

DEFORMITY

Counseling Guidelines for Anticipated Postsurgical Improvements in Pain, Function, Mental Health, and Self-image for Different Types of Adult Spinal Deformity

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Study Design. Retrospective analysis of a multicenter prospective adult spinal deformity (ASD) database.

Objective. Quantify postoperative improvements in pain, function, mental health, and self-image for different ASD types.

Summary of Background Data. Medical providers are commonly requested to counsel patients on anticipated improvements in specific health domains including pain, function, and self-image following surgery. ASD is a heterogeneous condition; therefore, health domain improvements may vary according to

deformity type. Few studies have quantified outcomes for specific ASD types.

Methods. Surgically treated ASD patients (≥ 4 levels fused) prospectively enrolled into a multicenter database, minimum 2-year follow-up, were categorized into ASD types according to Scoliosis Research Society-Schwab ASD classification (THORACIC, LUMBAR, DOUBLE, SAGITTAL, MIXED). Demographic, radiographic, operative, and patient reported outcome measures (NRS back and leg pain, SRS-22r, SF-36) data were evaluated. Preoperative and last postoperative values for pain, physical and social function, mental health, and self-image were evaluated, improvements in each domain were quantified, and domain scores compared to generational normative values. Postoperative improvements were also calculated for three age cohorts (<45 yr, 45–65 yr, and >65 yr) within each deformity type.

Results. 359 of 564 patients eligible for study (mean age 57.9 yr, mean scoliosis 43.4°, mean SVA 63.3 mm, mean 11.7 levels fused) had ≥ 2 yr follow-up. Domain improvements for the entire ASD population were 45.1% for back pain, 41.3% for leg pain, 27.1% for physical function, 35.9% for social function, 62.0% for self-image, and 22.6% for mental health ($P < 0.05$). LUMBAR, SAGITTAL, and MIXED had greatest improvements in pain and function, while THORACIC and DOUBLE had greatest improvements in self-image. Self-image was the most impacted preoperative domain and demonstrated the greatest postoperative improvement for all ASD types.

Conclusion. ASD patients demonstrated quantifiable postoperative improvements in pain, self-image, physical and social function, and mental health; however, improvements differed between ASD types. Further research is needed to understand specific patient expectations for ASD treatment.

Key words: adult spinal deformity, improvement, patient-reported outcome measures, surgery.

Level of Evidence: 3

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Effective surgical counseling requires comprehensible explanations of the risks and benefits for surgery. Patients and families commonly inquire about the anticipated improvements in pain, function, and appearance following adult spinal deformity (ASD) surgery. Few data exist to provide simple counseling parameters that quantify the anticipated postoperative improvements for pain, function, and self-image for ASD. This lack of information is, in part, because patient-reported outcome measures (PROMs) often generate summary scores that are conceptually difficult for patients to comprehend.¹⁻⁴ Concepts such as minimal clinically important difference (MCID) and substantial clinical benefit (SCB) help researchers and clinicians to understand the context of PROM scores by establishing clinically relevant thresholds for changes in PROM values; however, again, these values often do not provide easily understandable information for patient counseling.⁵⁻⁹

ASD can be associated with severe disability that can parallel the health deficits associated with other chronic diseases.¹⁰ However, ASD is a heterogeneous condition that encompasses a variety of spine deformities, and different ASD types are associated with different disability severity.¹⁰ We hypothesized that, if disability varies according to the type of ASD, then ASD treatment outcomes will also vary according to the type of ASD treated. We also hypothesized that each ASD type will display specific health deficits that are pathognomonic to that particular ASD type; namely, some types of ASD may demonstrate health deficits primarily in pain and physical function, whereas other types of ASD may be more impacted by deficits in self-image and social function. The purpose of this study was to: 1) identify the specific PROM domains most impacted preoperatively for each ASD type as categorized by the Scoliosis Research Society-Schwab ASD Classification (ASD type) for a large cohort of surgically treated ASD patients, 2) quantify the percentage of improvement in different health domains following surgery for each ASD type, at minimum 2-year follow-up; and 3) evaluate if ASD patients can return to “normal” following surgery by comparing the pre and postoperative health domains to normative population values.¹¹⁻¹³

MATERIALS AND METHODS

Study Inclusion Criteria

Data used for this study was obtained from a multicenter, prospective, longitudinal database (the database) consisting of operatively and nonoperatively treated ASD patients. Eleven participating sites located in the United States contributed patients to the database. Institutional review board (IRB) approval for this study was obtained at all participating centers prior to enrolling patients into the database. Database inclusion criteria is age >18 years and minimum one of the following: scoliosis >20°, sagittal vertical axis >5 cm (SVA), pelvic tilt >25° (PT), and/or thoracic kyphosis >60° (TK) as previously described.^{14,15} Additional inclusion criteria for this study were operative treatment with ≥4 posterior spinal levels fused, and minimum 2 year follow-

up. Exclusion criteria for database enrollment include spinal deformities associated with autoimmune, acute trauma, neoplastic, neuromuscular, syndromic, and/or infectious disorders. This was an observational study; therefore, there was no treatment randomization of any patients. This was not a controlled study; therefore, all treatment including indication for surgery and type of surgery performed was at the discretion of the surgeon and according to the consent process between the treating surgeons and the patients.

Radiographic and PROM Data

All radiographic analyses of the spinal axis were performed using 36 inch full-length films that visualized from the cervical spine to the pelvis. Antero-posterior (AP) and lateral films were obtained and spinal/spinopelvic alignment parameters were assessed using Spineview (Laboratory of Biomechanics, Paris, France).^{16,17} Spinal deformities were categorized according to the Scoliosis Research Society-Schwab ASD Classification (ASD type: THORACIC, LUMBAR, DOUBLE, SAGITTAL, MIXED), as previously recommended (Supplement Figure 1, <http://links.lww.com/BRS/B532>).¹⁸ Preoperative and last postoperative follow-up demographic, operative, radiographic, and PROM data were evaluated and compared including; numeric pain scales for back and leg pain (NRS-BACK, NRS-LEG), Scoliosis Research Society Questionnaire (SRS-22r) domain scores, and Short Form-36v2 Health Survey (SF-36). All SF-36 data were reported as norm-based scores (NBS) with ranges as recommended by the QualityMetric Inc. SF-36 version 2 manual.¹¹ Pre and postoperative PROM scores for each ASD type were compared and the percentage improvement for each domain was calculated. Each ASD type was divided into three age cohorts (<45 yr, 45–65 yr, and >65 yr), and the baseline, postoperative and percent improvement in PROM scores for each age cohort was calculated to evaluate the impact of age upon baseline health deficits and surgical outcomes for each ASD type. A separate age analysis was then performed by organizing patients in each ASD type into generational age groups as recommended by the QualityMetric Inc. SF-36 version 2 manual.¹¹ The SF-36 and SRS-22r domain scores for the different generational age groups within each spine deformity type were then compared to normative population values for each age generation, including bodily pain (SRS-22r pain domain), physical activity (SRS-22r activity domain), social function (SF-36 social function domain), self-image (SRS-22r self-image domain), and mental health (SRS-22r mental health domain), as previously reported.¹¹⁻¹³ Patients who postoperatively improved to within one standard deviation (SD) of the reported generational norm for the respective PROM domain value were considered a return to “normal” for that domain.

