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Impact of Lower Extremity Arthroplasty on Improvement of Quality-of-Life Outcomes Following Lumbar Fusion

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ABSTRACT

Background: Both hip-spine and knee-spine syndromes can significantly impact a patient's quality of life; however, few studies have investigated their effect on postoperative outcomes following lumbar fusion.

Objective: Our study aimed to evaluate the impact of a prior lower extremity arthroplasty on the improvement of patient-reported outcome measures (PROMs) following lumbar fusion surgery.

Methods: Patients undergoing primary, single, or multilevel lumbar interbody fusion were retrospectively reviewed. Patients missing preoperative PROMs were excluded. PROMs were collected preoperatively and postoperatively and included the Oswestry Disability Index (ODI), 12-Item Short Form Physical Component Summary, Patient-Reported Outcomes Measurement Information System Physical Function, and visual analog scale (VAS). A minimum clinically important difference (MCID) was calculated. Patients were categorized based on a history of hip/knee arthroplasty and propensity score matched. Intragroup improvement of PROM scores and intergroup differences in mean scores were evaluated using a paired t test and linear regression. MCID achievement differences were evaluated using logistic regression.

Results: A total of 335 patients were included, with 25 having a history of hip/knee arthroplasty. Arthroplasty patients were significantly older ($P = 0.001$) and typically had a higher Charlson Comorbidity Index ($P \leq 0.003$, both). Patients differed in spinal pathology of degenerative spondylolisthesis ($P = 0.049$). Nonarthroplasty patients demonstrated significant improvements in all PROMs by 2 years ($P < 0.001$, all). The arthroplasty group demonstrated significant improvements in all PROMs by 1 year ($P < 0.031$, all). Preoperative VAS back was significantly worse for nonarthroplasty patients ($P = 0.035$). MCID achievement did not significantly differ between groups except at 6 months for ODI ($P = 0.035$).

Conclusion: Following lumbar fusion, patients with a past surgical history did not demonstrate differences in outcome measures or MCID from those without. These results suggest that comorbid orthopedic conditions requiring surgery do not negatively impact the ability of patients to improve following lumbar fusion.

Clinical Relevance: Prior surgical history of lower extremity arthroplasty should not discourage the use of lumbar fusion when properly indicated, as patients reported clinical improvement regardless of history of hip or knee arthroplasty.

Level of Evidence: 3.

Lumbar Spine

Keywords: lumbar fusion, arthroplasty, knee, hip, outcome measures, minimum clinically important difference

INTRODUCTION

Lumbar fusion is an established treatment option for degenerative pathology of the lumbar spine such as symptomatic spondylolisthesis.[1] With the rate of elective lumbar fusions increasing, especially in patients older than 65 years,[2] it is necessary to investigate the impact that surgical history and underlying comorbidities have on lumbar fusion outcomes. Given the close physiological relationship between the spine and lower extremities, exemplified by both the hip-spine and knee-spine syndromes,[3,4] further research is needed to elucidate how degenerative pathology of the lower extremities and associated interventions may affect outcomes of lumbar fusion procedures.

As one of the leading causes of disability in older adults, osteoarthritis is a significant source of pain, functional limitation, and diminished quality of life for individuals worldwide.[5] Driven by cartilage degradation and inflammation in the joints, osteoarthritis is associated with a number of modifiable and nonmodifiable risk factors, including joint injury, obesity, and gender.[6] For those who fail conservative management, total joint arthroplasty is a definitive treatment option to provide pain relief and improved physical function.[6,7] While highly effective at relieving symptoms associated with osteoarthritis, several studies have demonstrated that patients with either knee or hip osteoarthritis who undergo a subsequent arthroplasty procedure have increased sagittal malalignment, lack of lumbar lordosis, and changed spinopelvic parameters.[8,9] Because of this, it is important to consider the effects of a hip or knee arthroplasty on lumbar spine procedures.

Several past studies have explored the relationship between lower extremity arthroplasty and the spine. Patel et al reported that patients undergoing a lumbar fusion with a history of total hip arthroplasty were at an increased risk of postoperative complications, revision surgery, and prolonged opioid use.[10] Furthermore, Ayers et al demonstrated that this complex relationship is not unique to the hip, reporting that patients undergoing total knee replacement experienced worse physical function at 6 months if they also had a history of low back, hip, or contralateral knee pain.[11] While these studies provide important insight, it is critical that the effects of arthroplasty and associated lower extremity arthritis are understood in a way that is clinically meaningful to the patient undergoing spine surgery.

