

Clinical Study

Frailty is an important predictor of 30-day morbidity in patients treated for lumbar spondylolisthesis using a posterior surgical approach

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Abstract

BACKGROUND CONTEXT: Traditionally, a nonoperative approach has been favored for elderly patients with lumbar spondylolisthesis due to a perceived higher risk of morbidity with surgery. However, most studies have used an arbitrary age cut-off to define “elderly” and this research has yielded conflicting results.

PURPOSE: The purpose of this study was to investigate the impact of frailty on morbidity after surgery for degenerative lumbar spondylolisthesis treated with a posterior approach.

STUDY DESIGN: A retrospective cohort study was performed.

PATIENT SAMPLE: The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database, with years 2010 to 2018 included in this study. Patients who received posterior lumbar spine decompression with or without single level posterior instrumented fusion for degenerative lumbar spondylolisthesis were included. Patients who received anterior and/or lateral approaches were excluded.

OUTCOME MEASURES: The primary outcome was Clavien-Dindo grade IV complication. Secondary outcomes were readmission, reoperation, and discharge to location other than home.

METHODS: Patient demographics and comorbidities were extracted. Logistic regression analysis was performed to investigate the association between outcomes and the Modified Frailty Index-5, adjusting for age, gender, body mass index, smoking status, and surgical procedure performed. A sub-analysis was done to assess the effect of frailty in three different age groups (18–45 years, 46–65 years, and >65 years) for the two surgical cohorts.

RESULTS: There were 15,658 patients in this study. The mean age was 62.5 years. Approximately 70% of the patients received decompression with fusion. Frailty was significantly associated with an increased risk of major complication, unplanned readmission, reoperation, and non-home discharge. The risk increased with increasing frailty. For patients who received decompression, frailty

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was associated with a higher risk of readmission and non-home discharge in patients >65 years. For patients who received decompression and fusion, frailty was associated with a higher risk of complications, readmission, and non-home discharge in patients >65 years.

CONCLUSIONS: Frailty is independently associated with a higher risk of morbidity after posterior surgery in patients with lumbar spondylolisthesis, especially in patients older than 65. These data are of significance to clinicians in planning treatment for these patients. © 2021 Elsevier Inc. All rights reserved.

Keywords:

Elderly; Frailty; Morbidity; Patient outcomes; Spondylolisthesis; Surgery

Introduction

With a growing geriatric population, spine surgeons are encountering elderly patients with degenerative lumbar spondylolisthesis more often [1,2]. Traditionally, elderly patients with degenerative lumbar spondylolisthesis have been managed conservatively with nonsurgical approaches due to a perceived increased risk of complication and mortality associated with surgery in individuals with advanced age [3–6]. However, the studies seeking a link between age and increased complications in patients surgically treated for degenerative lumbar spondylolisthesis have yielded conflicting results. In a survey of spine surgeons across North America, age over 65 was felt to be a significant factor that impacted surgical management recommendations to patients with lumbar spondylolisthesis [7]. Other studies suggest that elderly patients have better outcomes with surgery than with conservative management [8]. Additionally, several papers report similar postsurgical outcomes when comparing younger patients with older patients [8–11]. This raises the question as to whether age itself should determine the management received by this patient population, or whether other factors should be considered [12].

There is increasing evidence that frailty may be a better predictor of morbidity and mortality after lumbar spine surgery in the elderly population than age [13]. The Modified Frailty Index (MFI) is a comorbidity-based risk stratification tool that has been used in several surgical specialties to predict risk of postoperative mortality and adverse events [14–18]. This frailty index is based on the deficit accumulation model of frailty [19]. Indeed, several studies have found that the number of comorbidities is associated with increased risk of mortality and complications in patients receiving spine surgery [20–23]. A recent study by Weaver et al. found frailty, as measured by the modified 5-item frailty index, to be associated with higher risk of any complication, 30-day readmissions, and non-home discharge after elective posterior lumbar fusions for degenerative lumbar disease [24]. Degenerative lumbar disease includes a wide range of pathologies, from simple discopathies to spondylolisthesis with deformity. Additionally, for specific pathologies such as degenerative lumbar spondylolisthesis, it remains unclear whether the addition of fusion provides enough clinical benefit to outweigh the additional risks and costs compared to decompression alone [25–27]. Therefore, in this study we

propose narrowing the patient population to only include patients with degenerative lumbar spondylolisthesis and including patients who were treated with decompression alone or decompression with fusion, since both are viable surgical options for this pathology. The purpose of this study is to investigate the effect of frailty on morbidity in patients treated for degenerative lumbar spondylolisthesis using a posterior approach.

