Preoperative Malnutrition-Associated Spinal Malalignment with Patient-Reported Outcome Measures in Adult Spinal Deformity Surgery: A 2-Year Follow-Up Study

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Abstract:

Introduction: Malnutrition could lead to additional medical complications, and the prognostic nutrition index (PNI) is evaluated to assess the nutritional status of patients. However, the midterm postoperative outcomes of malnutrition in patients with adult spinal deformity (ASD) are unclear. This study aims to investigate postoperative midterm spinal alignment and patients' reported outcome measures (PROMs) in malnourished patients with ASD.

Methods: This study recruited 303 ASD patients who underwent surgery. Adult patients ≥50 years old were categorized into the PNI <50 (L group) and the PNI ≥50 (H group) groups. Demographic data, medical complications, mechanical complications, radiographic parameters, Oswestry Disability Index (ODI), and Scoliosis Research Society-22 (SRS-22) were analyzed.

Results: In this study, 303 patients participated, with 132 and 171 patients in the L and H groups, respectively. Significant differences were noted between the L and H groups in body mass index (22.5 vs. 23.6 kg/m^2, *p*=0.011), autoimmune disease (9.8% vs. 2.3%, *p*=0.005), and total number of medical complications (47.7% vs. 33.3%, *p*=0.011). The T1 slope was significantly higher in the L group than in the H group preoperatively (36.5 vs. 32.8°, *p*=0.042). However, no significant differences were noted in mechanical complications, ODI, SRS-22 scores, or radiographic parameters 2 years postoperatively between the L and H groups, except for the sagittal vertical axis (73.1 vs. 55.7 mm, *p*=0.014).

Conclusions: No significant difference was noted in the incidence of mechanical complications and PROMs 2 years postoperatively. Malnourished status was related to medical complications and global malalignment. However, good surgical outcomes can be expected even for malnourished patients.

Keywords:

nutritional status, prognostic nutritional index, adult spinal deformity, spinal alignment

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Introduction

The age of the global population has increased along with increasing lifespan longevity and decreasing fertility rates, which affect the incidence and burden of musculoskeletal diseases[1)]. Adult spinal deformity (ASD) includes scoliosis, sagittal and coronal imbalance[2)], and spinal malalignment as well as poor patient-reported outcome measures (PROMs) in patients with ASD. Over the past decades, surgical techniques have improved considerably in the treatment of patients with ASD. Minimally invasive surgery (MIS) approaches for fusing the spine are now widespread, and later lumbar interbody fusion (LLIF) as MIS is widely performed in ASD surgery[3)]. However, several factors challenge ASD surgery, e.g., aging and poor nutritional status.

Preoperative nutritional status is related to complications and operative outcomes in cancer patients[4,5)]. Currently, Patient-Generated Subjective Global Assessment, the Nutrition Risk Screening-2002, and Controlling Nutritional Status score have been used for nutritional evaluation[6-8)]. In addition, the prognostic nutritional index (PNI) can also assess the nutritional status of patients and predict the prognosis or

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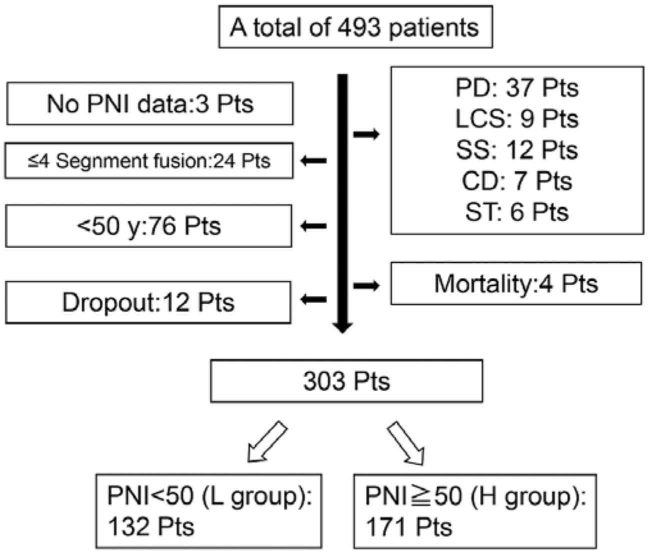

Figure 1. Flowchart recruitment of patients.
PNI prognostic nutritional index, *PD* Parkinson's disease, *LCS* lumbar canal stenosis, *SS* syndromic scoliosis, *CD* congenital deformity, *ST* spinal tuberculosis, *Pts* patients.

indication for surgery in cancer patients[9]. The importance of preoperative nutritional status in ASD has been recently noted. Lower PNI in spinal surgery is likely to result in medical complications, e.g., delirium and surgical site infection[10-12]. Meanwhile, nutritional interventions can reduce medical complications[13]. Thus, preoperative nutritional status is important in estimating complications in patients with ASD, and improving malnutrition reduce complications.

