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SHOULD PELVIC FIXATION BE INCLUDED IN NEUROMUSCULAR SCOLIOSIS SURGERY?

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ABSTRACT

Objective: The aim of the current study was to compare the activity levels and radiological outcomes of patients who underwent neuromuscular scoliosis (NMS) surgery with and without pelvic fixation.

Materials and Methods: Thirty-three NMS patients aged 10-20 years with a pelvic obliquity (PO) of 15° or more and a follow-up of at least 24 months who underwent posterior surgery for NMS at two different centers were included in the study. Out of the 33 patients, 16 without pelvic fixation (WoPF) and 17 with PF (WPF) underwent posterior spinal surgery. Radiological results and independent movement levels according to the Gross Motor Function Classification System (GMFCS) were compared in the two groups.

Results: The follow-up period of the patients was 46.69±21.95 months in WoPF and 43.88±20.05 months in WPF, and there was no significant difference between the two groups in postoperative radiological values (p=0.763). In the PO values, postoperative improvement was more pronounced in the WPF group (WoPF: 14.31°±8.292; WPF: 9.35°±5.338), but there was no statistically significant difference between the two groups (p=0.087). Patients' GMFCS levels were higher in the WPF group than in the WoPF group (WoPF: 2.75±1.29; WPF: 3.76±1.03). GMFCS levels of patients in both groups did not change and were similar to pre-operative levels.

Conclusion: The study demonstrated that NMS surgery with PF was not significantly different clinically and radiologically from surgery without PF. Considering PF-related complications in NMS surgery, surgery without PF may be an option in NMS patients with PO.

Keywords: Neuromuscular scoliosis, pelvic fixation, pelvic obliquity, activity level

INTRODUCTION

Pathological muscle tone in neuromuscular diseases causes advanced spinal curvature, asymmetric spinal growth due to secondary vertebral growth suppression on the concave side of the curve, and thus advanced spinal deformity[1]. Neuromuscular scoliosis usually consists of a characteristic C-shaped deformity with pelvic obliquity and imbalances in the coronal and sagittal planes. Scoliosis greater than 10° is commonly observed in individuals with neuromuscular disorders, with an average prevalence of 41%. Additionally, there is a positive correlation between the incidence of scoliosis and the severity of spinal curvature, which tends to increase with higher levels of the Gross Motor Function Classification System (GMFCS) in these patients[2]. While bracing can be used to promote trunk positioning and head control in the early stages of neuromuscular scoliosis, it does not significantly impact the natural progression of the deformity[3]. However, surgical treatment is recommended for patients with curves exceeding 40°, despite the higher complication rate associated with surgical interventions for neuromuscular scoliosis.

Pelvic fixation is commonly employed as an adjunct procedure during posterior surgery to address both spinal and pelvic deformities in patients with advanced neuromuscular scoliosis and pelvic obliquity. However, the utilization of pelvic fixation in patients with neuromuscular scoliosis remains a subject of controversy, primarily limited to non-ambulatory patients presenting with both scoliosis and pelvic obliquity. While certain studies have reported that pelvic fixation in neuromuscular scoliosis surgery with pelvic obliquity can result in improved spinal curvature and pelvic correction[4-6], it is important to note that the pelvic fixation to scoliosis surgery can lead to increased revision rates and additional morbidity. The inclusion of pelvic fixation in conjunction with posterior spinal fusion has been associated with an elevated incidence of surgical complications. These complications include prolonged operative time, increased blood loss, heightened exposure to X-rays due to additional imaging requirements, and higher rates of pseudoarthrosis and skin ulceration[7-9].

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The aim of this study was to compare the clinical and radiological outcomes of patients with and without pelvic fixation in addition to posterior spinal surgery for neuromuscular scoliosis with pelvic obliquity and to evaluate the effect of pelvic fixation on patients' activity levels.

MATERIALS AND METHODS

The study obtained approval from the Ethics Commission of Gazi University (approval number: 05, approval date: 21.03.2023) prior to conducting the research. It involved a retrospective review of patients who underwent posterior spinal surgery for neuromuscular scoliosis, performed by two experienced spine surgeons at two different medical centers. The inclusion criteria encompassed patients within the age range of 10 to 20 years, with a minimum clinical and radiological follow-up period of 2 years, and a pelvic obliquity exceeding 15°. Patients with insufficient follow-up or those who underwent revision surgery were excluded from the study. The patient population was divided into two groups: Those who received pelvic fixation in addition to posterior spinal surgery WPF group and those who did not receive pelvic fixation (WoPF group). The study included a total of 33 patients, with 16 in the WoPF group and 17 in the WPF group. A comprehensive comparison was conducted between patients in both groups, taking into account both clinical and radiological findings. The present study investigated the clinical findings of patients by examining the activity levels using the GMFCS during preoperative and postoperative assessments.

