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HEALTH SERVICES RESEARCH

# Outcomes and Complications With Age in Spondylolisthesis

*An Evaluation of the Elderly From the Quality Outcomes Database*

Michael Karsy, MD, PhD, MSc,[a] Andrew K. Chan, MD,[b] Praveen V. Mummaneni, MD,[b] Michael S. Virk, MD, PhD,[b] Mohamad Bydon, MD,[c] Steven D. Glassman, MD,[d] Kevin T. Foley, MD,[e] Eric A. Potts, MD,[f] Christopher I. Shaffrey, MD,[g] Mark E. Shaffrey, MD,[h] Domagoj Coric, MD,[i] Anthony L. Asher, MD,[i] John J. Knightly, MD,[j] Paul Park, MD,[k] Kai-Ming Fu, MD, PhD,[l] Jonathan R. Slotkin, MD,[m] Regis W. Haid, MD,[n] Michael Wang, MD,[o] and Erica F. Bisson, MD, MPH[a]

**Study Design.** Prospective database analysis.

**Objective.** To assess the effect of age on patient-reported outcomes (PROs) and complication rates after surgical treatment for spondylolisthesis

**Summary of Background Data.** Degenerative lumbar spondylolisthesis affects 3% to 20% of the population and up to 30% of the elderly. There is not yet consensus on whether age is a contraindication for surgical treatment of elderly patients.

**Methods.** The Quality Outcomes Database lumbar registry was used to evaluate patients from 12 US academic and private centers who underwent surgical treatment for grade 1 lumbar spondylolisthesis between July 2014 and June 2016.

**Results.** A total of 608 patients who fit the inclusion criteria were categorized by age into the following groups: less than 60 (n = 239), 60 to 70 (n = 209), 71 to 80 (n = 128), and more than 80 (n = 32) years. Older patients showed lower mean body mass index ($P < 0.001$) and higher rates of diabetes ($P = 0.007$), coronary artery disease ($P = 0.0001$), and osteoporosis ($P = 0.005$). A lower likelihood for home disposition was seen with higher age (89.1% in <60-year-old *vs.* 75% in >80-year-old patients; $P = 0.002$). There were no baseline differences in PROs (Oswestry Disability Index, EuroQol health survey [EQ-5D], Numeric Rating Scale for leg pain and back pain) among age categories. A significant improvement for all PROs was seen regardless of age ($P < 0.05$), and most patients met minimal clinically important differences (MCIDs) for improvement in postoperative PROs. No differences in hospital readmissions or reoperations were seen among age groups ($P < 0.05$). Multivariate analysis demonstrated that, after controlling other variables, a higher age did not decrease the odds of achieving MCID at 12 months for the PROs.

**Conclusion.** Our results indicate that well-selected elderly patients undergoing surgical treatment of grade 1 spondylolisthesis can achieve meaningful outcomes. This modern, multicenter US study reflects the current use and limitations of spondylolisthesis treatment in the elderly, which may be informative to patients and providers.

**Key words:** age, complications, elderly, EuroQol health survey, fusion, lumbar spine, Oswestry Disability Index, patient-reported outcomes, Quality Outcomes Database, spondylolisthesis, surgery.

**Level of Evidence:** 4

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From the [a]Department of Neurological Surgery, Clinical Neurosciences Center, University of Utah, Salt Lake City, UT; [b]Department of Neurological Surgery, University of California, San Francisco, CA; [c]Department of Neurological Surgery, Mayo Clinic, Rochester, MN; [d]Norton Leatherman Spine Center, Louisville, KY; [e]Department of Neurological Surgery, University of Tennessee Health Science Center, Semmes Murphey Neurologic and Spine Institute, Memphis, TN; [f]Department of Neurological Surgery, Indiana University, Goodman Campbell Brain and Spine, Indianapolis, IN; [g]Depart-Department of Neurosurgery, Duke Healthcare System, Durham, NC; [h]Department of Neurological Surgery, University of Virginia Health System, Charlottesville, VA; [i]Neuroscience Institute, Carolinas HealthCare System and Carolina NeuroSurgery & Spine Associates, Charlotte, NC; [j]Atlantic Neurosurgical Specialists, Morristown, NJ; [k]Department of Neurological Surgery, University of Michigan, Ann Arbor, MI; [l]Department of Neurological Surgery, Weill Cornell Medical Center, New York, NY; [m]Geisinger Health, Danville, PA; [n]Atlanta Brain and Spine Care, Atlanta, GA; and [o]Department of Neurosurgery, University of Miami, Miami, FL

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Address correspondence and reprint requests to Michael Karsy, MD, PhD, MSc, Department of Neurosurgery, Clinical Neurosciences Center, University of Utah, 175 North Medical Drive East, Salt Lake City, UT 84132; E-mail: neuropub@hsc.utah.edu

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Degenerative lumbar spondylolisthesis affects 3% to 20% of the population,[1] and the effect of age on spondylolisthesis incidence and outcome of surgical treatment has only recently been explored. The definition of the term "elderly" varies among medical organizations but generally includes patients more than 60 or

more than 65 years of age.[2] Furthermore, age alone increases challenges for surgical treatment, because patients typically have more medical comorbidities such as osteoporosis, diminished homeostatic reserve, pharmacological sensitivity, and reduced social/financial support. Results from the Study of Osteoporotic Fractures suggested increased prevalence of spondylolisthesis in the elderly, with up to 30% of patients showing a Meyerding grade I slip and 12% rate of progression.[3,4] Although numerous studies have demonstrated the benefit of surgical treatment in select cases,[5] evaluation of spine fusion in the elderly remains limited or inconclusive.[6] Use of the modified Frailty Index (mFI) has recently been addressed in the spine literature as a method of improving outcome prediction.[7]

We hypothesize that age plays a crucial role in the outcome and complications of surgical treatment for spondylolisthesis.