While the malnourished status is associated with medical complications, the association between nutritional status and spinal alignment or PROMs is unclear in patients undergoing ASD surgery. This study aims to investigate the influence of malnutrition on spinal alignment and PROMs in patients with ASD after surgery.

Materials and Methods

This study of ethical approval was obtained from the Institutional Review Board of Hamamatsu University.

Patients

This study reviewed 493 adult patients who underwent spinal corrective fusion between March 2010 and December 2019. ASD was defined as the presence of at least one of the following: pelvic tilt (PT) ≥25°, thoracic kyphosis (TK) ≥60°, the sagittal vertical axis (SVA) ≥50 mm, and/or degenerative or idiopathic scoliosis with a Cobb angle ≥20° in the coronal plane during whole-spine standing radiography.

Inclusion criteria followed: (1) over four fused vertebral segments, (2) age ≥50 years old, (3) postoperative follow-up ≥2 years, and (4) obtained written informed consent from patients. The exclusion criteria followed: (1) presence of Parkinson's disease, congenital scoliosis, syndromic scoliosis, spinal tuberculosis, surgery for only lumbar spinal canal stenosis, and (2) without PNI data. Patients were divided into the L (PNI <50) and H (PNI ≥50) groups. The following formula represents PNI: PNI=10×serum albumin level (Alb, in gram per microliters)+0.005×total lymphocyte count (TLC, per microliters). PNI <50 indicates malnutrition according to a previous study[10].

Measured data

Patient demographics were obtained: age (years), sex, height (in centimeters), weight (in kilograms), body mass index (BMI; in kilograms per square meter), hip T-score, smoking, diabetes mellitus, autoimmune disease, chronic kidney disease, respiratory disease, cardiovascular disease, stroke, liver cirrhosis, surgical procedure with three-column osteotomies (3-CO), surgical procedure with two-stage LLIF surgery, number of fused vertebrae, operation time, intraoperative bleeding, Charlson Comorbidity Index, and American Society of Anesthesiologists (ASA) grade. Preoperative laboratory biochemistry included Alb (in gram per deciliters), TLC (per microliter), hemoglobin (in gram per deciliters), white blood cell (per microliter), red blood cell (per microliter), platelet (per microliter), and total cholesterol (in milligram per deciliters). The upper instrumented vertebra (UIV) and the lower instrumented vertebra (LIV) were also obtained. The values for each vertebral level are as follows: T1=1, T2=2, T3=3, T4=4, T5=5, T6=6, T7=7, T8=8, T9=9, T10=10, T11=11, T12=12, L1=13, L2=14, L3=15, L4=16, L5=17, S1=18, and ilium=19. Medical and mechanical complications were noted. Medical complications were evaluated for admission (normally 30 days): surgical site infection, delirium, deep venous thrombosis, cardiac disorders, respiratory disorders, urological disorders, and pulmonary embolism. Mechanical complications were assessed up to 2 years after the surgery: proximal junctional kyphosis (PJK, proximal junctional angle (PJA ≥10°), and ≥10° compared to the preoperative measurement), proximal junctional failure (PJF, UIV, or UIV+1 fracture; PJK progression; or neurological deficit requiring surgery), distal junctional kyphosis (DJK, the distal junctional angle between the lower endplate LIV and lower endplate LIV-1 ≥10°, and ≥10° compared to the preoperative measurement), distal junctional failure (DJF, LIV, or LIV-1 fracture or DJK requiring surgery), and rod breakage.

Radiographic parameters were obtained before surgery, after surgery (first standing after surgery), and at the 2-year follow-up: cervical lordosis, C2-7SVA, T1 slope (TS), TK, lumbar lordosis (LL), PT, pelvic incidence (PI), SVA, C7 plumb line to the central sacral vertical line, Cobb, and PJA (the lower endplate of the UIV and the upper endplate of two supra-adjacent vertebrae).

