

**Lower Satisfaction after Adult Spinal Deformity Surgery in Japan than in the US
Despite Similar SRS22 Pain and Function Scores: A Propensity-Score Matched
Analysis**

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ABSTRACT

Study Design:

A multicenter retrospective case series

Objective:

The purpose of this study was to compare the clinical outcomes of a surgical treatment for ASD in the United States (US) with those in Japan (JP) in a matched cohort.

Summary of Background Data:

Surgical outcomes of thoracic-lumbar-sacral (TLS) spinal fusions in adult spinal deformity (ASD) patients who live in Asian countries are poorly understood.

Methods:

A total of 300 surgically treated ASDs of age >50yr with the lowest instrumented vertebra at the pelvis and a minimum follow-up of 2y were consecutively included. Patients were propensity-score matched for age, gender, levels fused, and 2y postop sagittal spinal alignment. Demographic, surgical, and radiographic parameters were compared between the US and JP groups.

Results:

A total of 186 patients were matched by propensity score and were almost identical within these parameters: age (US vs. JP: 66 ± 8 vs. 65 ± 7 y), gender (females: 90 vs. 89%), levels fused (10 ± 3 vs. 10 ± 2), 2y C7SVA (5 ± 5 vs. 5 ± 4 cm), 2y PI-LL ($9 \pm 15^\circ$ vs. $9 \pm 15^\circ$), and 2y PT ($25 \pm 10^\circ$ vs. $24 \pm 10^\circ$). ODI scores and SRS-22 function and pain scores were similar at 2y between the US and JP groups (ODI: 27 ± 19 vs. 28 ± 14 %, $p=.72$; SRS-22 function: 3.6 ± 0.9 vs. 3.6 ± 0.7 , $p=.54$; SRS-22 pain: 3.6 ± 1.0 vs. 3.8 ± 0.8 , $p=.11$). However, significantly lower satisfaction was observed in JP than in the US (SRS-22 satisfaction: 4.3 ± 0.9 vs. 4.0 ± 0.8 , $p<.01$).

Conclusions:

Surgical treatment for ASD was similarly effective in patients in the US and in JP. However, satisfaction scores were lower in JP compared to the US. Differences in lifestyle and cultural expectations may impact patient satisfaction following ASD surgery.

Key Words: Adult spinal deformity; ethnicity; spinopelvic fusion; spinal alignment; HRQOL

Level of Evidence: 3

KEY POINTS

- Propensity-score matched analysis for clinical outcomes for ASD surgery between patients in the US and patients in JP was performed.
- ASD surgery was similarly effective for improving the HRQOL of patients in the US and patients in JP with propensity-score matching for age, gender, levels fused, and postoperative spinal alignment.
- However, SRS22 satisfaction was lower in patients in JP.
- Lifestyle and cultural expectations may impact patient satisfaction following ASD surgery.

INTRODUCTION

It has been widely recognized that many patients in Asian countries are unsatisfied with orthopedic surgeries, especially arthroplasty.¹⁻³ To meet patient needs, many factors must be considered. For example, one must be aware of the cultural differences between Western and Asian countries.¹⁻³ It is well described that most of the people living in Asian countries prefer to sit on the floor, though younger generations have adapted to sitting on a chair.¹⁻⁴ Galanti et al. noted that knowledge of cultural customs can help avoid misunderstandings and enable practitioners to provide better care.⁴ Therefore, there is a growing need for culturally sensitive research that will provide quantitative and detailed information on patient satisfaction. However, to the best of our knowledge, the clinical outcomes and patient satisfaction following thoracic-lumbar-sacral (TLS) spinal fusions in adult spinal deformity (ASD) patients who live in Asian countries are poorly understood.⁵⁻⁷ Ishikawa et al. reported

