Safety of Outpatient Anterior Lumbar Interbody Fusion Surgery: A Systematic Review With Meta-Analyses

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Safety of Outpatient Anterior Lumbar Interbody Fusion Surgery: A Systematic Review With Meta-Analyses

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ABSTRACT

Background: Due to rapidly rising health care costs, leveraging outpatient surgery to reduce hospital inpatient burden is being explored. This study provides a systematic review of the literature on outpatient anterior lumbar interbody fusion (ALIF) with pooled analysis to determine its safety and feasibility.

Methods: Embase (Elsevier), MEDLINE (National Library of Medicine), CINAHL (EBSCO), and the Cochrane Library (Wiley) were searched on 8 April 2024 for articles mentioning the following search concepts: (1) ambulatory; (2) outpatient; and (3) ALIF surgery. Included studies had (1) patients undergoing outpatient ALIF; (2) an inpatient control group; (3) a sample size of ≥5 in each cohort; and (4) a population aged ≥18 years. Outcome data were extracted from studies meeting inclusion criteria, and Newcastle-Ottawa scores were assigned to included studies lacking a prospective, randomized design. Fixed and random effects models were used to establish ORs and mean difference with 95% CIs for each outcome.

Results: Pooled analysis included results from 4 studies. A total of 2070 patients underwent outpatient ALIF and 12,554 underwent inpatient ALIF. The results showed that compared with inpatient ALIF, outpatient ALIF resulted in a statistically significant decrease in postoperative adverse events (OR −0.89, 95% CI [−1.69, –0.09], I^2 = 54.88%, P = 0.03), comparable readmission rates (OR 0.02, 95% CI [−0.16, 0.20], I^2 = 0%, P = 0.816), and nearly statistically significant decrease in reoperation rates (OR −0.41, 95% CI [−0.83, –0.00], I^2 = 0%, P = 0.05).

Discussion: These meta-analyses suggest that outpatient ALIF is associated with a statistically significant decrease in postoperative adverse events without a significant difference in hospital readmission or reoperation rates. These results suggest that in carefully selected patients, outpatient ALIF is safe and feasible. This study is limited by pooled analysis of retrospective data.

Clinical Relevance: This systematic review contributes to the assessment of the safety of outpatient ALIF spine surgery.

Level of Evidence: 3.

Lumbar Spine

Keywords: anterior, lumbar, interbody, fusion, outpatient, ambulatory

INTRODUCTION

Anterior lumbar interbody fusion (ALIF) surgery has evolved to be an effective surgical technique, particularly for patients with discogenic back pain, as well as for the revision of failed posterior fusion.[1] The anterior retroperitoneal approach, often with the assistance of general or vascular surgery, facilitates access to the ventral surface of the exposed disc, allowing for efficient discectomy and direct implant insertion. The anterior access permits maximization of implant size and surface area, facilitating indirect foraminal decompression secondary to foraminal height restoration, as well as correction of lordosis. The ALIF approach is most suitable for the L5 to S1 level, caudal to the aorta and inferior vena cava bifurcations, and less so at L4 to L5 and more rostral levels due to obstructing vascular anatomy.[2]

Significant, life-threatening vascular injuries are reported in between 1.9% and 3% of cases.[3,4] In 1 series, 10 of 12 cases of significant vascular injury occurred at the L4 to L5 level with the remaining 2 cases occurring at the L5 to S1 level.[4]

In the setting of rapidly rising health care costs, different strategies have been proposed to contain expenditures.[5,6] One solution is the transition to outpatient surgery in an attempt to reduce the hospital inpatient burden. In prior studies, it has been shown that in appropriately chosen patients, outpatient spine surgery can reduce health care costs while maintaining patient safety.[5,7–9] The objective of the present study was to provide a systematic review of the literature on outpatient ALIF surgery with pooled meta-analyses to determine its safety and feasibility.

METHODS

Search Strategy

A systematic search was performed to determine the safety and feasibility of outpatient ALIF compared

with inpatient settings. The following databases were searched using a combination of subject headings and keywords: Embase (Elsevier), MEDLINE (National Library of Medicine), CINAHL (EBSCO), and the Cochrane Library (Wiley) on 8 April 2024.