Our study aims to evaluate the impact that a history of lower extremity arthroplasty plays on the improvement of patient-reported outcome measures (PROMs) for pain, disability, and physical function following lumbar fusion. By utilizing PROMs and assessing these measures in terms of the minimum clinically important difference (MCID), we sought to gain a better understanding of outcomes that the patient perceives as beneficial. Literature utilizing PROMs to assess the relationship between lower extremity degenerative disorders and the spine is limited. Although Djurasovic et al did utilize these metrics, they reported that patients undergoing lumbar fusion with hip and knee osteoarthritis could achieve meaningful improvement similar to those without osteoarthritis.[12] These findings largely contrast many other studies addressing different outcomes, making it critical to continue pursuing the investigation of this relationship. We hypothesize that patients with a history of lower extremity arthroplasty undergoing lumbar fusion will demonstrate less improvement in PROMs than those without a history of arthroplasty.

METHODS

Patient Population

A prospectively maintained surgical registry was retrospectively reviewed for patients who underwent a lumbar fusion procedure from December 2012 to February 2019. Inclusion criteria were patients undergoing primary, single- or multilevel, lumbar interbody fusion for treatment of degenerative pathology. Exclusion criteria were patients undergoing surgery for treatment of infection, trauma, or malignancy and patients missing preoperative PROMs. All lumbar fusion procedures were performed by a senior attending surgeon at the same academic institution. Institutional review board approval and informed patient consent were obtained prior to study commencement.

Data Collection

Patient demographics, perioperative characteristics, and PROM scores were collected. Demographic information included age, body mass index, gender, diabetic status, American Society of Anesthesiologists physical status classification, Charlson Comorbidity Index (CCI), insurance/payment collected, and comorbid medical diagnoses. Perioperative characteristics included preoperative spinal pathology, number of spinal levels fused, operative duration (from skin incision to skin closure), estimated blood loss (EBL), and postoperative length of stay (LOS). PROMs were administered at preoperative and 6-week, 12-week, 6-month, 1-year, and 2-year postoperative timepoints. PROMs included the Oswestry Disability Index (ODI), 12-Item Short Form Physical Component Summary (SF-12 PCS), Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS-PF), visual analog scale (VAS) back, and VAS leg. Patients who had previously undergone lower extremity (hip or knee) arthroplasty procedures at the same institution were identified using current procedural terminology codes.

Statistical Analysis

Patients were categorized based on whether they had a past surgical history of lower extremity arthroplasty. Propensity score matching was performed using the nearest neighbor match to minimize significant demographic differences between groups. Following propensity score matching, demographic and perioperative characteristics were compared between groups using χ^2 or Student *t* test for categorical and continuous variables, respectively. Postoperative improvement was assessed using paired Student *t* test to perform within-group comparison of preoperative PROM scores with scores at each postoperative timepoint. Intergroup group differences in PROM scores were assessed at each timepoint using simple linear regression. Achievement of an MCID was determined at each postoperative timepoint as a change in PROM score from preoperative baseline values, which met or exceeded the following previously established values: 1.2 (VAS back),[13] 1.6 (VAS leg),[13] 12.8 (ODI),[13] 4.9 (SF-12 PCS),[13] and 8.0 (PROMIS-PF).[14] The proportion of patients achieving

Table 1. Patient demographics.