## METHODS

### Patients

The Quality Outcomes Database (QOD) is a multicenter, prospective registry designed to evaluate demographic, clinical, and patient-reported outcome (PRO) metrics for neurosurgical procedures. Patients from 12 of the highest-enrolling US QOD centers who underwent surgical treatment for grade 1 lumbar spondylolisthesis between July 2014 and June 2016 were evaluated with minimum 24-month follow-up.

### Variables

Collected variables included patient demographics, symptoms, surgical parameters, complications, and outcomes (Tables 1–3). Patients were divided into four categories (age <60, 60–70, 71–80, and >80 years at time of surgery), categories that were based on the neurosurgical literature and the World Health Organization and the American Geriatrics Society categories.[2] Minimally invasive surgery (MIS) was categorized for any patient that underwent any component of an MIS surgery, including percutaneous screw placement, interbody placement, or decompression.

Patient satisfaction was assessed using the North American Spine Society (NASS) Satisfaction Questionnaire. PRO metrics (Oswestry Disability Index [ODI], EuroQol health survey [EQ-5D], Numeric Rating Scale for leg pain [NRS-LP] and back pain [NRS-BP]) were acquired at baseline and during follow-up. Minimal clinically important differences (MCIDs) for spondylolisthesis were defined in advance based on prior work as 14.3 points for ODI, 0.2 points for EQ-5D, 1.7 points for NRS-LP, and 1.6 points for NRS-BP.[8] Readmission and return to the operating room for reasons related and unrelated to surgery were assessed during follow-up time periods.

### Analysis

Continuous and discrete variables are reported as means ± standard deviation and frequencies, respectively. Continuous variables were evaluated using *t* tests or one-way analysis of variance (ANOVA) with Tukey post-hoc comparisons whereas discrete variables were evaluated by Chi-square test. A repeated measures generalized linear model was used to evaluate repeated PRO measures over time. Univariate and multivariate logistic regressions were used to identify the factors affecting whether patients met 12-month MCID; variables on univariate analysis with $P < 0.2$ were entered into the multivariate model. Missing values were not filled by any imputation methods. A $P < 0.05$ was considered statistically significant. SPSS (V24.0; IBM, Armonk, NY) was used for statistical analysis. Data integrity was maintained by individual site data coordinators as well as by regular auditing of the database.

## RESULTS

### Baseline Characteristics

A total of 608 patients were divided into less than 60 (n = 239), 60 to 70 (n = 209), 71 to 80 (n = 128), and more than 80 (n = 32) years categories (Table 1, Figure 1). Diabetes ($P = 0.007$), coronary artery disease ($P = 0.0001$), and osteoporosis ($P = 0.005$) were more common in older age groups whereas anxiety ($P = 0.03$) and depression ($P = 0.003$) were more common in younger age groups. A shift from back-dominant and mixed back/leg complaints in younger age groups to either back- or leg-dominant symptoms in older patients was seen ($P = 0.0001$); however, patient symptoms otherwise did not differ among groups. A higher number of younger patients were employed and working compared with the elderly ($P = 0.0001$). American Society of Anesthesia (ASA) grade increasingly favored severe systemic disease over mild systemic disease in the elderly ($P = 0.003$). A significantly higher proportion of younger patients underwent arthrodesis: less than 60-year-old (89.1%) *versus* more than 80-year-old patients (40.6%) ($P = 0.0001$).

### Surgical Outcomes

Patients less than 60 years showed higher estimated blood loss (EBL) and length of surgery compared with those 71 to 80 years or more than 80 years but not 60 to 70 years ($P < 0.05$, Tukey post-hoc analysis) (Table 2). A lower likelihood of home disposition and greater chance of post-acute facility disposition was seen with the elderly (89.1% in <60-year-old *vs.* 75% in >80-year-old patients) ($P < 0.002$). Return to work was higher in younger patients at 3 months ($P = 0.0001$) and 12 months ($P = 0.0001$) but did not differ among age groups at more than 24 months ($P = 0.5$) for patients eligible for return to work.