The authors focused the search on studies with adult patients by removing articles indexed as concerning nonhuman animals if these were not also indexed as concerning humans; we also removed articles indexed as concerning pediatric age groups if these were not also indexed as concerning adults. Because funds were not available for translation, searches were limited to English-language articles. Editorials, letters, dissertations/theses, and conference abstracts/presentations were excluded from the search.

The results retrieved from the databases were imported directly into the project's EndNote Library. EndNote's and subsequently Zotero's duplicate detection tools were used to identify duplicates, and the duplicates were removed. Two independent researchers (L.J.W. and B.L.S.) screened the remaining 13 articles.

Selection Criteria

The authors included all English-language articles that evaluated the safety and feasibility of outpatient ALIF surgery in comparison to controls who underwent ALIF surgery in the inpatient setting. Criteria for inclusion in the study were (1) patients undergoing ALIF surgery in an outpatient setting; (2) an inpatient control group; (3) a sample size of ≥5 patients in each group; (4) adult patient population aged ≥18 years; and (5) available data regarding postoperative adverse events, mortality, hospital readmission, and reoperation rate.

Outcomes

The outcomes of interest in this study included postoperative adverse events, mortality, hospital readmission rate, and reoperation rate.

Data Extraction

Before the commencement of our study, our study was registered on PROSPERO with ID number CRD42024549942. Our data were extracted independently by 2 researchers (L.J.W. and B.L.S.) and were collected using Microsoft Excel (Microsoft Corp., Redmond, Washington, USA). We recorded the following information: last name of the first author and year of study, location in which the study occurred, number of patients included in the study, patients' mean age, the number of instrumented levels, yes/no if posterior instrumentation was used, duration of follow-up period, postoperative adverse events, mortality, postoperative readmission, and reoperation rates. Ethical approval from our institutional review board was not necessary as the pooled data used for meta-analyses was extracted from publicly available published data in the included studies.

Quality Assessment/Risk of Bias

The Newcastle-Ottawa scale was used to assess the quality of included studies that did not have a prospective, randomized design.[10] Two reviewers (L.J.W. and B.L.S.) performed the quality assessments individually, and any discrepancies were resolved with discussion. Studies rated with 0 to 3 stars were considered low quality, studies with 4 to 6 stars were considered medium quality, and studies with 7 to 9 stars were considered high quality. We declare no financial or other conflicts of interest.

Statistical Analysis

Meta-analyses were performed on outcomes of interest if ≥3 study populations were available for pooled analysis of the designated outcomes of interest. Meta-analyses were performed to calculate the pooled mean difference with 95% CIs using a fixed-effect model for variables with low heterogeneity as measured by I^2 statistic and a random-effects model for continuous variables with higher risk for heterogeneity as measured by the I^2 statistic. I^2 values <25% were considered to have low heterogeneity, while all others were considered to have higher heterogeneity and were analyzed using the random-effects model. Statistical significance was achieved with a P value <0.05. Results are presented in forest plots. All analyses were completed using the meta-analysis functions in the open statistical software Jamovi version 2.4.7 (https://www.jamovi.org/).

RESULTS

Search Results

The approach for study inclusion or exclusion is outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart in Figure 1.

In the meta-analyses, 4 studies were included after studies that failed to meet inclusion criteria were removed. The characteristics of the 4 included studies are presented in Table 1.[11–14] All 4 studies were retrospective and performed in the United States. The