PROMs were evaluated using the Oswestry Disability Index (ODI) and Scoliosis Research Society-22 (SRS-22) questionnaire (function, pain, self-image, mental health, satisfaction, and total).

Table 1. Demographic Data Between Groups.

Variables	PNI <50 (L group)	PNI ≧50 (H group)	*P* value
Number	132	171	
Age (years)	69.9±7.1	68.6±7.7	0.141
Female sex	106 (80.3%)	152 (88.9%)	0.037[a]
Height (cm)	148.5±8.5	149.7±8.9	0.232
Weight (kg)	49.6±9.4	52.9±10.7	0.006[a]
BMI (kg/m^2)	22.5±3.3	23.6±4.0	0.011[a]
PNI	45.9±3.3	54.2±3.6	*P*<0.01[a]
Alb (g/dL)	4.0±0.3	4.5±0.2	*P*<0.01[a]
TLC (/μL)	1,159.6±350.6	1,913.6±607.8	*P*<0.01[a]
Hemoglobin (g/dL)	12.3±1.5	12.9±1.2	*P*<0.01[a]
White blood cell (/μL)	5,186.9±1,494.3	5,880.2±1,547.7	*P*<0.01[a]
Red blood cell (10^4/μL)	403.3±49.8	423.4±41.9	*P*<0.01[a]
Platelet (10^4/μL)	23.7±6.4	24.2±5.6	0.490
Total cholesterol (mg/dL)	193.5±31.7 (*n*=95)	218.0±34.2 (*n*=120)	*P*<0.01[a]
T-scores	−1.5±1.1	−1.6±1.1	0.558
Smoking	12 (9.1%)	21 (12.3%)	0.377
Surgical procedure			
3-CO	47 (35.6%)	59 (34.5%)	0.842
Second-stage surgery LLIF	51 (38.6%)	64 (37.4%)	0.830
UIV	8.7±2.1	8.9±1.9	0.258
LIV	18.5±1.2	18.5±1.4	0.759
Fusion level	10.1±2.2	9.7±2.1	0.211
Operation time (min)	423.6±86.5	425.1±93.5	0.889
ASA (grade I/II/III)	7/108/15	25/137/8	0.005[a]
Intraoperative bleeding	1,476.9±993.7	1,406.0±971.4	0.533
Diabetes mellitus	16 (12.1%)	16 (9.4%)	0.438
Autoimmune disease	13 (9.8%)	4 (2.3%)	0.005[a]
Chronic kidney disease	9 (6.8%)	8 (4.7%)	0.422
Respiratory disease	12 (9.1%)	15 (8.8%)	0.923
Cardiovascular disease	15 (11.4%)	17 (9.9%)	0.690
Stroke	6 (4.5%)	8 (4.7%)	0.956
Liver cirrhosis	0 (0.0%)	2 (1.2%)	0.507
CCI	0.5±0.9	0.4±0.7	0.101

Values expressed as mean±SD or number (percentage)

[a]Statistically significant difference

PNI prognostic nutritional index, *BMI* body mass index, *Alb* serum albumin level, *TLC* total lymphocyte count, *3-CO* three-column osteotomies, *LLIF* later lumbar interbody fusion, *UIV* upper instrumented vertebra, *LIV* lower instrumented vertebra, *ASA* American Society of Anesthesiologists, *CCI* Charlson Comorbidity Index

Statistical analysis

Continuous variables were shown as mean±standard deviation, and categorical variables were shown as absolute numbers and percentages. An unpaired *t*-test and chi-squared test were performed using SPSS, version 25 (IBM Corp., Armonk, NY, USA), to assess differences between the L and H groups. A *p* value <0.05 indicated statistical significance.