Statistical Methods

Statistical analyses were performed using JMP version 13.1.0 (SAS Institute Inc, Cary, NC). Student *t* test, Chi² were used for comparisons of continuous variables and binary variables respectively. For comparison of means between deformity type an ANOVA was performed using Tukey HSD.

TABLE 1. Demographic, Radiographic, and Operative Values for Spine Deformity Types

	All	Thoracic Scoliosis	Lumbar Scoliosis	Double Scoliosis	Sagittal Deformities	Mixed Deformities
N	359	18	54	64	94	129
Total follow up (years)	3.3 (2–7.5)	3.5 (2–5.5)	3.4 (2–6.1)	3.8 (2–7.5)	2.9 (2–6)	3.3 (2–6.6)
Preoperative age (years)	57.9 (18.6–86.2)	33.0 (18.6–60.7)	55.8 (18.6–75.6)	48.5 (19.0–72.9)	63.4 (19.9–86.2)	63.0 (18.7–84.4)
Total spinal fusion levels (mean)	11.7 (4–19)	11.3 (6–18)	10.9 (4–18)	12.7 (5–18)	10.7 (4–17)	12.4 (4–19)
Preoperative maximal scoliosis (degrees)	43.4 (6.3–112.7)	49.7 (31.5–77.2)	43.7 (30.0–98.4)	62.3 (34.9–112.7)	18.0 (6.3–28.2)	49.7 (29.5–102.5)
Postoperative maximal scoliosis (degrees)	20.1 (0.1–102.3)	21.1 (6.3–69.8)	17.6 (1.4–55.6)	26.1 (3–102.3)	9.6 (0.1–28.3)	24.9 (0.5–94.4)
Preoperative PI-LL (degrees)	16.0 (–43.1 to 101.7)	–4.0 (–32.1 to 18.7)	0.2 (–30.2 to 38.6)	1.5 (–32.5 to 33.4)	24.7 (–37.5 to 82.2)	26.0 (–43.1 to 101.7)
Postoperative PI-LL (degrees)	3.7 (–28.9 to 72.4)	–2.6 (–24.1 to 25.5)	–2.8 (–26.9 to 34.7)	0.1 (–28.9 to 33.7)	5.1 (–27.8 to 58.3)	8.2 (–23.6 to 72.4)
Preoperative SVA (mm)	63.3 (–83.7 to 326.5)	–13.4 (–59.6 to 34.8)	–0.6 (–83.7 to 39.8)	–5.0 (–80.5 to 38.4)	107.5 (46.1 to 326.5)	103.5 (37.5–283.5)
Postoperative SVA (mm)	31.9 (–97.7 to 237.2)	–12.3 (–97.7 to 46.1)	8.4 (–88.4 to 135.7)	–0.2 (–76.4 to 159.3)	52.3 (–44.5 to 175.2)	48.6 (–72.8 to 237.2)

SVA indicates sagittal vertical axis; LL, lumbar lordosis; PI, pelvic incidence; and P < 0.05 considered statistically significant.

RESULTS

All ASD Patients (n = 359)

Between 2008 and 2015, 359 of 564 patients eligible for study received surgery for ASD and had ≥2 year follow-up, mean follow-up 3.3 (2–7.5) years. Mean demographic, radiographic, and surgical values for the entire ASD cohort included; age= 57.9 (18.6–86.2) years, American Society of Anesthesiologists physical status classification system grade (ASA grade)= 2.4 (1–

4), maximal scoliosis= 43.4° (6.3°–112.7°), SVA= 63.3 (–83.7 to 326.5) mm, total spine levels fused= 11.7 (4–19), hospital length of stay (LOS)= 8.3 (3–49) days (Table 1).

Mean percentage improvements for specific PROM domains for the entire ASD study cohort included; back pain= 45.1%, leg pain= 41.3%, bodily pain= 51.8%, physical activity= 27.1%, social function= 35.9%, self-image= 62.0%, and mental health= 22.6%, (all values P < 0.05; Table 2). Compared with the general population,

TABLE 2. Preoperative, Postoperative and Improvement in Patient-reported Outcome Measures According to Spine Deformity Type

	All ASD	Thoracic Scoliosis	Lumbar Scoliosis	Double Scoliosis	Sagittal Deformities	Mixed Deformities
N	359	18	54	64	94	129
Preoperative back pain	7.1 (0–10)	6.1 (2–10)	6.8 (1–10)	6.4 (0–10)	7.8 (3–10)	7.3 (0–10)
Last postoperative back pain	3.9 (0–10)	3.8 (0–9)	3.6 (0–10)	4.1 (0–10)	4.3 (0–10)	3.6 (0–10)
P values preoperative vs. postoperative back pain	<0.0001	0.0713	<0.0001	<0.0001	<0.0001	<0.0001
% Change back pain	45.1	37.7	47.1	35.9	44.9	50.7
Preoperative leg pain	4.6 (0–10)	2.6 (0–8)	4.6 (0–10)	3.1 (0–10)	5.7 (0–10)	5.0 (0–10)
Last postoperative leg pain	2.7 (0–10)	1.2 (0–6)	2.6 (0–9)	2.1 (0–10)	3.6 (0–10)	2.6 (0–9)
P value preoperative vs. postoperative leg pain	<0.0001	0.1843	0.0012	0.0978	<0.0001	<0.0001
% change leg pain	41.3	53.8	43.5	32.2	36.8	48.0
Preoperative SRS-22r Pain	2.4 (1–5)	2.9 (1.8–4.4)	2.5 (1–4.4)	2.9 (1–4.6)	2.1 (1–3.8)	2.3 (1–5)
Last postoperative SRS-22r Pain	3.4 (1–5)	3.5 (1.5–5)	3.4 (1–5)	3.6 (1.8–5)	3.0 (1–5)	3.4 (1.2–5)
P value preoperative vs. postoperative SRS-22r pain	<0.0001	0.2320	<0.0001	<0.0001	<0.0001	<0.0001
% Improvement SRS-22r pain	51.8	24.7	47.3	33.4 ¹	57.4	62.4
Preoperative SRS-22r activity	2.9 (1–5)	3.5 (1.8–5)	3.1 (1.2–5)	3.3 (1.2–5)	2.6 (1–4.4)	2.8 (1.2–4.8)
Last postoperative SRS-22r activity	3.5 (1.3–5)	3.9 (1.8–5)	3.6 (1.8–5)	3.8 (1.6–5)	3.1 (1.3–5)	3.5 (1.4–5)
P value preoperative vs. postoperative SRS-22r activity	<0.0001	0.4318	0.0012	0.0016	<0.0001	<0.0001
% Improvement SRS-22r activity	27.1	14.2	26.3	21.7	29.8	30.7
Preoperative SF-36 Social Function	36.4 (13.2–56.9)	42.0 (18.7–56.9)	39.4 (18.7–56.9)	42.1 (13.2–56.9)	32.4 (13.2–56.9)	34.6 (13.2–56.9)
Last postoperative SF-36 Social Function	44.0 (13.2–56.9)	46.2 (18.7–56.9)	46.3 (13.2–56.9)	48.2 (13.2–56.9)	41.2 (13.2–56.9)	42.7 (13.2–56.9)
P value preoperative vs. postoperative SF-36 social function	<0.0001	0.6162	0.0035	0.0079	<0.0001	<0.0001
% Improvement SF-36 Social Function	35.9	16.5	28.8	27.8	44.2	39.6
Preoperative SRS-22r Self-image	2.4 (1–4.6)	3.1 (1.2–4.2)	2.6 (1–4.2)	2.6 (1–4)	2.2 (1–4.4)	2.3 (1–4.6)
Last postoperative SRS-22r Self-image	3.6 (1–5)	4.1 (2–5)	3.7 (2–5)	3.9 (1–5)	3.3 (1.2–5)	3.5 (1.6–5)
P value preoperative vs. postoperative SRS-22r self-image	<0.0001	0.0006	<0.0001	<0.0001	<0.0001	<0.0001
% Improvement SRS-22r self-image	62.0	36.6	54.4	59.4	62.7	69.4
Preoperative SRS-22r mental health	3.4 (1–5)	3.4 (1.6–4.4)	3.5 (1.8–5)	3.6 (1.4–5)	3.1 (1–5)	3.3 (1–5)
Last postoperative SRS-22r mental health	3.9 (1–5)	4.0 (1.6–5)	3.9 (2.4–5)	4.0 (1.2–5)	3.8 (1–5)	3.8 (1.2–5)
P value preoperative vs. postoperative SRS-22r mental health	<0.0001	0.0894	0.0072	0.0388	<0.0001	<0.0001
% Improvement SRS-22r mental health	22.6	19.1	17.5	13.8	32.6	22.5