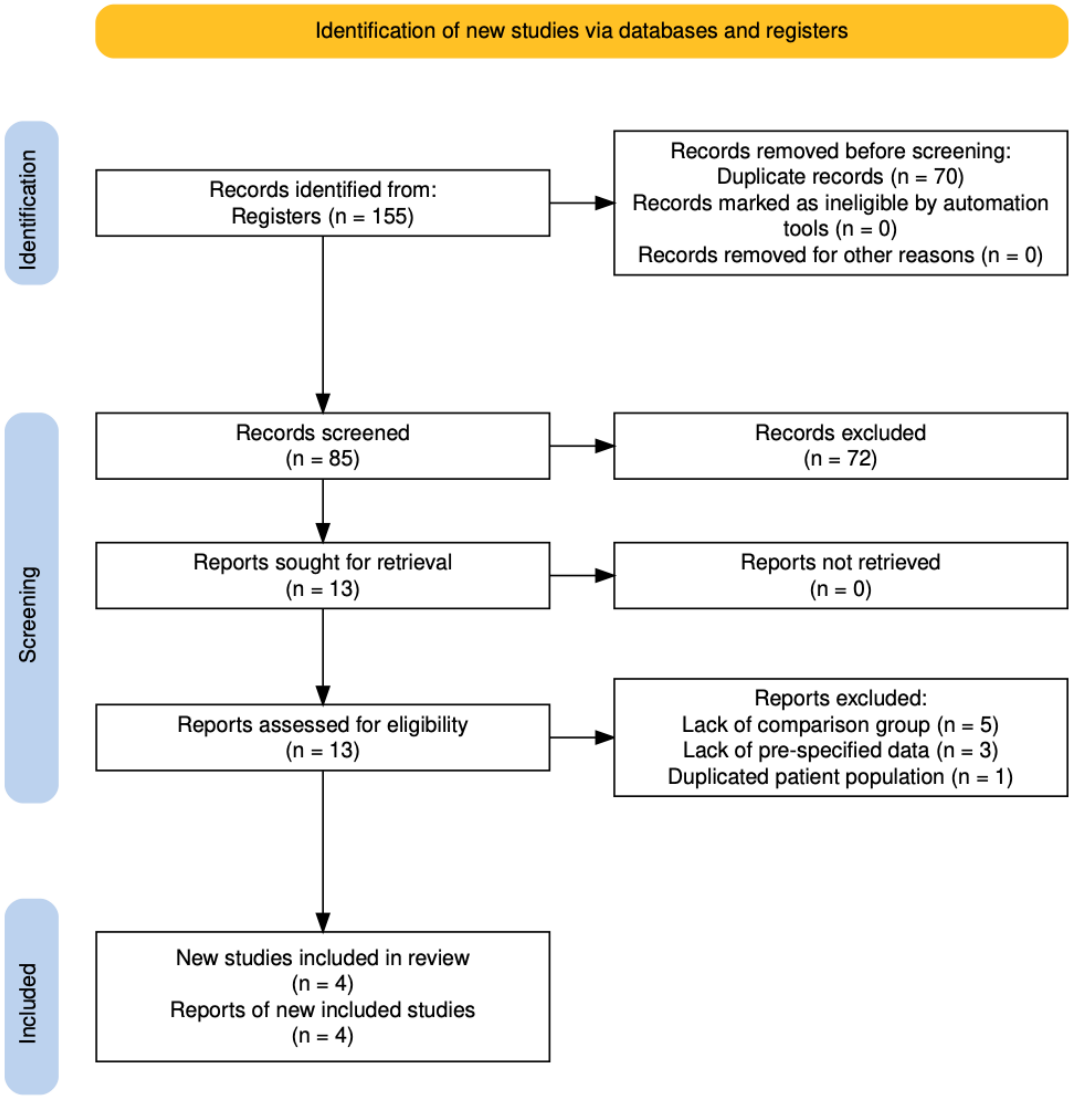

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart.

duration of follow-up was 30 days in 1 study,[11] 90 days in 2 studies,[13,14] and 24 months in 1 study.[12]

The meta-analyses included 14,624 patients whose demographics are included in Table 2. Of the 14,624 patients, 2070 patients underwent ALIF surgery in the outpatient setting, whereas 12,554 patients underwent ALIF surgery in the inpatient setting. The number of instrumented ALIF levels was 1 in 3 studies[11,12,14] and was 1 to 3 levels in 1 study.[13] In only 1 of the studies, it was reported that posterior instrumentation was used in addition to the ALIF surgery.[12]

The adverse events and mortality of patients included in the meta-analyses are outlined in Table 3. Of the 2,070 outpatient ALIF surgery patients, there were 0 mortalities (0%), and of the 12,554 inpatient ALIF surgeries, there were 4 mortalities (0.031%). Details of mortalities were not specified as these were all reported in the study by Jones et al,[11] which reported

Table 1. Characteristics of studies included in meta-analyses.

Study	Study Year	Study Design	Study Location	NOS	Follow-up Duration
Jones[11]	2022	Retrospective	USA	7	30 d
Snowden[12]	2020	Retrospective	USA	8	24 mo
Cuellar[13]	2021	Retrospective	USA	8	90 d
Kamalapathy[14]	2022	Retrospective	USA	8	90 d

Abbreviation: NOS, Newcastle-Ottawa Score.