that the frequency of strenuous activities significantly decreased postoperatively in approximately half of the Japanese patients with TLS fusion despite the significant improvement in HRQOL.⁵ However, the lack of a control group prevented this study from drawing conclusions regarding the clinical outcomes and patient satisfaction of TLS spinal fusion in ASD patients. In this study, we aimed to compare the clinical outcomes of the surgical treatment for ASD in the United States (US) with those of the same treatment in Japan (JP). It is widely accepted that randomized control trials (RCTs) are the gold standard for estimating the effect of treatments on clinical outcomes.⁸ However, in reality, RCTs are often impossible to conduct.⁸⁻¹⁰ Various demographic and radiographic factors, including age, level fused, lower instrumented vertebra (LIV), and spinal alignment, potentially affect the clinical outcomes of ASD surgery.¹¹⁻²² Therefore, to adjust for the potential confounding factors that affect clinical outcomes, we conducted the present study to clarify the influence of patients' nationality on clinical outcomes in a propensity-score matched ASD cohort.

MATERIALS AND METHODS

Patient population

This study used data from 2 previously described multicenter international ASD databases representing 300 consecutive primary ASD patients (195 patients in the US and 105 patients in JP) who had undergone corrective spine surgery.

Inclusion and exclusion criteria

Patients included in our study were older adults (age ≥ 50 years) diagnosed with a spinal deformity, which was defined by a Cobb angle $\geq 20^\circ$, C7 sagittal vertical axis (C7SVA) ≥ 5 cm, or pelvic tilt (PT) $\geq 25^\circ$. The patients selected for analysis had a fusion from the sacrum to the thoracic spine and complete 2-year follow-up data. Patients were consecutively included and were excluded if they did not have appropriate radiographs or had syndromic, neuromuscular, or other pathological conditions.

Data collection and radiographic assessment

We reviewed the charts and radiographs and recorded the following demographic and clinical data: age, gender, and history of spinal surgery. We also recorded the following surgical data: SRS-Schwab ASD classification, application of pedicle subtraction osteotomy (PSO), and number of fused vertebrae.²² We analyzed standing spine radiographs at baseline and at 6-week and 2-year follow-ups.

Inclusion of postoperative complications

Postoperative complications included all postoperative complications recorded in the charts and found in the radiographs within a 2y postoperation. Complications were categorized as a neurological complication, an implant-related complication, a surgical site infection, another type of infection, excessive bleeding, delirium, a cardiopulmonary complication, a gastrointestinal complication, or a renal complication.

Clinical outcomes

Patient outcomes were evaluated using two patient-reported outcome (PRO) measures of health-related quality of life (HRQOL): the Scoliosis Research Society patient questionnaire (SRS22) and the Oswestry Disability Index (ODI). Baseline and postoperative ODI and SRS22 were determined.

Propensity-score matching of the patient cohort

To account for the potential risk factors for inferior HRQOL, patients from the database were propensity-score matched for age, gender, levels fused, and 2y postoperative sagittal spinal alignment (C7SVA, PI-LL, and PT). There were 186 patients (93 patients in each group) who were matched by propensity score (table 1). The chi-square of the Hosmer-Lemeshow test for this propensity-score matching was 14.06, and the p value was 0.34, indicating good model adaptation.

Statistical analysis

Differences between the US and JP groups were compared by unpaired t-tests, and chi-square tests where appropriate. Pearson's correlation was used to analyze the correlations of 2y postoperative SRS22 satisfaction domain scores with baseline and 2y postoperative demographic and radiographic variables of each group. Sensitivity analyses of each variable of postoperative inferior SRS22 satisfaction domain scores (≤ 3.0) were performed using the area under the receiver operating characteristic curve (AUROC). A p value $< .05$ with a confidence interval of 95% was considered statistically significant. All analyses were performed using the Statistical Package for the Social Sciences (SPSS version 25.0. IBM Corp., Armonk, NY).

RESULTS

Complications in the propensity-score matched patient cohort

Among the 186 propensity-score matched patients, a similar number of patients in the US and JP groups experienced major complications (US vs. JP: 38% [n=35] vs. 30% [n=28], $p=.28$, table 1). The most common type of major complication in both countries was implant-related (18% [n=17] in the US and 22% [n=20] in JP, $p=.59$). Among the patients with implant-related complications, a similar number of patients in the US and JP groups required additional surgery within 2 years after the fusion surgery (US vs. JP: 17% [n=16] vs. 18% [n=17], $p=.85$, table 1).