There were no between-group differences seen for changes in NRS-BP ($P = 0.9$), NRS-LP ($P = 0.3$), EQ-5D ($P = 0.6$), or ODI ($P = 0.9$) on repeated-measures analysis (Figure 2A–D). A within-group improvement in NRS-BP ($P = 0.003$), EQ-5D ($P = 0.004$), and ODI ($P = 0.0001$) but not NRS-LP ($P = 0.07$) was seen for all age groups. Most patients met MCID for NRSBP (Figure 3A), NRSLP

**TABLE 1. Baseline Demographics for Patients Treated for Spondylolisthesis by Age Cohort**

| Variable | <60 Years (n = 239) | 60–70 Years (n = 209) | 71–80 Years (n = 128) | >80 Years (n = 32) | *P*-Value |
|---|---|---|---|---|---|
| Age, yr | 50.3 ± 8.1 | 65.0 ± 2.9 | 74.4 ± 2.8 | 83.7 ± 3.3 | 0.0001 |
| Sex (male) | 105 (43.9%) | 80 (38.3%) | 57 (44.5%) | 16 (50.0%) | 0.4 |
| BMI, mm/kg$^2$ | 31.6 ± 7.2 | 30.4 ± 6.1 | 28.8 ± 4.8 | 27.8 ± 4.7 | 0.0001 |
| Major past surgery | 30 (12.6%) | 23 (11.0%) | 14 (10.9%) | 3 (9.4%) | 0.9 |
| Comorbidities | | | | | |
| Previous smoker | 2 (0.8%) | 2 (1.0%) | 2 (1.6%) | 0 (0.0%) | 0.06 |
| Current smoker | 38 (15.9%) | 25 (12.0%) | 7 (5.5%) | 1 (3.1%) | |
| Diabetes | 25 (10.5%) | 45 (21.5%) | 23 (18.0%) | 8 (25.0%) | 0.007 |
| Coronary artery disease | 12 (5.0%) | 31 (14.8%) | 17 (13.3%) | 8 (25.0%) | 0.0001 |
| Anxiety | 52 (21.8%) | 39 (18.7%) | 15 (11.7%) | 2 (6.2%) | 0.03 |
| Depression | 57 (23.8%) | 50 (23.9%) | 13 (10.2%) | 3 (9.4%) | 0.003 |
| Osteoporosis | 8 (3.3%) | 16 (7.7%) | 8 (6.2%) | 6 (18.8%) | 0.005 |
| Dominant symptom | | | | | 0.0001 |
| Back dominant | 101 (42.3%) | 75 (35.9%) | 42 (32.8%) | 12 (37.5%) | |
| Leg dominant | 32 (13.4%) | 40 (19.1%) | 47 (36.7%) | 12 (37.5%) | |
| Back = leg | 106 (44.4%) | 94 (45.0%) | 39 (30.5%) | 8 (25.0%) | |
| Motor deficits | 53 (22.3%) | 46 (22.0%) | 29 (22.7%) | 11 (34.4%) | 0.5 |
| Ambulation | | | | | 0.2 |
| Independent | 215 (90.0%) | 185 (88.5%) | 112 (87.5%) | 25 (78.1%) | |
| With an assist device | 22 (9.2%) | 23 (11.0%) | 13 (10.2%) | 7 (21.9%) | |
| Wheelchair bound | 2 (0.8%) | 1 (0.5%) | 3 (2.3%) | 0 (0.0%) | |
| Symptom duration | | | | | 0.3 |
| <3 mo | 3 (1.3%) | 4 (1.9%) | 6 (4.7%) | 2 (6.2%) | |
| >3 mo | 228 (95.4%) | 196 (93.8%) | 119 (93.0%) | 28 (87.5%) | |
| Unknown | 8 (3.3%) | 9 (4.3%) | 3 (2.3%) | 2 (6.2%) | |
| ASA grade | | | | | 0.003 |
| I | 18 (7.5%) | 4 (1.9%) | 1 (0.8%) | 0 (0.0%) | |
| II | 126 (52.7%) | 115 (55.0%) | 68 (53.1%) | 14 (40.6%) | |
| III | 75 (31.4%) | 81 (38.8%) | 58 (45.3%) | 17 (53.1%) | |
| IV | 4 (1.7%) | 2 (1.0%) | 0 (0.0%) | 0 (0.0%) | |
| Arthrodesis | 213 (89.1%) | 168 (80.9%) | 73 (57.0%) | 13 (40.6%) | 0.0001 |
| MIS | 88 (36.8%) | 88 (57.9%) | 65 (50.8%) | 18 (56.2%) | 0.03 |
| Number of laminectomy levels | | | | | |
| 0 | 28 (11.7%) | 15 (7.2%) | 13 (10.2%) | 2 (6.2%) | 0.5 |
| 1 | 165 (69.0%) | 148 (70.8%) | 86 (67.2%) | 20 (62.5%) | |
| 2 | 46 (19.2%) | 46 (22.0%) | 29 (22.7%) | 10 (31.2%) | |

*Data are reported as mean ± SD or number (%).*

*ASA indicates American Society of Anesthesiologists; GED, general educational development; MIS, minimally invasive surgery; VA, Veterans Benefits insurance.*

(Figure 3B), EQ5D (Figure 3C), and ODI (Figure 3D). Overall, this signified improvement in PROs irrespective of age. Most patients stated that surgery met their expectations at 3, 12, and more than 24 months irrespective of age (Figure 2E). No differences in readmission (range 2.4–9.4%) or reoperation (range 0.0–9.4%) rates were seen among age groups (Table 2). Rates of complications requiring reoperation at 1, 2, and 3 years were 0% to 2.9%, 2.9% to 9.4%, 3.1% to 9.4%, and 3.1% to 9.4%, respectively, and were not affected by age (Table 3). Logistic regression showed that after controlling for demographic and surgical variables, a higher age did not decrease the odds of achieving MCID for the PROs at 12 months (Table 4, Supplemental Tables 1–4, http://links.lww.com/BRS/B515).