Table 2. Characteristics of patient demographics included in meta-analyses.

Study	No. of Patients		Mean Age, y		Level(s)	Posterior Instrumentation
	Outpatient	Inpatient	Outpatient	Inpatient		
Jones[11]	149	3579	NA	NA	1	N
Snowden[12]	29	33	44.2	51.6	1	Y
Cuellar[13]	124	102	43.6	47.6	1–3	N
Kamalapathy[14]	1768	8840	NA	NA	1	NA

Abbreviations: N, no; NA, not available; Y, yes.

the results of the American College of Surgeons-National Quality Improvement Program. Of the 2070 outpatient ALIF surgeries, 165 of the patients had an adverse event (7.97%), whereas 1453 of the 12,554 patients who underwent inpatient ALIF surgeries had an adverse event (11.6%). Wound complication and urinary tract infection (UTI) were the most common complications among both cohorts, with 2.32% and 2.27% of patients in the outpatient ALIF surgery group reporting wound complication and UTI, respectively, and 2.98% and 2.99% of the inpatient ALIF surgery group reporting wound complication and UTI, respectively. Vascular injury was reported in 55 of the 12,554 inpatient ALIF surgery patients (0.438%) and in <11 of the 2070 outpatient ALIF surgeries. Vascular injuries in the outpatient ALIF surgery cohort were only reported in the study by Kamalapathy et al.[14] The retrospective database used in this study, PearlDiver (PearlDiver Inc., Colorado Springs, CO), did not specify the exact number for adverse events with a reported frequency of <11.

Table 3. Adverse events of patients included in meta-analyses.

Adverse Events	Outpatient (N = 2070)	Inpatient (N = 12,554)
No. of patients with any adverse event	165	1453
Death	0	4
Vascular injury	<11	55
Sepsis	<11	99
Septic shock	0	2
Deep venous thrombosis	17	151
Myocardial infarction	<11	31
Cardiac arrest	0	3
Stroke	<11	16
Acute kidney injury	13	106
Acute renal failure	0	4
Postoperative ventilator use >48 h	0	5
Pulmonary embolus	<12	79
Unplanned reintubation	1	5
SSI	36	318
Wound complication	48	374
Wound dehiscence	0	5
Organ/space SSI	0	12
Deep SSI	0	12
Nausea/vomiting	<11	43
Urinary retention	<11	100
Urinary tract infection	47	376
Bleeding requiring transfusion	<11	167
Pneumonia	20	174
Progressive renal insufficiency	0	2
Superficial SSI	1	30
Hematoma	<11	38
Hematoma/seroma	2	2
Nerve root injury	0	1
Complex regional pain syndrome	0	1
Intraoperative dural tear	<11	33

Abbreviation: SSI, surgical site infection.

Meta-Analyses

The population sizes were sufficiently largr to perform meta-analyses for postoperative adverse events, readmission, and reoperation rates. A summary of the pooled results is provided in Table 4.

Adverse Events

The meta-analyses for postoperative adverse events included 4 studies.[11–14] The results of the pooled analysis show that patients who underwent ALIF surgery in the outpatient setting compared with the inpatient setting had a statistically significant decrease in the likelihood of having an adverse event (OR –0.89, 95% CI [–1.69, –0.09], I^2 = 54.88%, P = 0.03; Figure 2).

Readmission

The meta-analyses for postoperative readmission included 3 studies.[11,13,14] The results of the pooled analysis show that patients who underwent ALIF surgery in the outpatient setting compared with the inpatient setting had a slight increase in readmission rates, though not to a level of statistical significance (OR 0.02, 95% CI [–0.16, 0.20], I^2 = 0%, P = 0.816; Figure 3).

Reoperation

The meta-analyses for postoperative reoperation included 4 studies.[11–14] The results of the pooled analysis show that patients who underwent ALIF surgery in the outpatient setting compared with the inpatient setting had a decrease in reoperation rates, though not to a level of statistical significance (OR –0.41, 95% CI [–0.83, –0.00], I^2 = 0%, P = 0.05; Figure 4).

Table 4. Outcome measures of studies included in meta-analyses.