Radiographic comparisons in the propensity-score matched patient cohort

Significantly worse baseline spinopelvic alignment was seen in the JP group compared with the US group (US vs. JP: C7SVA: 6.3 ± 6.0 vs. 8.9 ± 6.4 cm, $p<.01$, PI-LL: 18.9 ± 17.7 vs. $38.1 \pm 22.7^\circ$, $p<.01$, PT: 26.1 ± 10.2 vs. $31.9 \pm 11.5^\circ$, $p<.01$, table 2). Postoperatively, the spinopelvic alignment was significantly improved in both groups and was similar between the US and JP groups at 2 years (US vs. JP: C7SVA: 4.7 ± 5.3 vs. 4.9 ± 4.0 cm, $p=.85$, PI-LL: 8.5 ± 15.4 vs. $9.3 \pm 15.1^\circ$, $p=.74$, PT: 24.9 ± 10.0 vs. $23.6 \pm 9.8^\circ$, $p=.38$, table 2).

Clinical outcomes in the propensity-score matched patient cohort

The baseline SRS22 pain score was significantly lower in the US group than in the JP group, while appearance and mental health scores were significantly lower in the JP group than in the US group (US vs. JP: SRS22 pain: 2.3 ± 0.8 vs. 2.9 ± 0.7 , $p<.01$, SRS22 appearance: 2.5 ± 0.7 vs. 2.2 ± 0.6 , $p=.02$, SRS22 mental health: 3.5 ± 0.9 vs. 2.8 ± 0.7 , $p<.01$, table 3). No differences were found in the other SRS22 domain scores and ODI score between these two groups. Postoperatively, the ODI score, the SRS22 activity, pain, appearance, and mental health scores, and the SRS22 total score were all similarly improved in both groups; however, the SRS22 satisfaction domain score was significantly lower in the JP group than in the US group (US vs. JP: SRS22 satisfaction: 4.3 ± 0.9 vs. 4.0 ± 0.8 , $p<.01$, table 3).

The correlation coefficient analyses between the 2y postoperative SRS22 satisfaction domain and the baseline and the 2y postoperative demographic and radiographic variables revealed that the 2y postoperative SRS22 satisfaction domain is strongly correlated with the postoperative SRS22 appearance domain in each group and moderately correlated with other

2y postoperative HRQOL domains in both groups. Notably, a weak but significant correlation was seen between baseline SRS22 activity and mental health domains and the postoperative satisfaction domain in the US group, while this correlation was not seen in the JP group. However, a significant correlation was seen between 2y postoperative spinopelvic alignment and postoperative satisfaction in the JP group, while no correlation was seen between postoperative satisfaction and spinopelvic alignment in both baseline and 2y postoperative assessments in the US group (table 4).

The ROC analyses between these variables and inferior postoperative satisfaction confirmed that in addition to the 2y postoperative HRQOL, baseline mental health in the US group and 2y postoperative spinopelvic alignment in the JP group were the significant discriminants in predicting inferior postoperative satisfaction (figures 1 and 2).

DISCUSSION

Clinical outcomes in the propensity-score matched patient cohort

The population of patients with ASD is a heterogeneous population in age, curve type, ADL, and associated comorbidities.¹¹⁻²² Therefore, it is difficult to analyze and compare how much corrective spine surgery improves patient HRQOL in different patient cohorts, especially cohorts with different cultures and lifestyles. Several possible factors affecting the HRQOL following ASD surgery have been identified, including age, extent of spinal fusion, sagittal spinal alignment, level of the LIV, surgical complications, and others. Among these factors, the impact of lumbosacral fusion on the HRQOL has been a controversial topic.^{5,6,23,24} Martín-Buitrago et al. reported that all of the HRQOL scores of ASD patients instrumented with iliac screws significantly improved 2 years after surgery.²³ On the other hand, Yoshida et al. reported that fusion to the sacrum greatly restricted the ability to stretch or bend the trunk, leading to limitations in daily activities.²⁴ In the present study, comparing patients adjusted for age, gender, LIV, fusion level, and postoperative spinal alignment, the postoperative HRQOL scores improved similarly in patients in the US and in patients in Japan, regardless of differences in the patients' cultures, lifestyles, and genetic backgrounds and whether the patients had the lumbosacral fusion. Thus, on the basis of currently available outcome measures, it cannot be said that lumbosacral fusion has a negative impact on the HRQOL of patients with different cultures and lifestyles.