Materials and methods

Patient population

This was a retrospective analysis of The American College of Surgeons National Surgical Quality Improvement Program database, with years 2010 to 2018 included in this study. Patients who received posterior lumbar spine decompression (CPT 63005, 63012, 63017, 63030, 63047) and lumbar spine decompression with single level posterior or posterolateral instrumented fusion (CPT 22612, 22630, 22633) for lumbar spondylolisthesis were included in this study (Supplementary Table 1). Diagnosis of degenerative lumbar spondylolisthesis was determined through ICD-9 and ICD-10 codes (ICD-10-CM M43.16, M43.1 and ICD-9 724.6, 738.4, 756.11, 756.12) (Supplementary Table 2). Patients were excluded if additional CPT codes included anterior (CPT 22558, 22585) and lateral approaches (CPT 22533, 22534).

Data extraction and outcomes

Patient demographics and characteristics were collected, including age, sex, body mass index (BMI), smoking status, comorbidities, and whether they received decompression or decompression with instrumented fusion. Model variables were chosen a priori based on literature review and clinical judgement [13]. Frailty was measured using the Modified Frailty Index-5 (mFI-5). The mFI-5 is a 5-item comorbidity-based index for frailty used for risk stratification. The score is calculated based on the presence or absence of the following 5 comorbidities: diabetes mellitus, congestive heart failure within 30 days prior to surgery, hypertension requiring medication, history of COPD or pneumonia, and partially dependent or totally dependent functional status [28].

The primary outcome was major complication within 30 days. “Major complication” was defined using the

Clavien-Dindo classification system for surgical complications, with grade IV complications considered a “major complication” [29,30]. This included cardiac arrest, myocardial infarction, septic shock, pulmonary embolism, postoperative dialysis, need for reintubation, and prolonged ventilator requirements [30]. Secondary outcomes were unplanned readmission, reoperation related to principal procedure, and discharge disposition other than home.

Statistical analysis

Descriptive statistics were used to describe patient demographics and outcomes. Student *t* test and Chi-square test were used to compare the patient demographics between patients that received decompression and patients that received decompression and fusion. Multivariable logistic regression analysis was used to test the association between frailty and the primary and secondary outcomes while adjusting for the effects of age, sex, BMI, smoking status, as well as surgical procedure performed. The mFI-5 was treated as a 4-level categorical variable. A patient with a score of 0 was considered “nonfrail,” a score of 1 was “prefrail,” a score of 2 was “frail,” and a score of 3 or higher was “severely frail” [31]. Age and BMI were treated as continuous variables. Sex, smoking status (smoker vs. non-smoker) and surgical intervention were treated as dichotomous variables. A sub-analysis was done to investigate the effect of frailty on different age groups. For the sub-analysis, the study cohort was separated by the surgical procedure performed. Age was stratified into three different age groups: 18 to 45 years, 46 to 65 years, and >65 years. The multivariable logistic regression for the sub-analysis was adjusted for sex, BMI, and smoking status. Due to testing multiple hypotheses in this study, the significance level was set to 0.01 to reduce the risk of a type 1 error.

All statistical analyses were performed using RStudio version 1.2.5001 on R version 3.6.1. The rms package was used (Harrell, FE. (2020). rms: Regression Modeling Strategies. R package version 6.0-0).

Results

Patient characteristics

There were 15,658 patients included in this study (Fig. 1). The mean age was 62.5 years and 63.2% were female. The average BMI was 30.7. For the mFI-5 score, there were 36.8% (n=5 768) with a score of 0, 44.8% (n=7 020) with a score of 1, 16.9% (n=2 645) with a score of 2, and 16.9% (n=225) with a score of 3 or higher (Table 1). Of the 15 658 patients, 27.7% (n=4 341) received decompression and 72.3% (n=11 317) received decompression with instrumented fusion. There were no significant differences between the two surgical groups with regards to age and frailty scores (Table 1).