Study	Outpatient	Inpatient	Adverse Events Outpatient	Adverse Events Inpatient	*P*
Jones[11]	149	3579	3	328	0.003
Snowden[12]	29	33	3	5	>0.05
Cuellar[13]	124	102	1	7	>0.05
Kamalapathy[14]	1768	8840	158	1113	<0.001
Study	**Outpatient**	**Inpatient**	**Return Admission Outpatient**	**Return Admission Inpatient**	***P***
Jones[11]	149	3579	6	166	0.727
Snowden[12]	29	33	NA	NA	NA
Cuellar[13]	124	102	2	2	>0.05
Kamalapathy[14]	1768	8840	145	704	0.865
Study	**Outpatient**	**Inpatient**	**Reoperation Outpatient**	**Reoperation Inpatient**	***P***
Jones[11]	149	3579	1	92	0.145
Snowden[12]	29	33	17	20	>0.05
Cuellar[13]	124	102	0	1	>0.05
Kamalapathy[14]	1768	8840	20	150	0.073

Abbreviation: NA, not available.

DISCUSSION

Outpatient spine surgery is increasing, providing a cost-efficient alternative to the inpatient hospital setting.[15,16] Outcomes between outpatient and inpatient posterior lumbar fusions, cervical fusions, and cervical disc arthroplasties have previously been studied with ample evidence to support their safety in the outpatient setting.[17] Only recently in 2020 did studies begin investigating the safety and feasibility of outpatient ALIF surgery.[12,18] It is estimated that in 2022, at the time of the most recent study investigating outpatient ALIF surgery, around 4% of ALIF surgeries were performed in the outpatient setting.[11] In carefully selected patients, there is an opportunity for a significant increase in the number of patients undergoing ALIF surgery who could be potentially off-loaded from the inpatient setting and safely undergo their surgery as an outpatient. The cost of outpatient ALIF surgery has been found to be statistically less expensive at $12,013, in comparison to inpatient ALIF surgery at $27,271 ($P < 0.001$).[14]

Outpatient surgery patient selection for anterior cervical discectomy and fusion and lumbar discectomy is well studied.[19,20] Specific to ALIF surgery, it has been found on propensity score analysis that female gender, age greater than 60 years, Charlson Comorbidity Index >3, diabetes mellitus, chronic obstructive pulmonary disease, coronary artery disease, hypertension, and tobacco use were all identified as independent risk factors for increased complications.[14] Similarly, in a retrospective study investigating independent risk affecting postoperative length of stay in patients undergoing ALIF surgery, on multivariate analyses, age >65 years, preoperative benzodiazepine use, 12-Item Short Form mental component score, estimated blood loss, operative time, and time to mobilize were all associated with a statistically significant increase in postoperative length of

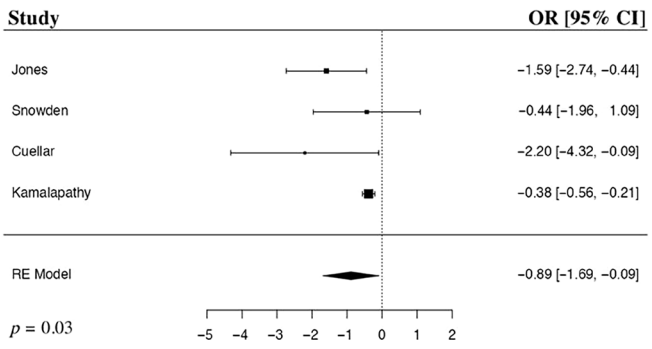

Figure 2. Forest plot demonstrating random effects model for postoperative adverse events in patients who underwent anterior lumbar interbody fusion surgery in the outpatient setting compared with the inpatient setting. RE, random effects.

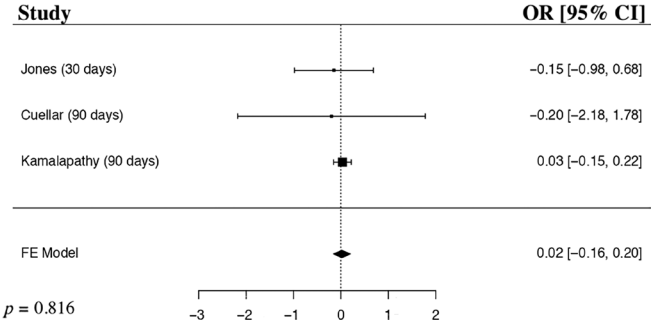

Figure 3. Forest plot demonstrating fixed effects model for postoperative readmission rate in patients who underwent anterior lumbar interbody fusion surgery in the outpatient setting compared with the inpatient setting. The time in parentheses denotes over what follow-up period the readmission rate was recorded. FE, fixed effects.