## DISCUSSION

### Study Findings

The results of this study suggest that, despite a higher rate of medical comorbidities and acute care facility disposition in

**TABLE 2. Outcome Data for Patients Treated for Spondylolisthesis by Age Cohort**

| Variable | <60 Years (n = 239) | 60–70 Years (n = 209) | 71–80 Years (n = 128) | >80 Years (n = 32) | *P*-Value |
|---|---|---|---|---|---|
| Estimated blood loss, mL | 220 ± 214 | 180 ± 191 | 153 ± 196 | 110 ± 115 | 0.002 |
| Length of surgery, min | 193 ± 83 | 176 ± 89 | 151 ± 84 | 135 ± 52 | 0.0001 |
| Length of stay, d | 3 ± 2 | 3 ± 2 | 3 ± 2 | 2 ± 2 | 0.07 |
| Disposition | | | | | 0.002 |
| Home or home health | 226 (94.6) | 192 (91.9) | 106 (82.8) | 24 (75.0) | |
| Acute care facility | 11 (4.6) | 17 (8.1) | 22 (17.2) | 7 (21.8) | |
| Hospital readmission | | | | | |
| Within 30 days | 6 (2.5) | 5 (2.4) | 5 (3.9) | 1 (3.1) | 0.9 |
| Within 3 months | 6 (2.5) | 5 (2.4) | 5 (3.9) | 3 (9.4) | 0.2 |
| Reoperation | | | | | |
| Within 30 days | 7 (2.9) | 2 (1.0) | 2 (1.6) | 0 (0.0) | 0.2 |
| Within 1 year | 10 (4.2) | 6 (2.9) | 4 (3.1) | 3 (9.4) | 0.3 |
| Within 2 years | 11 (4.6) | 11 (5.3) | 4 (3.1) | 3 (9.4) | 0.5 |
| Within 3 years | 17 (7.1) | 14 (6.7) | 4 (3.1) | 3 (9.4) | 0.4 |

*Data are reported as mean ± SD or number (%).*

**TABLE 3. Complication Data for Patients Treated for Spondylolisthesis by Age Cohort**

| Variable | <60 Years (n = 239) | 60–70 Years (n = 209) | 71–80 Years (n = 128) | >80 Years (n = 32) |
|---|---|---|---|---|
| Hospital readmission within 30 days | 9 (3.8) | 5 (2.4) | 6 (4.7) | 1 (3.1) |
| Pain | 2 | 1 | 1 | |
| Wound dehiscence/infection | 3 | 3 | | |
| CSF leak | 2 | | | |
| Ileus | | | 1 | |
| Reoperation or revision surgery | 2 | 1 | 2 | 1 |
| Hematoma | | | 1 | |
| Dehydration and syncope | | | 1 | |
| Hospital readmission within 3 months | 6 (2.5) | 5 (2.4) | 5 (3.9) | 3 (9.4) |
| Reoperation within 30 days | 7 (2.9) | 2 (1.0) | 2 (1.6) | 0 (0.0) |
| Wound washout | 2 | 2 | | |
| CSF leak | 2 | | | |
| Reoperation or revision surgery | 3 | | 1 | |
| Evacuation of hematoma | | | 1 | |
| Reoperation within 1 year | 10 (4.2) | 6 (2.9) | 4 (3.1) | 3 (9.4) |
| Wound washout | 3 | 2 | | |
| CSF leak | 2 | | | |
| Reoperation or revision surgery | 5 | 4 | 3 | 3 |
| Evacuation of hematoma | | | 1 | |
| Reoperation within 2 years | 14 (5.9) | 11 (5.3) | 4 (3.1) | 3 (9.4) |
| CSF leak | 2 | | | |
| Reoperation or revision surgery | 8 | 8 | 4 | 3 |
| Wound washout | 4 | 2 | | |
| SCS placement | | 1 | | |
| Reoperation within 3 year | 17 (7.1) | 14 (6.7) | 4 (3.1) | 3 (9.4) |
| Reoperation or revision surgery | 11 | 11 | 4 | 3 |
| Wound washout | 4 | 2 | | |
| CSF leak | 2 | | | |
| SCS placement | | 1 | | |