Characteristic	Total (*n* = 335)	No Arthroplasty (*n* = 310)	Arthroplasty (*n* = 25)	*P* Value[a]
Age, y, mean ± SD	53.1 ± 10.9	52.5 ± 10.9	61.4 ± 7.4	**0.001**
Body mass index, mean ± SD	30.8 ± 6.3	30.7 ± 6.3	31.9 ± 5.9	0.340
Gender				0.251
Female	37.3% (125)	36.5% (113)	48.0% (12)	
Male	62.7% (210)	63.5% (197)	52.0% (13)	
Diabetic status				0.645
Nondiabetic	89.3% (299)	89.0% (276)	92.0% (23)	
Diabetic	10.7% (36)	11.0% (34)	8.0% (2)	
Smoking status				-
Nonsmoker	100% (335)	100% (310)	100% (25)	
Smoker	0.0% (0)	0.0% (0)	0.0% (0)	
American Society of Anesthesiologists score				0.535
<2	83.6% (280)	85.2% (258)	88.0% (22)	
≥2	16.4% (55)	16.8% (52)	12.0% (3)	
Charlson Comorbidity Index score				**0.003**
<1	29.9% (100)	31.9% (99)	4.0% (1)	
≥1	70.1% (235)	68.1% (211)	96.0% (24)	
Insurance				**0.025**
Medicare/Medicaid	4.2% (14)	4.2% (19)	4.0% (1)	
Workers' compensation	26.9% (90)	28.7% (89)	4.0% (1)	
Private	68.9% (231)	67.1% (208)	92.0% (23)	
Comorbid diagnoses				
Myocardial infarction	2.7% (9)	2.6% (8)	4.0% (1)	0.673
Hypertension	30.7% (103)	31.0% (96)	28.0% (7)	0.757
Chronic lung disease	1.8% (6)	1.3% (4)	8.0% (2)	0.015

Note: **Boldface** indicates significance.
[a]*P* values calculated using χ^2 or *t* test.

MCID at each timepoint and overall was compared between groups using simple logistic regression. All statistical calculations were performed using Stata 16.1 (StataCorp LLC, College Station, Texas). An α of 0.05 was set as the threshold for statistical significance for all tests.

RESULTS

Following propensity score matching, a total of 335 patients were included in the final study cohort, of whom 25 had a history of lower extremity arthroplasty and 310 did not. Of the patients who had a history of arthroplasty, 12 had undergone hip arthroplasty and 13 had undergone knee arthroplasty. Mean patient age was 53.1 years, average body mass index was 30.8 kg/m^2, and 62.7% were men. Arthroplasty patients were significantly older (61.4 vs 52.5 years; $P = 0.001$), and CCI and insurance collected were significantly associated with arthroplasty groups ($P < 0.025$, $P < 0.003$) (Table 1). The majority of lumbar fusions were single-level procedures (90.1%), mean operative time was 142.6 minutes, mean EBL was 55.8 mL, and mean postoperative LOS was 38.1 hours. Prevalence of degenerative spondylolisthesis was significantly associated with arthroplasty groups ($P = 0.049$) (Table 2).

Table 2. Perioperative characteristics.

Characteristic	Total (*n* = 335)	No Arthroplasty (*n* = 310)	Arthroplasty (*n* = 25)	*P* Valuea
Spinal pathology				
Recurrent herniated nucleus pulposus	12.8% (43)	13.5% (42)	4.0% (1)	0.110
Degenerative spondylolisthesis	51.6% (148)	49.8% (131)	70.8% (17)	**0.049**
Isthmic spondylolisthesis	33.8% (96)	34.6% (90)	25.0% (6)	0.341
Degenerative scoliosis	10.8% (36)	10.0% (31)	20.0% (5)	0.120
Number of levels				0.283
Single	90.1% (302)	90.7% (281)	84.0% (21)	
Multilevel	9.9% (33)	9.3% (29)	16.0% (4)	
Operative time, min, mean ± SD	142.6 ± 49.4	142.6 ± 48.9	142.3 ± 57.4	0.978
Estimated blood loss, mL, mean ± SD	55.8 ± 35.9	55.0 ± 33.8	66.7 ± 56.9	0.126
Length of stay, h, mean ± SD	38.1 ± 26.2	38.1 ± 26.3	38.3 ± 24.7	0.981

Note: **Boldface** indicates significance.
[a]*P* values calculated using χ^2 test or *t* test.

Table 3. Differences in mean patient-reported outcome measures by arthroplasty group.