Results

The detailed recruitment of patients is summarized in Fig. 1. Moreover, 303 of the 493 patients were enrolled in the current study. Of the patients, 190 were excluded for the following reasons: Parkinson's disease (37 patients), lumbar canal stenosis (nine patients), syndromic scoliosis (12 patients), congenital deformity (seven patients), spinal tuberculosis (six patients), aged <50 (76 patients), segment fusion ≤4 (24 patients), without PNI record (three patients), mortality (four patients), and dropped out (12 patients). Table 1 shows the detailed patient background characteristics. More male patients were noted in the L group than in the H group. In addition, significantly lower weight, BMI, PNI, Alb, TLC, hemoglobin, white blood cell, red blood cell, and total cholesterol were observed in the L group than those in the H group. Moreover, the prevalence of ASA III grade and autoimmune disease was significantly higher in the L group (7/108/15 vs. 25/137/8, *p*=0.005) than that of the H group (9.8% vs. 2.3%, *p*=0.005).

Medical and mechanical complications analysis

The details of the medical and mechanical complications

Table 2. Details of Complications.

Variables	PNI <50 (L group)	PNI ≧50 (H group)	*P* value
Medical complications			
Total Patients with medical complications	44 (33.3%)	42 (24.6%)	0.093
Total cases number of medical complications	63 (47.7%)	57 (33.3%)	0.011[a]
Delirium	20 (15.2%)	10 (5.8%)	0.007[a]
SSI	7 (5.3%)	12 (7.0%)	0.542
DVT	5 (3.8%)	14 (8.2%)	0.117
Cardiac disorder	5 (3.8%)	4 (2.3%)	0.510
pneumonia	4 (3.0%)	4 (2.3%)	0.732
Gastro discorder	10 (7.6%)	5 (2.9%)	0.064
UTI	7 (5.3%)	4 (2.3%)	0.220
PE	1 (0.8%)	2 (1.2%)	1.00
Decubitus	1 (0.8%)	1 (0.6%)	1.00
Cerebral hemorrhage	1 (0.8%)	0 (0.0%)	0.436
Depression	0 (0.0%)	1 (0.6%)	1.00
Umbilical hernia	1 (0.8%)	0 (0.0%)	0.436
Re-intubation due to respiratory disorder	1 (0.8%)	0 (0.0%)	0.436
Mechanical complication			
Total patients with mechanical complications	46 (34.8%)	65 (38.0%)	0.571
Total cases of mechanical complications	54 (40.9%)	88 (51.5%)	0.068
PJF	16 (12.1%)	22 (12.9%)	0.846
PJK	7 (5.3%)	6 (3.5%)	0.445
DJF	5 (3.8%)	10 (5.8%)	0.412
DJK	0 (0.0%)	1 (0.6%)	1.00
Rod breakage	26 (19.7 %)	49 (28.7 %)	0.073

Values expressed as number (percentage)

[a]Statistically significant difference

SSI surgical site infection, *DVT* deep venous thrombosis, *UTI* urinary tract infection, *PE* pulmonary embolism, *PJF* proximal junctional failure, *PJK* proximal junctional kyphosis, *DJF* distal junctional failure, *DJK* distal junctional kyphosis

are summarized in Table 2. No significant difference in the total number of patients with medical complications was noted between the L and H groups (33.3% vs. 24.6%, respectively, p=0.093). However, the total number of medical complications in the L group was significantly higher than that in the H group (47.7% vs. 33.3%, respectively, p= 0.011). Moreover, a significantly higher incidence of delirium was observed in the L group than in the H group (15.2% vs. 5.8%, respectively, p=0.007); other medical complications were not significantly different between the two groups. Regarding mechanical complications, no differences in the total number of complications and detailed complications were noted between the L and H groups.

Comparison of radiographic parameters

Pre-, just-, and 2 years postoperative radiographic parameters are shown in Table 3. Significant differences in terms of preoperative TS (36.5° vs. 32.8°, respectively, p=0.042), just postoperative PI-LL (12.2° vs. 8.3°, respectively, p=0.019), and 2-years postoperative SVA (73.1 vs. 55.7 mm, respectively, p=0.014) between the L and H groups. No significant differences in the pelvis, lumbar spine, thoracic spine, cervical spine, and coronal plane between the L and H groups were observed at pre-, just-, and 2-years postoperation, respectively.

Comparison of PROMs

Preoperative and 2-year postoperative PROMs are summarized in Table 4. Lower ODI and higher SRS-22 scores indicate better clinical outcomes. The preoperative and 2-year postoperative ODI and SRS-22 scores between the L and H groups were not significantly different. The improvements in the ODI and SRS-22r scores were maintained in malnourished status. Compared with preoperative ODI and SRS-22r scores, the ODI scores significantly decreased, and SRS-22 domains (function, pain, self-image, mental health, satisfaction, and total) were significantly increased after ASD surgery in both groups.