Postoperative satisfaction in the propensity-score matched patient cohort

Although the ODI scores and SRS22 function, pain, appearance, and mental health scores of the US and JP group were equivalent after surgery, patient satisfaction was significantly inferior in the JP group compared with the US group. Additionally, the correlation analyses of the 2y satisfaction scores and demographic factors and ROC analyses of the radiographic parameters and HRQOL scores indicated that postoperative patient satisfaction was strongly correlated with the postoperative SRS22 appearance domain and the total score and moderately correlated with the other 2y postoperative SRS22 domain scores in both groups. Notably, different correlations with the satisfaction scores were observed for patients in the US and in JP.

The different expectations for orthopedic surgeries, especially arthroplasty, between Western and Asian countries have been well studied.¹⁻⁴ One would expect an Asian patient to have a concern for the range of motion, thereby affecting patient satisfaction.¹⁻⁴ This concern may be unique to Asian individuals who have higher demands for knee and trunk flexion due to their lifestyle.¹⁻⁴ Based on differences in expectations, one might expect slightly different satisfaction rates. Miner et al. reported that for Canadian patients, the postoperative range of motion was not associated with patient satisfaction after knee arthroplasty.¹ However, Bin Abd Razak et al. reported that Asian individuals required a large range of motion due to their lifestyle, which resulted in a different satisfaction rate after knee arthroplasty.³ The same concept can be applied to lumbosacral fusion in Asian patients. Ishikawa et al. concluded that the frequency of strenuous activities, such as weeding and farm work, significantly decreased postoperatively in approximately half of the Japanese ASD patients with TLS fusion despite the significant improvement in HRQOL.⁵ Hayashi et al. reported that postoperative appearance, pain, standing difficulty, and sagittal alignment were strongly correlated with postoperative patient satisfaction in ASD surgery in European countries.²⁵ One would expect an Asian patient to have a concern for the range of motion, thereby affecting patient satisfaction in addition to postoperative HRQOL and sagittal spinal alignment.²⁶ The findings of the present study are consistent with and confirmed the results of previous reports.

Shim et al. evaluated the sitting ability of patients who had lumbosacral fusion and concluded that the inability to sit on the floor after lumbar arthrodesis should be seriously considered if a lumbar arthrodesis is planned in a society where people's usual style of sitting is on the floor.²⁷ Togawa et al. also described the impact of spinopelvic fusion on the life of Japanese

elderly patients and concluded that although successful clinical results and deformity corrections were achieved, the ASD patients reported significant difficulty in trimming toenails, performing personal hygiene, picking up an item from the floor, and getting down on all four limbs.²⁸ The vast majority of Japanese patients in this study needed lifestyle adjustments from the Asian lifestyle (sleeping and sitting on a floor) to the Western lifestyle (sleeping on a bed and sitting on a chair) after surgery. Accordingly, the present study suggests that deterioration of the ability to sit on the floor might affect the satisfaction of Japanese ASD patients, even though the spinal alignment and functional outcomes were favorably improved.