Patient-Reported Outcome Measure	No Arthroplasty (Mean ± SD)	*P* Value[a]	Arthroplasty (Mean ± SD)	*P* Value[a]	*P* Value[b]
Oswestry Disability Index					
Preoperative	42.5 ± 16.8	-	39.8 ± 13.9	-	0.424
6 wk	35.8 ± 19.3	**<0.001**	35.4 ± 19.8	0.145	0.928
12 wk	29.6 ± 18.4	**<0.001**	25.2 ± 22.6	**0.002**	0.323
6 mo	24.9 ± 19.6	**<0.001**	19.2 ± 18.7	**<0.001**	0.226
1 y	23.3 ± 21.7	**<0.001**	25.4 ± 23.8	**0.005**	0.736
2 y	23.4 ± 22.0	**<0.001**	34.9 ± 33.8	0.177	0.167
12-Item Short Form Physical Component Summary					
Preoperative	30.8 ± 8.9	-	30.4 ± 8.0	-	0.850
6 wk	31.6 ± 8.7	0.079	34.1 ± 9.7	0.149	0.238
12 wk	35.4 ± 10.1	**<0.001**	40.0 ± 11.0	**0.005**	0.063
6 mo	39.3 ± 11.7	**<0.001**	39.9 ± 11.3	**<0.001**	0.831
1 y	40.5 ± 12.0	**<0.001**	42.6 ± 12.0	**0.001**	0.484
2 y	41.6 ± 11.7	**<0.001**	37.0 ± 13.8	0.261	0.245
Patient-Reported Outcomes Measurement Information System Physical Function					
Preoperative	35.1 ± 6.4	-	37.7 ± 6.5	-	0.171
6 wk	37.2 ± 6.4	**0.001**	40.1 ± 6.0	**0.031**	0.141
12 wk	40.8 ± 6.8	**<0.001**	42.8 ± 8.9	**0.020**	0.297
6 mo	44.3 ± 7.2	**<0.001**	41.7 ± 9.7	0.064	0.271
1 y	44.7 ± 9.1	**<0.001**	47.5 ± 11.7	**0.009**	0.302
2 y	45.0 ± 9.3	**<0.001**	47.7 ± 9.2	**0.018**	0.374
VAS back					
Preoperative	6.6 ± 2.4	-	5.5 ± 2.5	-	**0.029**
6 wk	4.0 ± 2.5	**<0.001**	3.1 ± 2.2	**0.003**	0.132
12 wk	3.6 ± 2.6	**<0.001**	3.6 ± 3.0	0.172	0.991
6 mo	3.4 ± 2.7	**<0.001**	2.5 ± 2.7	**0.001**	0.133
1 y	3.2 ± 2.9	**<0.001**	2.6 ± 2.8	**0.009**	0.933
2 y	3.4 ± 2.8	**<0.001**	3.9 ± 3.5	0.099	0.781
VAS leg					
Preoperative	5.8 ± 2.8	-	5.7 ± 2.1	-	0.780
6 wk	3.2 ± 2.9	**<0.001**	3.5 ± 2.8	**0.003**	0.706
12 wk	2.8 ± 2.7	**<0.001**	3.0 ± 3.2	**0.002**	0.703
6 mo	2.7 ± 2.8	**<0.001**	2.7 ± 2.9	**0.001**	0.992
1 y	2.7 ± 3.0	**<0.001**	3.4 ± 3.1	**0.009**	0.390
2 y	2.4 ± 2.8	**<0.001**	3.6 ± 3.6	0.104	0.262

Abbreviation: VAS, visual analog scale.
Note: **Boldface** indicates statistical significance.
[a]*P* values calculated using paired *t* test.
[b]*P* values calculated using linear regression.

Patients without a history of lower extremity arthroplasty demonstrated significant improvements in ODI, PROMIS-PF, VAS back, and VAS leg at all postoperative timepoints ($P < 0.001$, all) and in SF-12 PCS from 12 weeks through 2 years ($P < 0.001$, all). The arthroplasty group demonstrated significant improvements from 12 weeks through 1 year for ODI and SF-12 PCS ($P \leq 0.005$), at all timepoints except 6 months for PROMIS-PF ($P \leq 0.031$, all); 6 weeks, 6 months, and 1 year for VAS back ($P \leq 0.009$, all); and 6 weeks through 1 year for VAS leg ($P \leq 0.009$). Significant intergroup differences in PROM scores were demonstrated only for VAS back at the preoperative timepoint (6.6 ± 2.4 vs 5.5 ± 2.5, $P = 0.029$) (Table 3). A majority of patients in both groups achieved MCID overall for all measures. A significantly greater proportion of patients achieved MCID for ODI at 6 months in the arthroplasty group (55.1% vs 78.9%, $P = 0.035$) and for VAS leg at 6 weeks in the nonarthroplasty group (62.5% vs 38.1%, $P = 0.029$) (Table 4).

