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Plastic multilayered closure versus orthopedic surgeon closure after spinal instrumentation in pediatric neuromuscular scoliosis

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ABSTRACT

Objective To compare wound complication rates between orthopedic closure (OC) and plastic multilayered closure (PMC) in patients undergoing primary posterior spinal fusion for neuromuscular scoliosis (NMS). We hypothesize that multilayered closure will be associated with better postoperative outcomes.

Methods We collected data on pediatric patients diagnosed with NMS who underwent first time spinal instrumentation between 1 January 2018 and 31 May 2021. Patient demographics, length of surgery, spinal levels fused and operative variables, wound complication rate, treatments, and need for wound washout were reviewed in depth and recorded.

Results In total, 86 patients were reviewed: 46 with OC and 40 with PMC. There was a significant increase in operating room (OR) time with PMC compared with OC (6.7±1.2 vs 7.3±1.3, p=0.016). There was no difference in complication rate, mean postoperative day of complication or unplanned return to the OR for OC and PMC, respectively. There was a slightly significant increase in the number of patients going home with a drain in the PMC cohort compared with the OC cohort (2.1% vs 15%, p=0.046).

Conclusions PMC demonstrated longer OR times than OC and did not demonstrate a statistically significant reduction in wound complications or unplanned returns to the OR. However, other studies have demonstrated statistical and clinical significance with these variables. Surgical programs should review internal patient volumes and outcomes for spinal fusion in NMS patients and consider if PMC after spinal fusions in pediatric patients with NMS or other scoliosis subtypes is an appropriate option in their institution to minimize postoperative wound complications.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Plastic surgeon/multilayered wound closure is generally considered superior to other closures, and neuromuscular scoliosis (NMS) patients undergoing spinal instrumentation generally have higher rates of wound complications compared with non-NMS spinal instrumentation.

WHAT THIS STUDY ADDS

⇒ Plastic surgeon/multilayered wound closure may not have significant effects on wound complication rates in spinal instrumentation for neuromuscular patients.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Institutions using plastic multilayered/plastic surgeons for spine wound closure should re-evaluate in patients with NMS.

INTRODUCTION

Neuromuscular scoliosis (NMS) is a spinal deformity caused by myopathy or upper or lower motor neuron disease. Severe muscular or neurological involvement, often generating pelvic obliquity, can result in significant progression of the scoliosis.[1] Posterior spinal fusion, currently the most common technique for surgical management of NMS, has been shown to have positive clinical outcomes. Studies have shown significant improvements in lung function, seating position, activities of daily living and Cobb angle following this surgery, along with halted curve progression and controlled pelvic obliquity.[2 3]

Despite its efficacy, corrective surgery for NMS has been associated with high complication rates. A 30-year review found a surgical site infection rate of 10.3% overall, with significantly higher rates in patients with spina bifida, body mass index (BMIs) greater than 25 kg/m^2, pelvic fixation and increased number of levels fused.[4] Most deep infections occurred within 90 days of surgery and 36% required implant removal. Infections that occurred after 3 months required implant removal in 84% of cases.

Few studies have been conducted on spinal wound closure and its effects on wound dehiscence and infection rates. This is especially true for paraspinal muscle reapproximating techniques during closure. Plastic multilayered closure (PMC) has been suggested as a promising solution for high wound complication rates. A recent study found that PMC reduced rates of infection, wound dehiscence and return to the operating room (OR).[5]

This study seeks to compare wound complication rates between orthopedic closure (OC) and PMC in patients undergoing primary posterior spinal fusion for NMS in greater detail. We hypothesize that multilayered closure will be associated with better postoperative outcomes.