The importance of sagittal spinal alignment for the HRQOL of adult individuals has been well recognized.^{12,13,22,29} However, the optimal sagittal spinal alignment in each individual has not been fully identified. Moreover, the validation of this concept in different patient populations, including Asian populations, has not been fully described. Lafage et al. have reported that ideal spinopelvic values increased with age.²⁹ Banno et al. analyzed the spinopelvic alignment of 656 older Japanese volunteers and reported that the PT and PI-LL gradually increased with age, while the SVA tended to decrease after the 7th decade.³⁰ Yamato et al. recently reported that rigorous sagittal spinal realignment was correlated with the HRQOL of elderly Japanese patients with ASD.³¹ In the present study, the vast majority of the patients had a severe spinal deformity and therefore received a large amount of correction to achieve a balanced spine. A large amount of correction is a well-known risk for the development of implant-related complications. In the present study, the incidence of implant-related complications and reoperations were not different between the US and JP groups, indicating that spinal realignment had a similar risk for implant-related complications in ASD patients who live in geographically different areas and have different lifestyles and genetic backgrounds.

Previous experience of spinal surgery may have made a difference in the satisfaction of both groups of patients. In the present study, no JP group patients had prior spine surgery, while 40% of the US population had a prior spine procedure. Despite requiring a larger ASD procedure, perhaps these US patients had "experience" with surgery and so had a more realistic expectation of postoperative pain/function, and etc.

Study Limitations

Some limitations must be acknowledged. There was a lack of questionnaire items representing the lifestyle of individuals in Asian countries. Therefore, we could not fully identify the reason for inferior satisfaction of patients in JP who underwent the surgery for ASD; the reason may have been the TLS spinal fusion did not meet the patient's expectations for an Asian lifestyle or another possible reason. One can argue that the degree of satisfaction with surgeries, not only the surgery for ASD, is generally lower in Japanese patients than in American patients. However, similar degrees of satisfaction after adolescent idiopathic scoliosis (AIS) surgery in countries of different geographical locations have been described. Theologis et al. compared the baseline and postoperative satisfaction of surgically treated AIS in Caucasian, Hispanic, African American, and Asian populations and concluded that no differences were detected in satisfaction with AIS surgery among the ethnic groups.³² Taken together, we postulate that satisfaction for spinal surgery among patients in different countries is not different unless the procedure limits an individual's unique lifestyle that he or she expected to resume.

It is worth noting that this was the first study to directly compare how TLS fusion improved the ASD patient HRQOL in Western and Asian countries with patients adjusted for age, gender, extent of spinal fusion, LIV, and postoperative spinal alignment. In this analysis, corrective spine surgery for ASD was similarly effective for patients in the US and in JP. However, despite the similar postoperative spinal alignments and fusion levels, the 2y SRS22 satisfaction scores were lower for patients in JP. Consequently, spinal surgeons should note the different expectations of each individual on the surgical treatment for ASD and counsel patients about the implications of surgery based on the patient's lifestyle and cultural background.

CONCLUSION

In this analysis, corrective spine surgery for ASD was similarly effective for patients in the US and in JP. However, this study highlighted that despite the similar postoperative spinal alignments and fusion levels, the 2y SRS22 satisfaction scores were lower in patients in JP. It is possible that differences in lifestyle and cultural expectations may impact patient satisfaction following surgery for ASD.

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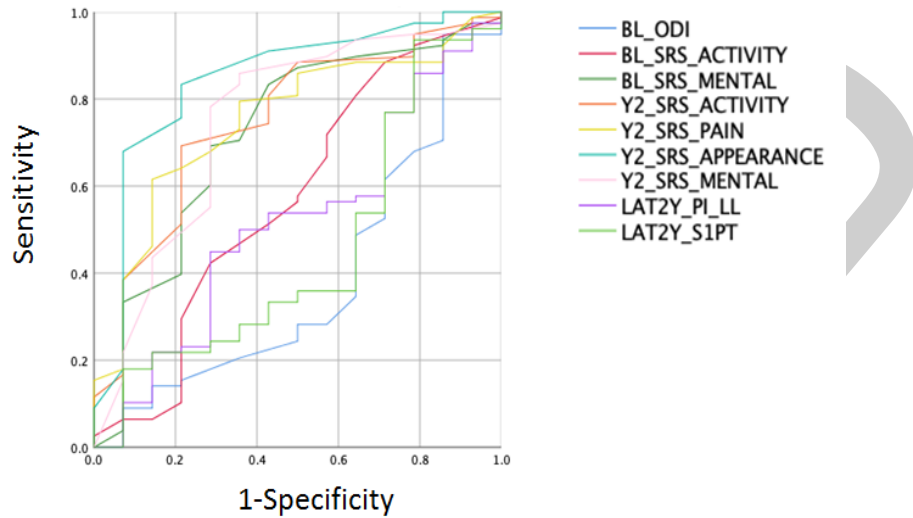
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Figure 1

Postoperative satisfaction was significantly correlated with baseline mental status in addition to the postoperative measures of HRQOL in ASD patients in the US.