In the analysis of the radiological findings, the study involved the assessment of plain radiographs of the patients at different time points: Preoperatively, early postoperatively (at 6 weeks), and during the last follow-up visit. The main focus was on measuring the Cobb angle of the primary spinal curvature and the angles of pelvic obliquity in the coronal plane using plain radiographs. Pelvic obliquity was assessed using the Maloney method[10], which measures the angle between the line perpendicular to the line connecting the iliac wing tips and the line connecting T1 and S1 (Figures 1a, c; Figures 2a, c). In the sagittal plane, the study involved measuring the angles of thoracic kyphosis and lumbar lordosis (Figures 1b, d; Figures 2b, d). Additionally, in the coronal plane, the angles of pelvic obliquity and scoliotic curvature of the spine were assessed. The analysis also included evaluating the extent of correction and potential loss of correction in the angles of thoracic kyphosis and lumbar lordosis in the sagittal plane. Furthermore, a comparison was made between the two groups to determine if there was a statistically significant difference.

Surgical Technique

All procedures were performed by two senior surgeons in two different centres using a standard posterior surgical approach. After general anaesthesia, the patient was placed in the prone position. Silicone pads were placed on the appropriate areas of the patient to prevent both pressure sores and bleeding. After sterile draping of the surgical field, a long incision was made in the posterior midline. The folds were crossed. The supraspinous and interspinous ligaments were preserved and the paraspinal muscles were dissected subperiosteally. To avoid proximal and distal junctional kyphosis, care was taken to protect the facet muscles and ligaments of the upper and lower vertebrae to be instrumented. After exposure of the levels to be instrumented, pedicle screws were inserted using a freehand technique. Pedicle screws measuring 6.5 mm in the lumbar and lower thoracic region, and 5.5 mm in the middle thoracic region, were inserted. Intraoperative radiographs were utilized to assess the adequacy of screw placement. The 6 mm diameter titanium rods were manually adjusted to achieve the desired sagittal alignment. Initially, the rod on the concave side was positioned. By rotating the rod approximately 90 degrees clockwise to correct the scoliotic curvature, the rod was secured by tightening the top screw on the neutral vertebra. Subsequently, the rod on the convex side was implanted. Derotation tubes were placed on both the neutral and apical vertebrae, and appropriate derotation of the apical vertebra was achieved. The concave side was then distorted, while the convex side was compressed, and the top screws were tightened.

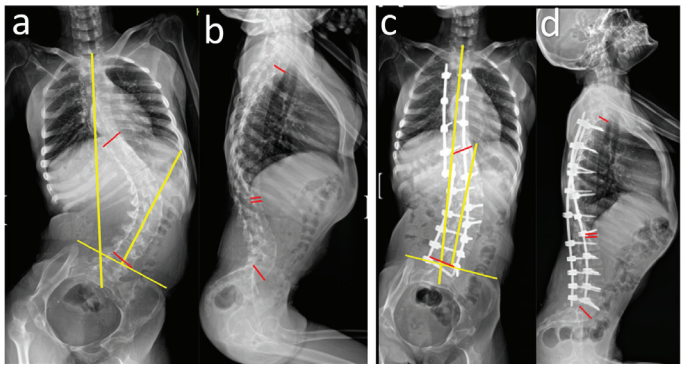

Figure 1. Preoperative and postoperative plain radiographs of a patient undergoing posterior spinal surgery without pelvic fixation. (**a, b:** Preoperative anterior posterior and lateral radiographs; **c, d:** Postoperative anterior posterior and lateral radiographs)

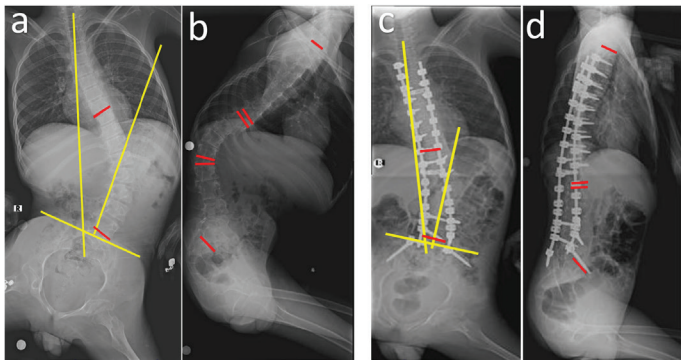

Figure 2. Preoperative and postoperative plain radiographs of a patient undergoing posterior spinal surgery with pelvic fixation. (**a, b:** Preoperative anterior posterior and lateral radiographs; **c, d:** Postoperative anterior posterior and lateral radiographs)

Throughout these procedures, continuous monitoring of sensorimotor and motor evoked potentials was maintained.