*CSF indicates cerebrospinal fluid; SCS, spinal cord stimulator.*

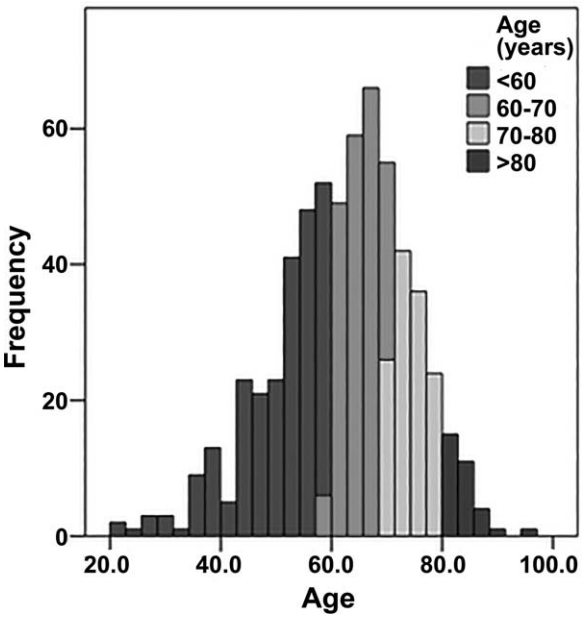


**Figure 1.** Age distribution for spondylolisthesis treatment and breakdown into age groups. A breakdown of age categories (<60, 60–70, 70–80, and >80 years of age) is shown for the patients included in this study (mean age: 62.2 ± 12.0 yrs, median age: 63.0 yrs, range 20.8–95.0 yrs). For the 608 patients, 39.3% (n = 239) were less than 60 years of age (dark grey), 34.4% (n = 209) were 60 to 70 years (light grey), 21.1% (n = 128) were 70 to 80 years (white), and 5.3 (n = 32) were more than 80 years (dark black).

the elderly, similar improvements in PRO measures (*i.e.*, NRS-BP, NRS-LP, EQ-5D, ODI, and NASS satisfaction scores) and similar complication rates were seen after surgery regardless of age. PROs improved at 3-month follow-up, which persisted more than 24 months postoperatively and met MCID for most patients regardless of age group. Despite a higher proportion of younger patients undergoing fusion, multivariate analysis showed that 12-month MCID was met after adjusting for other clinical and surgical covariates. These results support the use of operative treatment of spondylolisthesis in the elderly, although proper patient selection and counsel is important.

## Effect of Age on Lumbar Disease Outcomes

Degenerative lumbar spondylolisthesis is prevalent and increasing in the elderly, and the healthcare burden is likely to increase as the population ages. Spine surgery outcomes specifically of the elderly have been widely discussed but evidence has been inconclusive at times.[6] Several recent approaches have involved use of PROs, multicenter collaboration, and registries in retrospective and randomized clinical trials to evaluate the impact on lumbar fusion in spondylolisthesis.[5] Improved understanding of spine surgery in the elderly is warranted as prevalence of spine diseases and overall healthcare costs are predicted to increase.

A number of retrospective studies have aimed to evaluate the role of age in spine surgery. Marbacher *et al*[9] evaluated 707 patients who underwent lumbar fusion with up to 24 months of follow-up and acquisition of PROs. Surgical complication rates in patients 50 to 65, more than or equal to 65, and more than or equal to 85 years of age were 6.3%, 6.0%, and 15.0%, respectively ($P = 0.09$). No differences in PROs, including Core Outcome Measures Index domains, Global Outcomes Score, or patient-rated satisfaction, were seen at up to 24 months of follow-up. Our current results support the findings of this study. Our study did achieve lower complication rates (range 1.0–9.4%) and without a significant difference due to age. A number of retrospective reports have shown efficacy for spine fusion in the elderly but have differed on the exact age groups evaluated and lacked a comparator group of younger patients.[10–16] Comparison of complication rates to the literature remains limited because these rates depend highly on an institution's patient population, clinicians, and types of surgical approaches.

The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database has been widely used for the evaluation of age in spine surgery. Several studies evaluating posterior lumbar fusion identified an overall complication rate ranging from 2% to 16%, with higher rates in the elderly.[17–19] Murphy *et al*[18] showed an overall complication rate, including minor and major complications, increased with age (2.0%, 3.1%, and 4.1% for 65–74, 74–84, and ≥85 years of age, respectively). The overall complication rates and likelihood for nonroutine disposition reported with NSQIP were much higher than those reported in our data. This suggests heterogeneity in the NSQIP patient population, possibly including patients with trauma or tumors along with degenerative spine disease. The advantages of the QOD database are that the results are multicenter, prospectively collected, and centrally audited, which can make the results more generalizable and accurate.

## Frailty

The Clinical Frailty Scale or Frailty Index Score, initially developed by Rockwood and Mitnitski, and now with multiple iterations has been one measure to help identify elderly patients at risk with medical or surgical treatment.[7,20–25] Yagi *et al*[20] applied a mFI and the Charlson Comorbidity Index (CCI) to 156 patients with spinal deformity, 152 patients with degenerative spondylolisthesis, and 173 patients with lumbar stenosis who underwent surgical treatment. The mFI and CCI were significantly worse in patients with spinal deformity. Postoperative PROs worsened for those with poor preoperative mFI and CCI scores. The 2-year major complication rate increased with frailty in spinal deformity but not other types of degenerative spine disease. Passias *et al*[21] developed a cervical deformity frailty index in 121 patients that correlated with longer inpatient hospital stay, greater baseline neck pain, worsened neck PROs, higher odds of superficial infection, and greater mortality. Lakomkin *et al*[22] calculated mFI and CCI scores for 2170 patients in the NSQIP who underwent treatment of spinal tumors. Higher CCI but not mFI scores were independent predictors of mortality, adverse events, and LOS. Ali *et al*[23] evaluated data from the NSQIP from 2006 to