SF-36 indicates Short Form-36v2 Health Survey; MCS, mental component summary; PCS, physical component summary; SRS-22r, Scoliosis Research Society Questionnaire-22r.

the PROM health domains most impacted for the entire ASD study cohort included self-image, bodily pain, and physical activity. Self-image demonstrated the greatest return to population norm following ASD surgery for all ASD patients (Figure 1). The age-associated improvements for all ASD patients demonstrated greater improvements in bodily pain, physical activity, and social function for the 45–65 (n=161) and >65 (n=136) groups compared to <45 age group (n=60), but similar improvements in self-image and mental health for all age groups (Supplement Figure 2, <http://links.lww.com/BRS/B532>).

Thoracic Scoliosis (n = 18; THORACIC; Thoracic Scoliosis >30°, Thoracolumbar/Lumbar Scoliosis <30°, All Sagittal Modifiers=Mild Grade; Supplement Figure 1, <http://links.lww.com/BRS/B532>)

Mean values for THORACIC included; age= 33.0 (18.6–60.7) years, ASA grade= 1.7 (1–3), maximal scoliosis= 49.7° (31.5°–77.2°), total spine levels fused= 11.3 (6–18; Table 1). Postoperative improvements for THORACIC included; back pain= 37.7%, leg pain= 53.8%, bodily pain= 24.7%, physical activity= 14.2%, social function=

16.5%, self-image= 36.6%, and mental health= 19.1% (P < 0.05 for self-image; Tables 1 and 2). Compared with the normative population, self-image and bodily pain were most impacted preoperatively for THORACIC. Self-image was the health domain that demonstrated the greatest return to population norm following surgery for THORACIC. Conversely, social function, and mental health domains demonstrated the least amount of return to population norm for THORACIC (Figure 2). Evaluating the impact of age upon THORACIC outcomes demonstrated that improvements were primarily for self-image in the <45 (n = 14) and 45–65 (n = 4) age groups (P < 0.05), there were no THORACIC patients in the >65 age group (Supplement Figure 3, <http://links.lww.com/BRS/B532>).

Lumbar Scoliosis (n = 54; LUMBAR; Thoracolumbar/Lumbar Scoliosis >30°, Thoracic Scoliosis <30°, All Sagittal Modifiers=Mild Grade; Supplement Figure 1, <http://links.lww.com/BRS/B532>)

Mean values for LUMBAR cohort included; age= 55.8 (18.6–75.6) years, ASA grade= 2.2 (1–4), maximal scoliosis= 43.7° (30.0°–98.4°), total spine levels fused=