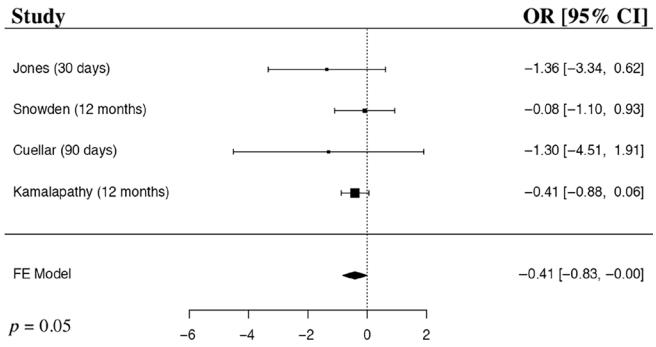

Figure 4. Forest plot demonstrating fixed effects model for postoperative reoperation rate in patients who underwent anterior lumbar interbody fusion surgery in the outpatient setting compared with the inpatient setting. The timing in parentheses denotes over what follow-up period the reoperation rate was recorded. FE, fixed effects.

stay. These results are consistent with the results from Cuellar et al,[13] which reported a statistically significant decrease in estimated blood loss of 64.8 mL in the outpatient group compared with 108.9 mL in the inpatient group ($P < 0.01$) and increased surgical time in the inpatient group of 117.1 minutes compared with 97.7 minutes for the outpatient surgery group. Furthermore, a prospective surgical registry study investigating risk factors for inpatient admission following ALIF surgery found the following radiographic findings to be risk factors: operation at the L4 to L5 level, co-existing degenerative disc disease with foraminal stenosis, and a herniated nucleus pulposus.[21]

Outpatient surgery centers inherently screen healthier patients with various health cutoffs, including those for age, body mass index (BMI), and medical comorbidities. While one would expect that due to the retrospective design of the included studies, the patients who underwent outpatient ALIF surgery were naturally healthier than the patients who were selected to have their surgery in the inpatient setting, there were actually no significant demographic differences concerning gender, age, BMI, and other comorbidities aside from the study by Kamalapathy et al[14] in which more patients in the outpatient group had a BMI >30 kg/m^2 (P = 0.003) in comparison to the inpatient cohort. It is possible, however, that because the majority of the patients included in the pooled analysis are from 2 retrospective database studies,[11,14] there may be some demographic differences that were not captured by the databases.

Our results can thus be interpreted that in patients carefully selected to undergo outpatient ALIF surgery, there are at least comparable levels of adverse events, hospital readmission rates, or need for reoperation. Our results may even suggest a decreased likelihood of adverse events in the outpatient setting. It is also worth noting that optimization of future results in the outpatient setting is heavily dependent on not only an experienced spine surgeon but also an experienced anesthesia team and approach surgeon.

Limitations

This study is limited by pooled available data, largely from retrospective databases for analysis. Significant heterogeneity existed between the studies, specifically, the meta-analysis of adverse events. The lack of a standardized follow-up period for comparison likely contributed to this heterogeneity. Another limitation of the study is that there was heterogeneity concerning whether posterior instrumentation was used in addition to the ALIF. In Jones et al[11] and Cuellar et al,[13] posterior instrumentation was not used. In Snowden et al,[12] some patients underwent posterior instrumentation, while these surgical details were not provided in the Kamalapathy et al[14] study. Lastly, the study by Cuellar et al[13] was the only one include more than single-level ALIF (including up to 3 levels). In order to make the results more homogeneous with respect to the number of levels, only their data regarding single-level ALIF were included in meta-analyses. By reducing heterogeneity as much as possible to account for the number of levels, there is some lost generalizability as the results of this study only reflect patients undergoing single-level ALIF surgery.

CONCLUSIONS

The results of these meta-analyses suggest that outpatient ALIF surgery is associated with a statistically significant decrease in postoperative adverse events without a significant difference in hospital readmission or reoperation rates. These results suggest that in carefully selected patients, outpatient ALIF surgery is safe and feasible. More robust, prospective studies are necessary to help inform the safety and feasibility of outpatient ALIF surgery.

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Data Availability Statement: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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