Representative cases

Fig. 2 shows a 71-year-old female patient with ASD in the L group on radiographs. Fig. 2A, 2B, 2C show preoperative TS at 54° and SVA at 257.2 mm, postoperative TS at 32° and SVA at 74.8 mm, and 2-years postoperative TS at 43° and SVA at 103.3 mm, respectively. Fig. 3 shows a 72-year-old female patient with ASD in the H group on radiographs. Fig. 3A, 3B, 3C show preoperative TS at 23° and SVA at 132 mm, postoperative TS at 22° and SVA at 32

Table 3. Radiographic Parameters.

Variable	PNI <50 (L group)	PNI ≧50 (H group)	*P* value
Preoperation			
CL (°)	23.2±17.8	19.6±17.7	0.087
C2-7SVA (mm)	22.1±20.4	19.1±17.0	0.177
TS (°)	36.5±16.5	32.8±14.6	0.042[a]
TK (°)	28.0±21.7	24.8±20.9	0.2
PT (°)	34.6±13.2	35.4±9.9	0.563
PI (°)	53.4±12.0	51.8±11.6	0.225
LL (°)	13.6±21.5	13.1±22.9	0.835
PI-LL (°)	39.8±22.7	38.7±22.6	0.669
SVA (mm)	127.3±77.8	109.5±79.6	0.054
C7-CSVL (mm)	10.6±39.4	11.0±35.6	0.94
Cobb (°)	30.1±20.8	26.7±21.9	0.183
PJA (°)	5.4±8.8	4.9±7.1	0.596
Just postoperation			
CL (°)	17.4±15.6	16.2±14.4	0.498
C2-7SVA (mm)	16.3±16.0	16.5±12.9	0.894
TS (°)	28.2±11.9	27.4±9.8	0.522
TK (°)	35.1±12.5	34.7±11.3	0.784
PT (°)	23.0±10.8	21.3±9.6	0.15
PI (°)	53.2±12.1	51.5±10.3	0.176
LL (°)	41.1±13.9	43.2±12.9	0.173
PI-LL (°)	12.2±14.8	8.3±13.5	0.019[a]
SVA (mm)	50.2±54.4	41.5±43.9	0.138
C7-CSVL (mm)	6.7±22.7	2.6±24.6	0.139
Cobb (°)	10.4±10.1	9.4±9.5	0.351
PJA (°)	12.7±9.0	12.1±7.7	0.514
2 years postoperation			
CL (°)	20.6±15.2	17.8±15.7	0.125
C2-7SVA (mm)	20.2±18.7	22.3±15.0	0.311
TS (°)	32.8±14.4	31.5±12.2	0.444
TK (°)	42.0±17.9	41.8±14.3	0.941
PT (°)	27.5±10.7	25.6±10.3	0.132
PI (°)	54.8±13.4	52.9±10.7	0.193
LL (°)	38.0±16.9	40.4±15.2	0.215
PI-LL (°)	16.7±20.2	12.6±16.1	0.061
SVA (mm)	73.1±65.8	55.7±52.6	0.014[a]
C7-CSVL (mm)	10.2±23.7	5.2±24.0	0.083
Cobb (°)	10.5±9.8	9.5±8.3	0.35
PJA (°)	17.2±10.3	17.1±10.9	0.93

Values expressed as mean±SD

[a]Statistically significant difference

CL cervical lordosis, *SVA* sagittal vertical axis, *TS* T1 slope, *TK* thoracic kyphosis, *PT* pelvic title, *PI* pelvic incidence, *LL* lumbar lordosis, *PI-LL* PI minus LL, *C7-CSVL* C7 plumb line to the central sacral vertical line, *PJA* proximal junctional angle

mm, and 2-years postoperative TS at 40° and SVA at 45 mm, respectively. In the malnourished patient in the L group, TS was higher before surgery, and SVA was higher 2 years after surgery.