US

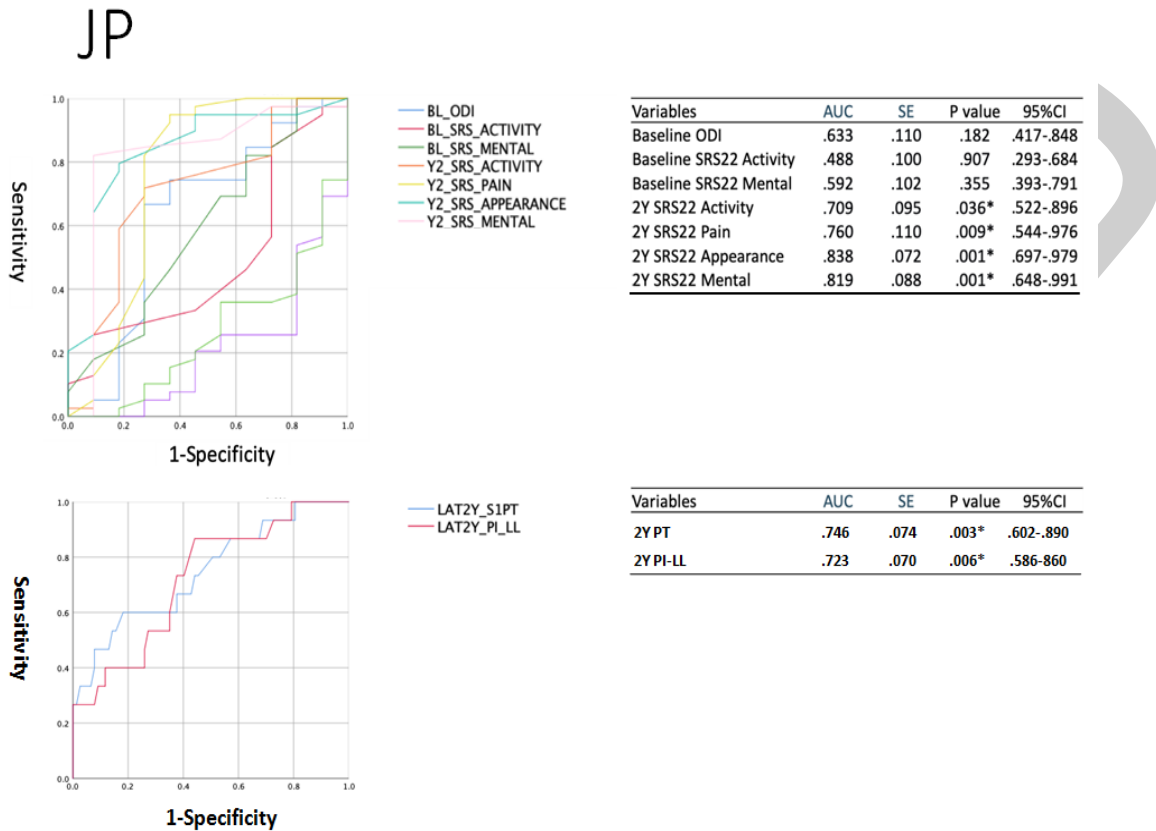


Variables	AUC	SE	P value	95%CI
Baseline ODI	.384	.086	.169	.215-.553
Baseline SRS22 Activity	.573	.092	.387	.392-.754
Baseline SRS22 Mental	.719	.079	.009*	.564-.875
2Y SRS22 Activity	.751	.070	.003*	.613-.889
2Y SRS22 Pain	.752	.066	.003*	.622-.883
2Y SRS22 Appearance	.846	.062	.000*	.724-.967
2Y SRS22 Mental	.748	.079	.003*	.594-.903
2Y PI-LL	.516	.084	.845	.351-.682
2Y PT	.452	.089	.572	.279-.626

ACU

Figure 2

Postoperative satisfaction was significantly correlated with postoperative spinopelvic alignment in addition to the postoperative measures of HRQOL in ASD patients in JP.