MATERIALS AND METHODS

Participants

At our institution, PMC became the standard for pediatric spine wound closure after spinal fusions extending to the pelvis beginning in July 2019 due to suggestions of existing literature showing reduced complications and compliance with relevant faculty. After institutional review board exemption, we conducted a retrospective analysis of data collected on patients aged 3–18 years or younger with a diagnosis of NMS who underwent first time spinal instrumentation between 1 January 2018 and 31 May 2021. Exclusion criteria included idiopathic scoliosis, revision surgery for scoliosis, surgery for causes other than NMS and surgical approach from a site other than the back. A total of 101 patients were identified who had been diagnosed with NMS and underwent a spinal fusion. Fifteen patients were removed due to a diagnosis of idiopathic scoliosis (n=7), instrumentation not reaching the pelvis (n=3), spondylolisthesis (n=2), congenital scoliosis (n=1), history of neonatal spinal cord injury (n=1) and revision with no data for index surgery (n=1). Totally, 86 patients met the final inclusion criteria. Though PMC became the norm at our institution in July 2019, there were five PMC cases before this date and one OC case after this date in our dataset. Eight fellowship trained orthopedic surgeons performed the surgeries. Nine plastic surgeons were involved in closures. Sacral-alar-iliac screws were used for pelvic fixation. Other variables such as irrigation, wound debridement, staples versus no staples, occlusive dressing and other special dressings such as a vacuum-assisted dressing, or length of time dressing remains in place, were similar between the cohorts.

Patient demographics, length of surgery, spinal levels fused and operative variables, wound complication rate, treatments, and need for wound washout were reviewed in depth and recorded. Postoperative wound complications only included wound-related issues such as wound dehiscence, superficial and deep surgical site infections, and hematomas. Need for return to the OR was individually assessed by the attending surgeon. Deep wound aspiration was not necessarily routine. Non-wound related complications after surgery were not included. Complications and reoperations within 90 days were recorded, including the indication for reoperation. Length of stay (LOS) was calculated as the number of days a patient remained in the hospital following the index surgery.

Surgical technique

After debridement of the remaining soft tissues around the wound, OC involved the deep paraspinal muscles and muscular fascia being approximated above the spine implants, with subsequent subcutaneous tissues, and then skin closure. We termed it orthopedic closure

Table 1 Demographics and index surgery

	OC group (n=46)	PMC group (n=40)	P value
Age (years)*	12.4±2.46	12.2±2.8	0.711
Gender, n (%)			1.00
Male	19 (41)	17 (43)	
Female	27 (59)	23 (57)	
Race, n (%)			0.298
White	18 (39)	23 (58)	
Hispanic/Latino	16 (35)	10 (25)	
Black	8 (17)	6 (15)	
Asian	4 (9)	1 (2)	
BMI*	21.2±5.7	19.9±5.0	0.263
Primary diagnosis, n (%)			0.235
Cerebral palsy	28 (61)	19 (48)	
Other†	14 (30)	11 (28)	
Muscular dystrophy	2 (4)	5 (12)	
SMA	2 (4)	5 (12)	
OR time (hours)*	6.7±1.2	7.3±1.3	**0.016**
Spinal levels fused*	15.5±1.4	15.1±2.5	0.309
Estimated blood loss (mL)*	864±547	710.5±645.4	0.237
pRBC transfused (mL)*	342±318	258.5±428.3	0.301
Cell saver (mL)*	311±240	256.9±296.3	0.359
LOS (days)*	9.8±10.1	10.7±9.3	0.687

P values in bold indicate significant results.
*Data were presented with mean±SD.
† Other primary diagnoses (pooled) included spina bifida (n=4), congenital myopathy (n=3), trisomy 18 (n=2), congenital hypotonia (n=2), chromosome 1 deletion syndrome (n=1), MECP2 duplication syndrome (n=1), arthrogryposis multiplex congenita (n=1), neurofibromatosis type 1 (n=1), Pallister-Killian Syndrome (n=1), type 1 cerebellar ataxia (n=1), partial trisomy 1 (n=1), Wolf-Hirschhorn syndrome, non-specific paraplegia (n=1), hypomyelinating leukodystrophy type 6 (n=1), McCune-Albright syndrome (n=1) and congenital hydrocephalus (n=1).
BMI, body mass index; LOS, length of stay; OC, orthopedic closure; OR, operating room; PMC, plastic multilayered closure; pRBC, packed red blood cells; SD, standard deviation; SMA, spinal muscular atrophy.

to signify that an orthopedic surgeon performed the closing steps, but this is essentially the same as a typical non-standardized wound closure technique for the spine.

After debridement of the remaining soft tissues around the wound, PMC involved paraspinal muscle release with possible suprafascial dissection extended laterally to take tension off the wound. Paraspinal muscle flaps are raised for complete muscular coverage of the hardware and sewn together in an inverted horizontal mattress fashion to overlap the muscle edge in the dead space. A drain is then placed into the donor site gutters and secured. The skin flaps are then undermined for additional excursion, and superficial fascia is closed. Skin is then closed in layers in an interrupted fashion.