Primary outcome (major complication)

The incidence of a recorded major complication within 30 days of surgery was 1.6% (n=253). The odds of a major complication increased with increasing frailty after adjusting for age, BMI, sex, smoking status, and addition of fusion (Table 2). Compared to patients who were nonfrail, prefrail patients (OR 1.68 95% CI 1.20–2.35), frail patients (OR 1.79 95% CI 1.20–2.67), and severely frail patients (OR 2.71 95% CI 1.25–5.89) had a significantly increased risk of major complication (Fig. 2).

Secondary outcomes (unplanned readmission, reoperation, and discharge disposition)

The unplanned readmission rate was 4.4% (n=694). The odds of readmission increased with increasing frailty, after adjusting for age, BMI, sex, smoking status, and addition of fusion (Table 2). Compared to patients who were nonfrail, prefrail patients (OR 1.32 95% CI 1.08–1.62), frail patients (OR 1.94 95% CI 1.54–2.44), and severely frail patients (OR 2.46 95% CI 1.51–4.01) had an increased risk of readmission (Fig. 3).

The reoperation rate was 2.8% (n=438). mFI-5 ($p=.009$) was a significant variable when adjusted for age, BMI, sex, smoking status, and addition of fusion (Table 2). Compared to nonfrail patients, frail patients had increased odds of reoperation (OR 1.46 95% CI 1.17–2.06). Prefrail and severely frail patients did not have a significant increase in odds of reoperation (Fig. 3).

The rate of being discharged to a location other than home was 19.5% (n=3 050). mFI-5 was a significant variable ($p<.001$) when adjusted for age, BMI, sex, smoking status, and addition of fusion (Table 2). The odds of being discharged to a location other than home increased with increasing frailty. Compared to patients who were nonfrail, prefrail patients (OR 1.16 1.04–1.28), frail patients (OR 1.71 95% CI 1.51–1.94), and severely frail patients (OR 2.19 95% CI 1.63–2.95) had increased odds of non-home discharge (Fig. 3).

Sub-analysis on the impact of frailty in different age groups for decompression

For patients 18 to 45 years old, frailty was not associated with risk of major adverse events, readmission, reoperation, or non-home discharge. For patients 46 to 65 years old, being severely frail was associated with a higher risk of readmission (OR 8.49 95% CI 2.56–28.23) and being frail was associated with a higher risk of non-home discharge (OR 1.94 95% CI 1.31–2.86). For patients older than 65, being frail and severely frail were associated with a higher risk of readmission (frail: OR 3.23 95% CI 1.65–6.34; severely frail: OR 4.43 95% CI 1.34–14.63) and non-home discharge (frail: OR 1.82 95% CI 1.35–2.44; severely frail: OR 3.68 95% CI 1.88–7.22) (Table 3).

