented. The magnitude of coronal deformity and pelvic obliquity correction was calculated by comparing the difference between preoperative and postoperative radiographs using standardized technique [12]. All radiographs were reviewed and measured for implant failure, screw lucency, coronal deformity, and pelvic obliquity by a fellowship-trained orthopedic surgeon.

Because of a small number of subjects, GMFCS levels 1, 2, and 3 were collapsed into a single category to compare in relation to GMFCS 4 and 5 categories. Pelvic obliquity correction was categorized into correction less than 10°, between 10° and 15°, between 15° and 20°, and greater than 20°.

The effects of several predictors, including fixation group, diagnosis, BMI, ambulatory status, GMFCS, screw diameter, rod diameter, alloy type, 10°/15°/20° obliquity correction groups, distal crosslink, number of levels fused, and spastic muscle tone on the primary outcome, failure rate, were first modeled individually using logistic regression. These single-predictor models were used to assess predictor functional form and to screen the predictors for inclusion in the final model. Any predictor that was significant at the .10 alpha level in a single-predictor model was included in the final multiple logistic regression model. All statistical analyses were conducted using SAS (SAS Institute, Cary, NC).

## Results

A total of 108 patients met the initial inclusion criteria. The authors excluded 6 patients because of a lack of 2-year follow-up; 2 lacked appropriate radiographs. This resulted in a final cohort of 100 patients for analysis.

There were 38 female and 62 male patients, with an average age of 13.8 years at surgery (range, 7–21 years). Table 1 lists the demographics of the patient cohort (diagnosis, GMFCS, gender, age, and BMI). Seventy-five patients had hybrid constructs and 25 had pedicle screw constructs (defined as more than 90% fixation points being pedicle screws). The average patient follow-up time from the index fusion procedure was 5.5 years (range, 2.1–9.6 years).

Distal implant density varied from 4 to 8 points of fixation; 6 points (bilateral L4 pedicle screws, bilateral L5 pedicle screws, and bilateral iliac screws) was by far the most common construct (89% of constructs). Stainless steel was used in most constructs (97 of 100; 97%). The remainder of the constructs were titanium (3 of 100; 3%). Rod diameter was variable: 4.5 mm (18 of 100, 18%), 5.5 mm (44 of 100; 44%), and 6.35 mm (38 of 100; 38%). Iliac screw diameter was also variable: 5.5 mm (36 of 100; 36%), 6.5 mm (49 of 100; 49%), and 7.5 mm (14 of 100; 14%); 1 case was not recorded. The average correction for coronal deformity was 59% (range, 12% to 92%; standard deviation, 18%). Table 2 lists pelvic obliquity correction.

Of 100 patients, 27 (27%) had failure of iliac fixation. The majority of these failures were the result of a disengaged rod or screws (82%). Lucency greater than 2 mm around screws occurred in 51 of 100 patients (51%). Failure of iliac fixation occurred in 9 of 51 patients with lucency (18%) and 18 of 49 without it (37%), and was not

Table 1  
Demographics.

|  | Total patients, n | Cohort (%) |
|--|-------------------|------------|
| Diagnosis and subcategory  |                   |            |
| Cerebral palsy   | 67                | 67         |
| Duchenne muscular dystrophy  | 17                | 17         |
| Syndrome-related diagnoses   | 10                | 10         |
| Myelomeningocele   | 2                 | 2          |
| Spinal cord injury   | 4                 | 4          |
| Gross motor function classification system                                       |                   |            |
| I–III  | 5                 | 5          |
| IV   | 47                | 47         |
| V  | 48                | 48         |
| Gender   |                   |            |
| Female   | 38                | 38         |
| Male   | 62                | 62         |
| Mean age at surgery, y (average [standard deviation])                            | 13.8 (3.16)       |            |
| Median body mass index at surgery, kg/m <sup>2</sup> (average [minimum–maximum]) | 16.5 (11.0–34.1)  |            |

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