Data analysis

Continuous variables were compared with an independent t-test. Dichotomous categorical variables such as sex, wound complication rates, unplanned returns to the OR and the number of patients going home with a drain were compared with Fisher's exact test. Other categorical variables were compared using the χ^2 test for independence. Statistical significance was defined as a two-tailed p-value <0.05. Statistical analysis was performed using Microsoft Excel (Microsoft Excel data analysis software: V.16.15, Microsoft, Redmond, Washington, USA).

RESULTS

Demographics and index surgery

A total of 86 patients were reviewed: 46 with OC and 40 with PMC. There was no statistical difference between the cohorts in age, gender, race, BMI or primary diagnosis. For index surgery, there was also no difference in spinal levels fused, estimated blood loss, packed red blood cells (pRBCs) transfused, cell saver volume, or LOS (table 1). There was an increase in OR time with PMC compared with OC (6.7±1.2 vs 7.3±1.3, p=0.016).

Wound complications comparison

There were 15 wound complications for the entire cohort (17.4%). There was no difference in complication rate (20.8% vs 12.5%, p=0.394), mean postoperative day of complication (38.3±27.1 vs 32.2±17.6, p=0.659) or unplanned return to the OR (12.5% vs 5%, p=0.275) for OC and PMC, respectively (table 2). There was a slightly significant increase in the number of patients going home with a drain in the PMC cohort compared with the OC cohort (2.1% vs 15%, p=0.046). Patients were only readmitted postoperatively if they required a return to the OR except for one patient in the plastic cohort readmitted for a decreased level of consciousness.

Complications and BMI

There was no difference in BMI of patients with no wound complications compared with patients with complications (20.7±6.1 vs 20.5±5.8, p=0.45). There was also no difference in BMI of patients who had at least one complication (20.3±6.5 vs 21.6±5.7, p=0.34) for OC and PMC, respectively (table 3).

Complications and bacteriology

Table 4 depicts all cases with complications. Cultures were acquired in 8 cases, with 7 coming back positive and 6 showing a polymicrobial infection. There was one case where a culture was obtained but came back with no organisms isolated. *Pseudomonas aeruginosa* was the most common pathogen present (n=4, 27%), followed by methicillin-sensitive *Staphylococcus aureus* (n=2, 13%) and *Escherichia coli* (n=2, 13%). There were also cases of *Enterobacter cloacae* (n=1), *Streptococcus pyogenes* (n=1), *Klebsiella pneumonia* (n=1), *Proteus mirabilis* (n=1) and *Citrobacter freundii* (n=1).

DISCUSSION

Posterior spinal fusion is associated with a high complication rate, higher risk of revision compared with other surgical procedures and high costs. There are many risk factors for the index surgery, with infections and wound complications being one of the more common and frequent.[6–8] Some studies have even found transfusion to be a risk factor for infection.[9 10] These risks are increased in the pediatric population. In contrast with fusion in adolescent idiopathic scoliosis, fusion in NMS has increased hospital LOS, complication rates and cost.[4 11–14] To minimize wound complications and cost, Garg and colleagues[9] described a multilayered and flap closure technique for pediatric spinal deformity.

PMC for spinal wounds have been described in the literature. In 2022, Wright *et al*[15] described a series of 301 patients (76% having comorbidities) undergoing muscle flap closure with a major wound complication rate of 20%. In 2015, Cohen *et al*[16] described 102 PMCs

Table 2 Wound complications and reoperations

	OC group (n=46)	PMC group (n=40)	P value
Complication, n (%)	10 (20.8)	5 (12.5)	0.394
Average postoperative day of complication, mean±SD	38.3±27.1	32.2±17.6	0.659
Unplanned return to OR, n (%)	6 (12.5)	2 (5)	0.275
Number of patients going home with a drain, n (%)	1 (2.1)	6 (15)	**0.046**

P values in bold indicate significant results.
OC, orthopedic closure; OR, operating room; PMC, plastic multilayered closure; SD, standard deviation.