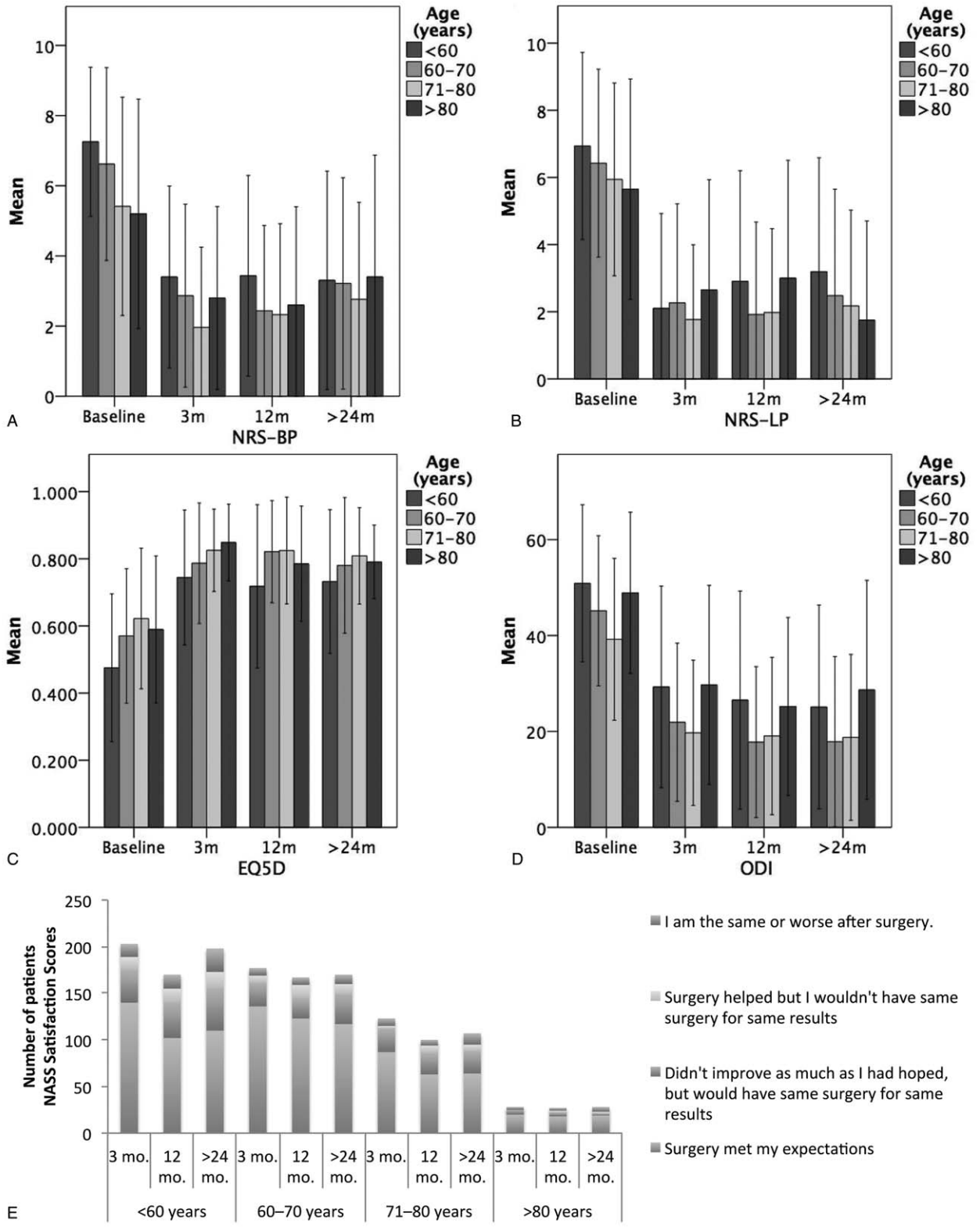


**Figure 2.** Patient-reported outcomes (PROs) for spondylolisthesis treatment by age groups. Using a generalized linear model with repeat measures, comparison of within-subject (*i.e.*, same patient across time) and between-subject (*i.e.*, discrete patient age groups) mean PRO measures was performed. **A**, Numeric Rating Scale for back pain (NRS-BP) showed a significant within-subject ($P = 0.003$) but not between-subject ($P = 0.9$) difference. **B**, Numeric Rating Scale for leg pain (NRS-LP) did not show a difference within ($P = 0.07$) or between subjects ($P = 0.3$). **C**, EuroQol health survey (EQ-5D) showed a significant within-subjects ($P = 0.004$) but not between-subjects ($P = 0.6$) difference. **D**, Oswestry Disability Index (ODI) was significantly different within-subjects ($P = 0.0001$) but not between subjects ($P = 0.9$). **E**, North American Spine Society (NASS) satisfaction questionnaire is shown dividing patients into 1 of 4 scores depending on their views of their surgical experience. Similar improvements in scores were seen over time and across age groups.