The instrumentation levels were T3 or T4 level cranially. In the WoPF group, it was placed caudally at the L5 level. In WPF patients, iliac screws were inserted under fluoroscopic guidance and fixed to the rods using iliac connectors.

No thoracoplasty was performed in any patient. On the first postoperative day, ambulatory patients who were hemodynamically stable were mobilized and nonambulatory patients were seated at the bedside.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY). A significance level of $p<0.05$ was considered statistically significant. Categorical variables were presented as numbers and percentages, while continuous variables were expressed as mean ± standard deviation. The chi-square test was used to compare categorical variables. The normality of continuous variables was assessed using visual examination (histogram and probability graphs) as well as analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). For data comparison, the independent samples t-test and Mann-Whitney U test were employed based on the evaluation of normality.

RESULTS

In the group WoPF, the patients had a mean age of 16.81±1.8 years, while in the group WPF, the mean age was 15.76±1.2 years. The mean follow-up periods for the WoPF and WPF groups were 46.69±21.95 months (ranging from 26 to 96 months) and 43.88±20.05 months (ranging from 26 to 90 months), respectively (Table 1). Among the patients in the WoPF group, 8 (50%) out of 16 had cerebral palsy, 3 (19%) had Duchene muscular dystrophy, 3 (19%) had spinal muscular atrophy, and 2 (12%) had Friedreich ataxia. In the WPF group, 6 (35%) out of 17 patients had cerebral palsy, 7 (41%) had Duchene muscular dystrophy, 2 (12%) had spinal muscular atrophy, 1 (6%) had Friedreich ataxia, and 1 (6%) had Ullrich muscular dystrophy (Table 2).

Radiologically, the preoperative scoliosis angles were found to be higher in the group WoPF compared to the group WPF. The mean Cobb angles were 78.0°±15.75 in the WoPF group and 57.59°±19.4 in the WPF group (Table 3; p=0.006). However, there was no statistically significant difference observed in Cobb angles between the early postoperative (6^{th} week) measurements (19.25°±8.614 in the WoPF group; 20.41°±12.089 in the WPF group) and the final control radiographs (22.00°±8.914 in the WoPF group; 20.53°±12.053 in the WPF group) (Table 3; p=0.709; 0.763).

In terms of pelvic obliquity, the preoperative values were 24.50°±10.532 in the WoPF group and 20.41°±7.500 degrees in the WPF group with no significant difference. At the early (12.69°±7.726 in the WoPF group; 9.41°±5.444 in the WPF group) and final postoperative controls (14.31°±8.292 in the WoPF group; 9.35°±5.338 in the WPF group), pelvic obliquity values improved more in the WPF group (Table 3). However, there was no statistically significant difference between the two groups (preoperative p=0.260; postoperative p=0.217 in early control and p=0.087 in final control) (Table 3).

On sagittal plane radiographs, thoracic kyphosis angles were higher in patients without PF than in patients with PF preoperatively (45.25°±24.349 in the WoPF group; 28.35°±19.493 in the WPF group), in early postoperative (34.69°±9.958 in WoPF group; 30.29°±9.399 in WPF group) and final control radiographs (36.69°±10.682 in WoPF group; 30.88°±9.158 in WPF group), the thoracic kyphosis angle values were higher in patients without PF. However, there was no statistically significant difference between the two groups (Table 3) (early postoperative control: p=0.363; final follow-up: p=0.179).