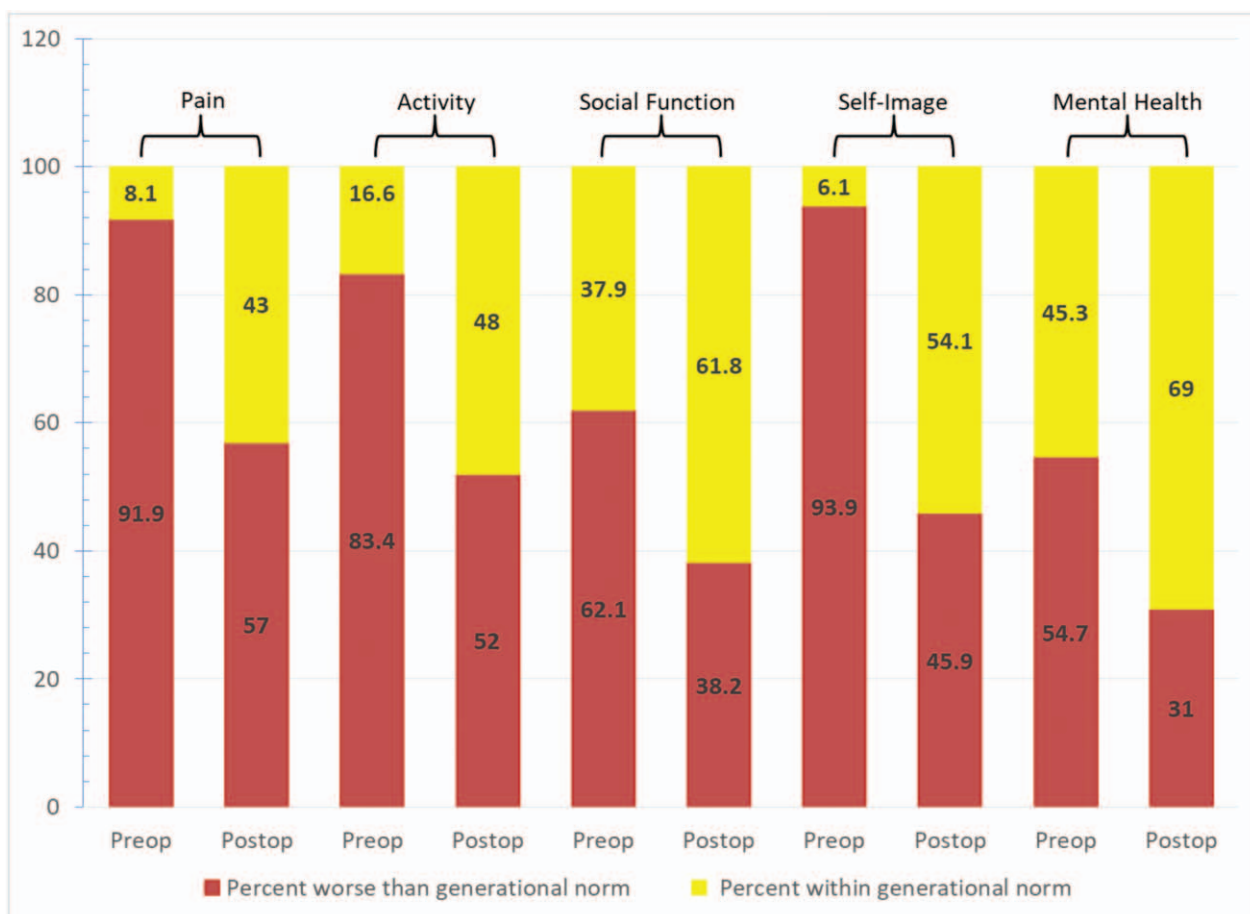


Figure 1. All adult spinal deformity; preoperative and postoperative health domains as percentage of patients >1 standard deviation from reported United States Population Normative and Generational Values.^{11–13} Pain indicates Scoliosis Research Society Questionnaire (SRS)-22r Bodily Pain Domain, Activity, SRS-22r Activity Domain; Social Function, Short Form-36v2 Social Function Domain; Self-Image, SRS-22r Self-Image Domain; and Mental Health, SRS-22r Mental Health Domain. Values are as a percent greater than one standard deviation (SD) worse than generational normal and percent within one SD of generational norm.

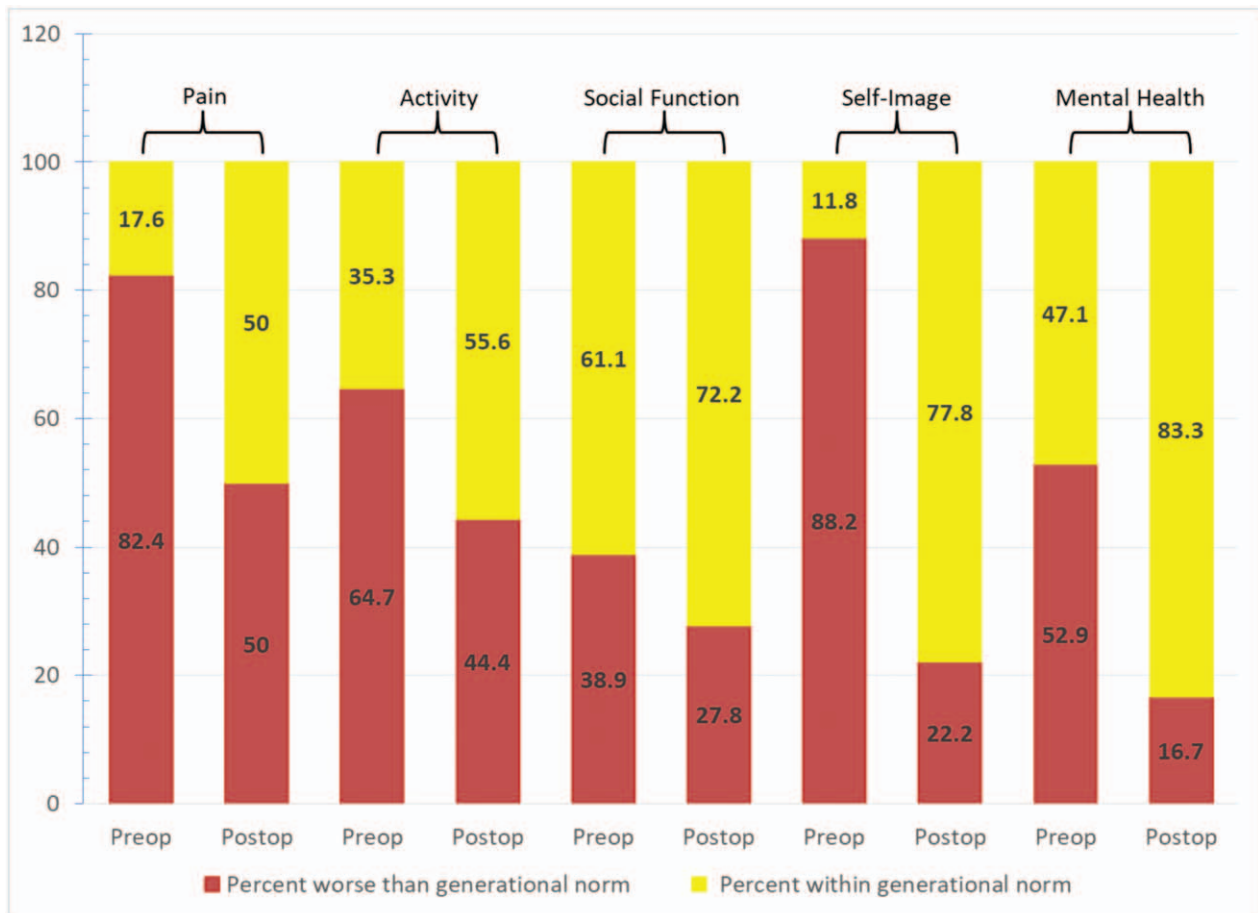


Figure 2. THORACIC ASD; preoperative and postoperative health domains as percentage of patients >1 standard deviation from reported United States Population Normative and Generational Values. Pain indicates Scoliosis Research Society Questionnaire (SRS)-22r Bodily Pain Domain, Activity, SRS-22r Activity Domain; Social Function, Short Form-36v2 Social Function Domain; Self-Image, SRS-22r Self-Image Domain; and Mental Health, SRS-22r Mental Health Domain. Values are as a percent greater than one standard deviation (SD) worse than generational normal and percent within one SD of generational norm.

10.9 (4–18; Table 1). Postoperative improvements were: back pain= 47.1%, leg pain= 43.5%, bodily pain= 47.3%, physical activity= 26.3%, social function= 28.8%, self-image= 54.4%, and mental health= 17.5% ($P < 0.05$ for all values; Tables 1 and 2). Preoperative PROM domains most impacted for LUMBAR compared with population norms were self-image and bodily pain. Postoperative return to population norm was greatest for self-image and bodily pain (Figure 3). Age-associated improvements for LUMBAR <45 ($n = 11$) were primarily for self-image (38.6%; $P < 0.05$), whereas improvements in the 45–65 ($n = 26$) and >65 ($n = 17$) age groups were in bodily pain, physical function, and self-image ($P < 0.05$; Supplement Figure 4, <http://links.lww.com/BRS/B532>).