DISCUSSION

Aging in populations such as the United States has led to increasing numbers of patients with age-associated degenerative pathology of the spine and the lower extremity. This, in turn, has been associated with an increasing volume of both arthroplasty and lumbar spinal surgery with projections for continued rapid growth in years to come.[15,16] These factors have caused a growing interest in the relationship between pathology of the lumbar spine and the lower extremity, as well as the effects of concomitant pathology and subsequent treatment on patient outcomes. A majority of the literature to date has focused on the impacts of spinal surgery on outcomes in lower extremity arthroplasty, as well as

Table 4. Rates of minimum clinically important difference achievement by arthroplasty group.

Outcome Measure	6 wk	12 wk	6 mo	1 y	2 y	Overall
Oswestry Disability Index						
No arthroplasty	36.6%	44.2%	55.1%	60.6%	62.7%	65.1%
Arthroplasty	42.9%	52.6%	78.9%	78.6%	44.4%	72.0%
P value[a]	0.573	0.479	**0.035**	0.172	0.296	0.477
12-Item Short Form Physical Component Summary						
No arthroplasty	30.4%	48.1%	57.1%	68.0%	64.0%	69.4%
Arthroplasty	33.3%	55.6%	47.1 %	66.7%	44.4%	69.6%
P value[a]	0.796	0.586	0.434	0.917	0.256	0.987
Patient-Reported Outcomes Measurement Information System Physical Function						
No arthroplasty	15.8%	29.1%	48.2%	51.1%	56.0%	59.3%
Arthroplasty	20.0%	30.0%	33.3%	30.0%	42.9%	63.6%
P value[a]	0.735	0.950	0.386	0.199	0.505	0.774
VAS back						
No arthroplasty	67.7%	70.9%	73.1%	75.4%	71.6%	84.1%
Arthroplasty	65.0%	55.6%	66.7%	76.9%	62.5%	79.2%
P value[a]	0.799	0.183	0.561	0.902	0.598	0.539
VAS leg						
No arthroplasty	62.5%	65.5%	63.6%	64.6%	59.9%	79.6%
Arthroplasty	38.1%	47.4%	57.9%	57.1%	55.6%	72.0%
P value[a]	**0.029**	0.119	0.626	0.587	0.395	0.389

Abbreviation: VAS, visual analog scale.
Note: **Boldface** indicates statistical significance.
[a]*P* values calculated using logistic regression.

on the intertwined effects of lower extremity arthroplasty and spinal fusion on sagittal alignment and hip stability.[17–22] However, to date, there is a paucity of data on the impacts of lower extremity arthritis or arthroplasty on outcomes following lumbar spinal surgery.

A recent analysis by Djurasovic et al assessed health-related quality-of-life improvement after lumbar fusion in patients with a diagnosis of lower extremity arthritis managed conservatively or with arthroplasty.[23] The authors found similar improvements following lumbar fusion in patients without lower extremity arthritis, with conservatively managed arthritis, and with arthritis treated with arthroplasty at timepoints up to 1 year. A 2018 analysis by Eneqvist et al assessed patient-reported outcomes (PROs) in patients undergoing lumbar spinal surgery with a history of total hip arthroplasty and identified a higher VAS back at 1-year follow-up relative to patients without a history of arthroplasty.[24] The authors noted that at 1 year, other PROs, including EuroQol five-dimension scale, VAS leg, ODI, and satisfaction were not affected by a history of arthroplasty. Other analyses have indirectly touched on the impact of lower extremity arthritis on outcomes in lumbar spinal surgery with a number of studies reporting a correlation between preoperative ambulatory status and postoperative outcomes.[25] Our analysis sought to build up on these prior works to further elucidate the impacts of hip or knee arthroplasty on outcomes following lumbar fusion.

Demographics were similar between groups with the exception of age, CCI, and insurance type. Patients in the arthroplasty group had a mean age roughly 10 years greater than that of the nonarthroplasty group (61.4 vs 52.6, respectively). This is somewhat expected given the known association between age and lower extremity arthritis. A greater percentage of patients in the arthroplasty group had a CCI ≥1 (96% vs 68.1%, respectively), but rates of individual comorbidities were similar between groups. Consequently, it is possible that this differential in CCI is merely reflective of the age discrepancy between groups.