ACC

Table 1. Comparisons of demographics and surgical descriptions between the US and JP groups.

	US	JP	P value
Age	65.8 ± 7.8	65.2 ± 7.5	0.60
Gender (percentage of females)	83 (90%)	82 (89%)	0.82
History of spine surgery	30 (40%)	0 (0%)	<0.01*
Levels fused	10.1 ± 4.3	10.2 ± 2.7	0.79
Level of LIV (pelvis)	93 (100%)	93 (100%)	>0.99
Major complications	35 (38%)	28 (30%)	0.28
Reoperations	16 (17%)	17 (18%)	0.85
Implant-related complications	17 (18%)	20 (22%)	0.59

Means and standard deviations. Percentages in parenthesis. * indicates statistically significant.

Table 2. Comparisons of baseline and 2-year postoperative spinopelvic alignments between the US and JP groups.

Spinopelvic alignment	Baseline			2-year follow-up		
	US	JP	P value	US	JP	P value
PT (<i>deg.</i>)	26.1±10.2	31.9±11.5	<0.01*	24.9±10.0	23.6±9.8	0.38
PI-LL (<i>deg.</i>)	18.9±17.7	38.1±22.7	<0.01*	8.5±15.4	9.3±15.1	0.74
C7SVA (<i>cm</i>)	6.3±6.0	8.9±6.4	<0.01*	4.7±5.3	4.9±4.0	0.85

Means and standard deviations. * indicates statistically significant.

Table 3. Comparisons of baseline and 2-year postoperative measures of HRQOL between the US and JP groups.

	Baseline			2-year follow-up		
	US	JP	P value	US	JP	P value
ODI (%)	46.9 ± 17.4	49.2 ± 15.6	0.42	27.5 ± 19.3	28.5 ± 13.9	0.72
SRS22						
Activity	2.9 ± 0.8	2.9 ± 0.7	0.87	3.6 ± 0.9	3.6 ± 0.7	0.54
Pain	2.3 ± 0.8	2.8 ± 0.7	<0.01*	3.6 ± 1.1	3.8 ± 0.8	0.11
Appearance	2.5 ± 0.7	2.2 ± 0.6	0.02*	3.7 ± 0.9	3.7 ± 0.8	0.94
Mental health	3.5 ± 0.9	2.8 ± 0.7	<0.01*	4.0 ± 0.8	3.8 ± 0.7	0.12
Satisfaction				4.3 ± 0.9	4.0 ± 0.8	<0.01*
Total	2.8 ± 0.6	2.7 ± 0.5	0.34	3.8 ± 0.8	3.8 ± 0.6	0.97

Means and standard deviations. * indicates statistically significant.

Table 4. Correlation between 2-year postoperative satisfaction and variables in the US and JP.

Correlation coefficient (<i>r</i>)	Baseline		2-year	
	US	JP	US	JP
Spinopelvic alignment				
PT	n.s.	n.s.	n.s.	-0.30**
PI-LL	n.s.	n.s.	n.s.	-0.27*
C7SVA	n.s.	n.s.	n.s.	-n.s.
HRQOL				
ODI	-0.26*	n.s.	-0.47**	n.s.
SRS22 Activity	0.21*	n.s.	0.51**	0.43**
SRS22 Pain	n.s.	n.s.	0.51**	0.57**
SRS22 Appearance	n.s.	n.s.	0.65**	0.72**
SRS22 Mental health	0.27**	n.s.	0.34**	0.43**

* Indicates p value <0.05. ** indicates p value <0.01