Double Scoliosis ($n = 64$; DOUBLE; Thoracic and Thoracolumbar/Lumbar Scoliosis >30°, All Sagittal Modifiers=Mild Grade; Supplement Figure 1, <http://links.lww.com/BRS/B532>)

Mean values for DOUBLE included; age= 48.5 (19.0–72.9) years, ASA grade= 2.1 (1–3), maximal scoliosis= 62.3°

(34.9°–112.7°), total spine levels fused= 12.7 (5–18; Table 1). Postoperative improvements for DOUBLE were: back pain= 35.9%, leg pain= 32.2%, bodily pain= 33.4%, physical activity= 21.7%, social function= 27.8%, self-image= 59.4%, and mental health= 13.8% ($P < 0.05$ for all values except for leg pain; Tables 1 and 2). Self-image and bodily pain were most impacted preoperatively for DOUBLE compared with population norms, and self-image improved the most for DOUBLE compared with population norms (Figure 4). Bodily pain and self-image improved most for DOUBLE < 45 ($n = 20$) and 45–65 ($n = 37$) age groups ($P < 0.05$). There were no significant domain improvements for the DOUBLE >65 age group ($n = 7$; Supplement Figure 5, <http://links.lww.com/BRS/B532>).

Sagittal Deformities ($n = 94$; SAGITTAL; All Sagittal Modifiers=Moderate-Severe Grade, Thoracic and Thoracolumbar/Lumbar Scoliosis <30°; Supplement Figure 1, <http://links.lww.com/BRS/B532>)

Mean values for SAGITTAL included; age= 63.4 (19.9–86.2) years, ASA grade= 2.6 (1–4), SVA= 107.5 (46.1–

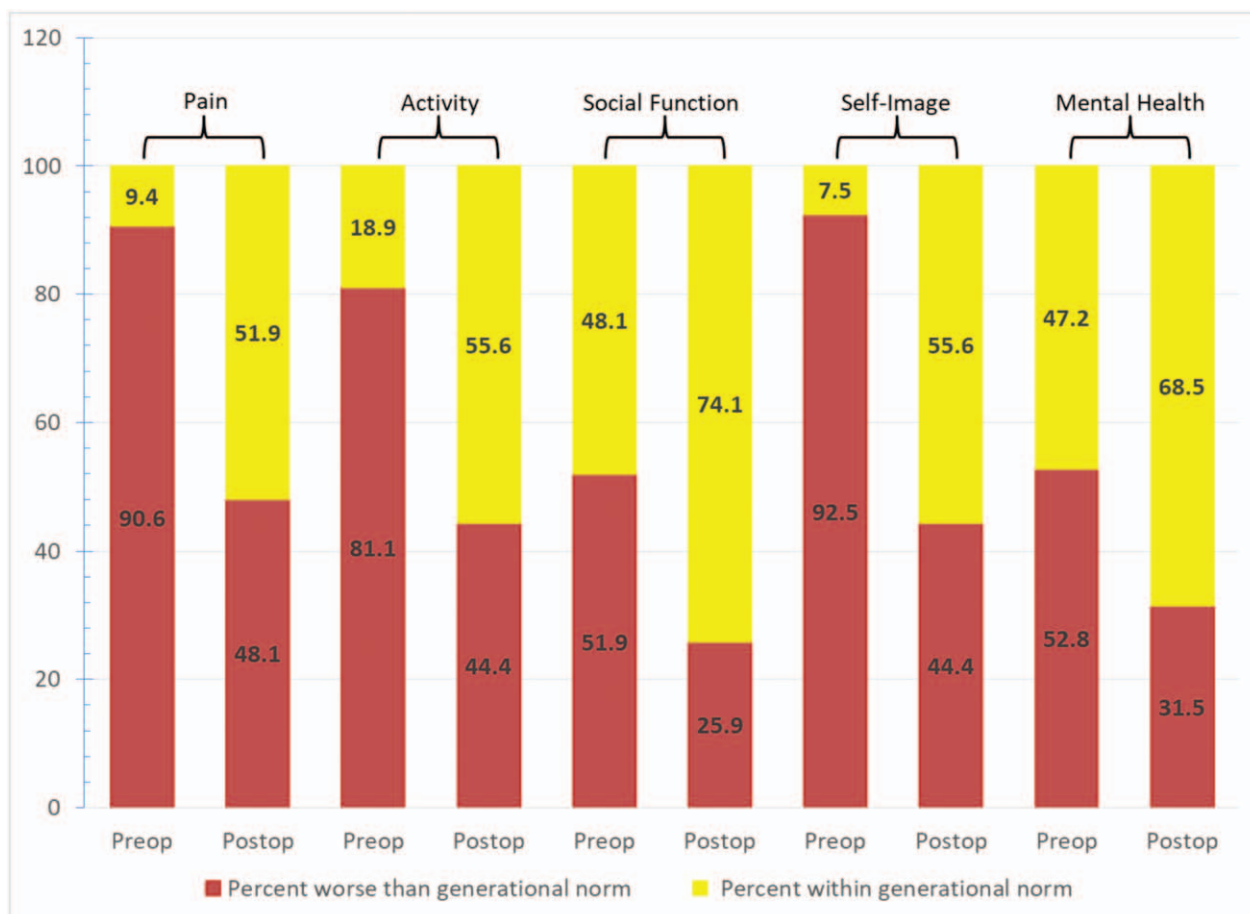


Figure 3. LUMBAR ASD; preoperative and postoperative health domains as percentage of patients >1 standard deviation from reported United States population normative and generational values. Pain indicates Scoliosis Research Society Questionnaire (SRS)-22r Bodily Pain Domain, Activity, SRS-22r Activity Domain; Social Function, Short Form-36v2 Social Function Domain; Self-Image, SRS-22r Self-Image Domain; and Mental Health, SRS-22r Mental Health Domain. Values are as a percent greater than one standard deviation (SD) worse than generational normal and percent within one SD of generational norm.

326.5) mm, total spine levels fused= 10.7 (4–17; Table 1). Postoperative improvements for SAGITTAL were: back pain= 44.9%, leg pain= 36.8%, bodily pain= 57.4%, physical activity= 29.8%, social function= 44.2%, self-image= 62.7%, and mental health= 32.6% ($P < 0.05$ all values; Tables 1 and 2). Preoperative self-image, bodily pain, and physical activity domains were most impacted compared with population norms. Self-image and bodily pain improved the most for SAGITTAL with return to population norms postoperatively; however, >50% of the SAGITTAL cohort remained >1 SD worse than the normative population for physical activity, bodily pain, and self-image postoperatively (Figure 5). SAGITTAL age <45 ($n=10$) demonstrated significant postoperative improvement in self-image (87.1%; $P < 0.05$), whereas the SAGITTAL 45–65 ($n=32$) and >65 ($n=52$) age groups had significant postoperative improvements in all domains ($P < 0.05$; Supplement Figure 6, <http://links.lww.com/BRS/B532>).