Table 3 BMI and wound complications

	Patients, n (%)	BMI, mean±SD	P value
No wound complications	71 (83)	20.7±6.1	0.45
≥1 complication	15 (17)	20.5±5.8	
OC ≥1 complication	10 (22)	20.3±6.5	0.34
PMC ≥1 complication	5 (13)	21.6±5.7	

BMI, body mass index; OC, orthopedic closure; PMC, plastic multilayered closure; SD, standard deviation.

reconstructions in 96 patients (86% classified as high risk) with a markedly low major wound complication rate of 6% and overall wound complication rate of 10%. In 2019, Weissler *et al*[17] also showed low complication outcomes despite a similar high comorbidity cohort of 782 cases. They compared their series to a cohort of 22,430 patients from the American College of Surgeons National Surgical Quality Improvement Program database.[18] They found lower wound dehiscence rates, wound infection rates and readmission rates in their cohort compared with the comparison cohort. In contrast, Zhong *et al*[19] reviewed 357 spine surgeon closures compared with 52 PMCs, with PMC having increased odds for seroma formation (OR 7.8). They found no difference in complication rates, surgical site infection and return to the OR.

There are fewer studies exploring PMC for the pediatric non-idiopathic scoliosis population. There are only two studies with direct comparison between PMC and OC or non-standardized closure in non-idiopathic scoliosis spinal fusions. In 2017, Ward and colleagues[5] compared 42 non-standardized closures with 34 PMCs. They found lower wound complication rates (19%) in the PMC cohort compared with the non-standardized closure cohort (0%), with 11.9% requiring reoperations. In 2018, Imahiyerobo *et al*[20] compared 56 OCs and 59 PMCs with a decrease from 19.1% in the OC cohort to 5.1% in the PMC cohort. It should be noted that all infections in their study were in the NMS subset of their overall cohort, while our study deals entirely with NMS as a primary diagnosis.

Our results showed a paucity of differences between PMC and OC. Only the operative time and the number of patients going home with a drain were significant, with an increased number in the PMC cohort for both. Elevated operative time was likely due to the necessity of coordination with the plastic surgery team into the primary procedure, an additional timeout for their portion of the case and increased closure time due to the higher complexity of PMC. There appeared to be a

Table 4 Wound complication in patients

Patient	OC or PMC	Levels fused	Postoperative day of complication	Unplanned return to OR	Treatment or procedure	Culture
Case 1	OC	15	57	Yes	Revision, I&D ×2	MSSA, *Streptococcus pyogenes*
Case 2	OC	16	70	No	Local wound care, antibiotics	MSSA, *Pseudomonas aeruginosa*
Case 3	OC	16	6	Yes	I&D ×3	*No organisms isolated*
Case 4	PMC	16	57	No	Local wound care	N/A
Case 5	OC	16	13	No	IV antibiotics	*E. coli, Pseudomonas*
Case 6	OC	14	10	Yes	I&D	*E. coli, Pseudomonas*
Case 7	OC	16	36	No	Local wound care	N/A
Case 8	PMC	16	30	No	N/A	*Pseudomonas*
Case 9	OC	16	17	Yes	I&D ×2, local wound care	*Enterobacter cloacae, gram positive cocci*
Case 10	OC	16	80	No	Local wound care	N/A
Case 11	OC	16	48	No	Local wound care, antibiotics	N/A
Case 12	PMC	17	29	Yes	I&D	N/A
Case 13	PMC	15	37	No	Local wound care	N/A
Case 14	OC	15	25	Yes	I&D	*Klebsiella pneumoniae, Proteus mirabilis, Citrobacter freundii*
Case 15	PMC	15	8	Yes	I&D	N/A

E. coli, *Escherichia coli*; I&D, incision and drainage; MSSA, methicillin-sensitive *Staphylococcus aureus*; N/A, not available; OC, orthopedic closure; OR, operating room; PMC, plastic multilayered closure.

trend in unplanned returns to the OR for wound complications in OC (12.5%) versus PMC (5%). With greater numbers over time, this trend may have been clinically significant. It should be noted that our OC cohort had a higher percentage of cerebral palsy diagnoses compared with the PMC group (61% vs 48%). Spinal fusion in cerebral palsy patients is known to have complication rates as high as 36%–39%.[21 22]

We also reviewed the complication cohort to evaluate whether BMI was a risk factor for complication in our study. We found that there was no difference in BMI for patients with complications compared with patients without complications. For patients that did have complications, there was also no difference in BMI between OC and PMC. Previous studies have shown that BMI can affect short-term outcomes of posterior spinal fusion in pediatric patients. Farahani *et al*[23] found that low BMI is an independent predictor of blood loss, pneumonia and readmissions, while studies conducted by Katyal *et al*,[24] Malik *et al*[25] and Ramos *et al*[26] indicate that obese individuals have significantly higher rates of wound complications, infections and reoperations.