Table 1. Demographic characteristics and basic information of the patients

	WoPF group	WPF group	p value
Patients (n)	16	17	
M ± SD (age)	16.81±7.305	15.76±5.019	0.845
Follow-up M ± SD (month)	46.69±21.951	43.88±20.056	0.709

WoPF: Without pelvic fixation, WPF: With pelvic fixation, M: means, SD: Standard deviation

Table 2. Neuromuscular diseases

	WoPF group [n (%)]	WPF group [n (%)]
Cerebral palsy	8 (50%)	6 (35%)
Duchene muscular dystrophy	3 (19%)	7 (41%)
Spinal muscular atrophy	3 (19%)	2 (12%)
Friedreich ataxia	2 (12%)	1 (6%)
Ullrich muscular dystrophy	0	1 (6%)

WoPF: Without pelvic fixation, WPF: With pelvic fixation

The mean lumbar lordosis values were 47.19°±16.204 in those without PF and 28.24°±23.012 in those with PF (p=0.011). At early postoperative control, mean lumbar lordosis angles were 40.50°±8.075 in those without PF and 33.18°±15.989 in those with PF, and 42.13°±8.107 in those without PF and 32.47°±15.529 in those with PF. Lumbar lordosis angles were not significantly different between the two groups in the early and final postoperative controls (early postoperative control: p=0.245; final follow-up: p=0.068) (Table 3).

When assessing the activity levels of the patients based on the GMFCS, the mean preoperative level for patients in the group WoPF was 2.75±1.291. Among the WoPF patients, there were 4 patients at level I, 3 patients at level II, 2 patients at level III, and 7 patients at level IV. There were no patients in level V. In contrast, the mean GMFCS levels for patients in the group WPF were higher compared to the WoPF group, with a mean of 3.76±1.033. In the WPF group, there was 1 patient at level I, 2 patients at level II, 4 patients at level III, 8 patients at level IV, and 2 patients at level V. Among the WPF patients, 9 (56%) were non-ambulatory, while among the WoPF patients, 14 (82%) were non-ambulatory. At the last postoperative follow-up, there were no changes in the activity levels in both groups, and the GMFCS levels remained the same as preoperatively (Table 4).

DISCUSSION

The necessity of pelvic fixation in surgical interventions for neuromuscular scoliosis remains uncertain. The findings of the current study align with the perspective that argues against the need for pelvic fixation. The outcomes of the current study revealed no significant clinical or radiographic differences between patients who underwent surgery with and WoPF. These results suggest that pelvic fixation may not provide additional benefits in terms of clinical and radiographic outcomes in patients with neuromuscular scoliosis.

Although neuromuscular scoliosis surgery carries a high reported complication rate of 47%, surgical intervention is still recommended for advanced cases of scoliosis[11]. One effective approach to address pelvic obliquity is the incorporation of pelvic fixation during posterior surgery. However, it is crucial to carefully consider the potential additional morbidities associated with this technique[12]. Generally, pelvic fixation is performed in nonambulatory patients who present with pelvic obliquity in the context of neuromuscular scoliosis[4,13,14].

In their study, Hasler et al.[14] recommended the use of pelvic fixation in the surgical treatment of neuromuscular scoliosis patients with rigid pelvic obliquity greater than 150, particularly in nonambulatory patients. They emphasized the importance of pelvic and scoliosis correction in these cases. However, Farshad

Table 3. Results of preoperative and postoperative radiological evaluation of the patients

	WoPF group (°) (M ± SD)	WPF group (°) (M ± SD)	p value
Cobb angle			
Preoperative	78.00±15.752	57.59±19.413	0.006
Early control	19.25±8.614	20.41±12.089	0.709
Final follow-up	22.00±8.914	20.53±12.053	0.763
Pelvic obliquity angle			
Preoperative	24.50±10.532	20.41±7.500	0.260
Early control	12.69±7.726	9.41±5.444	0.217
Final follow-up	14.31±8.292	9.35±5.338	0.087
Thoracic kyphosis angle			
Preoperative	45.25±24.349	28.35±19.493	0.041
Early control	34.69±9.958	30.29±9.399	0.363
Final follow-up	36.69±10.682	30.88±9.158	0.179
Lumbar lordosis angle			
Preoperative	47.19±16.204	28.24±23.012	0.011
Early control	40.50±8.075	33.18±15.989	0.245
Final follw-up	42.13±8.107	32.47±15.529	0.068

WoPF: Without pelvic fixation, WPF: With pelvic fixation, M: means, SD: Standard deviation

Table 4. Results of the GMFCS evaluation

GMFCS levels	WoPF group (M ± SD)	WPF group (M ± SD)	p value
Preoperative I/II/III/IV/V	4/3/2/7/0 (2.75±1.291)	1/2/4/8/2 (3.76±1.033)	0.028
Final follw-up I/II/III/IV/V	4/3/2/7/0 (2.75±1.291)	1/2/4/8/2 (3.76±1.033)	0.028