Mixed Deformities ($n = 129$; MIXED; Thoracic and/or Thoracolumbar/Lumbar Scoliosis >30° and One or More Sagittal Modifiers=Moderate-Severe Grade; Supplement Figure 1, <http://links.lww.com/BRS/B532>)

Mean values for the MIXED cohort included; age= 63.0 (18.7–84.4) years, ASA grade= 2.5 (1–4), maximal scoliosis= 49.7° (29.5°–102.5°), levels fused= 12.4 (4–19; Table 1). Postoperative improvements for MIXED included: back pain= 50.7%, leg pain= 48.0%, bodily pain= 62.4%, physical activity= 30.7%, social function= 39.6%, self-image= 69.4%, and mental health= 22.5% (all values $P < 0.05$; Tables 1 and 2). Preoperative domains most impacted compared with population norms for MIXED included self-image, bodily pain, and physical activity. Postoperative improvements with respect to return to population norms were greatest for self-image and bodily pain (Figure 6). The MIXED 45–65 ($n=63$) and >65 ($n=61$) age groups had significant improvements in all health

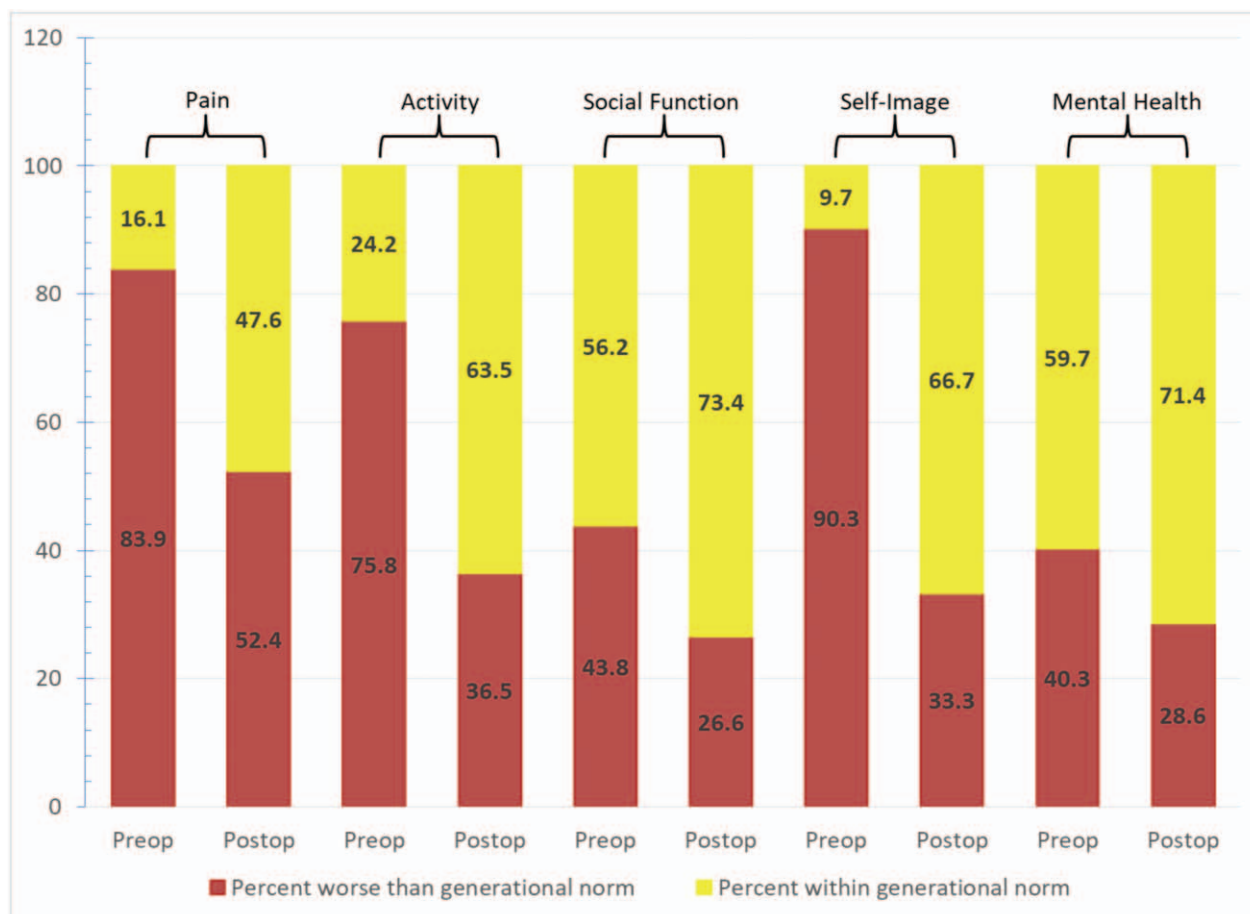


Figure 4. DOUBLE ASD; preoperative and postoperative health domains as percentage of patients >1 standard deviation from reported United States population normative and generational values. Pain indicates Scoliosis Research Society Questionnaire (SRS)-22r Bodily Pain Domain, Activity, SRS-22r Activity Domain; Social Function, Short Form-36v2 Social Function Domain; Self-Image, SRS-22r Self-Image Domain; and Mental Health, SRS-22r Mental Health Domain. Values are as a percent greater than one standard deviation (SD) worse than generational normal and percent within one SD of generational norm.

domains ($P < 0.05$); however, the <45 age group ($n = 5$) did not demonstrate significant improvements in any health domains ($P < 0.05$; Supplement Figure 7, <http://links.lww.com/BRS/B532>).

DISCUSSION

Surgical treatment for ASD improves patient-reported quality of life. In a recent systematic review of the literature regarding effectiveness of different treatment modalities for ASD, Teles *et al*¹ concluded that surgery significantly improves back and leg pain, reduces disability (as measured by ODI), and improves PCS and MCS components of the SF-36. Similarly, Bridwell *et al*² reported the greatest improvements following adult scoliosis surgery were in self-image and pain domains. The findings in the present study further support that surgery for ASD improves pain and function. Importantly, however, this study adds new information to the existing literature by quantifying the anticipated improvements for pain, physical function, social function, mental health, and self-image for each ASD type. This highlights that the health deficits and postoperative

improvements in specific health domains vary according to the specific types of ASD. This study also found that the pain and physical function domains within each ASD type worsen with age, which is consistent with previous reports.^{19,20} The physical, social, and psychological impairments that ASD has upon affected patients vary according to the deformity type, and while these health domains will improve following surgery, patient expectations for surgical improvements should be tempered by our findings that most ASD patients will not return to the same pain, self-image, physical and social function, and mental health levels reported by the general population that does not have ASD.