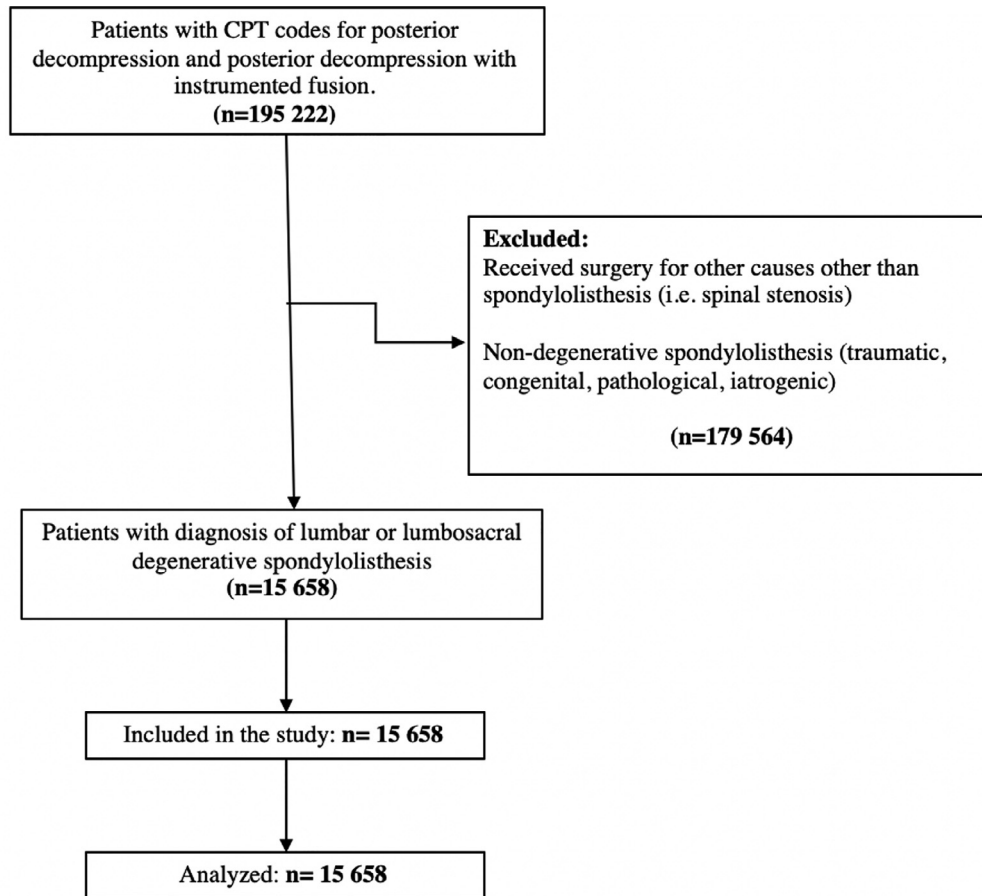


Fig.1. Flow diagram for inclusion and exclusion.

Sub-analysis on the impact of frailty in different age groups for decompression and fusion

For patients 18 to 45 years old, frailty was not associated with major adverse events, readmission, reoperation, or non-home discharge. For patients 46 to 65 years old, being frail was associated with an increased risk of non-home discharge (OR 1.96 95% CI 1.54–2.48) and being severely

frail was associated with an increased risk of non-home discharge (OR 2.21 95% CI 1.17–4.17) as well as major adverse events (OR 5.43 95% CI 1.53–19.25). For patients older than 65, frailty was associated with an increased risk of major adverse events, readmission, and non-home discharge. Compared to nonfrail patients, prefrail patients (OR 2.33 95% CI 1.18–4.58) and frail patients (OR 2.71 95%

Table 1
Patient demographics and characteristics

Patient demographics and characteristics	Decompression n=4341	Decompression and fusion n=11 317	
Age (y), mean (SD)	63.2 (12.2)	62.2 (12.1)	p=.51
Sex, n (%)			
Female	2688 (61.9%)	7215 (63.8%)	p<.05
BMI (kg/m ²), mean (SD)	30.4 (6.6)	30.8 (6.6)	p=.98
Smoker, n (%)	646 (14.9%)	1936 (17.1%)	p<.05
Modified Frailty Index-5, n (%)			p=.49
Nonfrail	1636 (37.8%)	4129 (36.5%)	
Prefrail	1908 (44.0%)	5112 (45.2%)	
Frail	734 (16.9%)	1911 (16.9%)	
Severely frail	60 (1.4%)	165 (1.5%)	

Table 2
Multivariable analysis for primary and secondary outcomes

	Major complication	Unplanned readmission	Reoperation	Discharge to non-home location
Age	1.03 [1.02–1.04]*	1.02 [1.01–1.03]*	1.00 [0.99–1.01]	1.06 [1.06–1.07]*
mFI-5				
Prefrail	1.68 [1.20–2.35]*	1.32 [1.08–1.62]*	1.08 [0.85–1.37]	1.16 [1.04–1.28]*
Frail	1.79 [1.20–5.89]*	1.94 [1.54–2.44]*	1.56 [1.17–2.06]*	1.71 [1.51–1.94]*
Severely frail	2.71 [1.25–3.61]*	2.46 [1.51–4.01]*	1.24 [0.59–2.61]	2.19 [1.63–2.95]*
Sex (female)	0.84 [0.65–1.09]	1.06 [0.91–1.25]	1.06 [0.87–1.30]	1.61 [1.47–1.76]*
Body mass index	1.02 [1.00–1.04]	1.03 [1.02–1.04]*	1.04 [1.03–1.06]*	1.03 [1.02–1.03]*
Smoker	1.30 [0.91–1.85]	1.29 [1.05–1.60]	1.41 [1.10–1.80]*	1.09 [0.96–1.24]
Addition of fusion	0.97 [0.74–1.28]	1.22 [1.02–1.46]	1.36 [1.08–1.71]*	0.98 [0.89–1.07]

All results are presented as OR [95% CI].