WoPF: Without pelvic fixation, WPF: With pelvic fixation, M: means, SD: Standard deviation, GMFCS: Gross Motor Function Classification System

et al.[15] conducted an investigation to determine the benefits of pelvic fixation in both ambulatory and non-ambulatory patients with neuromuscular scoliosis and pelvic obliquity. Their study included 49 patients who underwent posterior surgery for neuromuscular scoliosis. The researchers reported a complication rate of 50% in patients WPF, compared to 29% in patients WoPF. They found that complications were primarily attributed to implant failure and observed no significant difference between the two groups in terms of pelvic obliquity correction and correction of scoliotic curves. Based on their findings, Farshad et al.[15] concluded that pelvic fixation is not mandatory for patients with nonambulatory neuromuscular scoliosis. Furthermore, they cautioned against the use of pelvic fixation to avoid complications in patients with scoliosis greater than or equal to 60° and up to 35°[15].

In the current study, the majority of patients included were non-ambulatory individuals with CMFCS level III-IV. Radiological assessment revealed that patients who underwent pelvic fixation exhibited better outcomes in terms of correcting pelvic obliquity associated with obesity. However, no statistically significant difference was observed between the two groups. Following a minimum follow-up period of 2 years, patients WoPF demonstrated an average increase of 20 degrees in pelvic obliquity angle. Nonetheless, there was no significant difference in pelvic obliquity angles between the two groups during the early postoperative period and at the last follow-up assessment.

During the early postoperative period, scoliosis angles were effectively corrected at the bender level in both groups, and no significant increase in scoliosis angles was observed in either group at the final follow-up. In terms of radiological measurements in the sagittal plane, it was noted that the WoPF group had higher angles of thoracic kyphosis and lumbar lordosis preoperatively compared to the non-WoPF group. However, there were no statistically significant differences in thoracic kyphosis and lumbar lordosis angles between the two groups during the early postoperative period and at the final follow-up (as indicated in Table 3).

When considering the impact of pelvic fixation on patients' activity levels, there is a limited number of studies available in the literature regarding this matter in the context of neuromuscular scoliosis surgery[16,17]. In a study conducted by Menger et al.[18], involving 25 patients, they reported a clinical regression in activity level in one patient who underwent pelvic fixation. Among 8 patients with limited ambulation, 2 reported a subjective decrease in their walking ability. Drake et al.[4], in a retrospective analysis of 118 patients, including 11 non-ambulatory individuals, who underwent surgery for neuromuscular scoliosis, investigated the impact of pelvic fixation on ambulation. They reported no decrease in patient activity levels.

In the current study, it was observed that patients WPF generally had lower preoperative and postoperative CMFCS levels. However, it was not find any significant positive or negative changes in the preoperative and postoperative GMFCS scores in both groups (Table 4).

Study Limitations

The study had several limitations that should be acknowledged. Firstly, its retrospective design introduces inherent limitations in terms of data collection and potential biases. Secondly, important parameters such as the duration of surgery, blood loss, length of hospital stay, postoperative intensive care requirements, and rates of revision were not reported, which could have provided valuable insights into the surgical outcomes. However, despite these limitations, the study was able to present a comparison of radiological values between patients with and WoPF, as well as an assessment of activity levels.

CONCLUSION

The current study findings indicate that pelvic fixation does not offer significant advantages in terms of radiological outcomes and activity levels among patients undergoing surgery for neuromuscular scoliosis with pelvic obliquity. Consequently, it suggests that pelvic fixation may not be obligatory in the surgical management of patients with neuromuscular scoliosis and moderate pelvic obliquity. Considering the potential complications associated WPF, surgical intervention WoPF could be a viable alternative for patients with neuromuscular scoliosis who do not exhibit severe pelvic obliquity. However, further research is necessary to validate these findings and establish more comprehensive guidelines for selecting surgical approaches in this specific patient population.

Ethics

Ethics Committee Approval: The study obtained approval from the Ethics Commission of Gazi University (approval number: 05, approval date: 21.03.2023) prior to conducting the research.
Informed Consent: Retrospective study.
Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: A.Y., Ö.F.K., A.Ş., Concept: A.C.B., A.Y., M.A.T., S.Y., B.K.Y., A.Ş., Design: A.C.B., M.A.T., Ö.F.K., S.Y., A.Ş., Data Collection or Processing: A.C.B., S.Y., B.K.Y., Analysis or Interpretation: A.Y., M.A.T., Ö.F.K., S.Y., B.K.Y., A.Ş., Literature Search: A.C.B., A.Y., Ö.F.K., S.Y., B.K.Y., Writing: A.C.B., M.A.T., S.Y.
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