At this time, no studies have done a cost comparison of PMC versus OC or a non-standardized closure. Theoretically, PMC incurs higher costs secondary to increased supply usage, increased OR time as demonstrated in our study and additional surgeon fees. If PMC can be shown statistically to prevent readmission and unplanned return to the OR, this could be justified. A larger cohort comparison and cost-analysis is required to make a definitive statement.

Limitations

Limitations of this study include those intrinsic to a retrospective design, including a lower level of evidence compared with prospective or randomized controlled trials, and selection bias. There may be variations in both PMC and OC that are surgeon dependent, and this is a small volume of patients. There may be other factors influencing wound healing and infection rates that would be apparent in a larger study. Though there is a trend in complications favoring PMC, this difference was not statistically significant, and a larger cohort is needed to be statistically certain. Our study may be underpowered. During the PMC time frame, two pediatric orthopedic spine surgeons left the institution and one joined. Comorbidities were not accounted for in the cohort. Revision surgeries were not included as a population for review.

Conclusions

Infections and wound complications following spine surgery are common but significant adverse events. In our study, PMC demonstrated longer OR times than OC and did not demonstrate a statistically significant reduction in wound complications or unplanned returns to the OR. However, other studies have demonstrated statistical and clinical significance with these variables. A larger multicenter study comparing OC versus PMC is needed to determine statistical significance, preferably prospective. Surgical programs should review internal patient volumes and outcomes for spinal fusion in NMS patients and consider if PMC after spinal fusions in pediatric patients with NMS or other scoliosis subtypes is an appropriate option in their institution to minimize postoperative wound complications.

Contributors EUE: study design, chart review, data organization, statistical analysis, manuscript preparation and guarantor; PT: data organization, chart review and manuscript preparation; NB: data organization, chart review; manuscript preparation; II: study design, data organization, statistical analysis and manuscript preparation; EPB: study design and manuscript preparation; BGS: study design and manuscript preparation.

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Author note All authors whose names appear on the submission: (1) made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; (2) drafted the work or revised it critically for important intellectual content; (3) approved the version to be published; and (4) agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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REFERENCES

1 Wishart BD, Kivlehan E. Neuromuscular scoliosis: when, who, why and outcomes. *Phys Med Rehabil Clin N Am* 2021;32:547–56.
2 Larsson E-LC, Aaro SI, Normelli HCM, *et al*. Long-term follow-up of functioning after spinal surgery in patients with neuromuscular scoliosis. *Spine* 2005;30:2145–52.
3 Holt JB, Dolan LA, Weinstein SL. Outcomes of primary posterior spinal fusion for scoliosis in spinal muscular atrophy: clinical, radiographic, and pulmonary outcomes and complications. *J Pediatr Orthop* 2017;37:e505–11.
4 Ramo BA, Roberts DW, Tuason D, *et al*. Surgical site infections after posterior spinal fusion for neuromuscular scoliosis: a thirty-year experience at a single institution. *J Bone Joint Surg Am* 2014;96:2038–48.
5 Ward JP, Feldman DS, Paul J, *et al*. Wound closure in nonidiopathic scoliosis: does closure matter? *J Pediatr Orthop* 2017;37:166–70.
6 Montgomery DM, Aronson DD, Lee CL, *et al*. Posterior spinal fusion: allograft versus autograft bone. *J Spinal Disord* 1990;3:370–5. Available: https://pubmed.ncbi.nlm.nih.gov/2134450/
7 Triulzi DJ, Vanek K, Ryan DH, *et al*. A clinical and immunologic study of blood transfusion and postoperative bacterial infection in spinal surgery. *Transfusion* 1992;32:517–24.
8 Barsdorf AI, Sproule DM, Kaufmann P. Scoliosis surgery in children with neuromuscular disease: findings from the US national inpatient sample, 1997 to 2003. *Arch Neurol* 2010;67:231–5.
9 Garg S, Khechoyan D, Kim EB, *et al*. Multilayered and flap closure technique for pediatric spinal deformity surgery. *J Am Acad Orthop Surg* 2020;28:e92–9.