* Indicates significant at <0.05 level.

CI 1.30–5.63) had a higher risk of major adverse events. Prefrail (OR 1.85 95% CI 1.24–2.74), frail (OR 2.84 95% CI 1.86–4.34), and severely frail (OR 3.05 95% CI 1.43–6.49) had a higher risk of readmission. Prefrail (OR 1.45 95% CI 1.22–1.71), frail (OR 2.10 95% CI 1.73–2.56), and severely frail (OR 2.70 95% CI 1.76–4.13) was associated with a higher risk of non-home discharge Table 4.

Discussion

Symptoms of lumbar spondylolisthesis significantly impact a patient's quality of life and productivity [32]. This is a major concern in the elderly population since impairment of mobility can lead to rapid deconditioning and loss of independence [33]. There has been much focus on how age impacts outcomes after spine surgery [34–40]. However, most of these studies do not adjust for factors such as comorbidities and frailty, which may impact outcomes more than age itself. In this study, we investigated the effect of frailty, as measured by mFI-5, on 30-day morbidity in patients who received surgery for lumbar spondylolisthesis. We found increasing frailty to be associated with increasing odds of major complication, readmission,

reoperation, and non-home discharge. Findings from this study suggest frailty is an important factor for risk stratification of patients receiving surgery for degenerative lumbar spondylolisthesis. To our knowledge, this is the first study using a large patient cohort to examine the impact of frailty on morbidity after posterior decompression with and without fusion in patients with degenerative lumbar spondylolisthesis.

The mFI-5 is a frailty index based on 5 patient comorbidities. It is equally effective at predicting morbidity and mortality as the original mFI-11, which is based on 11 patient comorbidities [28]. Since its development, mFI-5 has been used as a risk stratification tool in various surgical specialties, including general surgery, orthopedic surgery, and vascular surgery [14–18]. In this study, we found increasing frailty, as measured by mFI-5, to be associated with a higher risk of morbidity. When compared to nonfrail patients, the likelihood of having major complication was 68% higher in prefrail patients, 79% higher in frail patients, and 171% higher in severely frail patients. Similarly, for unplanned readmission prefrail patients had a 32% increase in odds, frail patients had a 94% increase in odds, and severely frail patients had 146% increase in odds. For

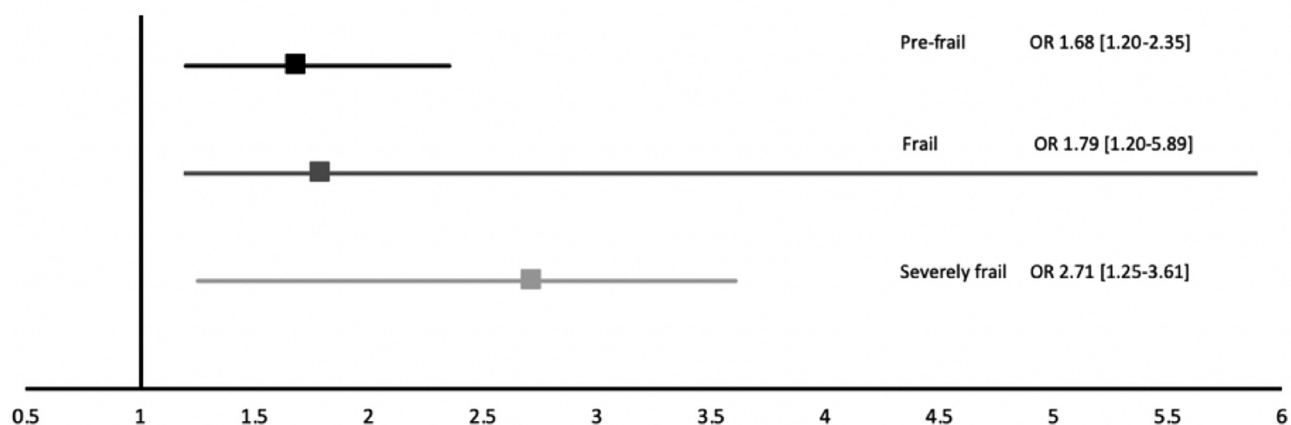


Fig. 2. Forest plot of the impact of frailty on risk of major complications.