Providing realistic expectations for treatment outcomes following surgery allows patients to weigh the risk/benefit ratio of a potential surgery. Outcome measures including the SF-36, ODI, and SRS-22r provide summary scores that are important for research; however, these values are not understandable for most patients. The ability to describe anticipated improvements in specific values including back pain, leg pain, physical function, social function, and self-image hold important value for patient education.

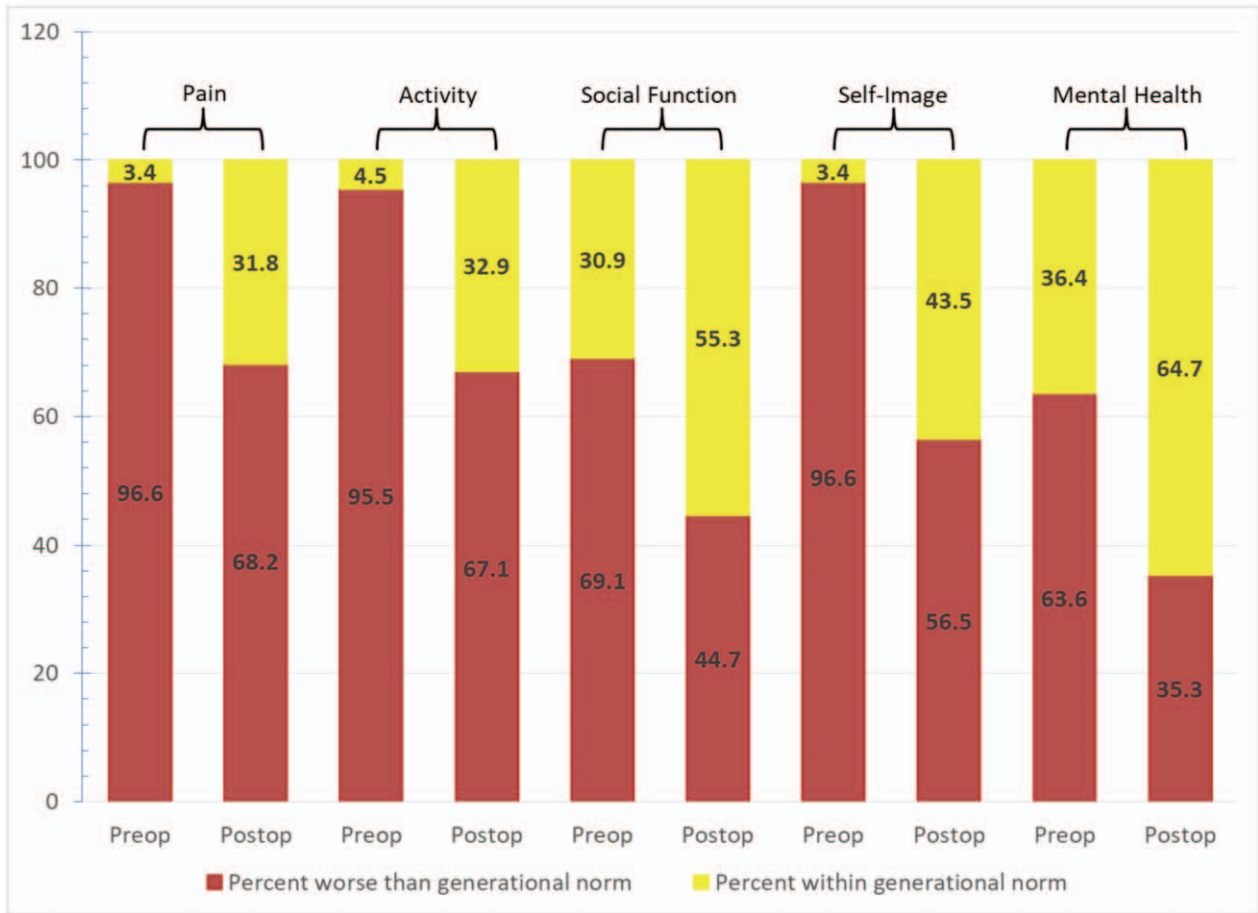


Figure 5. SAGITTAL ASD; preoperative and postoperative health domains as percentage of patients >1 standard deviation from reported United States population normative and generational values. Pain indicates Scoliosis Research Society Questionnaire (SRS)-22r Bodily Pain Domain, Activity, SRS-22r Activity Domain; Social Function, Short Form-36v2 Social Function Domain; Self-Image, SRS-22r Self-Image Domain; and Mental Health, SRS-22r Mental Health Domain. Values are as a percent greater than one standard deviation (SD) worse than generational normal and percent within one SD of generational norm.

Consequently, the ability to counsel a patient that the anticipated outcome for surgery is a 50% reduction in back pain is likely more informative than reporting that the anticipated outcome for surgery is a 50% reduction in the SF-36 PCS.^{21,22} We found that for all ASD patients there was a 45% improvement in back pain, a 41% improvement in leg pain, and a 30% improvement in physical function. However, THORACIC patients reported a 17.5% improvement in physical function while the MIXED patient reported a 39.6% improvement. These discrepancies in improvements according to ASD type were common across most domains and demonstrate the heterogeneity of ASD as a disease. These findings are consistent with previous reports that the severity of ASD disability is contingent upon the ASD type.¹⁰ These findings may also provide an effective resource for identification of good surgical candidates. For example, based upon our findings a THORACIC patient whose main complaint is poor self-image is potentially a good surgical candidate, whereas a THORACIC patient whose main complaint is poor physical

function is likely to improve very little following surgery and is potentially not an ideal surgical candidate.

The use of population norms to gauge the impact of a disease and evaluate the efficacy of a specific treatment helps provide context to the amount the patient is affected. Self-image was uniformly the most impacted domain for all ASD types, as nearly 90% of patients in each ASD type reported self-image scores >1 standard deviation worse than the general population. Improvement in self-image varied, however, as THORACIC demonstrated the greatest return to population norm, whereas SAGITTAL had the worst return to population normative values. This concept is important because it demonstrates that for some deformity types there are domains that are improvable, but the health deficit for that domain cannot be completely resolved. One reason for this is that domains such as physical function are limited by pain preoperatively; however postoperatively spine range of motion is limited due to a multilevel fusion, therefore despite a reduction in pain the physical function scores remain impacted compared with the general population. This