Discussion

The foremost finding in this study was that malnourished patients had higher values of preoperative TS and SVA 2 years after surgery compared with well-nourished patients. However, no significant differences were observed in other radiological parameters and PROMs. Thus, ASD surgery can result in good PROM even in malnourished patients. However, a correction loss was noted in global alignment compared with the well-nourished group. It is believed that this is the first study to assess the relationship between nutritional status and long-term outcomes in patients with ASD.

Malnourished status is a poor prognostic factor for complications and mortality in postoperative patients with various cancers[14]. PNI is an adequate predictor of nutritional

Table 4. ODI and SRS-22 Scores.

Variable	PNI <50 (L group)	PNI ≧50 (H group)	*P* value
Preoperation			
ODI	47.3±17.6	44.6±16.8	0.185
SRS-22 Function	2.5±0.7	2.5±0.7	0.57
SRS-22 Pain	2.8±0.9	2.9±0.8	0.246
SRS-22 Self-image	1.9±0.6	2.0±0.7	0.215
SRS-22 Mental health	2.5±0.9	2.5±0.9	0.902
SRS-22 Satisfaction	3.0±0.7	3.2±0.7	0.245
SRS-22 Total	2.5±0.6	2.6±0.5	0.309
2 Years postoperation			
ODI	31.5±20.8*	31.3±19.4**	0.91
SRS-22 Function	3.2±0.8*	3.2±0.8**	0.912
SRS-22 Pain	3.8±1.0*	3.8±0.8**	0.882
SRS-22 Self-image	3.3±0.8*	3.3±0.8**	0.624
SRS-22 Mental health	3.4±0.9*	3.3±0.9**	0.814
SRS-22 Satisfaction	3.5±0.9*	3.5±1.0**	0.862
SRS-22 Total	3.4±0.7*	3.4±0.7**	0.915

Values expressed as mean±SD

*$p<0.05$ compared with preoperative domain in L group; **$p<0.05$ compared with preoperative domain in L group