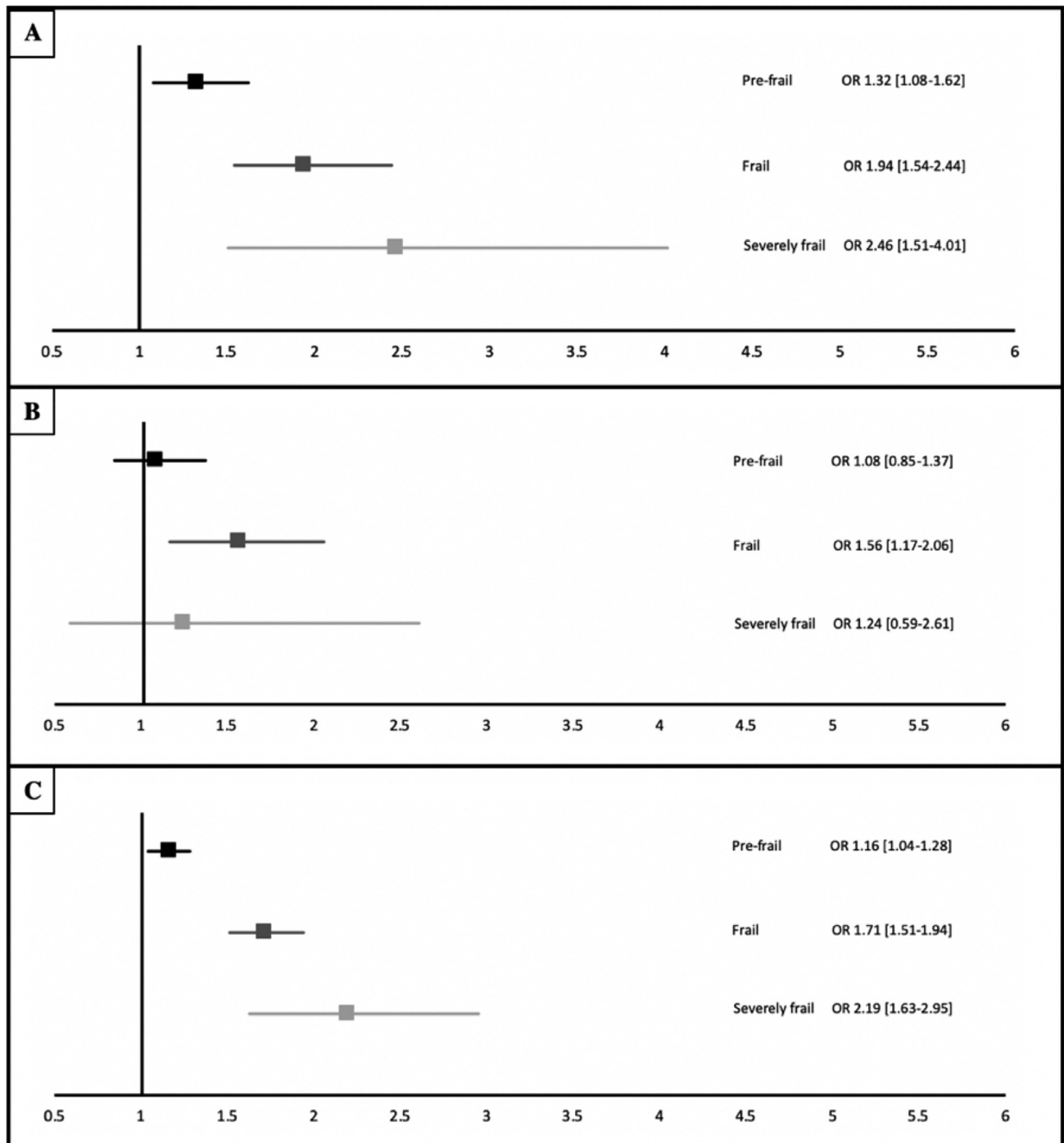


Fig. 3. Forest plot of the impact of frailty on risk of (A) unplanned readmission, (B) reoperation, and (C) non-home discharge.