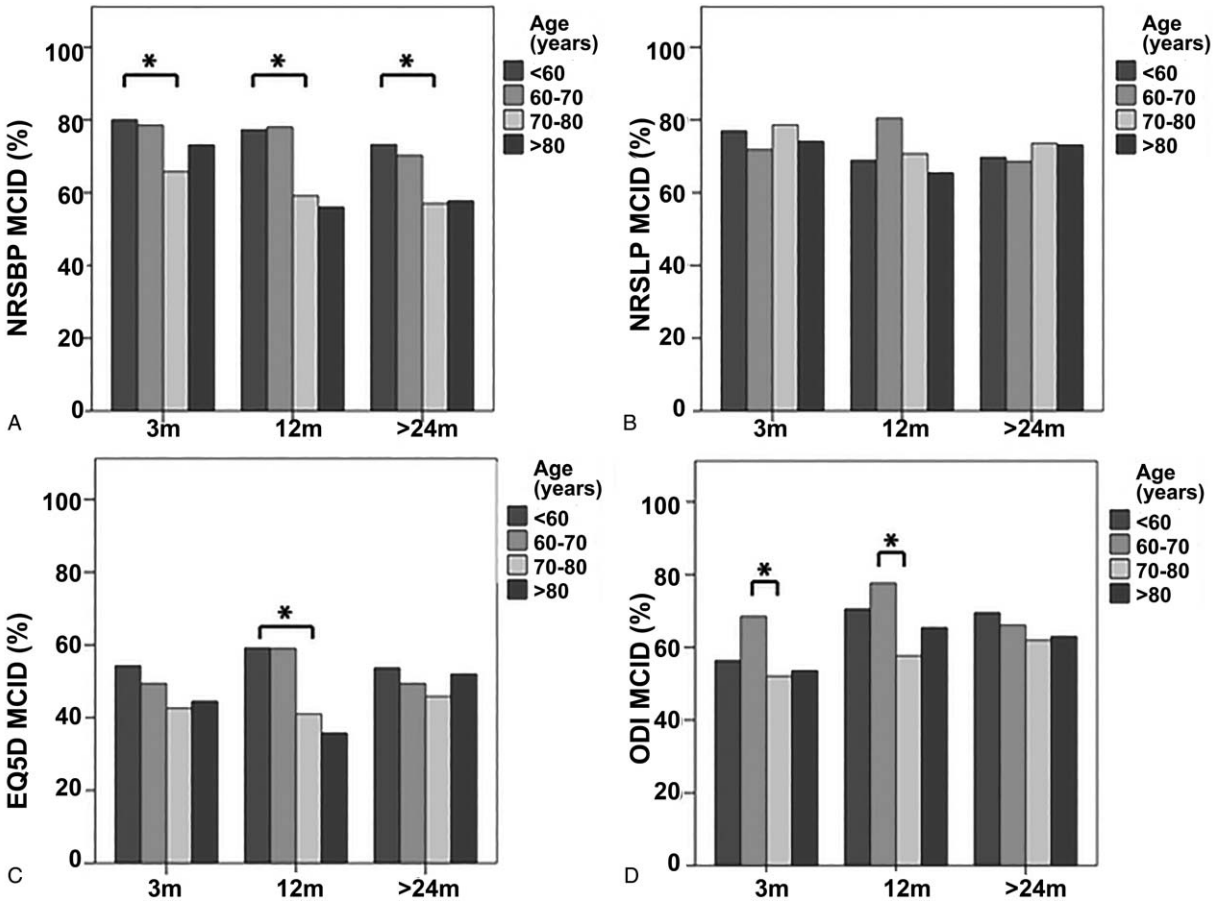


**Figure 3.** Minimal clinically important differences (MCIDs) for patient-reported outcomes in the surgical treatment of spondylolisthesis. Using a generalized linear model with repeat measures, the percentages of patients within each age cohort that met MCID were compared. **A**, Differences in Numeric Rating Scale for back pain (NRSBP) were seen between less than 60, 60 to 70, and 71 to 80 year olds at 3, 12, and more than 24 months ($P < 0.05$). **B**, No differences in Numeric Rating Scale for leg pain (NRSLP) were seen among ages or follow-up intervals. **C**, Differences in EuroQol health survey (EQ-5D) were seen between less than 60- and 71 to 80-year-olds at 12 months only ($P < 0.05$). **D**, Differences in Oswestry Disability Index (ODI) were seen between 60–70- and 71–80-year-olds at 3 months and 12 months ($P < 0.05$).

2010 and identified 18,294 patients who underwent spine surgery; they found that a higher mFI correlated with higher rates of surgical site infection and mortality. A multivariable analysis showed that mFI and ASA more than 3 were independent predictors of major complications (defined as Clavien IV) and death. Leven *et al*[7] evaluated 6094 patients who underwent lumbar interbody fusion between 2005 and 2012 and demonstrated that higher mFI scores resulted in an independently increased rate of any complication, sepsis, wound complication, prolonged LOS, and readmission. These results certainly suggest that variation in outcomes of the elderly who undergo spine fusion can be due to differences in patient population and selection.