ODI Oswestry Disability Index, *SRS-22* Scoliosis Research Society-22

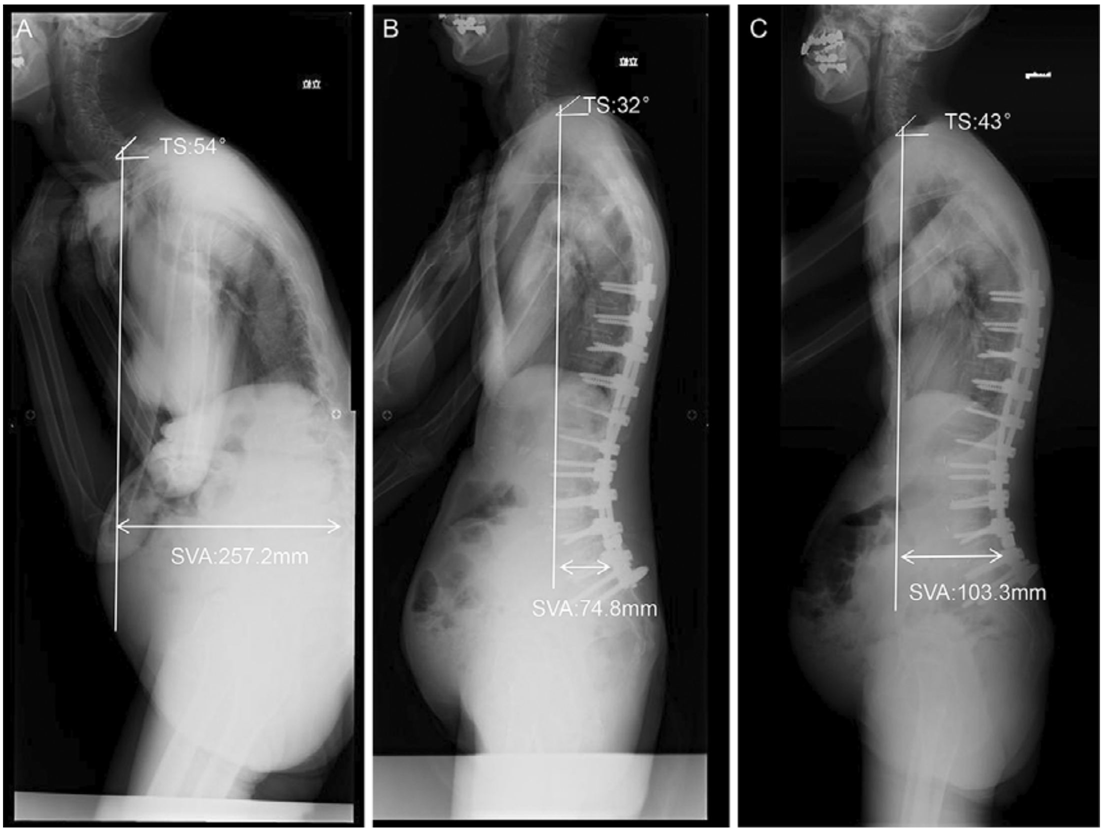

Figure 2. Radiographs of the patient in the L group.
A 71-year-old female patient with ASD. A Preoperative radiograph: TS (54°) and SVA (257.2 mm). B Postoperative radiograph: TS (32°) and SVA (74.8 mm). C Radiograph 2 years after surgery: TS (43°) and SVA (103.3 mm).

status, total cholesterol, TLC, serum albumin, and BMI, all of which were lower in the malnourished L group[15]. Table 1 shows that malnourished patients had a higher prevalence of autoimmune disease and severe ASA grades. Patients with a

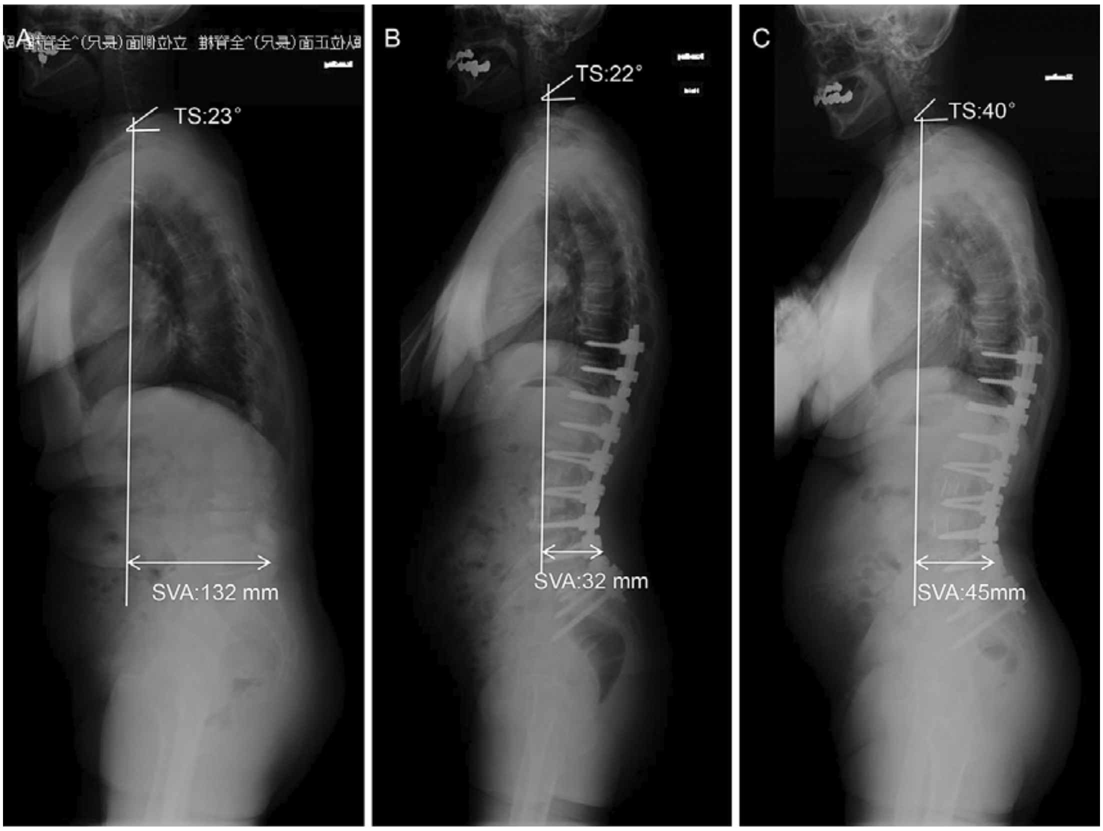

Figure 3. Radiographs of the patient in the H group.
A 72-year-old female patient with ASD. A Preoperative radiograph: TS (23°) and SVA (132 mm). B Postoperative radiograph: TS (22°) and SVA (32 mm). C Radiograph 2 years after surgery: TS (40°) and SVA (45 mm).