reoperation after index surgery, frail patients had a 56% increase in odds. For non-home discharge, prefrail patients had a 16% increase in odds, frail patients had a 71% increase in odds, and severely frail patients had a 119% increase in odds. Our results are similar to results from the few other studies investigating mFI-5 in spine surgery. In patients who received kyphoplasty vertebral augmentation, as mFI-5 increased from 0 to ≥ 2 , the rate of overall

complications increased three-fold from 3.7% to 10.4% and readmission increased from 8.9% to 12.9% [41]. In a study investigating patients who underwent surgery for adult spinal deformity, as mFI-5 score increased, the rate of severe adverse events increased four-fold [31]. Weaver et al. investigated the impact of frailty on morbidity after elective 1-2 level posterior lumbar fusion in patients with any degenerative lumbar disease [24]. They found an mFI-5

Table 3
Sub-analysis for decompression only stratified by age groups (18–45 years, 46–65 years, >65 years)

	Major adverse events			Readmission			Reoperation			Non-home discharge		
	18–45	46–65	>65	18–45	46–65	>65	18–45	46–65	>65	18–45	46–65	>65
Prefrail	0.81 [0.08–8.55]	0.88 [0.35–2.24]	2.76 [1.12–6.77]	1.52 [0.37–6.20]	0.88 [0.46–1.67]	1.77 [0.94–3.34]	-	1.18 [0.56–2.51]	1.84 [0.74–4.57]	0.81 [0.31–2.12]	1.34 [0.98–1.83]	1.25 [0.97–1.60]
Frail	2.38 [0.17–33.16]	0.67 [0.17–2.63]	1.97 [0.67–5.83]	4.16 [0.69–24.98]	1.50 [0.72–3.12]	3.23 [1.65–6.34]*	3.84 [0.64–23.05]	1.25 [0.47–3.30]	2.49 [0.93–6.68]	3.68 [1.12–12.11]	1.94 [1.31–2.86]*	1.82 [1.35–2.44]*
Severely frail	-	8.24 [1.58–43.01]	2.85 [0.32–25.1]	-	8.49 [2.56–28.23]*	4.43 [1.34–14.63]*	-	2.76 [0.34–22.46]	1.71 [0.19–15.10]	-	2.06 [0.67–6.35]	3.68 [1.88–7.22]*

All results are presented as OR [95% CI].

* Indicates significant at <0.05 level.

Table 4
Sub-analysis for decompression and fusion stratified by age groups (18–45 years, 46–65 years, >65 years)

	Major adverse events			Readmission			Reoperation			Non-home discharge		
	18–45	46–65	>65	18–45	46–65	>65	18–45	46–65	>65	18–45	46–65	>65
Prefrail	2.33 [0.52–10.40]	1.67 [0.94–2.98]	2.33 [1.18–4.58]*	2.95 [1.26–6.93]	1.14 [0.83–1.55]	1.85 [1.24–2.74]*	1.52 [0.67–3.45]	1.04 [0.72–1.50]	1.06 [0.66–1.71]	1.82 [0.99–3.35]	1.21 [0.99–1.46]	1.45 [1.22–1.71]*
Frail	-	2.22 [1.11–4.45]	2.71 [1.30–5.63]*	1.54 [0.19–12.51]	1.32 [0.89–1.96]	2.84 [1.86–4.34]*	-	1.54 [0.99–2.38]	1.60 [0.97–2.68]	1.81 [0.51–6.41]	1.96 [1.54–2.48]*	2.10 [1.73–2.56]*
Severely frail	-	5.43 [1.53–19.25]*	1.77 [0.38–8.28]	-	1.16 [0.35–3.80]	3.05 [1.43–6.49]*	-	0.48 [0.07–3.58]	1.58 [0.58–4.32]	-	2.21 [1.17–4.17]*	2.70 [1.76–4.13]*

All results are presented as OR [95% CI].

* Indicates significant at <0.05 level.

score of 2 or higher to be associated with higher odds of any complication (OR 1.45), readmission (OR 1.46), and discharge to a location other than home (OR 1.80). Unlike the study by Weaver et al., we only included patients who had degenerative lumbar spondylolisthesis. Interestingly, we found higher odds of complication, readmission, reoperation, and non-home discharge in patients being treated for degenerative lumbar spondylolisthesis than reported by Weaver et al. for all degenerative lumbar pathologies treated with decompression and fusion. This suggests that risks associated with surgery may not be only dependent on the type of surgery performed, but are also influenced by the pathology being treated. Future studies on the impact of frailty on outcomes after spine surgery should either focus on a specific pathology or control for different pathologies in the analysis; in doing so, results could be used appropriately in a clinical setting. Based on results from this study and the limited studies investigating mFI-5 in spine surgery, frailty appears to be an important predictor of morbidity after spine surgery.