Analysis of perioperative characteristics demonstrated similar indications for surgery between groups with the exception of a greater percentage of the arthroplasty group carrying a diagnosis of a degenerative spondylolisthesis (70.8% vs 49.8%). Number of levels treated, operative time, EBL, and LOS were also similar between groups. As such we would not expect perioperative factors to be a confounder in our analysis.

Preoperative PROs were similar between groups with the exception of VAS back, which was significantly greater in the no arthroplasty group (6.6 vs 5.5). The no arthroplasty group demonstrated statistically significant improvement from preoperative values at 6 weeks, 12 weeks, 6 months, 1 year, and 2 years for ODI, SF-12 PCS, PROMIS-PF, VAS back, and VAS leg (all $P < 0.001$) with the exception of SF-12 PCS at the 6-week timepoint ($P = 0.079$). Results were more heterogenous in the arthroplasty group but still demonstrated significant improvements. Generally, patients in the arthroplasty group experienced significant improvement in

PROs following surgery that persisted up until 2 years. ODI and SF-12 PCS were not significantly improved at 6 years in the arthroplasty group. These results indicate that patients with and without a history of lower extremity arthroplasty experience similar improvements in PROs following lumbar spinal fusion at least up until the 2-year timepoint. The reason underlying the discrepancy in PRO improvement at 2 years cannot be fully elucidated in this analysis, but it is likely multifactorial and could be partially secondary to development of further lower extremity arthritis or the need for subsequent lower extremity arthroplasty given that there is a known increased risk of the need for contralateral arthroplasty following index hip or knee arthroplasty.[26]

Rates of MCID achievement were similar between the groups at all timepoints with the exception of ODI at 6-months, at which point MCID achievement was lower in the no arthroplasty group (55.1% vs 78.9%), and VAS leg at the 6-week timepoint, which, conversely, was greater for the no arthroplasty group (62.5% vs 38.1%). It was noted that the percentage MCID attainment for ODI, SF-12 PCS, VAS back, and VAS leg dropped in the arthroplasty group between the 1-year and 2-year timepoints, though this did not result in a significant discrepancy in MCID achievement between groups.

Results of this analysis are largely congruent with those of Djurasovic and Eneqvist, though with the longer follow-up included in this analysis a drop-off in PRO improvement was identified at the 2-year timepoint. Despite this drop-off, the percentage of patients reaching MCID was similar between arthroplasty and nonarthroplasty groups through the 2-year timepoint. Our findings further supplement literature suggesting that patients with concomitant lower extremity arthritis and a history of arthroplasty of the lower extremity can undergo lumbar spinal fusion without a negative impact on postoperative improvement and recovery.

Limitations

One of the limitations of this analysis was its retrospective and nonrandomized nature, which introduces the possibility of selection bias. Additionally, demographic analysis identified a mean age discrepancy between groups of roughly 10 years. It is possible that the more advanced age of the arthroplasty group could have a negative impact on recovery. However, the mean age of both groups was less than 65 years, and we would not suspect this relatively small age differential in 2 groups of nongeriatric patients to significantly alter outcomes. It is also noted that the nonarthroplasty group had a significantly higher rate of workers' compensation insurance. Given the known negative effects of workers' compensation claims on PROs in spinal surgery, this could have had a dampening effect on PRO improvement in the no arthroplasty group. Another limitation of this analysis is generalizability to more extensive lumbar fusions given that 90% of patients underwent fusion at a single level. The relationship between concomitant lower extremity arthritis and more extensive fusion for thoracolumbar deformity requires further investigation.

CONCLUSION

All patients, regardless of prior lower extremity arthroplasty, demonstrated significant improvement throughout the postoperative period, though these improvements were less consistent and did not persist through 2 years for patients with a history of arthroplasty. When directly compared between groups, patient-reported pain, disability, and physical function were largely similar regardless of arthroplasty history. Furthermore, most patients were able to achieve a clinically meaningful improvement in all measured outcomes regardless of whether they had previously undergone an arthroplasty procedure. Our results suggest that past surgical history of hip or knee arthroplasty should not necessarily discourage the use of lumbar fusion when properly indicated, as these patients are likely to experience significant clinical benefit.

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