### Limitations

Although the strengths of this study include the prospective collection of data, multicenter format, and utilization of PROs, several limitations persist. One limitation of this study is that while it is multicenter, it may not reflect the entire population of patients with spine disease and the elderly in the United States. Likely, there is significant institutional and regional variation that cannot be captured even with a multicenter study. Despite a multivariate analysis to adjust for differences in clinical factors that may affect PROs, limited numbers of patients in the higher age groups (*i.e.*, only 32 patients in the >80-year-old cohort) may underpower this subgroup analysis. Another limitation is that a central adjudication committee was not used to enroll patients. Although individual centers used shared criteria for the selection of surgical patients, surgeons ultimately selected patients for treatment based on their own interpretation. These factors may result in a selection bias of patients.

## CONCLUSION

Overall, this study supports the role of spine surgery in the treatment of spondylolisthesis for the elderly, who generally achieved similar complication rates and PRO improvements compared with younger patients. The mean PRO improvements in all patient groups met the MCID. Proper patient

**TABLE 4. Multivariate Logistic Regression of Factors Predictive of Reaching MCID for PROs (NRSBP, NRSLP, ODI, EQ5D)**

| | NRSBP | | NRSLP | | ODI | | EQ5D | |
|---|---|---|---|---|---|---|---|---|
| Variable | OR (95% CI) | *P*-Value | OR (95% CI) | *P*-Value | OR (95% CI) | *P*-Value | OR (95% CI) | *P*-Value |
| Age, yr | | | | | | | | |
| <60 | 0.96 (0.33, 2.81) | 0.9 | 1.5 (0.6, 3.6) | 0.4 | 0.9 (0.3, 2.4) | 0.8 | 1.3 (0.5, 3.3) | 0.5 |
| 60–70 | 1.2 (0.4, 3.4) | 0.8 | 2.6 (1.008, 6.5) | 0.5 | 1.3 (0.5, 3.6) | 0.6 | 1.7 (0.7, 4.1) | 0.2 |
| 70–80 | 0.97 (0.34, 2.76) | 0.9 | 1.3 (0.5, 3.3) | 0.6 | 0.6 (0.2, 1.7) | 0.3 | 1.1 (0.4, 2.7) | 0.9 |
| >80 | Ref | 0.9 | Ref | 0.05 | Ref | 0.09 | Ref | 0.4 |
| BMI | | | 0.95 (0.92, 0.99) | 0.004 | | | | |
| Diabetes | | | | | | | | |
| CAD | 0.8 (0.4, 1.7) | 0.6 | | | | | | |
| Anxiety | | | | | | | 1.4 (0.8, 2.5) | 0.3 |
| Depression | 1.2 (0.6, 2.2) | 0.6 | 1.7 (0.9, 3.0) | 0.08 | 1.2 (0.7, 2.0) | 0.6 | 1.2 (0.7, 2.0) | 0.6 |
| Osteoporosis | | | | | 2.2 (0.8, 6.1) | 0.1 | | |
| Dominant symptom | | | | | | | | |
| Back dominant | 0.8 (0.4, 1.4) | 0.8 | 0.8 (0.5, 1.3) | 0.3 | 0.6 (0.4, 1.04) | 0.07 | 0.8 (0.5, 1.2) | 0.2 |
| Leg dominant | 0.4 (0.2, 0.7) | 0.003 | 1.5 (0.8, 2.7) | 0.2 | 0.8 (0.4, 1.5) | 0.5 | 0.8 (0.5, 1.5) | 0.5 |
| Back = leg | Ref | 0.01 | Ref | 0.1 | Ref | 0.2 | Ref | 0.5 |
| ASA | | | | | | | | |
| I | | | | | | | 0.7 (0.06, 7.7) | 0.8 |
| II | | | | | | | 0.5 (0.05, 4.7) | 0.5 |
| III | | | | | | | 0.3 (0.03, 2.9) | 0.3 |
| IV | | | | | | | Ref | 0.08 |
| Arthrodesis | 1.7 (0.9, 3.4) | 0.1 | | | 1.2 (0.7, 2.2) | 0.6 | 2.2 (1.3, 3.7) | 0.003 |
| Number of laminectomy levels | | | | | | | | |
| 0 | Ref | 0.5 | Ref | 0.8 | | | | |
| 1 | 0.6 (0.2, 1.6) | 0.3 | 0.995 (0.5, 2.1) | 0.99 | | | | |
| 2 | 0.6 (0.2, 1.8) | 0.4 | 1.2 (0.5, 2.9) | 0.7 | | | | |
| EBL | 1.000 (0.998, 1.001) | 0.8 | | | | | | |
| MIS | 0.8 (0.5, 1.3) | 0.4 | | | | | | |
| Length of surgery | 1.0001 (0.997, 1.004) | 0.6 | | | 1.002 (0.999, 1.004) | 0.3 | | |

*ASA indicates American Society of Anesthesiologists; BMI, body mass index; CAD, coronary artery disease; EBL, estimated blood loss; MIS, minimally invasive surgery.*

selection and counseling is key to achieving a good outcome, and age—while considered as a factor—should not be an absolute contraindication.

## ➢ Key Points

- ❑ Older patients had similar improvement in patient-reported outcomes after the surgical treatment of degenerative grade 1 spondylolisthesis.
- ❑ Medical and surgical complications with the surgical treatment of degenerative grade 1 spondylolisthesis were not worsened with age.
- ❑ Most patients surgically treated for degenerative grade 1 spondylolisthesis achieved the minimal clinically important difference for various patient-reported outcomes.

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