PNI <50 had more comorbidities before surgery and were at greater risk in the perioperative period. Consistent with these findings, patients had a higher rate of complications immediately following ASD surgery. Similar to the results of a previous report[10], delirium was the most common complication, with a higher incidence in malnourished patients. Other complications had no differences between the two groups. However, the total number of medicinal complications was higher in the L group than that in the H group. More medical complications require more medical resources for treatment and are costlier. A recent study found that postoperative nutritional interventions for malnourished patients with ASD can reduce medical complications[13].

Mechanical complications are the most common complications of ASD surgery, which may negatively affect clinical outcomes. PJK or PJF is a reason commonly given for revision surgery in patients with ASD. Higher BMI, older age, osteoporosis, and radiographic parameters are risk factors[16-18]. Rod breakage may cause severe pain and loss of correction, frequently requiring revision surgery[19]. Screw loosening indicates loss of screw fixation and possible development of pseudarthrosis[20]. However, whether the nutritional status has an impact on the development of mechanical complications in patients with ASD is unclear. In the results of the current study, PJF and PJK did not differ between the two groups. No differences were noted in the incidences of DJK and DJF. Moreover, nutritional status did not affect rod breakage. Interestingly, malnutrition status is a risk factor for medical rather than mechanical complications.

Table 3 shows that preoperative TS and SVA values 2 years after surgery were remarkably higher in malnourished patients than in well-nourished patients. Preoperative SVA also tended to be more severe in the L group (p=0.054), although no difference was observed between the two groups. In addition, TS reflects upper thoracic alignment, and previous studies have reported that malnourished patients had higher values of TS and TK compared with well-nourished patients, and TS had a significant correlation with SVA[10,21]. Therefore, high TS before surgery should be influenced by malnutrition and high SVA. Although SVA was not significantly different between the L and H groups before ASD surgery, the SVA was greater in the malnourished group 2 years after ASD surgery compared with well-nourished patients. PI-LL in the L group was significantly higher just after the surgery. Thus, the suboptimal correction could affect higher SVA in the L group years after the surgery. However, no significant differences in each region of the spine (from cervical to pelvic) were noted 2 years after ASD surgery. These results revealed that malnutrition status may have poor upper thoracic alignment. Nevertheless, ASD surgery appeared to have obtained poor sagittal global alignment in the malnourished group.

It is believed that nutritional status is associated with PROM. Malnourished patients had lower PROMs compared with well-nourished patients[22,23]. More recently, a multicenter randomized controlled study found that oral nutritional supplements failed to increase PROMs in malnourished patients[24]. However, no studies on middle or long-term PROMs were noted after malnutrition in patients with ASD after surgery. In the current study, the PROMs (both ODI and SRS-22) between the L and H groups before and 2 years after surgery were not significantly different. Nutritional status may not be associated with PROMs after ASD surgery. Moreover, spinal malalignment also impacts decreased PROMs. Although this study showed that the SVA was different between the two groups 2 years after the surgery, no significant difference between the two groups wsd noted. The reason may be that the SVA values in the malnourished group were not particularly high compared to the H group. Thus, although nutritional status affects postsurgical medical complications and global sagittal alignment, it does not affect the midterm quality of life of ASD patients after surgery.

This study had several limitations. Firstly, male sex representation differed between the L and H groups, which caused spinal alignment bias. However, the results of the current study showed no difference between groups. Secondly, postoperative nutritional status was not obtained. In future studies, more patients will be recruited, bias will be eliminated, and more accurate results will be obtained. Finally, while nutritional status is related to spinal alignment, whether improving nutritional status also improves spinal alignment is unclear. Conducting a nutrition intervention trial may be necessary to verify whether alignment changes.

In conclusion, malnourished status (PNI <50) did not affect the incidence of mechanical complications and PROMs 2 years after ASD surgery. However, malnourished patients with ASD had a higher incidence of medical complications. Moreover, malnourished patients had significantly more severe TS before surgery and SVA 2 years after surgery. With all outcomes in mind, ASD surgery can produce positive PROMs in both malnourished and well-nourished patients.

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