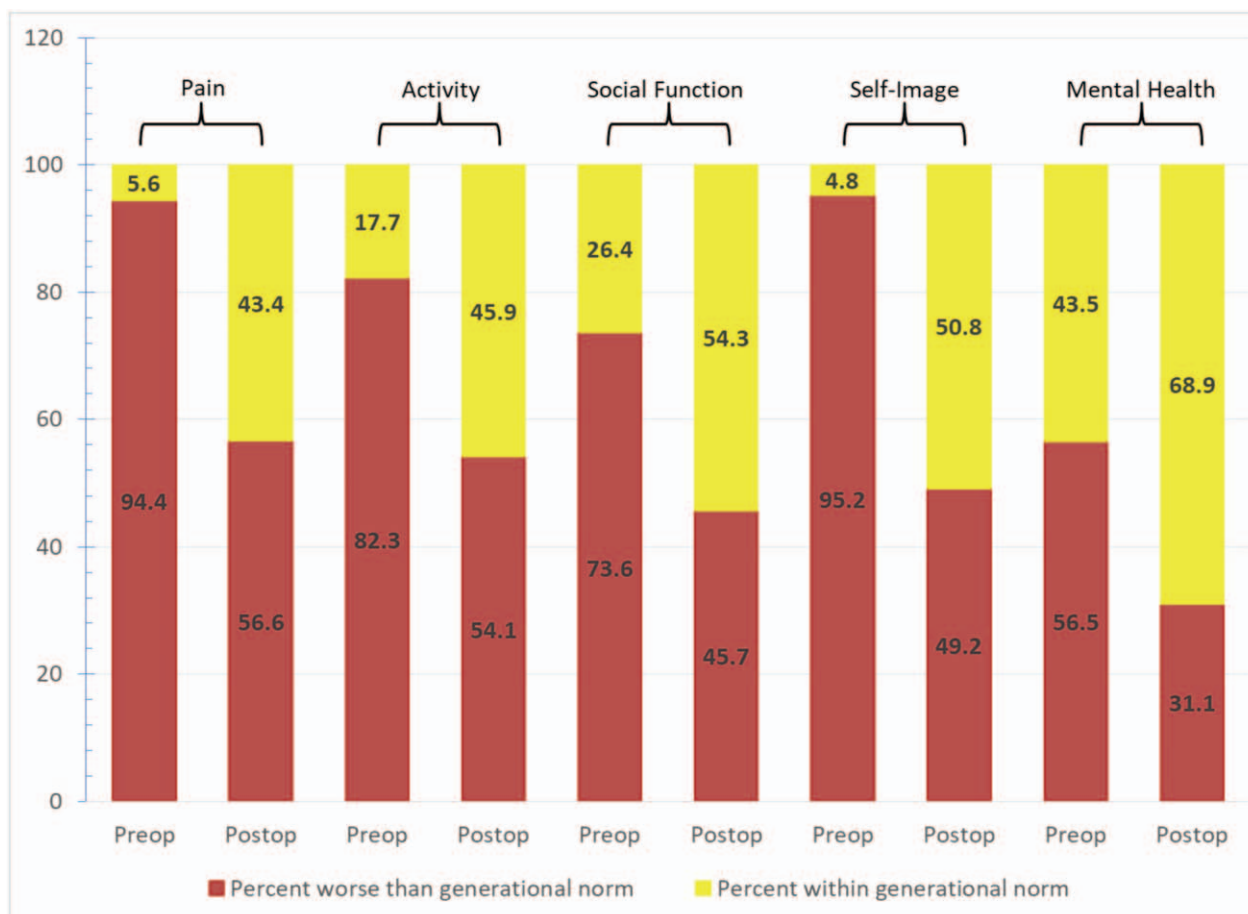


Figure 6. MIXED ASD; preoperative and postoperative health domains as percentage of patients >1 standard deviation from reported United States population normative and generational values. Pain indicates Scoliosis Research Society Questionnaire (SRS)-22r Bodily Pain Domain, Activity, SRS-22r Activity Domain; Social Function, Short Form-36v2 Social Function Domain; Self-Image, SRS-22r Self-Image Domain; and Mental Health, SRS-22r Mental Health Domain. Values are as a percent greater than one standard deviation (SD) worse than generational normal and percent within one SD of generational norm.

phenomenon was seen for the SAGITTAL group, as this cohort demonstrated good improvements in pain but physical function and activity remained markedly impacted. These findings underscore the fact that surgery for ASD can improve outcomes; however, surgery via a multilevel fusion does not restore “normalcy” to the patient.

This study found that self-image was the most negatively impacted preoperative health domain for the majority of ASD types, and consistently demonstrated the most improvement of all health domains following surgery. These findings are consistent with findings reported by Bridwell *et al*, where the ASD deformity types evaluated (thoracic, lumbar, and double major scoliosis) demonstrated significant improvements in self-image following surgical management for ASD.² Our study further highlights the importance measuring patient perception of self-image and counseling ASD patients on the potential improvement in the self-image domain following surgical management. These findings also emphasize the importance that questionnaires that are created and/or used to evaluate patient-reported outcomes for ASD to integrate a health domain that evaluates self-image.

There are several limitations to this study. All ASD patients evaluated for this study were treated surgically; therefore, it is possible that there is a patient selection bias for the cohort evaluated and ASD patients outside this cohort may report less pain and disability and may be minimally impacted by their corresponding spine deformity. There was also no treatment standardization for any of the patients in this study; consequently, this study cannot and does not recommend a specific type of surgical treatment for each ASD patient type. Additionally, the sample sizes for the age cohorts for each ASD type were not equal; therefore, there may be an age-associated bias for outcomes reporting for each ASD type. We attempted to rectify this limitation by reporting on the outcomes for each age cohort in the ASD types. The strengths of this study include a large multicenter patient population with a robust PROM data profile and diverse spine deformity types that allowed for in-depth analysis of the patient population. These data cannot avoid the inherent biases of an observational study; therefore, further research is needed to improve the understanding of ideal treatment for ASD.

In conclusion, this prospective, multicenter study found that ASD patients demonstrate quantifiable improvements in pain, physical and social function, mental health, and self-image; however, these improvements are particular to patient ASD type. We have provided guidelines for anticipated postoperative improvements in pain, function, mental health, and self-image for each spine deformity type. We believe that these findings demonstrate that ASD is a heterogeneous condition; therefore, the physicians treating ASD should evaluate the type and severity of each deformity to accurately counsel patients in an individualized manner. We hope that these results can improve counseling guidelines for physicians to share with ASD patients considering surgery and help to improve patient and physician communication.

➤ Key Points

- ❑ Postoperative improvements for ASD patients not divided into specific ASD types include 45% for back pain, 41% for leg pain, 30% for physical function, 62% for self-image, 36% for social function, and 23% for mental health ($P < 0.05$, except mental health).
- ❑ Postoperative improvements vary according to ASD types. LUMBAR, SAGITTAL, and MIXED demonstrated greater improvements in pain and physical function, while THORACIC and DOUBLE demonstrated greater improvements in self-image ($P < 0.05$).
- ❑ Preoperative pain and physical function domains within each ASD type worsened with age, and, accordingly, older age groups demonstrated greater pain and physical function domains improvements postoperatively.
- ❑ Compared with the general population, self-image is the health domain most negatively impacted by ASD and is the health domain that demonstrated the greatest surgical improvement for all ASD types.
- ❑ Despite improvements in all health domains, ASD patients do not return to quality of life values reported by the normative population.

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