With an aging population, age has been a focus in outcomes after spine surgery. However, results from these studies have been conflicting. Several studies report significantly higher rates of morbidity in the elderly population [21,23,42]; whereas other studies report similar morbidity compared to a younger population and favorable outcomes [43–45]. Additionally, many of the studies looking at the effect of age on outcomes after spine surgery use arbitrary age cut-offs of 65, 70, 80, and 85, making it difficult to compare results. In this study, we found age to be associated with a higher risk of major complication (OR 1.03), unplanned readmission (OR 1.02), and discharge to a location other than home (OR 1.06). Age was not associated with reoperation. Our sub-analysis investigated the impact of frailty in three different age groups. For patients who received decompression alone, being frail or severely frail was associated with a higher risk of readmission and non-home discharge only for patients 46 to 65 years old or greater than 65 years old. For patients who received decompression and fusion, being prefrail, frail, and severely frail was associated with a higher risk of major adverse events, readmission, and non-home discharge in patients older than 65. Being frail or severely frail was associated with a higher risk of major adverse events and non-home discharge in patients 46 to 65 years of age. Frailty did not have an impact on younger patients. Our findings suggest that frailty is an important predictor to consider when making clinical decisions, especially in those who are older than 65 years of age, due to its significant impact on morbidity after surgery. The results from our sub-analysis can be used to aid clinicians in risk stratification based on age, frailty, and surgical procedure.

There are several strengths to this study. Firstly, this is a study which examines outcomes in a large number of patients, which allows for better performance on statistical analyses. Secondly, there was little missing data from the

dataset, minimizing bias in the estimation of parameters and maintaining representativeness of the study population. Thirdly, our primary outcome, major complication, was defined using an established complication classification system, which allows for objectivity and reproducibility [29]. Lastly, this study had a focused patient population, which included all patients diagnosed with degenerative lumbar spondylolisthesis that were treated with a posterior approach. The anterior and lateral approaches were excluded due to the significant difference in technique compared to the posterior approach. Additionally, the posterior approach is the most common approach for this pathology [46]. Although there have been other studies investigating the impact of frailty on outcomes after spine surgery, most of these studies included a wide number of pathologies and procedures in the study population. This makes it difficult to use the results to guide management or to counsel patients receiving surgery for a specific pathology. Future research on the impact of frailty on outcomes after spine surgery should focus on specific pathology and procedures so results can be used for proper risk stratification and patient counselling. Understanding how frailty impacts outcomes after spine surgery will also aid in future studies on possible interventions, such as prehabilitation.

Despite the multiple strengths of this study, we acknowledge a number of limitations. Firstly, this study represents a retrospective analysis of data derived from an administrative database. Due to this limitation, clinical factors that may contribute to decision-making bias have not been captured in the database. For example, in our study we included all patients with degenerative lumbar spondylolisthesis; however, their specific indication for surgery was not collected in the database. The data collected by the chosen database also restricts the potential outcomes that can be studied. The National Surgical Quality Improvement Program database only collects 30-day outcomes; therefore, important outcomes that occur at a later time point cannot be studied. In addition, administrative databases may have inaccuracies and inconsistencies with data entry, which could impact interpretation of results. In this study, only patients who received surgery for degenerative lumbar spondylolisthesis were included in this study. There is likely a selection bias between patients who received surgery and were included in this study compared to patients who did not receive surgery.

Conclusions

In conclusion, our study found frailty to be independently associated with a higher risk of major complication, readmission, reoperation, and non-home discharge in patients treated for lumbar spondylolisthesis using a posterior approach. The risk increased with increasing frailty. Frailty had the largest impact on patients who were older than 65. Results of this study will aid spine surgeons in risk stratifying patients with degenerative lumbar spondylolisthesis based on frailty and

age. This was a study focusing on 30-day morbidity after surgery, which does not capture how frailty affects short-term and long-term clinical outcomes. Future studies need to be done on how frailty impacts clinical outcomes in elective lumbar spine surgery.

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Declarations of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found in the online version at <https://doi.org/10.1016/j.spinee.2021.08.008>.

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