10 Sponseller PD, Shah SA, Abel MF, *et al*. Infection rate after spine surgery in cerebral palsy is high and impairs results: multicenter analysis of risk factors and treatment. *Clin Orthop Relat Res* 2010;468:711–6.
11 Benson ER, Thomson JD, Smith BG, *et al*. Results and morbidity in a consecutive series of patients undergoing spinal fusion for neuromuscular scoliosis. *Spine (Phila Pa 1976)* 1998;23:2308–17.
12 Modi HN, Suh S-W, Yang J-H, *et al*. Surgical complications in neuromuscular scoliosis operated with posterior- only approach using pedicle screw fixation. *Scoliosis* 2009;4:11.
13 Rumalla K, Yarbrough CK, Pugely AJ, *et al*. Spinal fusion for pediatric neuromuscular scoliosis: national trends, complications, and in-hospital outcomes. *J Neurosurg Spine* 2016;25:500–8.
14 Reames DL, Smith JS, Fu K-MG, *et al*. Complications in the surgical treatment of 19,360 cases of pediatric scoliosis: a review of the scoliosis research Society morbidity and mortality database. *Spine (Phila Pa 1976)* 2011;36:1484–91.
15 Wright MA, Weinstein AL, Bernstein JL, *et al*. Muscle flap closure following complex spine surgery: a decade of experience. *Plast Reconstr Surg* 2020;146:642e–50e.
16 Cohen LE, Fullerton N, Mundy LR, *et al*. Optimizing successful outcomes in complex spine reconstruction using local muscle flaps. *Plast Reconstr Surg* 2016;137:295–301.
17 Weissler EH, Jenkins AL 3rd, Hecht AC, *et al*. Plastic surgeon closure of index spinal cases: a single-institution review of 928 cases. *Clin Spine Surg* 2019;32:E397–402.
18 Kimmell KT, Algattas H, Joynt P, *et al*. Risk modeling predicts complication rates for spinal surgery. *Spine (Phila Pa 1976)* 2015;40:1836–41.
19 Zhong J, Balouch E, O'Malley N, *et al*. Comparison of plastic surgeon and spine surgeon closure in revision short segment thoracolumbar spinal fusions. *Spine (Phila Pa 1976)* 2021;46:1279–86.
20 Imahiyerobo T, Minkara AA, Matsumoto H, *et al*. Plastic multilayered closure in pediatric nonidiopathic scoliosis is associated with a lower than expected incidence of wound complications and surgical site infections. *Spine Deform* 2018;6:454–9.
21 Yaszay B, Bartley CE, Sponseller PD, *et al*. Major complications following surgical correction of spine deformity in 257 patients with cerebral palsy. *Spine Deform* 2020;8:1305–12.
22 Samdani AF, Belin EJ, Bennett JT, *et al*. Major perioperative complications after spine surgery in patients with cerebral palsy: assessment of risk factors. *Eur Spine J* 2016;25:795–800.
23 Farahani F, Riccio AI, Ramo BA. Low BMI (<10th percentile) increases complications and readmissions after posterior spinal fusion in adolescent idiopathic scoliosis. *Spine Deform* 2021;9:1533–40.
24 Katyal C, Grossman S, Dworkin A, *et al*. Increased risk of infection in obese adolescents after pedicle screw instrumentation for idiopathic scoliosis. *Spine Deform* 2015;3:166–71.
25 Malik AT, Tamer R, Yu E, *et al*. The impact of body mass index (BMI) on 30-day outcomes following posterior spinal fusion in neuromuscular scoliosis. *Spine (Phila Pa 1976)* 2019;44:1348–55.
26 De la Garza Ramos R, Nakhla J, Nasser R, *et al*. Effect of body mass index on surgical outcomes after posterior spinal fusion for adolescent idiopathic scoliosis. *Neurosurg Focus* 2017;43:E5.